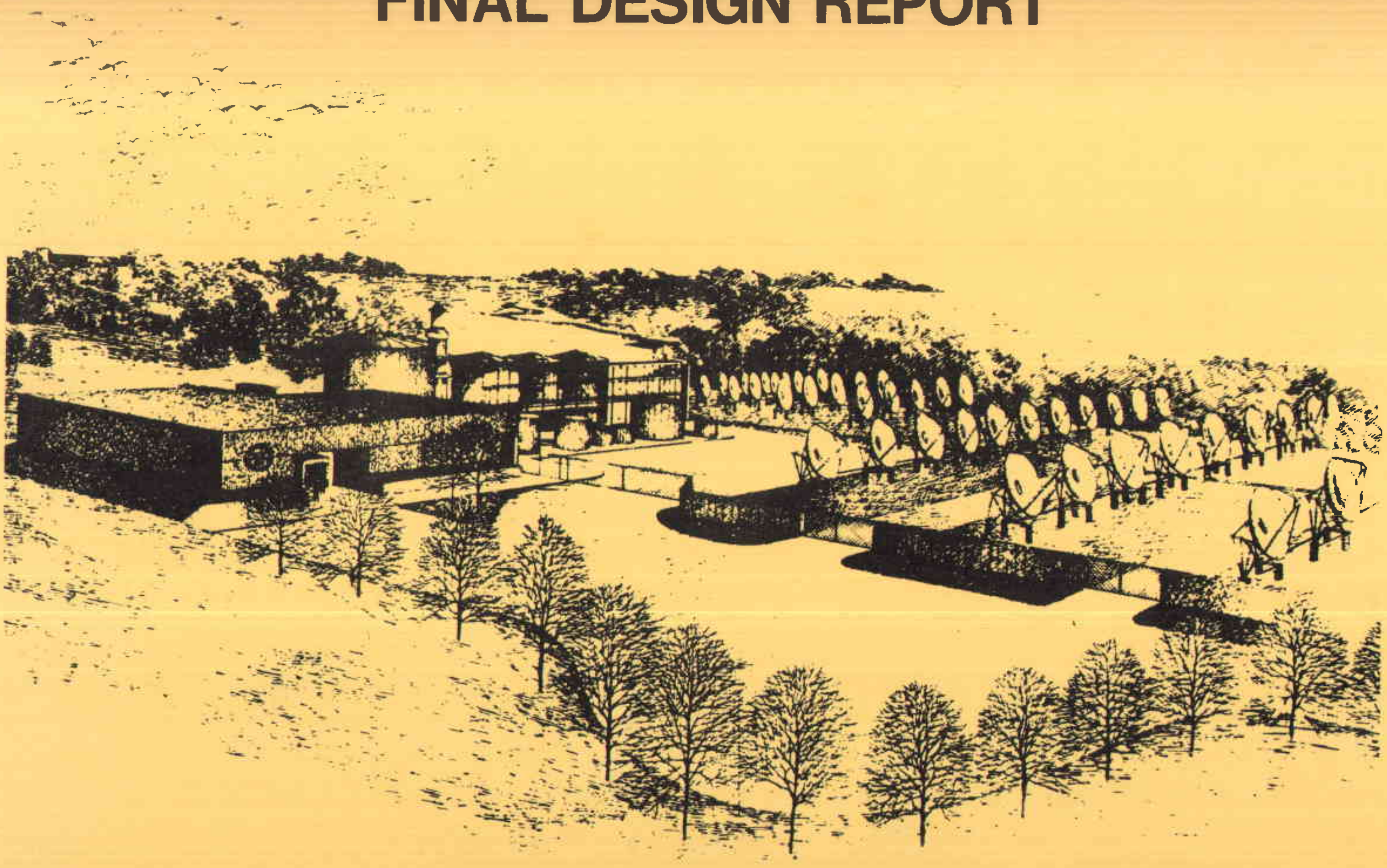
DOCUMENT NO. 78SDS4234
DATE: JANUARY 10, 1980
REVISION 1

1363

SOLAR TOTAL ENERGY PROJECT, SHENANDOAH

SYSTEM DESCRIPTION FINAL DESIGN REPORT



U.S. DEPARTMENT OF ENERGY
CONTRACT NUMBER DE-AC04-77ET20260

GENERAL ELECTRIC

ADVANCED ENERGY DEPARTMENT

JOB HUNKE

DOCUMENT NO. 78SDS4234
DATE: JANUARY 10, 1980
REVISION 1

1363

SOLAR TOTAL ENERGY PROJECT
SHENANDOAH

SYSTEM DESCRIPTION
FINAL DESIGN REPORT

U.S. DEPARTMENT OF ENERGY
CONTRACT NUMBER DE-AC04-77ET20260

GENERAL ELECTRIC

ADVANCED ENERGY DEPARTMENT

PREFACE

The Solar Total Energy Program (STEP) is a separate activity of the National Solar Electric Applications Program and is supported by the U. S. Department of Energy. During the program, a series of solar total energy systems is planned which will be designed, constructed, and operated to provide electricity and thermal energy to localized users such as Government and institutional facilities, apartment houses, shopping centers, and industrial and commercial plants, buildings, and complexes. The overall purpose of these energy systems is to demonstrate the high potential that solar energy offers for total energy systems, to develop a solar-oriented technology compatible with the high temperature demands of electric power conversion via thermodynamic cycles, and to privide the stimulus required so that private industry will aggressively participate, both as manufacturers and users.

The first industrial application of the solar total energy concept has been initiated as a cooperative venture of the U. S. Department of Energy and the Georgia Power Company. The Solar Total Energy Program consists of the design, construction, operation, and technical evaluation of a solar total energy system providing power to a knitwear factory operated by Bleyle of America, Inc. The detailed design phase of the project is currently underway, with completion occurring in the first quarter of 1980. The factory, initially equipped with its own independent (conventional) energy source, will derive greater than 50 percent of its annual energy needs from the sun when the solar energy system becomes operational in 1981.

The site for the STEP is located in the industrial park of Shenandoah, Georgia, which is about 25 miles south of the Atlanta airport on U. S. highway I-85. The land has been provided by Shenandoah Development, Inc., and exclusive use of the land will remain with the U. S. Government for the term of the agreement. The General

Electric Company/Space Division has been selected as the designer of the DOE funded and owned solar total energy system. Sandia Laboratories is the DOE technical manager for the STE program.

The objectives of the Solar Total Energy Program include the following:

- To obtain experience with hardware on large scale solar energy systems.
- To establish an industrial engineering capability for subsequent large scale solar total energy demonstration projects.
- To reduce the uncertainty of cost and performance estimates for large solar projects.
- To disseminate information on solar total energy systems.
- To design a system large enough to encounter the problems of a full-scale demonstration and to be scalable to higher power levels.
- To utilize all collected solar energy in a cost-effective manner.

Under terms of the cooperative agreement, the Georgia Power Company and DOE share site costs on a 50-50 basis for those activities of common interest. Additional services are provided to DOE by Georgia Power and their participants on a reimbursable basis. Member organizations of the Georgia Power team and their activities include:

- Shenandoah Development, Inc.
  Developer and factory building owner
- Georgia Institute of Technology
  Solar consultation to Georgia Power
- Heery and Heery, Inc.
  Site architectural and engineering liaison services
- Owens - Corning Fiberglass
  Energy conservation services
- Westinghouse Electric Corp.
  Site liaison.

The General Electric Company, Space Division (GE/SD) was selected by DOE following a competitive conceptual design phase as the subcontractor to design the DOE funded and owned STES at Shenandoah. GE/SD has engaged the following organizations as members of the STES team:

- GE Energy Systems Technology Division
  Steam system analysis and component selection
- GE Simulation and Control Systems Department
  Control system design and analysis
- Lockwood-Greene
  Engineering and architectural design.

Sandia Laboratories, Albuquerque, N.N., is DOE's technical manager for the STEP. This program is an outgrowth of research started in 1972 by Sandia.

TABLE OF CONTENTS

TABLE OF CONTENTS (Cont)

TABLE OF CONTENTS (Cont)

TABLE OF CONTENTS (Cont)

TABLE OF CONTENTS (Cont)

TABLE OF CONTENTS (Cont)

LIST OF ILLUSTRATIONS

LIST OF ILLUSTRATIONS (Cont)

LIST OF TABLES

LIST OF ACRONYMS

ACRONYM	DEFINITION	FIRST SECTION
A/D	Analog to Digital (Converter)	4.3.4.3.3
AAC	Absorption Air Conditioner (or Conditioning)	6.2.1
AISC	American Institute of Steel Construction	3.11.1
ANSI	American National Standards Institute	3.11.1
ASME	American Society of Mechanical Engineers	3.11.1
ASHRAE	American Society of Heating Refrigeration and Air Conditioning Engineers	2.1.1
BIL	Base Insulation Level	8.3.3.9
CFR	Code of Federal Regulations	3.11.1
CFS	Collector Field Subsystem	7.2.3.1.1
CAIS	Control and Instrumentation Subystem	2.1.2.4.1
CPU	Central Processing Unit	7.3.3
DEC	Digital Equipment Cooperation	7.3.1
DMA	Direct Memory Access	7.3.31
EMF	Electromotive Force (Voltage)	4.3.4.2.3
ES	Electrical Subsystem	8.0
GFE	Government Furnished Equipment	2.1.2.2
GPC	Georgia Power Company	3.1
HTS	High Temperature Storage	2.1.2.1
HUD	Housing and Urban Development (Administration)	2.2
HVAC	Heating, Ventilating and Air Conditioning	2.1.1
ICD	Interface Control Drawing	3.4.2
IES	Independent Energy Sources	3.2
I/O	Input/Output	7.3.3
LTS	Low Temperature Storage	6.1.1
MEA	Mechanical Equipment Area	2.1.2.1
MOS	Metal Oxide Semiconductor	7.3.3.1
MSY	Mean Solar Year	Fig. 4.3.3-8

LIST OF ACRONYMS (Continued)

ACRONYM	DEFINITION	FIRST SECTION
NEMA	National Electrical Manufacturers Association	3.11.1
NFPA	National Fire Protection Association	3.11.1
NPSH	Net Pump Suction Head	4.4.1.1
ODT	On-Line Debugging Technique	7.3.3.2
OSHA	Occupational Safety and Health Administration	3.11.1
PCS	Power Conversion Subsystem	2.1
P&ID	Piping & Instrumentation Diagram	6.1.2
PSW	Processor Status Word	7.3.3.2
RAM	Random Access Memory	7.3.3.2
RMS	Root-Mean-Square	4.3.3.1
ROM	Read Only Memory	7.3.3.2
RTD	Resistance Temperature Detector	4.2.5.3
SCS	Solar Collection Subsystem	2.1
SDI	Shenandoah Development Incorporated	2.2
SGS	Steam Generator Supply (Subsystem)	4.3.1.3
STEP	Solar Total Energy Program	Preface
STES	Solar Total Energy System	2.1
TBD	To Be Determined	
TEMA	Tubular Exchanger Manufacturers Association	3.11.2
TES	Thermal Energy Storage	2.1.2.4.1
TIG	Tungsten Inert Gas	4.3.1.1
TUS	Thermal Utilization Subsystem	2.1

SECTION 1

SECTION 1

INTRODUCTION

This document presents the description of the final design for the Solar Total Energy System (STES) to be installed at the Shenandoah, Georgia, site for utilization by the Bleyle knitwear plant. Thus, the document is intended to be a comprehensive technical manual that explicitly defines the requirements and the design features and characteristics of the individual subsystems and components which comprise the Solar Total Energy System for Shenandoah.

This document is an update of the System Description issued July 10, 1978 (78SD4234) and reflects the subsystem and component characteristics of the final system configuration.

Section 2 of the document first presents a general description of the energy system along with the location and site description. The Solar Total Energy Program objectives are listed also. The system design criteria and requirements are presented next in Section 3. Included in this section are the performance criteria and operating requirements; environmental conditions of operation; interface requirements with the Bleyle plant and the Georgia Power Company lines; maintenance, reliability, and testing requirements; health and safety requirements; and other applicable ordinances and codes. The remaining sections of the document describe the major subsystems of the STES. Section 4 presents the Solar Collection Subsystem (SCS), Section 5, the Power Conversion Subsystem (PCS), and Section 6, the Thermal Utilization Subsystem (TUS). The Control and Instrumentation Subsystem (CAIS) is described in Section 7, and the Electrical Subsystem (ES), in Section 8. Each of these sections include design criteria and operational requirements specific to the subsystem, including interface requirements with the other subsystems, maintenance and reliability requirements, and testing and acceptance criteria. The detailed description of the subsystem is presented along with the pertinent performance characteristics. Major components of each subsystem are described in more detail. Specific features of the control and instrumentation provisions for the subsystem are discussed, and subsystem operational modes are described.

SECTION 2

SECTION 2

SYSTEM DEFINITION

2.1 SCOPE

A Solar Total Energy System (STES) is defined as an energy system which uses collected solar energy to supply high grade (electrical/mechanical) and low grade (thermal) energy needs for selected applications. The basic function of the STES at Shenandoah is to supply the electric power, process steam, and heating and cooling demands of the 2323 square meters (25000 ft^2) Bleyle Plant.

Figure 2.1-1 presents an artist's concept of the Shenandoah STEP site and system. The STES design is essentially composed of three hydraulic loops or subsystems which transfer the collected solar energy into the appropriate energy forms required by the Bleyle Plant and a central control subsystem which monitors and controls the overall system operation.

The Solar Collection Subsystem (SCS) utilizes a series of hydraulic circuits which transport the collected solar energy from the collector field either to the high temperature storage or directly to the steam generator to the Power Conversion Subsystem (PCS). In the PCS, electrical power is produced by a dual steam turbine-generator while steam for process use is extracted from the rear of the first turbine to simulate operation of an extraction turbine likely to be used in larger commercial-size applications. The Thermal Utilization Subsystem (TUS) utilizes another series of hydraulic circuits to transport the heat rejection energy from the PCS to the low temperature storage or directly to the space heating and cooling units.

2.1.1 SITE LOADS

As a total energy system, the STES has been designed to serve all of the loads on the site and sized to supply at least 50 percent of the 2323 square meter (25,000 square

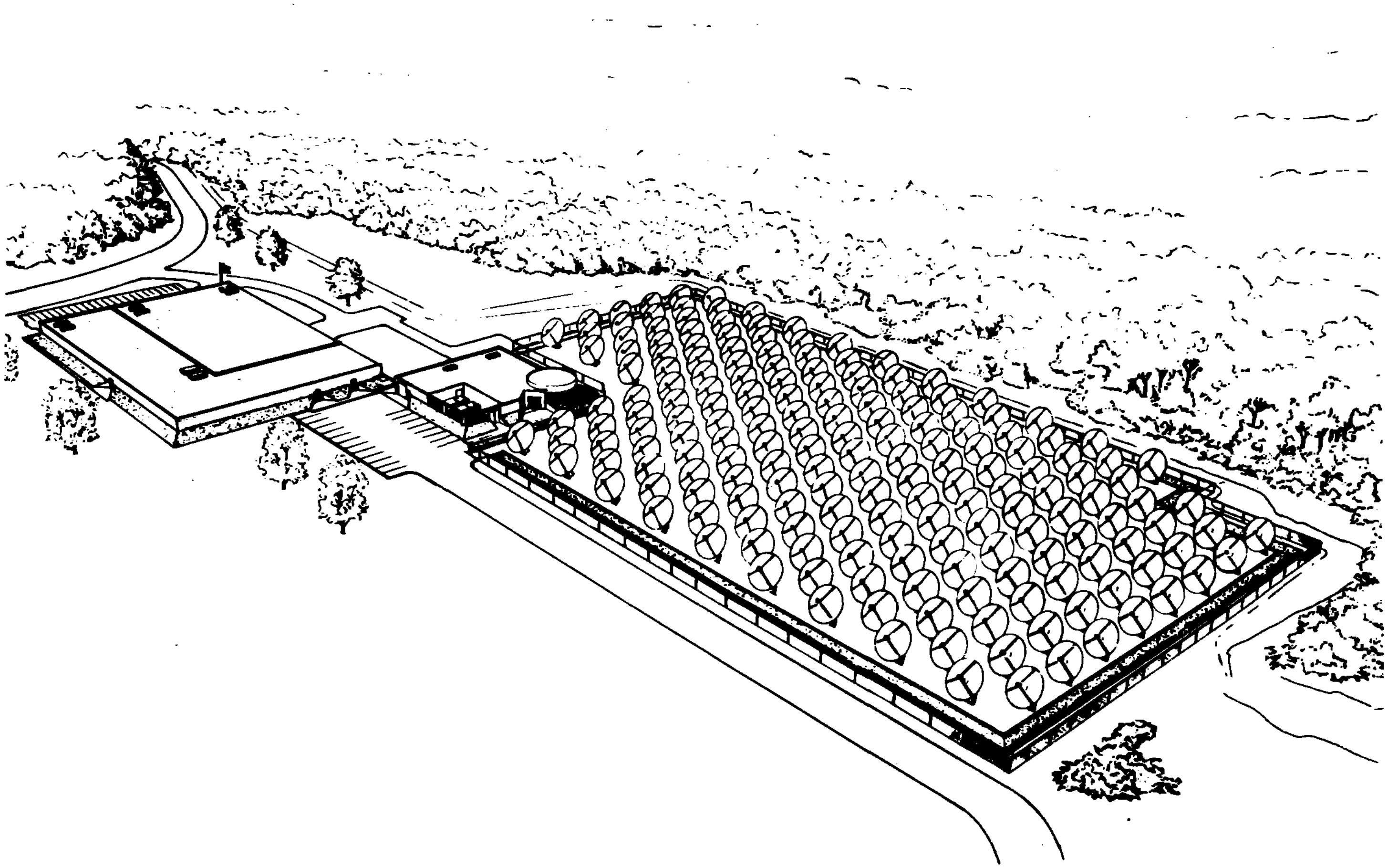


Figure 2.1-1. Solar Total Energy-Large Scale Experiment at Shenandoah, Georgia

foot) Bleyle Plant loads with solar energy consistent with the overall program objectives stated in the Preface. The site loads include the Bleyle Plant electric loads and STES operating power and power for the STES Mechanical Building, process steam to the Bleyle Plant used for pressing fabric and heating and cooling for both the Bleyle Plant and the STES Mechanical Building. The design loads used to size the STES are summarized in Table 2.1.1-1. In normal operation, the site electric load will not exceed 300 kW. To accommodate load fluctuations and to provide a better match with the site thermal loads, the STES operates with a 50 to 75 kW base load from the utility, and electric load follows between 150-250 kW in normal operation. Except for lunch and shift breaks, the plant electric load profile is relatively constant over the two shift operation as shown in Figure 2.1.1-1.

The plant's process steam demand is currently supplied by a natural gas fired boiler. Process steam at saturated conditions is required during all working hours, with the design profile shown in Figure 2.1.1-2.

TABLE 2.1.1-1. STES DESIGN LOADS

Served Load	Peak Load Requirement		STES Capacity
	Bleyle Plant	STES Building and Operating Loads	
ELECTRICAL	161 KW	137 KW*	400 KW
COOLING	113 TONS	20 TONS	133 TONS
HEATING	324 KBTU/HR	32 KBTU/HR	356 KBTU/HR
PROCESS STEAM	1380 LBS/HR	0	1380 LBS/HR

* INCLUDES MARGIN

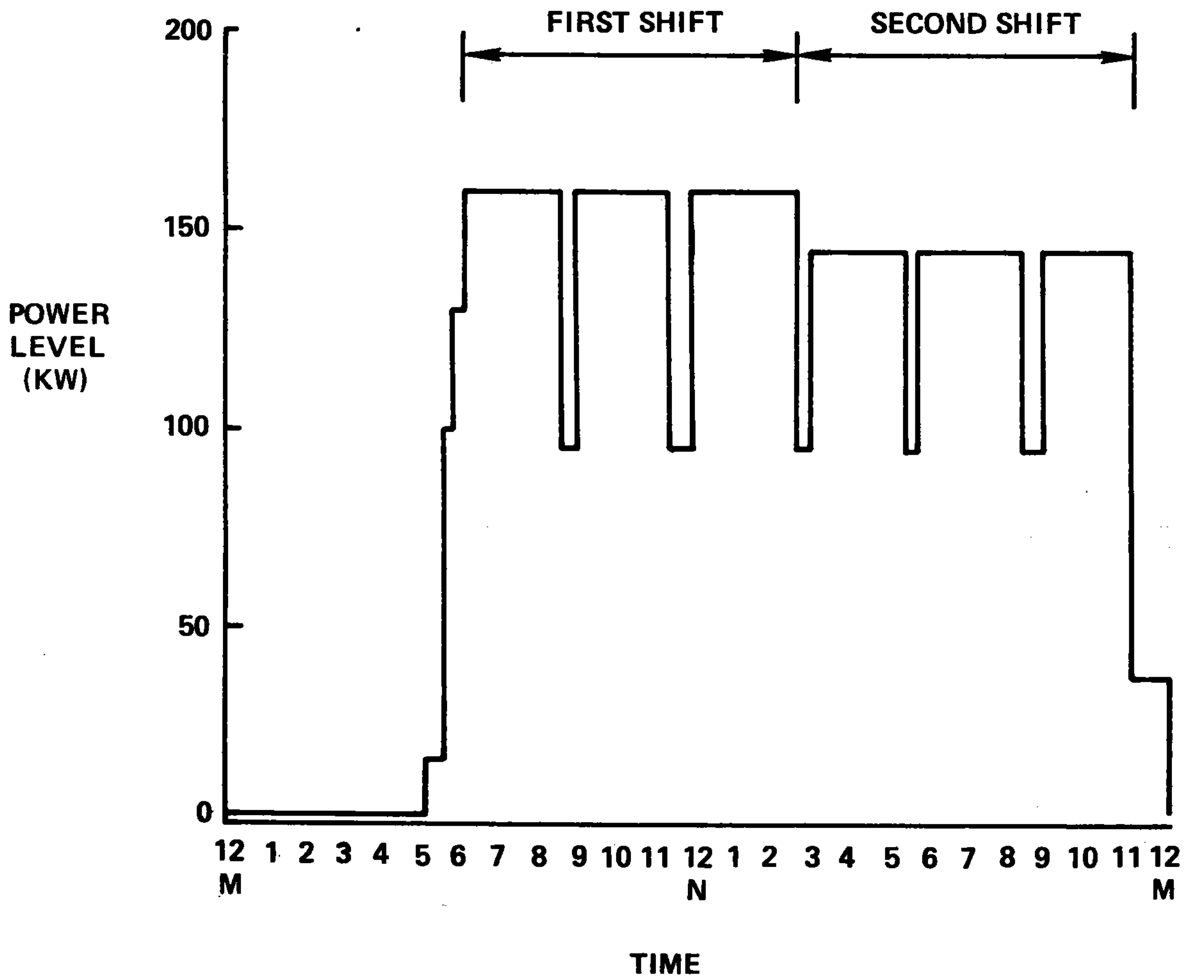


Figure 2.1.1-1. Bleyle Plant Electric Loads

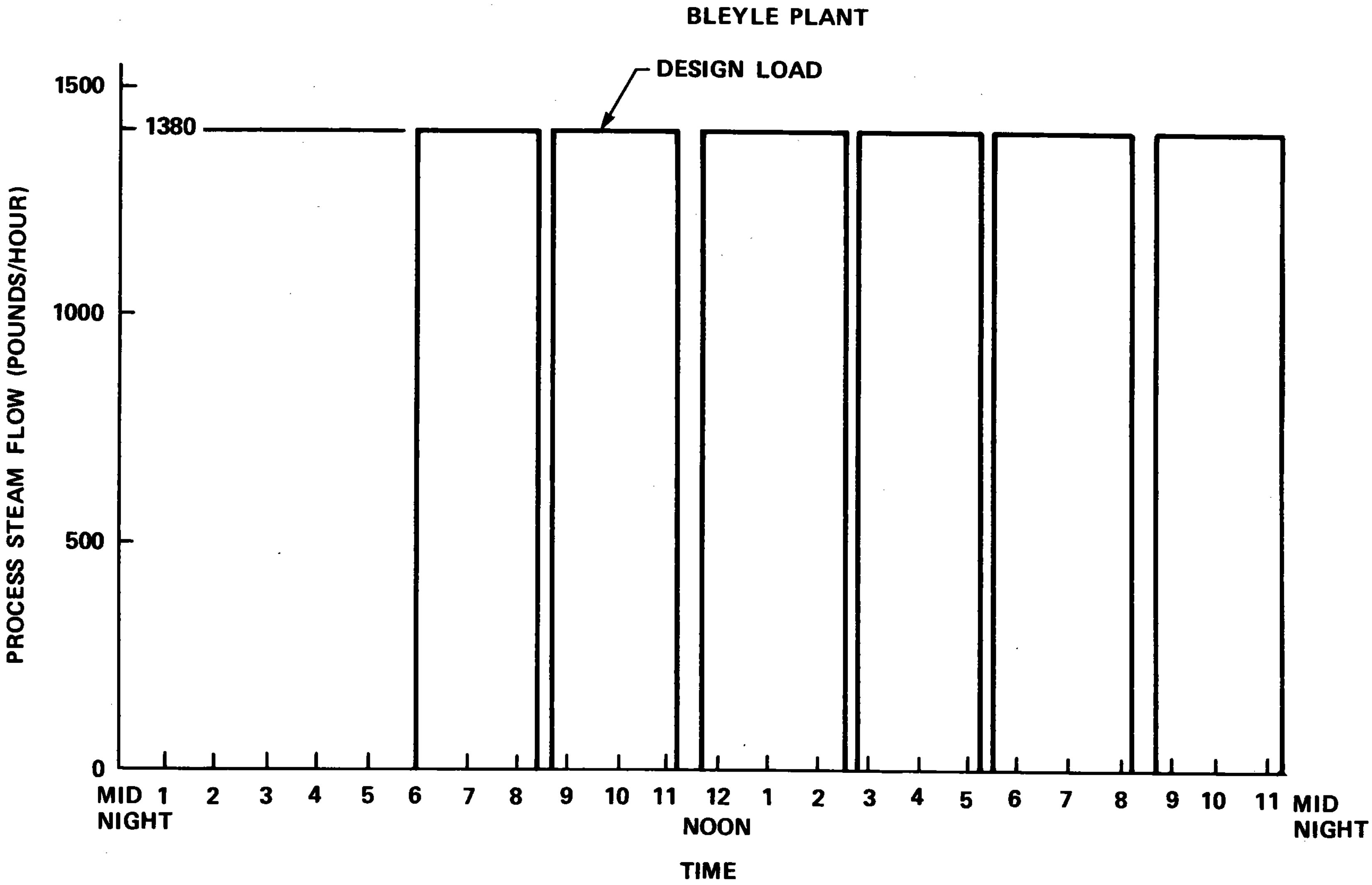


Figure 2.1.1-2. Process Steam Demand

The design cooling loads, based on ASHRAE design conditions, are summarized for the Bleyle plant and STES Mechanical Building in Table 2.1.1-1. The cooling loads consist primarily of internal heat generated by the process and building lighting and are relatively constant during plant operating hours. However, the plant heating, ventilating, and air conditioning (HVAC) system incorporates an economizer cycle which supplies a major portion of the internally generated cooling load from December to February. To provide a more optimum site thermal-to-electric load ratio for the STES, the cooling loads are served by a chilled water system supplied by an absorption chiller.

The maximum site heating load is 1.04×10^5 J/s (356×10^3 Btu/hr) which would occur if the design outdoor ambient temperature occurred when the plant was not in operation and with the system supplying maximum ventilation to the Bleyle plant.

2.1.2 OVERALL SYSTEM DESCRIPTION

The system is a fully cascaded total energy system design as shown in the Figure 2.1.2-1 schematic, featuring high temperature paraboloidal dish solar collectors with a 235 concentration ratio, a steam Rankine cycle power conversion system capable of supplying 100-400 kW(e) output with an intermediate process steam take-off point, and a back pressure condenser for heating and cooling. The design also includes an integrated control system employing the supervisory control concept to allow maximum experimental flexibility.

2.1.2.1 Solar Collection Subsystem

The Solar Collection Subsystem consists of an array of 120 seven-meter diameter, parabolic dish collectors, which provide a 139°K (250°F) temperature rise to a flow of Syltherm^{TM} 800* fluid through each collector in a series/parallel arranged, closed, hydraulic circuit. The design collector output temperature is 672°K (750°F). The receiver is a cavity type with the incident concentrated solar flux impinging upon an

*Syltherm^{TM} 800 is a registered trademark of the Dow Corning Corp.

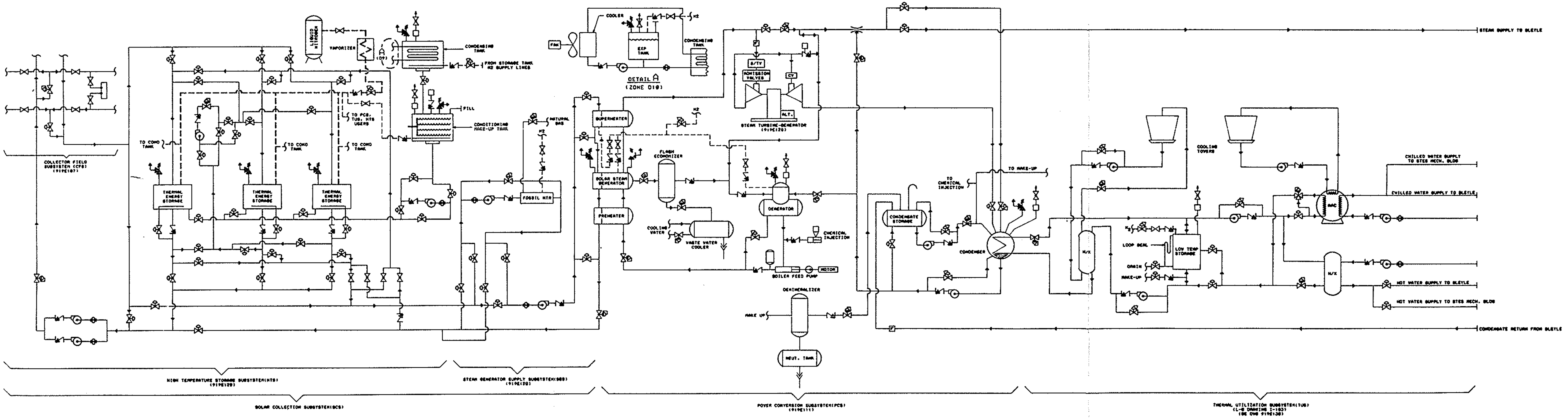


Figure 2.1.2-1. Shenendoah System Schematic

absorptive surface enclosed within an insulated cylindrical shell, The parabolic dish design, Figure 2.1.2-2, is based on a low-cost five meter antenna which Scientific-Atlanta supplies for communication/Earth station applications. As seen from the figure the dish is made up of individual petals which are die-stamped aluminum, and the entire assembly is field assembled. The aluminum is polished, and a weather surface is applied to allow maintenance of reflectance in the range of 0.88. The unit tracks individually in polar and declination axes.

The field piping network consists of field welded steel tubing covered with high temperature insulation. The parabolic dish collectors are arrayed on the Shenandoah collector field in a repeating diamond pattern (Figure 2.1.2-3).

The trickle oil concept was selected for the High Temperature Storage subsystem (HTS). This concept offers a low-cost solid storage medium for essentially all heat storage, thus reducing to a minimum the inventory of high-cost heat transfer oil. Sand is not necessary to fill voids between the solid medium pieces to reduce the fluid volume, so the filtration and cleaning of sand throughout the system is not required. Figure 2.1.2-4 presents a schematic diagram that shows the major components of a large trickle oil storage tank. The system includes manifolds for the backup dual-media approach.

Storage heat is either charged or discharged by trickling oil over a cold or hot storage bed, and the heat is transferred by a thin film of oil trickling over the iron ore. A drain plate is used to collect the oil into a sump area at the bottom of the tank. The design for the STES at Shenandoah has 0.79×10^{11} joule (75 MBtu) net capacity stored in three tanks: one to provide one hour of system operation at nominal load, 3.04 meters in diameter and 3.65 meters high (10 feet in diameter, 12 feet high); and the remaining two 5.7 meters in diameter and 4.87 meters high (19 feet in diameter, 16 feet high). During operation of the trickle oil storage system, flow is always into the top of each compartment, whether charging or discharging. A series of flow control valves and thermal switches direct the flow to the desired tanks.

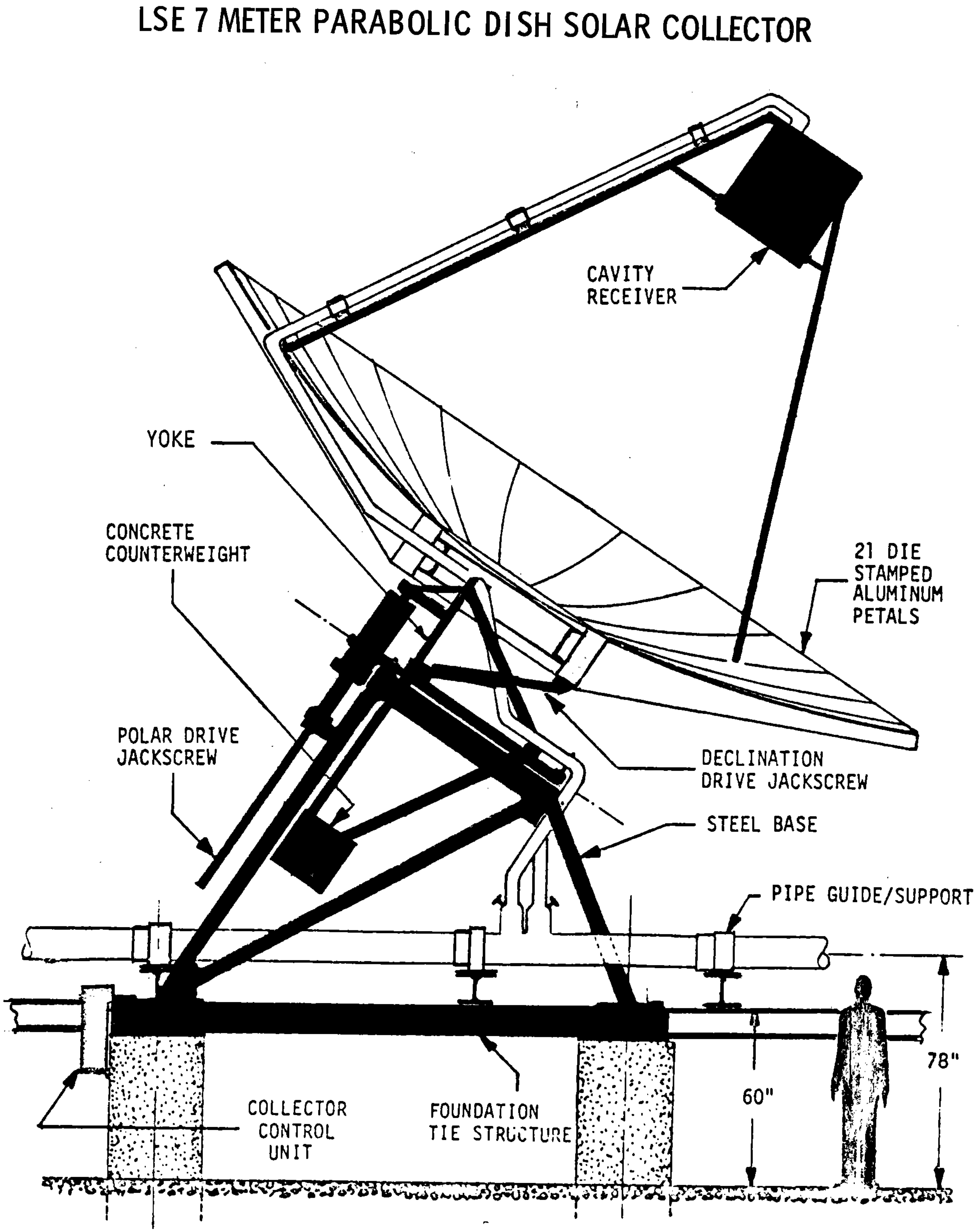


Figure 2.1.2-2. GE Parabolic Dish Solar Collector

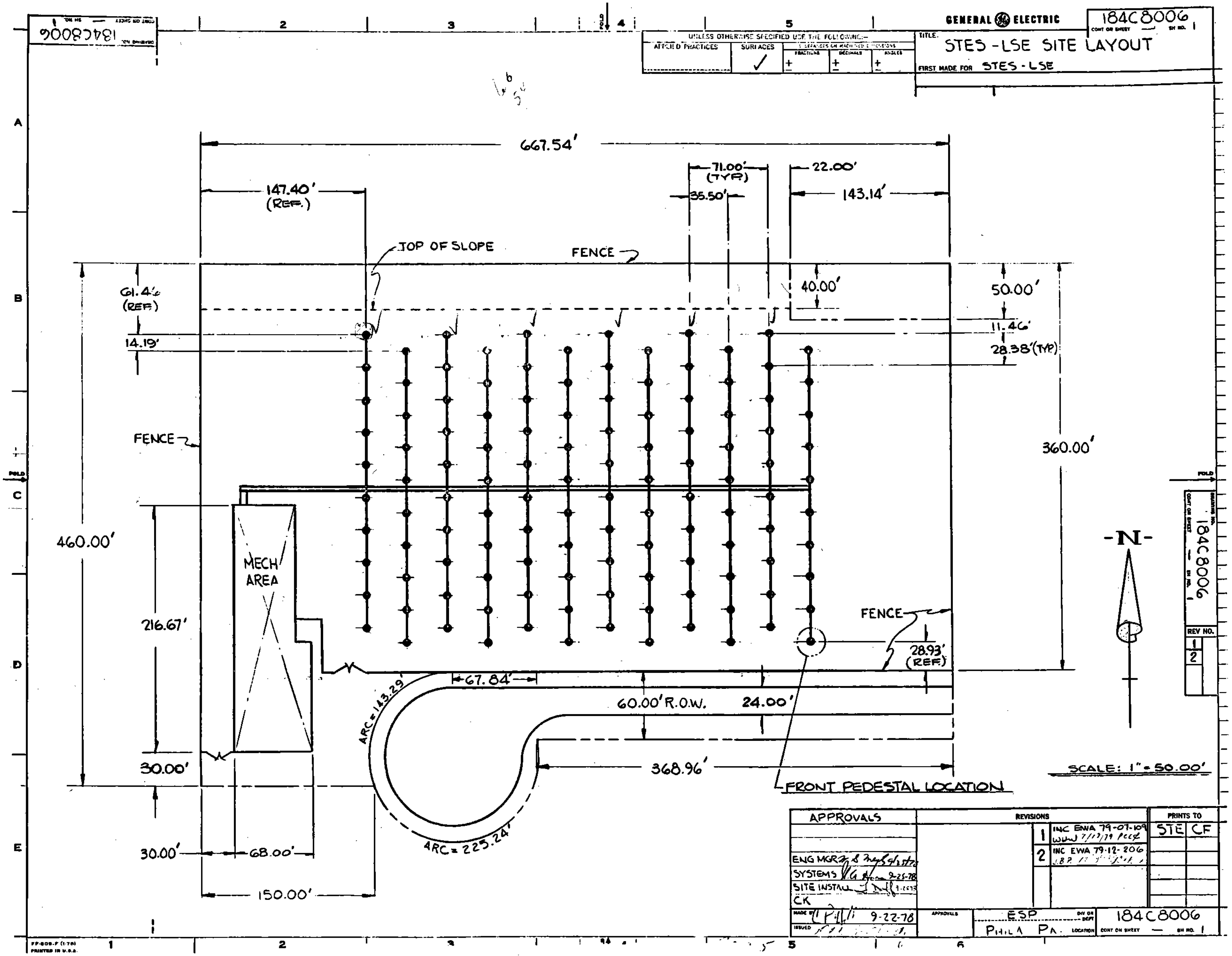
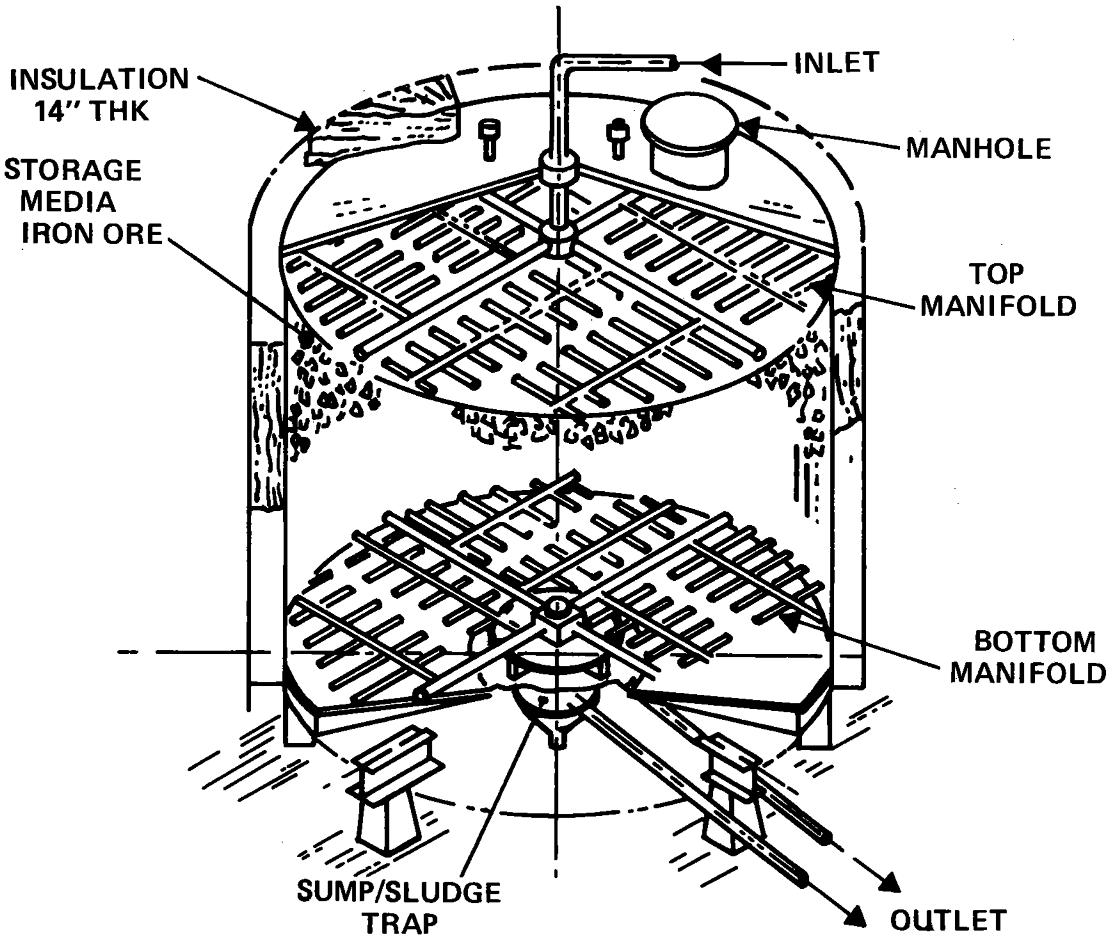


Figure 2.1.2-3. STEP Site Layout



SIZE: LARGE TANK
19' DIA x 16' HIGH
(LESS COVER)
34,023 GAL/313 TONS IRON ORE

SMALL TANK -
10' DIA x 12' HIGH
(LESS COVER)
7,069 GAL/ 62 TONS IRON ORE

Figure 2.1.2-4. Trickle Oil HTS Tank

The Solar Collection Subsystem also includes a fossil fired heater capable of supplying the PCS heat input requirement when the HTS is depleted.

2.1.2.2 Power Conversion Subsystem

The Power Conversion Subsystem consists of a three piece pool-type boiler with preheater, boiler and superheater, a steam turbine-generator set rated at 400 kW(e) supplied by Mechanical Technology, Inc as Government Furnished Equipment (GFE), a condenser and condensate storage tank, make-up demineralizer, deaerating heater, and boiler feed pump. The components are shown schematically in Figure 2.1.2-5. In normal operation, steam at 655°K (720°F) and 4.8×10^6 N/m^2 (700 psig) is generated in the boiler-superheater, heated by Syltherm™ 800, and delivered to the turbine inlet. The turbine generator set consists of two high speed (42,450 rpm) turbines coupled to a gearbox which reduces the speed to the 30 rev/s (1800 rpm), 60 Hz alternator. The back of the first turbine has a take-off for process steam and steam for regenerative feed water heating. The second turbine operates into a condenser at 383°K (230°F) to provide 372°K (210°F) water to the Thermal Utilization Subsystem. Steam make-up is preheated to 383°K (230°F) by being introduced as a spray into the condenser.

2.1.2.3 Thermal Utilization Subsystem

The Thermal Utilization Subsystem major components include a 1×10^{10} joule (10 MBtu) capacity sensible heat low temperature water storage system, a 9.0×10^5 J/s (256 ton) absorption chiller derated to provide 4.7×10^5 J/s (133 tons) with inlet hot water at 372°K (210°F), and two separate cooling towers for heat rejection from both the absorption chiller and the PCS condenser. The storage system is available to supply heating or cooling loads when the PCS is not operating such as at night or on weekends. The full system capacity, sized for a 11°K (20°F) temperature differential, is contained in a single tank 7 meter (23 feet) in diameter by 6.0 meter (20 feet) high.

The absorption chiller and cooling towers are standard off-the-shelf items which will not require design modifications. The absorption chiller has self contained controls to sense load variations and will supply chilled water directly to the Bleyle Plant piping system. The system will have the capability to supply heating to the office area and cooling to the plant process areas simultaneously.

2.1.2.4 Control and Instrumentation Subsystem

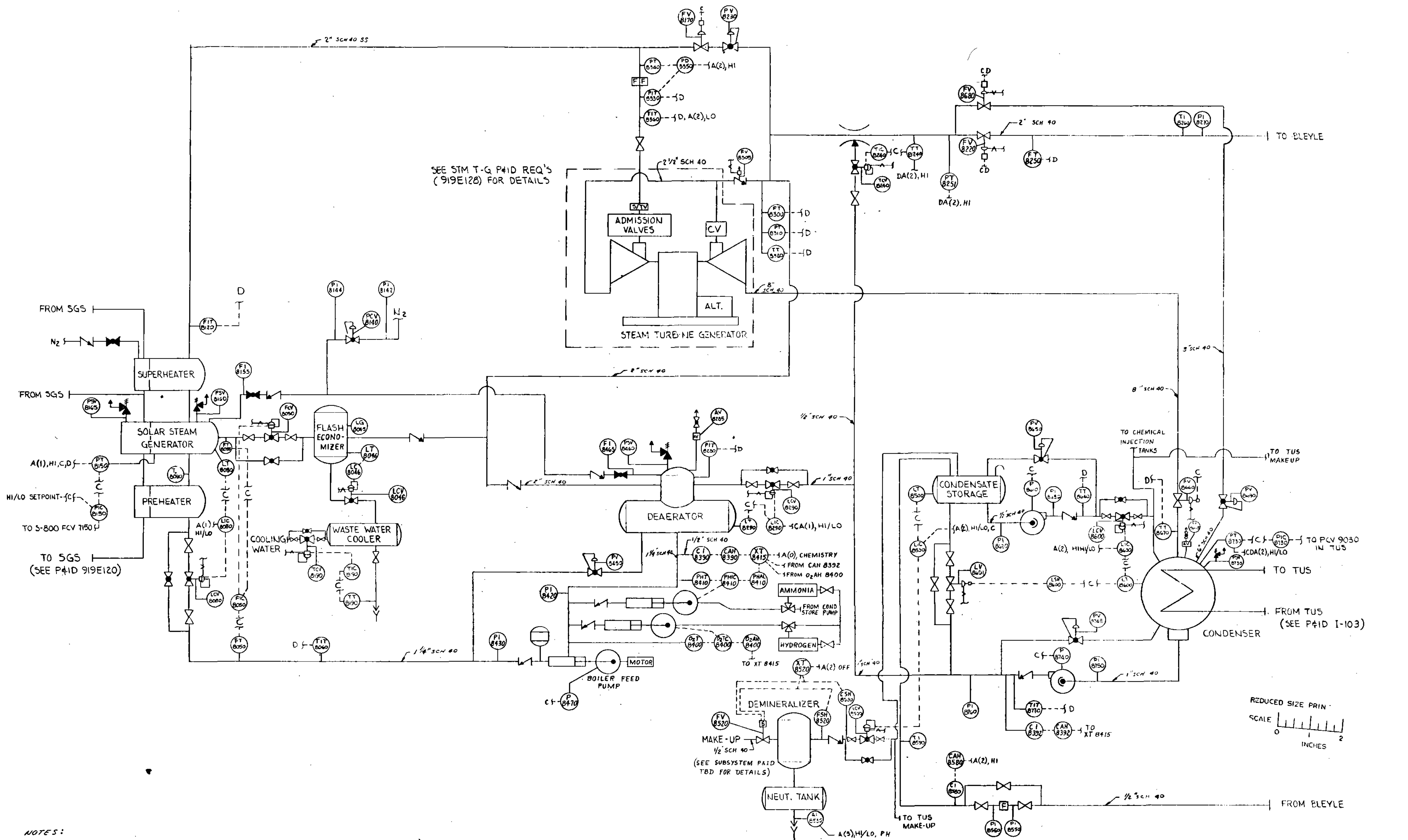
2.1.2.4.1 Basic Operating Philosophy

The Control and Instrumentation Subsystem (CAIS) design allows maximum operational flexibility. Six modes of operation are defined.

-Normal
-Experimental
-Diagnostic
-Fail Safe
-Degraded
-Maintenance

In the normal mode of operation the control system will initiate collector tracking, energy storage, electrical power generation, and auxiliary air conditioning or heating. The electrical requirements of the Bleyle Plant will be monitored and sufficient power generated to supplement the base load supplied by Georgia Power Company. On week-ends and during periods of lower power demand, energy will be stored for later use.

A switch to alternate modes will allow the operator to initiate solar collection experiments, monitoring, and recording experimental data as needed. The operator may initiate computer stored diagnostic routines in the event of a malfunction. The critical components of the system are fail-safed to prevent damage during power or primary control failures or over temperature conditions. Finally, the system will be



NOTES:

1- LOCAL CONTROL COMPONENTS (TRANSMITTERS, CONTROLLERS, CONTROL VALVES) SHOWN AS ELECTRICAL CONTROL/PNEUMATIC OPERATION TO INDICATE FUNCTIONS. SPECIFIED LOCAL CONTROLS MAY BE OTHERS, HOWEVER TRANSMITTER INTERFACE WITH PCS MICROPROCESSOR IS TO BE ELECTRICAL (4-20 mA)

2- MODE SELECTION VALVES (POSITIONED VIA PCS μP) TO BE ELECTRICAL CONTROL/PNEUMATIC OPERATION. VALVES TO BE EQUIPPED WITH POSITION SWITCHES

3- VENT, DRAIN, SMALL PIPE SIZES, AND ADDITIONAL PV'S AND OTHER SPECIALTIES NOT SHOWN. STANDARD ENGINEERING PRACTICE TO BE EMPLOYED.

4- ADDITIONAL COOLING WATER CONNECTIONS NOT SHOWN

5- ELECTRICAL SYSTEM/INSTRUMENTATION SHOWN ON GPC INTERFACE DRAWING E3.

6- COMPONENT LOCAL CONTROL/PANEL INTERFACE TBD. REFER TO COMPONENT SPECIFICATIONS

7- SEE INSTRUMENTATION LIST (63A136372) FOR DETAILS.

KEY TO NON-STANDARD DESIGNATIONS

- AV - AUTO VENT
- X - COMPONENT CONTROL/STATUS

MICROPROCESSOR (μP) OR LOCAL CONTROLLER SIGNAL I/F'S

- C - CONTROL
- D - DATA FOR SYSTEM PERFORMANCE EVALUATION
- E - DATA FOR EXPERIMENT
- A(1) - ALARM, REMOTE READOUT (PANEL LIGHT), EMERGENCY
- A(2) - ALARM, REMOTE PRINTOUT (CRT), OPERATOR ACTION
- A(3) - ALARM, LOCAL, MAINTENANCE RESOLUTION

Figure 2.1.2-5. Power Conversion Subsystem Flow Circuit operational in a degraded mode when certain components, such as a collector branch, are not available due to routine maintenance or component failures.

Control of the solar collectors will be achieved via a serial control loop from the central computer. Coarse solar tracking will be provided by a computer stored algorithm during start-up and coast, with fine tracking provided by an optical feedback control loop. The temperature of the fluid at each receiver will be monitored and branch fluid flow rate adjusted to achieve the desired fluid temperature. Automatic defocus will activate should the fluid in any collector receiver exceed a safe temperature. Automatic stowing will actuate if necessary to protect a collector under adverse climatic conditions.

The High Temperature Storage (HTS) subsystem will be carefully monitored with level and temperature sensors to determine charge and discharge readiness. The Syltherm™ 800 fluid will be routed according to the HTS status. Additionally, if the system is fully charged and no additional energy can be handled, collector stowage will automatically occur to prevent fluid over-temperature. A micro-processor control unit controls the HTS and interfaces the HTS with the central console.

The Power Conversion Subsystem incorporates the steam generation plant (boiler) and the steam turbine-generator. This subsystem is also under control of the micro-processor. Automatic start-up/shut-down sequences as well as built-in protection functions are an inherent part of this equipment. The electrical requirements of the knitwear factory will be monitored and generator output moderated according to need.

Heat to the Thermal Utilization Subsystem is provided by means of a fluid coolant loop from the PCS condenser. The control system will provide coolant flow and temperature control to maintain the PCS condenser pressure and temperature. The absorption air conditioning and hot water heating system will respond to the requirements of the Bleyle Plant as well as the STES Mechanical Building. The micro-processor control unit will provide control and monitor functions for this system.

2.1.2.4.2 Control System Design

The Control and Instrumentation Subsystem is comprised of a central control console, the central mini-computer and two micro-processor control units. The operator shall have the capability to monitor and control basic system functions from the control panel. All other detailed monitored and controlled functions will be via the computer keyboard and CRT (Cathode Ray Tube) interface. Monitored data will be recorded from experiments, alarms, and normal operation on magnetic tape storage and in hard copy form on the computer line printer. Signal conditioning circuitry will be provided as needed in the processors. The mini-computer is programmable to allow a high degree of system control and monitoring flexibility.

2.1.3 SYSTEM PERFORMANCE

For the system design of 120 seven-meter diameter dishes and $0.79^{5} \times 10^{11}$ joule (75 MBtu) of high temperature storage capacity, direct solar contribution to the plant loads includes an estimated 34 percent of the annual electrical energy requirements, 54 percent of the process steam required, and 78 percent of the energy required to drive the absorption air conditioning system. This results in an annual solar replacement of 54 percent. Remaining low grade 372°K (210°F) thermal energy may be used to supply part of the hot water requirements for other nearby applications. On cloudy days, after solar energy is expended, the total energy system can be operated on the fossil heater. The system thus has the capability to supply the full plant loads on-site.

2.2 LOCATION AND SITE DESCRIPTION

The proposed Solar Total Energy System will be located in Shenandoah, Georgia. Shenandoah is a new town near Newnan, Georgia about 40 kilometers (25 miles) southwest of Atlanta as shown in Figure 2.2-1. This new community is being developed

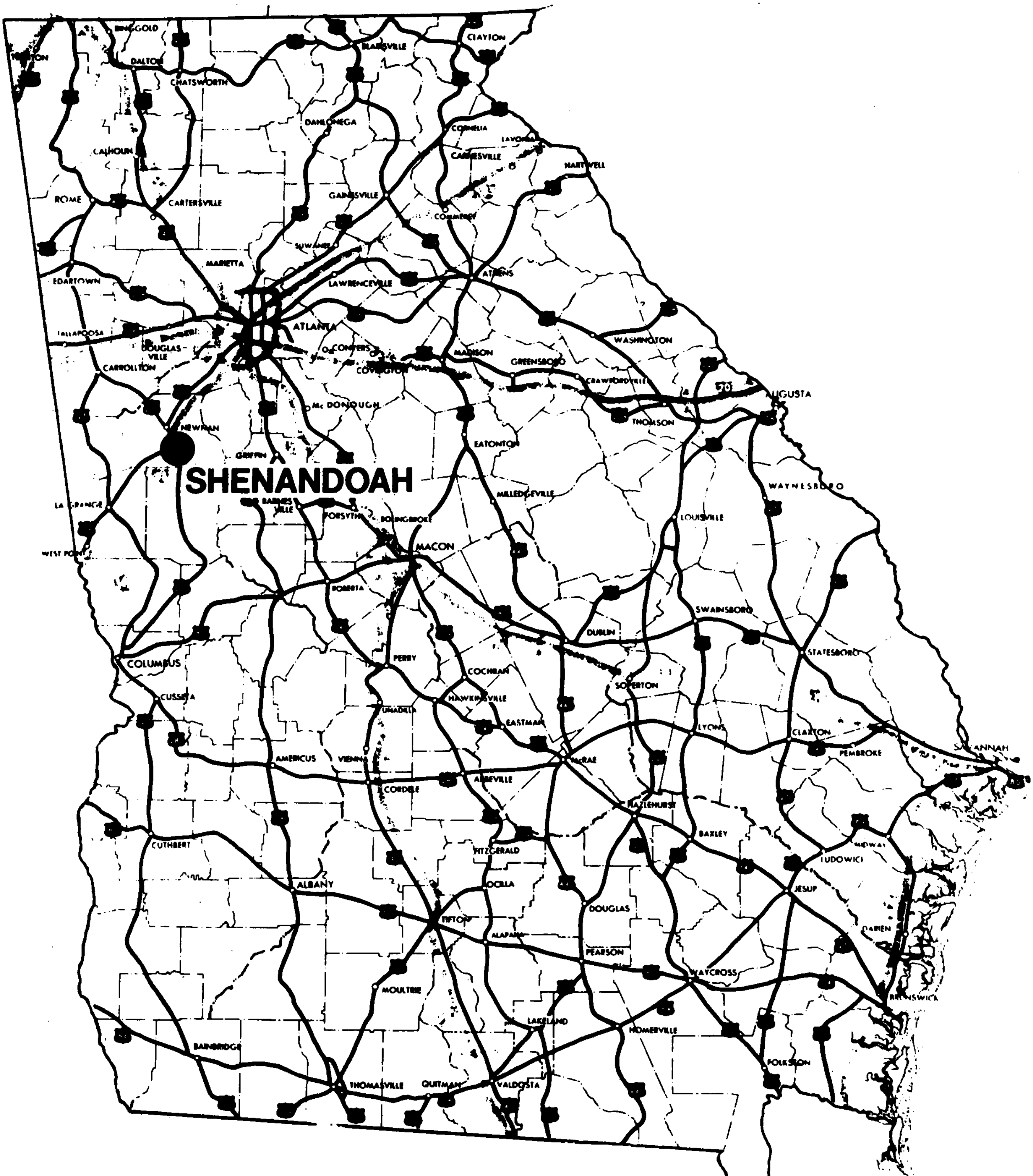


Figure 2.2-1. Location Map

by Shenandoah Development Incorporated (SDI) which was established in 1969 by Unioamerica-Incorporated. Approximately 30 square kilometers (7,400 acres) are currently being developed by SDI.

The site that was made available by SDI for the proposed total energy facility is defined in Figure 2.2-2 (Plat I). It consists of approximately 23,150 square meters (5.72 acres) of gently sloping land. As depicted in Figure 2.2-3, the site is near the intersections of Interstate 85 and Georgia Highway 34. The site is connected to Newnan by Georgia Highway 34 and Atlanta by Interstate 85. The Bleyle knitwear plant is located along the west property line of the development.

Access to the Bleyle facilities will be via Amlajack Boulevard. The property adjacent to the north boundaries of the Bleyle facility/STES site is neither owned nor controlled by SDI. Located near the northeast corner of the collector tract is a parcel of land measuring 15 meters by 44 meters (50 feet x 143 feet). This property is owned by the Housing and Urban Development Administration (HUD) and is designated as a green area. Green areas are intended to be land which will never be developed. However, the HUD property can be modified to control erosion at the STES site, if required.

Positioned directly south of the site on a parcel of land with a peak elevation of 296 meters (970 feet) is a 3785 cubic meter (1,000,000 gallon) water tower. The height of the water tower is approximately 51 meters (166 feet). SDI owns and operates the water facility.

Located on the STES site itself are two man made structures. The first is a meteorological station on a 6 meter by 6 meter (20 ft. by 20 ft.) concrete pad. This station will eventually be dismantled and relocated to record data in conjunction with STES operations. The second structure is a 0.2 meter (8 inch) concrete sanitary sewer line. The concrete pipe is located approximately 2.7 meters (9 feet) below the existing grade elevation. Service to the sewer is via two manholes located on Figure 2.2-2.

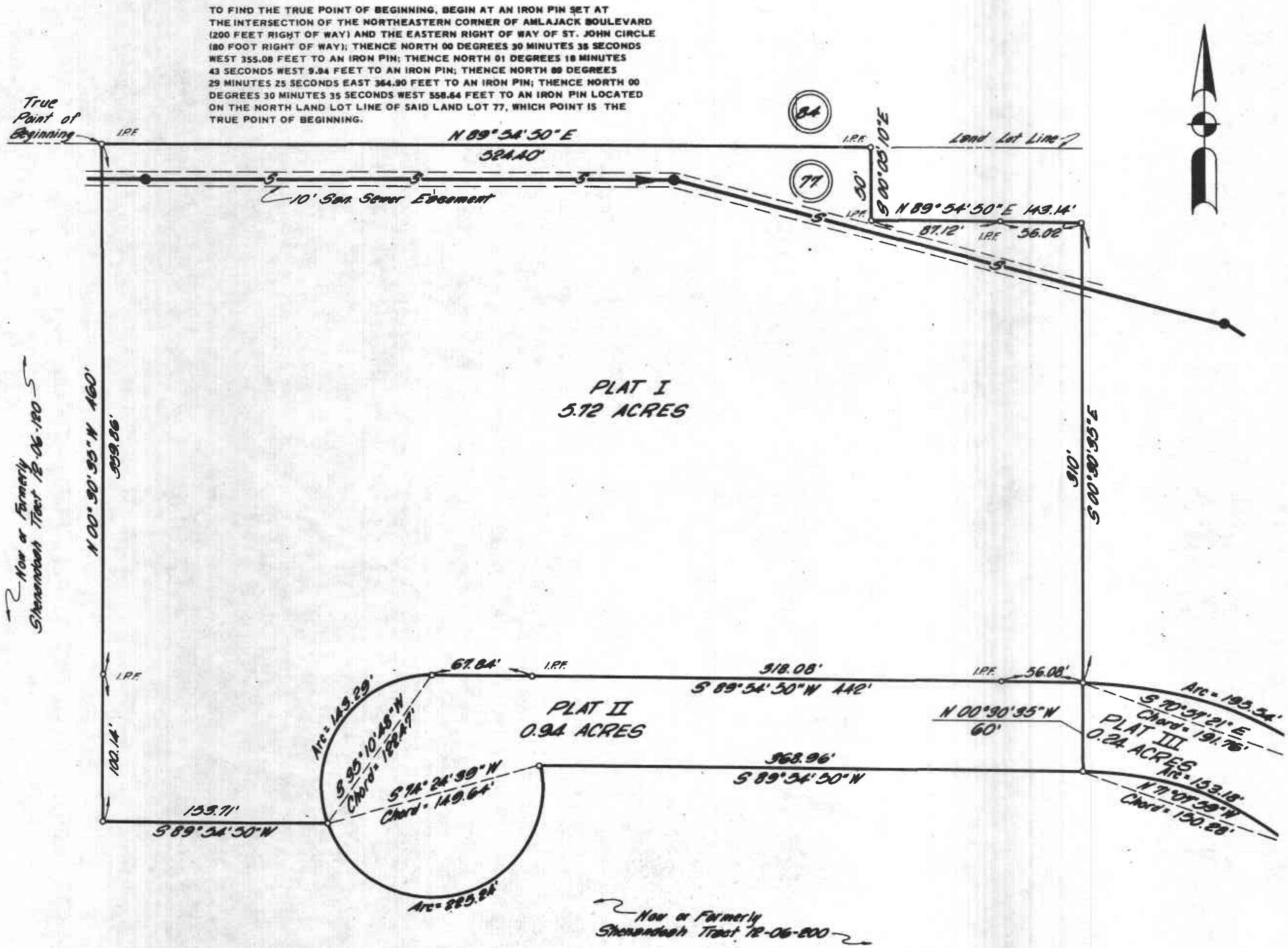


Figure 2.2-2. The Plot Plan (5.72 Acre Plot)

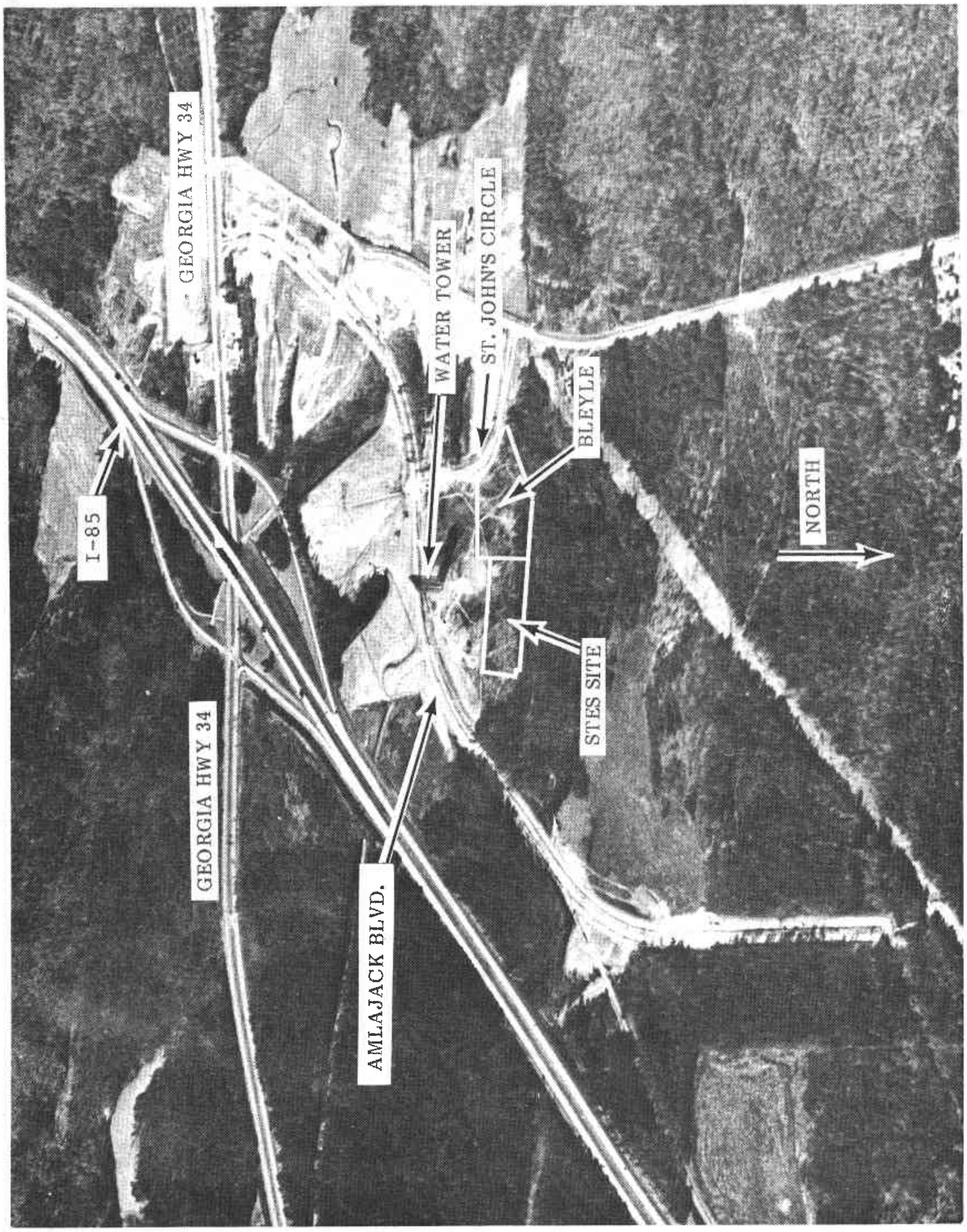


Figure 2.2-3. Aerial Photograph - Looking South

It should be noted that the sanitary sewer has a three meter (10 feet) easement and the manhole elevations will need to be adjusted to any changes in surrounding ground elevations.

All other lands that adjoin the collector boundary line are owned by SDI. SDI has plans to install a road southeast of the site to provide access to Amlajack Boulevard. Since the region between the collector field and Amlajack Boulevard has not been assigned to a third party by SDI, the exact position of the road is not final. The land in this area will be graded in conjunction with STES site preparation. This will reduce the potential for shadowing the solar collector field and thus enhance system performance.

2.3 EXPERIMENT OBJECTIVES

Specifically stated, the experiment objectives are to:

a) Develop within industry the engineering and development experience on large scale solar total energy systems for subsequent demonstration projects.

b) Assess the interaction of solar energy technology with the application environment.

c) Narrow the prediction uncertainty of the cost and performance of solar total energy systems.

d) Expand solar engineering capability and experience with large-scale hardware systems.

e) Disseminate information on solar total energy.

SECTION 3

SECTION 3

SYSTEM DESIGN CRITERIA

3.1 PERFORMANCE CRITERIA

a) The STES shall be designed to supply at least 50% of the annual energy requirements (combined thermal and electric) of the Bleyle knitwear plant.

b) The quality of the electric power generated by the STES must fall within the limits established by the Georgia Power Company (GPC):

Voltage: 480v ±5%

Frequency: 60Hz ±1/2%

Maximum Voltage Waveform Distortion: 5%

c) The quality of the process steam supplied at the Bleyle Plant interface from the STES must satisfy the following process requirements:

At max. flow rate of 0-.174 kg/s (0-1380 lb/hr) - steam at 7.93×10^5 N/m^2 and 466°K (115 psia/379°F)

3.2 SYSTEM OPERATIONAL REQUIREMENTS

a) The STES shall be capable of operating in parallel with the independent energy sources (IES) on a daily basis.

b) The STES shall be capable of supplying electrical power to the GPC grid network.

c) The STES shall be capable of being completely disconnected from the Bleyle Plant.

d) The STES shall be capable of operating as a peak shaving system, i.e., supplying peak electric loads while a base load is supplied by the electric utility.

e) The STES shall have stand alone operational capability, i.e., be capable of supplying all the Bleyle Plant energy requirements independent of the IES during selected experimental operating conditions.

f) A high temperature thermal energy storage subsystem (HTS) shall be included in the design of the STES to store excess energy collected during system operation and to extend its operational capability during periods of no insolation.

g) A standby fossil fuel heater shall be included in the design of the STES to provide system operational capability independent of solar insolation and and stored energy.

3.3 ENVIRONMENTAL CONDITIONS

Ambient Temperatures

Maximum	313°K (104°F)
Minimum	254°K (-3°F)

Wind

Design operating speed	13.4m/s (30 mph)
Design survival speed	31.3m/s (70 mph) (sustained)
	40.2m/s (90 mph) (gusts)

Hail

Survive damage to structural and mechanical mechanisms - Design diameter	.015m (0.6 inch)

Lightning

Survive damage due to lightning strike having characteristics:

Peak discharge current	100,000 amps
Rise time	1 micro sec

(These numbers account for over 98 percent of recorded lightning strikes.)

3.4 INTERFACE REQUIREMENTS

3.4.1 SITE

a) The entire STES, including solar system components and the STES Mechanical Building, shall be constructed within the boundaries of the 23,150 square meters (5.72 acres) tract specified as Plat I on Figure 3.4.1-1. No portion of the system shall extend beyond these boundaries.

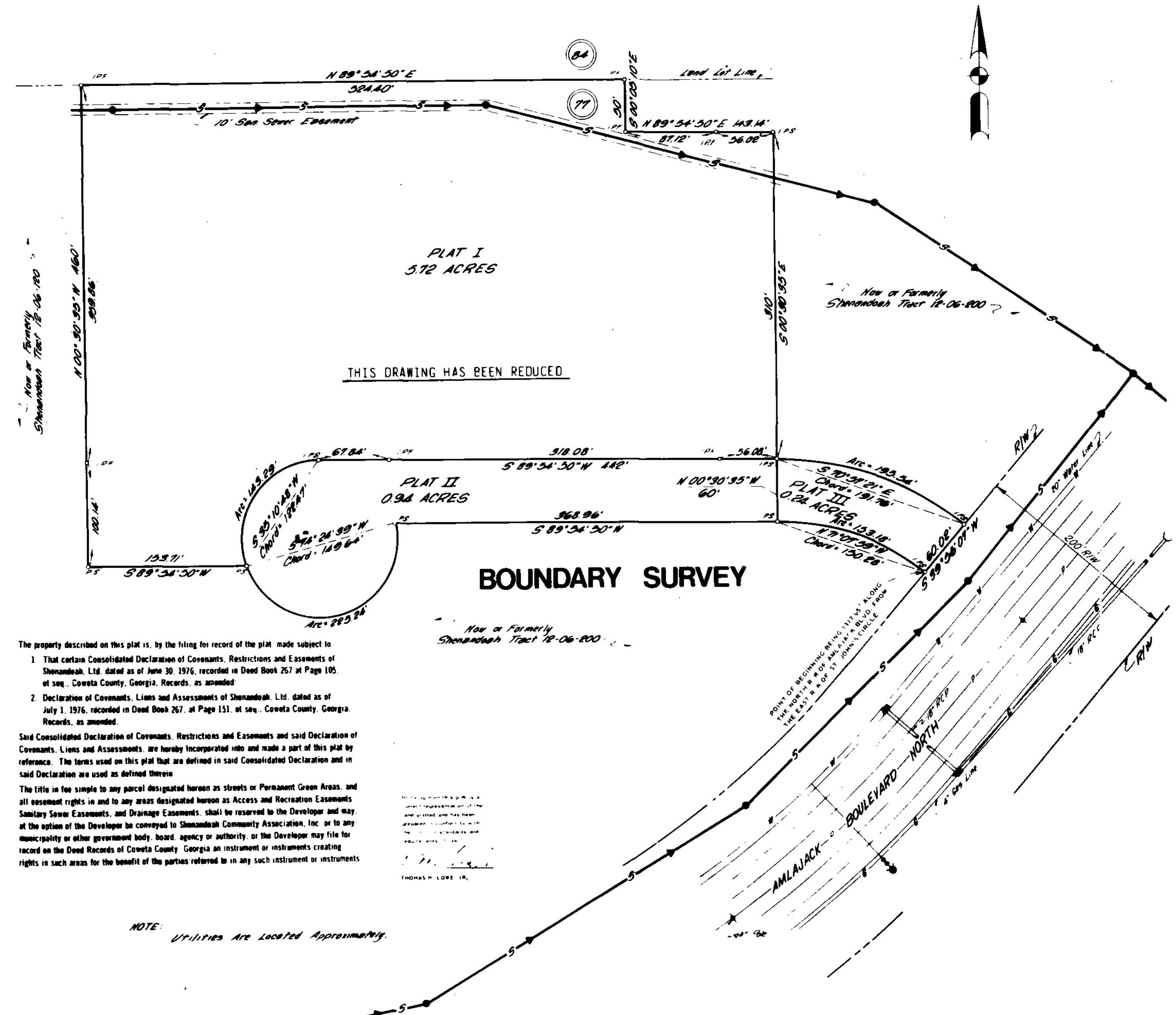


Figure 3.4.1-1. The Plot Plan (5.72 Acre Plot)

b) An access road to the STES shall be provided and constructed within the boundaries of the tracts specified as Plat II and Plat III of the site as shown on Figure 3.4.1-1.

c) In accordance with the terms of the Solar Easement Agreement between Shenandoah, Ltd. and the Georgia Power Company, the allowed maximum height of any improvement located on the land adjacent to the STES site shall not be exceeded.

d) Access for all utility connections and easements shall be provided.

e) A meteorology station shall also be located within the site boundaries.

3.4.2 MECHANICAL

All interconnections between the STES mechanical systems (steam, heating and cooling) and the Bleyle Plant shall be compatible with the Bleyle Plant piping as indicated on Heery & Heery's STES Interface Control Drawing (ICD) No. M-4, Figure 3.4.2-1.

3.4.3 ELECTRICAL

a) The existence and/or operation of the STES shall not cause any interruption of service in the GPC system.

b) The existence and/or operation of the STES shall not cause any degradation of electrical service to the Bleyle Plant.

3.5 CONTROL & INSTRUMENTATION REQUIREMENTS

a) All control systems of the STES shall be capable of operation within the full range of the expected seasonal and diurnal variations in their control parameters.

b) The control and instrumentation system of the STES shall have the capability of being placed in a supervisory control mode, where an individual operator can assume direct control over the system and/or selected components via the computer terminal.

c) All control systems of the STES shall be capable of monitoring, reporting, and recording those parameters essential in evaluating the system and subsystem performance.

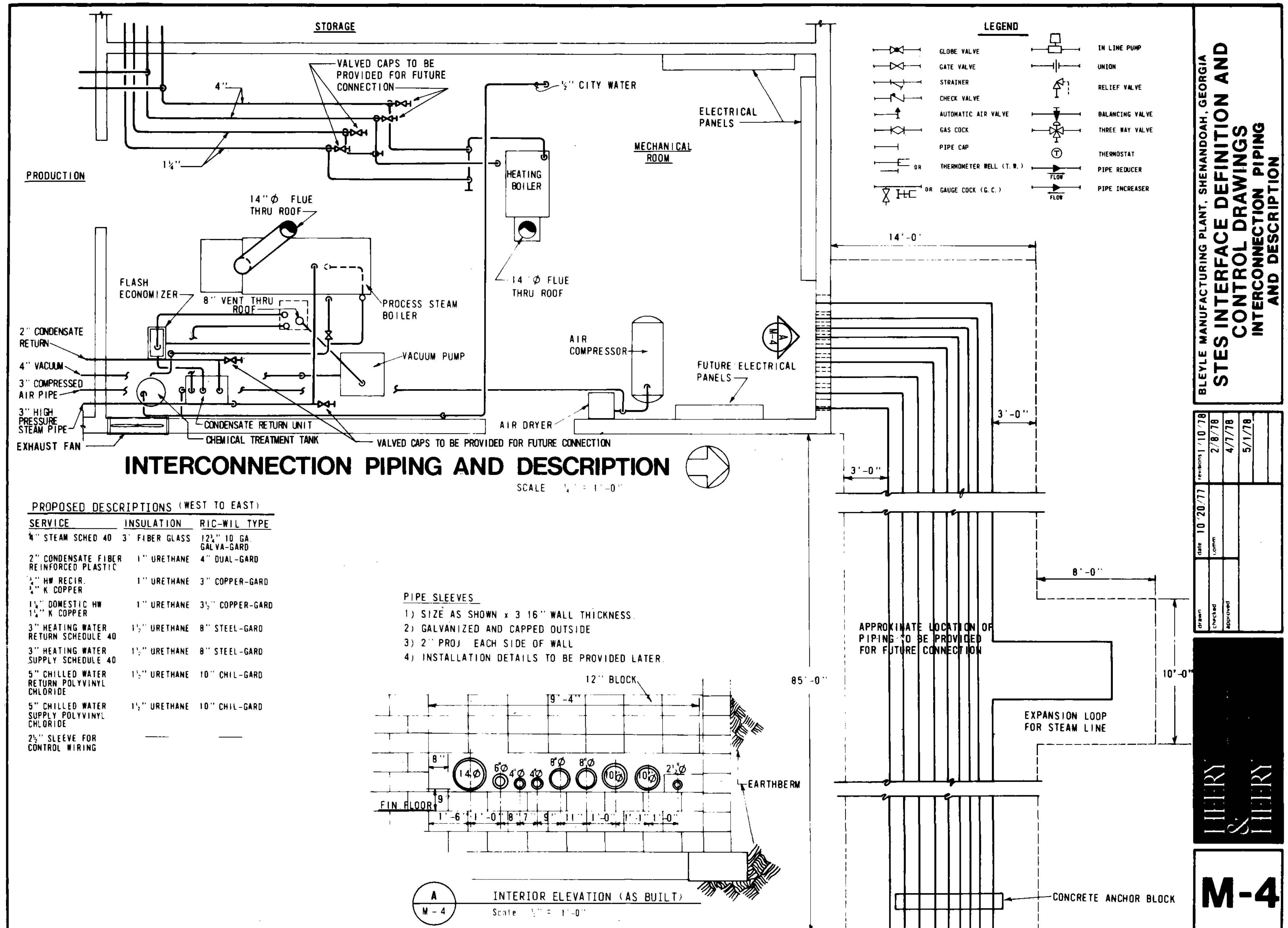


Figure 3.4.2-1. Interconnection Piping and Description

3.6 STES MECHANICAL BUILDING REQUIREMENTS

a) The STES Mechanical Building and ancillary equipment shall be located entirely within the site boundaries of the STES tract.

b) The location of the Mechanical Building and ancillary equipment shall satisfy the minimum setback requirements established to prevent shadowing of the collector field.

3.7 MAINTENANCE AND RELIABILITY REQUIREMENTS

a) The STES shall be designed to achieve a minimum system operating life of 2 years with normal maintenance.

b) A primary and secondary (backup) power system shall be provided to all critical systems and controls to allow for the safe shutdown of the STES.

c) To maximize the availability of the STES, no scheduled maintenance shutdowns will occur during the operating day. Normal maintenance will be accomplished during the evening for the solar collectors and during the early morning hours for the remainder of the power plant.

e) The STES shall be designed for an operating availability of 95 percent or greater based on an overall system reliability analysis.

3.8 TESTING REQUIREMENTS

a) Sensors, measuring, and monitoring devices shall be incorporated into the design of the STES to permit the collection of engineering data for evaluation of the system design, performance, and operational characteristics. Specific sensors and locations are defined in the Test and Evaluation Plan for the STES.

b) The quantity and type of all energy sources displaced by the STES shall be carefully monitored and recorded.

c) Data shall be obtained during both normal and experimental operating modes in accordance with the procedures described in the Test and Evaluation Plan for the STES.

3.9 HEALTH & SAFETY REQUIREMENTS

a) The STES shall be designed to prevent injury to personnel and damage to structures resulting from exposure to concentrated solar beams.

b) The STES shall be designed to prevent the exposure of personnel to high temperatures by providing sufficient insulation around all high temperature components.

c) The STES shall be designed to reduce fire and burn hazards.

d) Adequate precautions shall be incorporated into the design of the STES to reduce the hazards of exposure to high voltage, superheated steam, and equipment-generated high noise levels.

e) The design of the STES and its components shall comply with the requirements of the General Electric Company Organization and Policy Guides related to product safety matters:

Policy 1.1 - Participation in Hazardous Business
Policy 3.4 - Product Service
Policy 20.9 - Product Quality
Policy 20.12 - Product Safety
Policy 20.13 - Environmental Protection

f) All efforts shall be taken to minimize the potential adverse environmental effects resulting from the construction and operation of the STES.

3.10 LAWS & ORDINANCES

3.10.1 FEDERAL REGULATIONS

a) Clean Air Act

b) Noise Control Act

c) National Environmental Policy Act

d) Federal Water Pollution Control Act

e) Solid Waste Disposal and Resource Recovery Act

f) Toxic Substance Control Act

3.10.2 STATE & LOCAL REGULATIONS

a) Georgia Water Quality Control Act of 1964

b) Georgia Erosion & Sedimentation Control Act of 1975

e) Georgia Dept. of Natural Resources, Environmental Protection Division

   1) Chapter 391-3-1, Air Quality Control

   2) Chapter 391-3-4, Solid Waste Management

d) Southern Standard Building Code -1973

e) Building Codes of the County of Coweta

f) Shenandoah Development Incorporated

   1) Development Guidelines

   2) Technical Specifications

g) Building Code Requirements for Minimum Design Loads in Buildings and Other Structures

3.11 CODES & STANDARDS

3.11.1 SYSTEMS

a) Occupational Safety and Health Administration (OSHA)

   1) 29 CFR Part 1910 - Occupational Safety and Health Standards

   2) 29 CFR Part 1926 - Safety and Health Regulations for Construction

b) National Fire Protection Association (NFPA) National Fire Codes - 1977

   1) NFPA 70-1975 National Electrical Code

   2) NFPA 101-1976 Life Safety Code

   3) Other National Fire Codes - 1977 (Vol. 1-16) as applicable

c) American National Standards Institute (ANSI)

   1) ANSI C2-1973 National Electrical Safety Code

   2) Other ANSI Standards for Safety as applicable

d) American Society of Mechanical Engineers (ASME) Boiler & Pressure Vessel Code

1) Section II-Materials Specification

2) Section V-Nondestructive Examination

3) Section IX-Welding & Brazing Qual.

e) National Electrical Manufacturers Association (NEMA)-Applicable Standards

f) American Institute of Steel Construction (AISC)-Steel Construction Manual

g) American Concrete Institute-Applicable Standards

h) American Petroleum Institute-Applicable Standards

3.11.2 COMPONENTS

a) Pumps

Hydraulic Institute Standards for Rotary, Reciprocating, and Centrifugal Pumps

b) Heat Exchangers

Tabular Exchanger Manufacturers Association (TEMA)-Applicable standards

c) Tanks

ASME Code, Section VIII - Unfired Pressure Vessels

d) Piping

ANSI B31.1-1977, Power Piping

ANSI B31.3-1976, Chemical Plant and Petroleum Refinery Piping

3.12 GENERAL DESIGN GUIDELINES

a. "Facilities General Design Criteria" (Handbook) ERDA Manual Appendix 6301, March 25, 1977 - Sections as applicable.

SECTION 4

SECTION 4

SOLAR COLLECTION SUBSYSTEM (SCS)

4.1 SCOPE

4.1.1 FUNCTION

The Solar Collection Subsystem uses the sun's energy to heat the Syltherm^{TM} 800 fluid flowing through the collector field. This heated fluid is then transported to the steam generator where its heat energy is used to produce steam for the Power Conversion Subsystem. A high temperature thermal energy storage subsystem is provided in the SCS to store excess solar energy. This storage subsystem supplies heated Syltherm^{TM} 800 fluid to the steam generator during evening operation and periods of low solar insolation. A fossil fuel fired Syltherm^{TM} 800 heater is also provided in the SCS to supply heat energy during system starup operations and whenever the thermal energy storage is depleted.

4.1.2 SUBSYSTEM CONFIGURATION

The Solar Collection Subsystem is divided into three subloops (or subsystems) as shown in Figure 4.1.2-1. Each of these subloops is named for the function it performs within the SCS. The Collector Field Subsystem (CFS) contains the solar collectors and the collector field supply pumps. This subsystem can deliver the solar heated Syltherm^{TM} 800 fluid to either the High Temperature Storage Subsystem or to the Steam Generator Supply Subsystem. The piping diagram of the CFS is shown in Figure 4.1.2-2.

The High Temperature Storage (HTS) Subsystem contains the storage tanks for the heated Syltherm^{TM} 800 and the HTS transfer pump which is used in charging these storage tanks. The system piping diagram for the HTS subsystem is shown in Figure 4.1.2-3.

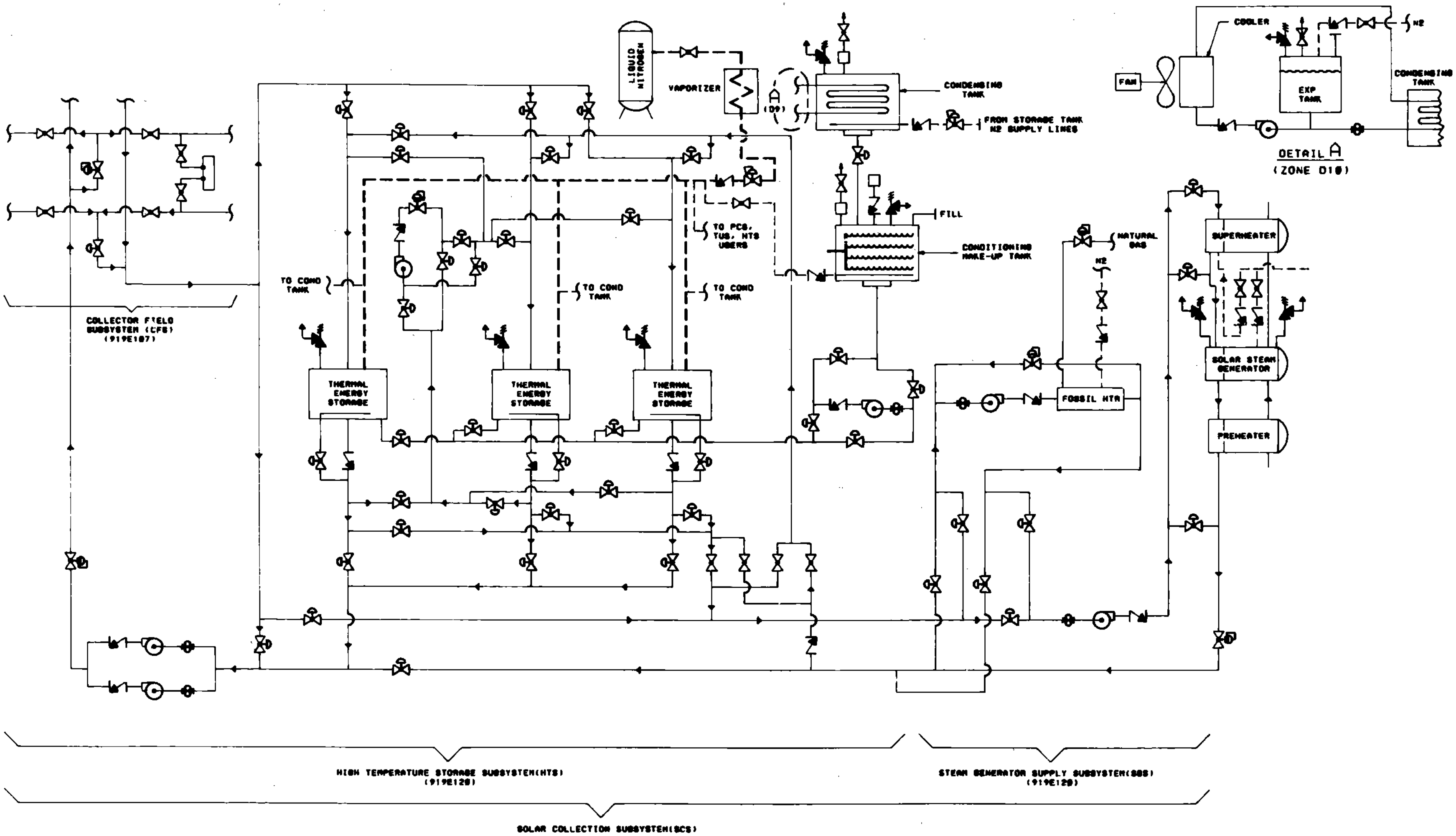


Figure 4.1.2-1. Solar Collection Subsystem

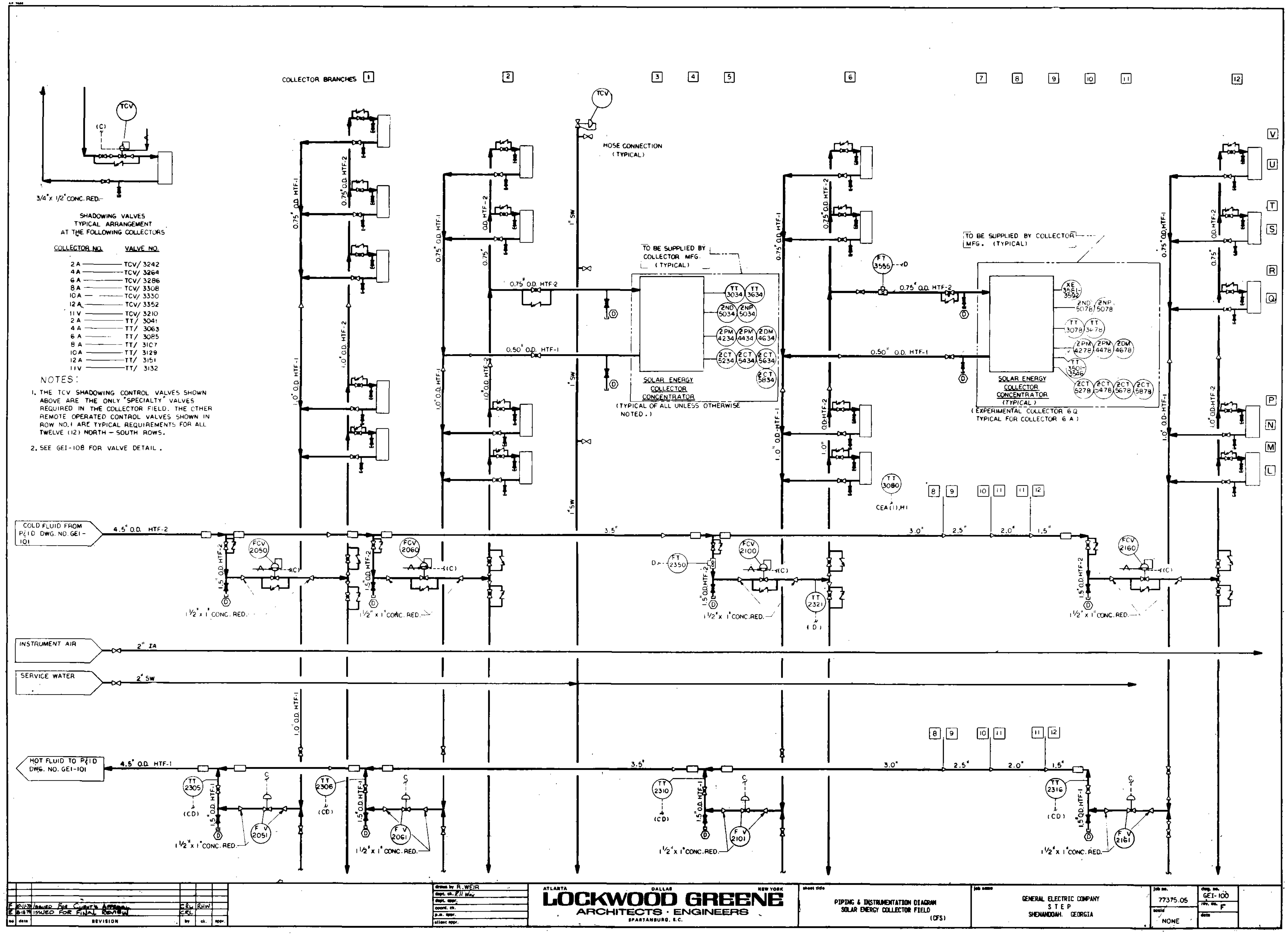


Figure 4.1.2-2. Piping and Instrumentation Diagram Solar Collector Field

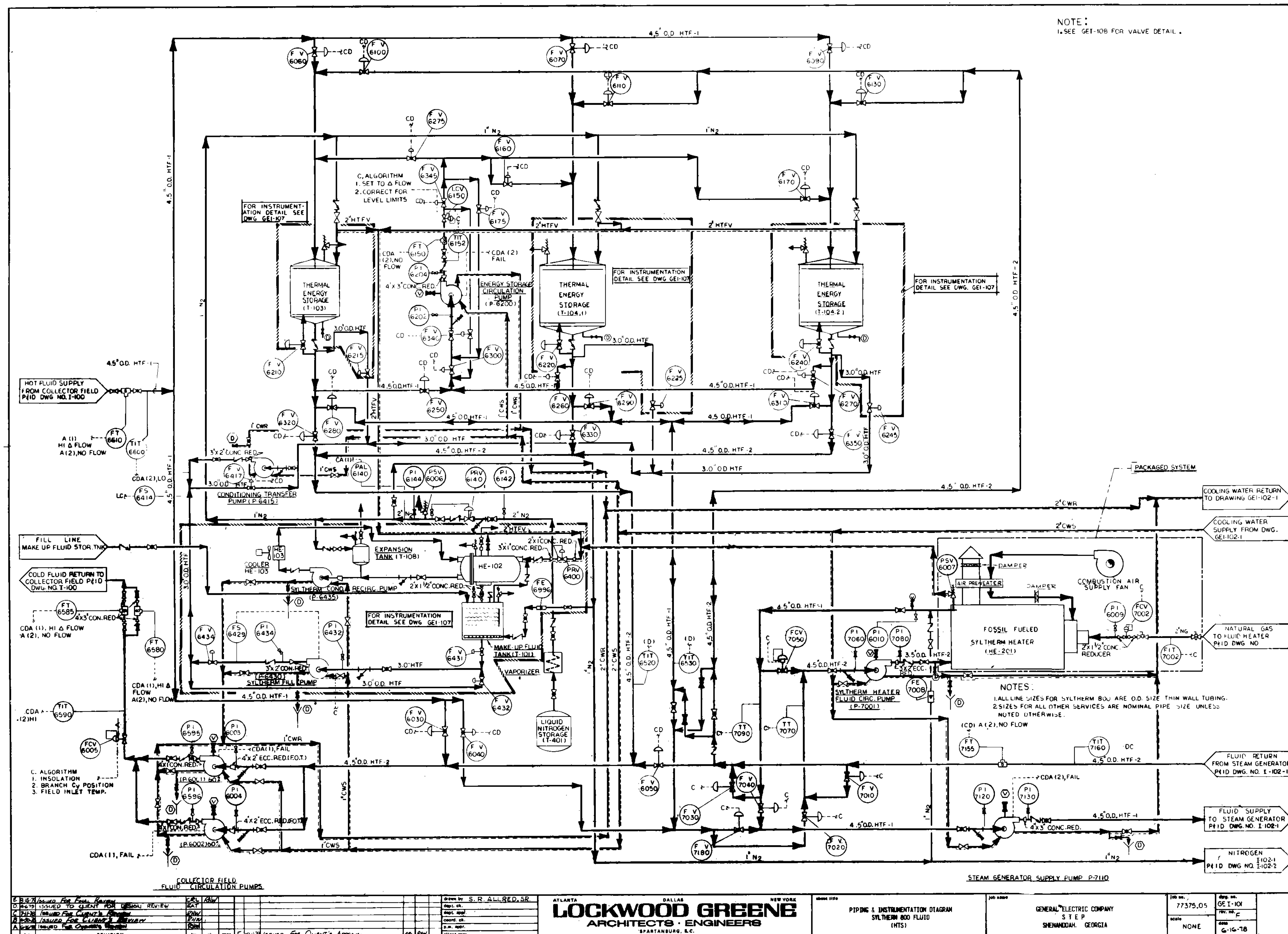


Figure 4.1.2-3. Piping and Instrumentation Diagram for the HTS Subsystem

The Steam Generator Supply (SGS) Subsystem contains the steam generator supply pumps along with the Syltherm^{TM} 800 fossil fired heater and its associated booster pump. This subsystem supplies the heated fluid from either the CFS or the HTS subsystem to the steam generator. The steam generator itself serves as the system boundary between the Solar Collection Subsystem and the Power Conversion Subsystem. The various input/output devices used throughout the SCS serve as the system interface and communication link with the Control and Instrumentation Subsystem

4.2 DESIGN CRITERIA

4.2.1 PERFORMANCE CRITERIA

a) The SCS shall be designed to collect an average annual amount of solar energy equal to approximately 1.2×10^{13} joules (11×10^9 Btu).

b) The high temperature HTS system shall be sized to have a storage capacity of 0.63×10^{11} joules (60×10^6 Btu).

c) The standby fossil fuel heater shall be capable of supplying the thermal energy equivalent of the collected solar energy. It will have a heating capacity of 2.3×10^6 joules/sec (8×10^6 Btu/hr).

d) The collector field shall be designed for a temperature rise of 139°K (250°F) in the heat transfer fluid with a minimum field return temperature of 658°K (725°F) during normal operation.

e) The collector field shall be designed to accommodate a maximum flow rate of .0176 m^3/s (280 gpm).

4.2.2 SYSTEM OPERATIONAL REQUIREMENTS

a) The minimum required level of solar insolation for system operation shall be 236 W/m^2 (75 Btu/ft^2-hr). The solar collectors shall be capable of acquiring the sun at 6:00 AM solar time and tracking the sun until 6:00 PM solar time under all levels of insolation. In the event that insolation levels are below minimum requirements for operation, the collectors shall be capable of continued tracking for a specified time period under computer control and then acquire and optically track the sun when the insolation level reaches the minimum required value.

b) A minimum of 6.3 x 10^9 joules (6 x 10^6 Btu) must be stored in the high temperature HTS subsystem before the SCS can begin normal operation in the solar total energy mode.

c) The SCS shall be capable of detecting abnormal operating conditions (overtemperature, control malfunctions, power failures) and, in conjunction with the system controls, taking protective action:

   1) The collector will have the capability to defocus to protect the collector fluid components (receiver, piping, etc.) from conditions where overtemperature, loss of fluid flow, or other malfunctions may lead to excessive temperatures in the operating fluid and/or the collector components.

   2) The collector will be capable of moving to the defocus position under system emergency power when the normal power supply to the collector controls and other electrically powered components have failed.

d) Each collector shall be capable of being stowed in a position which minimizes the danger of damage to the collector resulting from the extremes of wind, hail, rain, and other natural hazards.

e) Individual manual control valves and isolation valves shall be provided for each solar collector in the piping field. Automatic control and isolation valves shall be provided for the major branch connections in the field.

f) The design of the High Temperature Storage Subsystem shall contain an adequate space allowance for the thermal expansion of the heat transfer fluid without degrading system performance.

4.2.3 INTERFACE REQUIREMENTS

a) Electrical power shall be provided for the collector field pumps, motorized valves, collector drives, controls, and sensors.

b) An adequate quantity of nitrogen gas shall be provided to supply and maintain a nitrogen atmosphere in the high temperature storage tanks.

c) Acceptable grade tap water will be provided in the collector field for the periodic washing of collectors. The number of outlets, size of pipe, etc., shall be adequate to support the maintenance requirements for periodic cleaning of the collector reflector surfaces.

d) Filtered, oil free, compressed air will be provided for operation of pneumatic controls.

4.2.4 MAINTENANCE & RELIABILITY REQUIREMENTS

a) The design of the SCS shall incorporate adequate provisions for the filling and draining of the collector field and all interconnecting piping.

b) The following components of the solar collector shall be field replaceable in order to maintain a high component operation availability:

   Reflector petal
   Receiver
   Drive components (motor, screwjacks, bearings)
   Piping components (tubing, insulation, protective jackets)
   Instrumentation and control units (valves, thermocouples, sun tracker, switches)

   Component replacement and maintenance operations shall be accomplished using standard tools and fixtures and shall minimize the use of special equipment.

c) The entire piping network of the SCS shall be assembled using welded pipe connections to minimize leakage. Flanged connections should only be used where major component removal is required.

d) Periodic cleaning of the collector reflector surface is required. Normal cleaning procedures will include a water spray wash with special detergents utilized under extreme dirt build-up conditions.

e) Provisions for periodic optical alignment of the collectors and calibration of the control sensors shall be required. Alignment and calibration procedures shall be accomplished using standard tools and fixtures where possible.

f) Periodic measurement and calibration of position indicators along with lubrication of screwjack drives, valve motor drives, and other components will be conducted as part of a regular maintenance program.

4.2.5 TESTING AND INSPECTION REQUIREMENTS

4.2.5.1 Acceptance Testing

Acceptance testing for the collector will consist of assembly fit-checks and inspection and functional checkout prior to pre-operational testing. Acceptance testing of the as-received components for the collector will include dimensional and fit checks on the mount assembly, reflector components, receiver, drive components, and control/

sensors. After assembly, functional checkout of the drive operating mechanism, control position/command control calibration, checkout operation for the defocus/protective component operations, and functional checks of the isolation and/or control valves shall be conducted. The functional checkout testing shall verify that the normal operational motion of the collector performs according to normal operational requirements and that all safety and hazard avoidance components and operations are functional.

4.2.5.2 Pre-Operational Testing

After completion of plumbing connections of the receiver, piping flexible joints, and valves to the field piping, the collector piping shall be isolated and pneumatically tested to detect leaks. After the collector is filled with coolant from the pipe field, collector control checkout will proceed with the collector in full operational status at maximum insolation levels required for checkout testing. Performance testing to establish the standards shall be conducted, with operational performance within tolerance bands, prior to connection of the collector to power plant central control.

4.2.5.3 Periodic Performance Testing

Periodic performance monitoring utilizing operational thermocouples, resistance temperature detectors (RTD), and system controls will be used to verify that collector performance is within operating tolerance bands. Such periodic performance determinations will not be highly precise measurements due to a lack of individual collector flow measurements. Flows will be estimated to a particular collector through a knowledge of the flow control valve and the up-stream pressure. Flow through an individual collector is determined by assuming the division of flow is in accordance with the hydraulic flow model.

Mass flow rate through a collector, a knowledge of the instantaneous insolation, and a measurement of the outlet temperature yield specific collector performance. Correlation of a representative number of individual collectors performance with overall field performance over a long period is expected. The lack of such correspondence may indicate degradation (or improvement) of the pipe field insulation performance.

4.2.5.4 Periodic Inspection

Periodic visual inspection of drive jacks, declination and polar position indicators, emergency release/protective devices, joints and seals, valves and other dynamic components, and those subject to potential leaking shall be conducted at regular intervals. Visual inspection of receiver coatings for discoloration, cracking, peeling, etc. shall also be conducted. Visual inspection of reflector coatings and insulation and insulation jackets shall be conducted at regular intervals.

4.2.6 SPECIAL FEATURES

4.2.6.1 Collector Field Spacing Requirements

The geometry of the collector field including collector positioning and spacing has been selected to maximize the annual collection of solar energy consistent with costs, area limitations, and thermal output requirements. See Figure 2.1.2-3.

4.2.6.2 Optical Hazards

Provisions to limit access to unauthorized and/or untrained personnel within the defined optical hazard areas of the collector field shall be provided. Provisions for limiting access to extreme optical hazards areas shall also be provided for operating and maintenance personnel. Appropriate barriers, warnings, and safety equipment shall be provided to these personnel when they are within the extreme hazard areas.

4.3 DESIGN DESCRIPTION

4.3.1 DETAILED SUBSYSTEM DESCRIPTION

4.3.1.1 Collector Field Subsystem

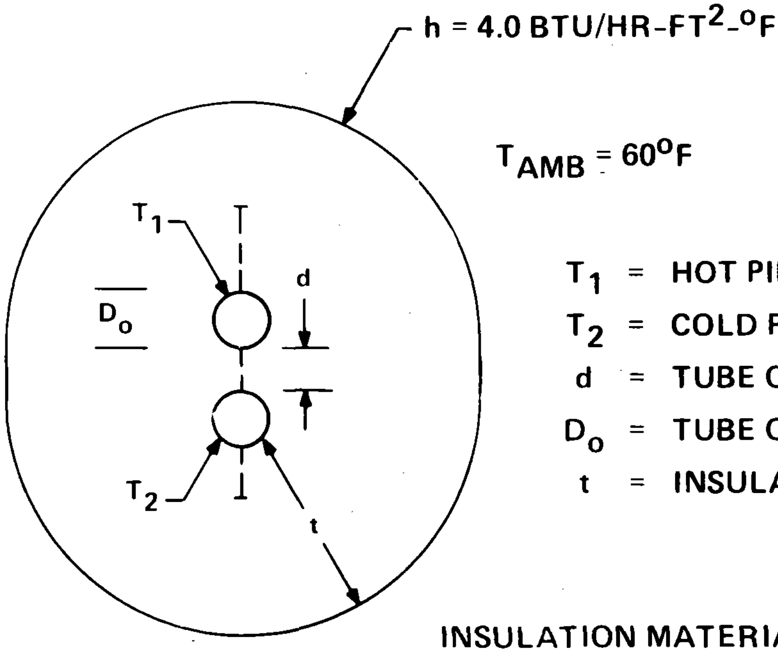
The collector field subsystem consists of the collector field supply pumps and the heat transfer fluid supply and return lines to the solar collectors. The main supply and return lines to the collector field run in the east-west direction, while the branch lines to and from the individual collectors run in the north-south direction. The collector field piping configuration is shown in Figure 4.1.2-2. These supply and return lines are constructed of seamless carbon steel tubing which complies with the requirements of ASTM A192.

The main supply and return lines consist of tubes of different diameters which have been reduced by steps to maintain a relatively constant flow velocity of approximately 2.4 m/s (8 ft/sec) throughout the collector field. The size of the lines entering and leaving the Mechanical Building are 0.114 meter (4.5 inches) O.D. with a .0032 meter (0.125 inch) wall thickness. The branch lines are also tapered to maintain a relatively constant flow velocity. The lines running up to and down from the receiver are of different diameters. The down or hot side has a slightly smaller diameter than the cold side to decrease temperature drop during low flow conditions.

Under design conditions, Syltherm 800 is pumped to the collectors at a supply temperature of 533°K (500°F) and returns from the field at 672°K (750°F). The main supply and return lines are covered with insulation whose thickness is based upon the tube temperature (500°F or 750°F) and diameter. The required insulation materials and thicknesses are shown in Table 4.3.1-1. This insulation is covered with a 16 gage aluminum jacket which is sealed at the joints with a mastic. The branch lines are nested within a similar type of insulation jacket. This nesting of the two fluid lines with the same insulation jacket results in a net heat loss savings of between 35 to 40% over singly insulated tubes. A schematic representation of this nesting technique is shown in Figure 4.3.1-1. The individual collectors are also joined to the branch lines via nested tubing up to and down from the receiver.

Forged carbon steel, manually operated, Y pattern globe valves are installed in the supply and return lines of each individual collector to allow isolation for maintenance and provide thermal trim potential. Thermal trim is accomplished only during initial system startup to give temperature balance between collectors in a branch. Fluid flow control to each branch is provided by pneumatically actuated flow control valves which operate in response to the maximum collector output temperature in the branch. A schematic representation of the branch line valve arrangement is shown in Figure 4.3.1-2. Two pneumatically operated globe valves are required; one, a modulating valve for flow control and the other, an on-off valve for branch isolation. A picture of a typical pneumatic control valve for this application is shown in Figure 4.3.1-3. Due to the weight of the control valve actuation mechanism, each control valve is separately supported.

Due to the low viscosity and surface tension of Syltherm™ 800 at operating temperatures, the entire field piping network is completely welded. Tungsten Inert Gas (TIG) welding will be used throughout. All valves and fittings in sizes 0.051 meter (2 inches) and smaller will be socket welded. Butt welds will be used for all sizes greater than two inches. Loads resulting from thermal expansion will be controlled by the use of inline, externally pressurized compensators placed in the branch lines. A typical compensator of this type is pictured in Figure 4.3.1-4. The external surface of the insulation will be guided to prevent lateral instabilities.



$T_{AMB} = 60^oF$

T_1 = HOT PIPE SURFACE TEMPERATURE — ^oF
T_2 = COLD PIPE SURFACE TEMPERATURE — ^oF
d = TUBE OR PIPE SEPARATION — IN.
D_o = TUBE OUTSIDE DIAMETER — IN.
t = INSULATION THICKNESS

INSULATION MATERIAL EQUIVALENT TO CERTAINTEED 850

$k\ @\ T_{avg} = 400^oF$ IS $\frac{.42\ \text{BTU IN.}}{\text{HR–FT}^2\text{–}^oF}$

$\rho = 5.25\ \text{LBS/FT}^3 \qquad C_p = \frac{.2\ \text{BTU}}{\text{LB–}^oF}$

Figure 4.3.1-1. Nested Pipe Analysis

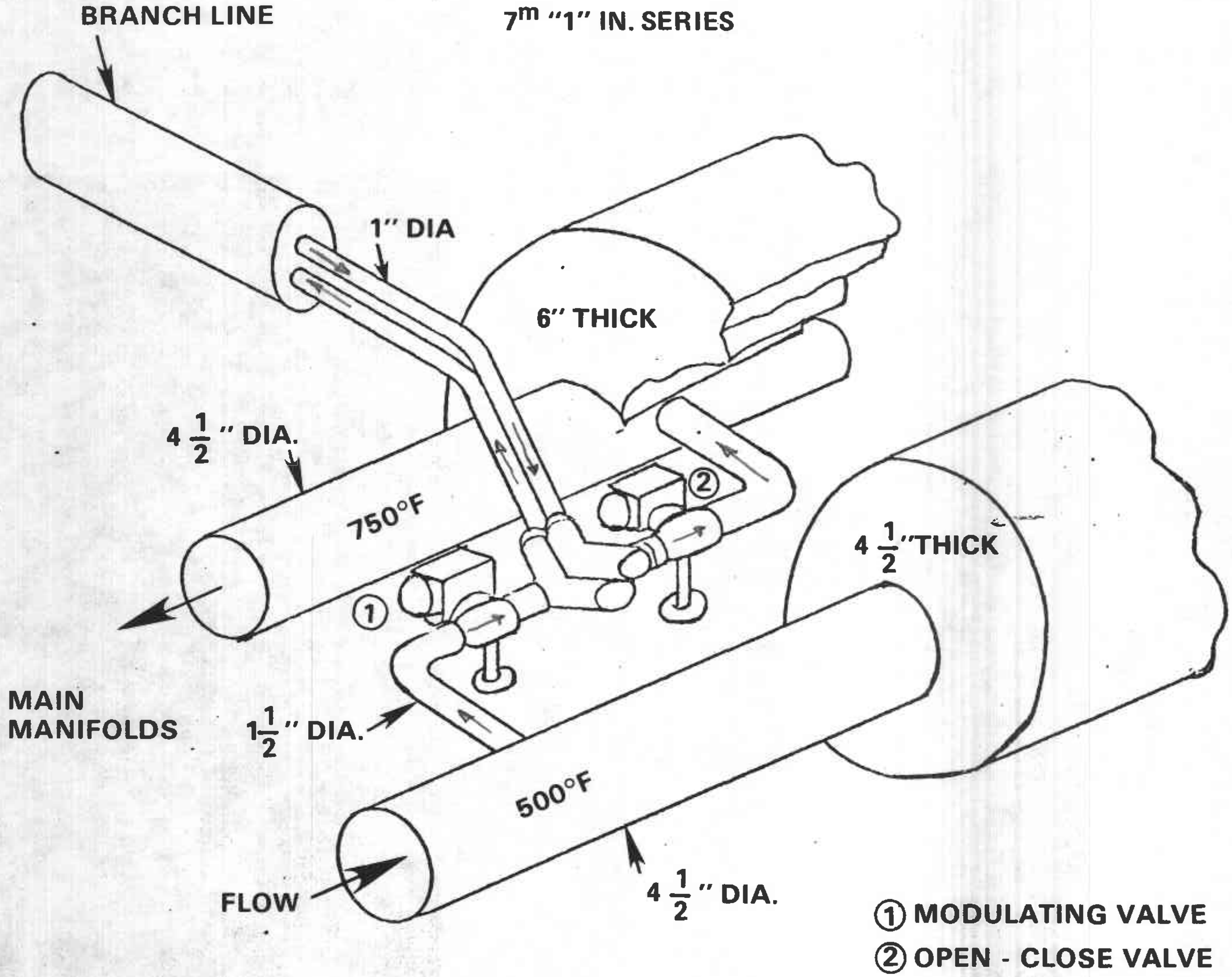
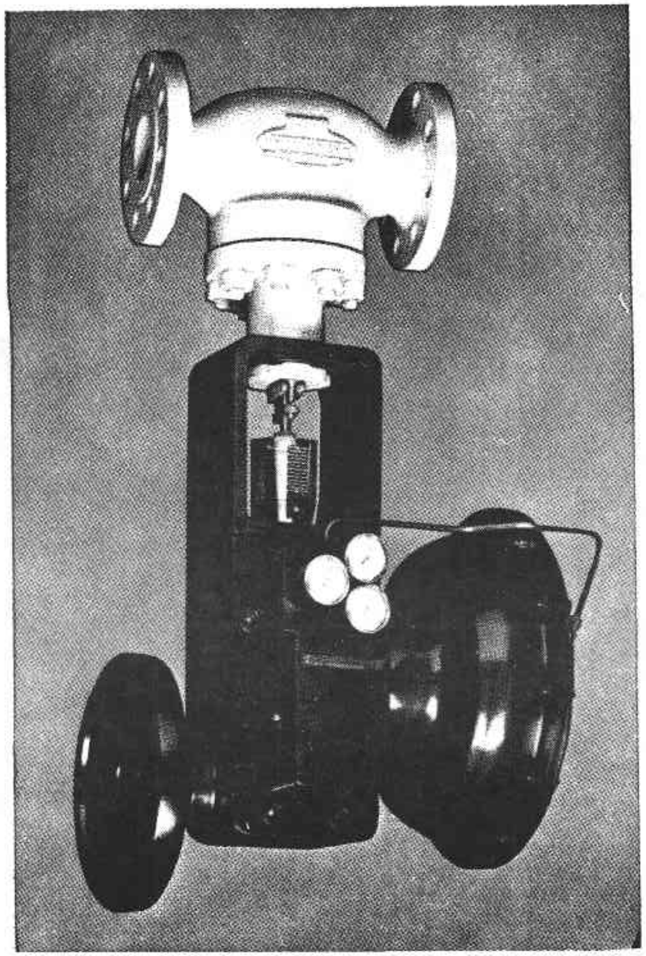
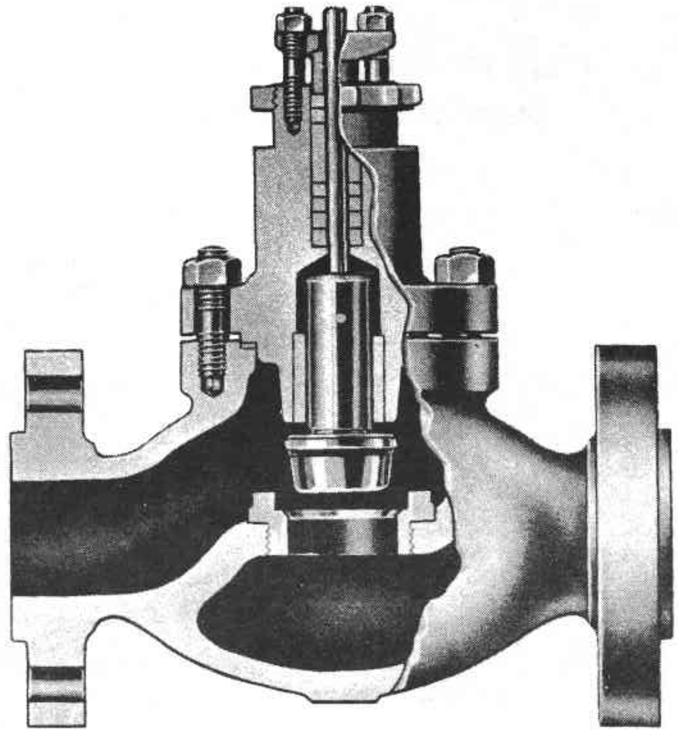


Figure 4.3.1-2. Branch Isolation and Control





Full Capacity Trim

Figure 4.3.1-3. Pneumatic Control Valves

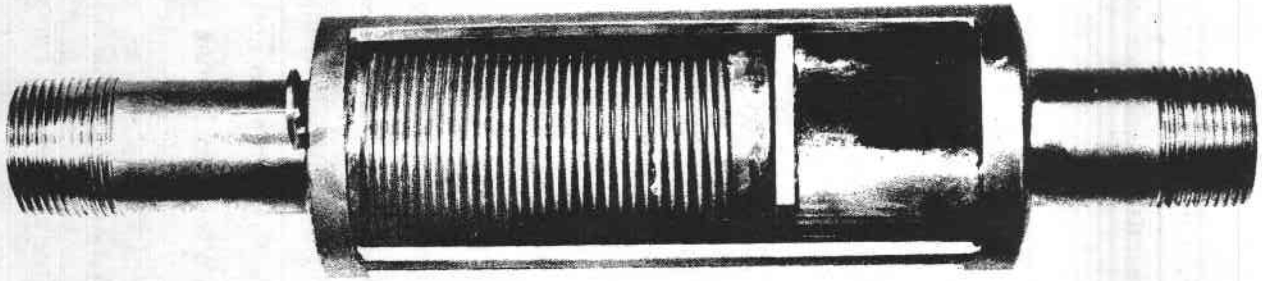


Figure 4.3.1-4. Thermal Expansion Compensator Linear Type

4.3.1.2 High Temperature Storage (HTS) Subsystem

The HTS Subsystem consists of the three HTS tanks and the HTS transfer pump along with the interconnecting piping and valves and associated instrumentation and controls. Interconnecting flow paths throughout the HTS subsystem allow for the transfer of hot Syltherm^{TM} 800 fluid from the collector field to the HTS tansk, from one HTS tank to another, and from the HTS tanks to the Steam Generator Supply subsystem. The piping configuration is shown in Figure 4.1.2-3.

The subsystem is designed for a trickle oil mode of operation. The design includes the capability for operation in a fluid filled or dual media storage mode. The subsystem utilizes a packed bed of iron ore as the solid storage medium operating over a temperature range of 533 to 672°K (500 to 750°F).

In the trickle oil mode, heat transfer is accomplished by a gravity fed trickle oil flow through the bed. The iron ore thermal capacity storage medium provides a net thermal capacity of .79 x 10^{11} joules (75 MBtu) when all tanks are fully charged. The capacity of the HTS exceeds the design requirement of 60 MBtu's as standard tank sizes (diameter and height) were employed to facilitate fabrication. Both the outlet from the collectors (charge flow) and the return from the solar steam generator (discharge flow) enter the top manifold over the bed and are returned from the bottom of the bed. The gravity flow thus requires that the bed be fully charged before it can be discharged, or at least the bottom of the bed be at the delivery temperature for discharge (672°K or 750°F). A sump is required beneath the tank to collect the fluid. No bottom manifold, however, is required to maintain a thermocline at the bottom of the bed.

In the dual media appraoch, the combined heat capacity of the iron ore and the Syltherm 800 fluid is 1 x 10^{11} joules (96 MBtu), assuming 30% fluid filled voids. An additional manifold is required at the bottom of the bed to maintain thermocline stability. The dual media operation provides hot flow entering and leaving the top of the tank, and cold flow entering and leaving the bottom of the tank.

The first tank is sized to provide approximately one hour of energy delivery to the solar steam generator at normal operating conditions. The remaining two tanks are sized equally to provide the remaining thermal capacity.

Seamless carbon steel tubing which complies with the requirements of ASTM A192 is used throughout the HTS subsystem. The standard tube size used is 0.114 meter (4.5 inches) O.D. with a .0032 meter (0.125 inch) wall thickness. These tubes are insulated as specified in Table 4.3.1-1. The subsystem is completely welded except for the flanged connections to the HTS pumps. Thermal expansion of the piping system is controlled by inline, free flex bellows, expansion points. Pipe supports and lateral restraints are installed in accordance with ANSI B31.1 Power Piping Codes.

4.3.1.3 Steam Generator Supply (SGS) Subsystem

The Steam Generator Supply subsystem consists of the steam generator supply pump, the Syltherm^{TM} 800 fossil fired heater (FFH), and the fossil heater booster pump. The steam generator supply pump delivers heated Syltherm^{TM} 800 fluid to the steam generator at a rate controlled by the steam demand of the PCS. This 672°K (750°F) fluid is supplied either directly from the collector field or from the HTS tanks during normal operations. During startup and when solar insolation levels are below minimum requirements, the fossil fired heater is used to provide the heated Syltherm^{TM} 800 to the steam generator.

The fluid lines in the SGS subsystem are constructed of seamless carbon steel tubing which complies with the requirements of ASTM A192. All joints are TIG welded except for flanged connections to the system pumps. Tubes having a 0.114 meter (4.5 inch) O.D. with a .0032 meter (0.125 inch) wall thickness are used throughout the subsystem. The tubing is covered with insulation and 16 gauge aluminum jacketing covers the insulation. Free flex expansion joints are installed to compensate for thermal expansion. The SGS piping configuration appears on Figure 4.1.2-3.

Table 4.3.1-1. Tubing Insulation Schedule*

Tube Outer Dia. - Inches	533°K (500°F)		672°K (750°F)	
	Thickness (inches)	Material	Thickness (inches)	Material
1/2 x 3/4 up and down nested	4.0	Certainteed 850	4.0	Certainteed 850
5/8 nested	4.0	Certainteed 850	4.0	Certainteed 850
3/4 nested	4.0	Certainteed 850	4.0	Certainteed 850
1.0 nested	4.0	Certainteed 850	4.0	Certainteed 850
1.5 single	3.0	Certainteed 850	4.0	Certainteed 850
2.0 single	3.5	Certainteed 850	4.5	Certainteed 850
2.5 single	3.5	Certainteed 850	5.0	Certainteed 850
3.5 single	4.0	Certainteed 850	5.5	Certainteed 850
4.5 single	4.5	Certainteed 850	6.0	Certainteed 850

*All Insulation Multilayer

The stop valves used throughout the SGS subsystem are pneumatically operated globe valves rated for 672° K (750° F) operation. These valves are butt welded in place and covered by an insulation jacket. Valve stems will be mounted horizontally or below horizontal to prevent insulation contamination in the event of a seal leak. This mounting configuration is identical to that used in the collector field and High Temperature Storage subsystem.

4.3.2 SUBSYSTEM PERFORMANCE CHARACTERISTICS

4.3.2.1 Collector Field Subsystem

The table given below is based on the pipe field layout defined in Figure 4.1.2-2.

Collector Field	
Collector Loop Heat Loss	176680 J/S (603,000 Btu/hr)
Thermal Capacity	4.73 x 10^9J (4480000 Btu)
Fluid Capacity	4.5 m^3 (1184.0 gal)
Supply Line Temperature	533° K (500° F)
Return Line Temperature	672° K (750° F)
Mech Bldg.	
Thermal Energy Storage:	
-Piping Steady State Heat Loss	10080 J/S (37400 Btu/hr)
-Thermal Capacity	9.9 x 10^8J (939900 Btu)
-Fluid Capacity	3.3 m^3 (884 gal)
-Field Supply Line Temp	533° K (500° F)
-Field Return Line Temp	672° K (750° F)

Performance data for the field and Mechanical Building was calculated using material property data given in Figures 4.3.2-1 and 4.3.2-2. Pressures, temperatures, and flow rates for the Collector Field Subsystem are shown on Figure 4.3.2-3.

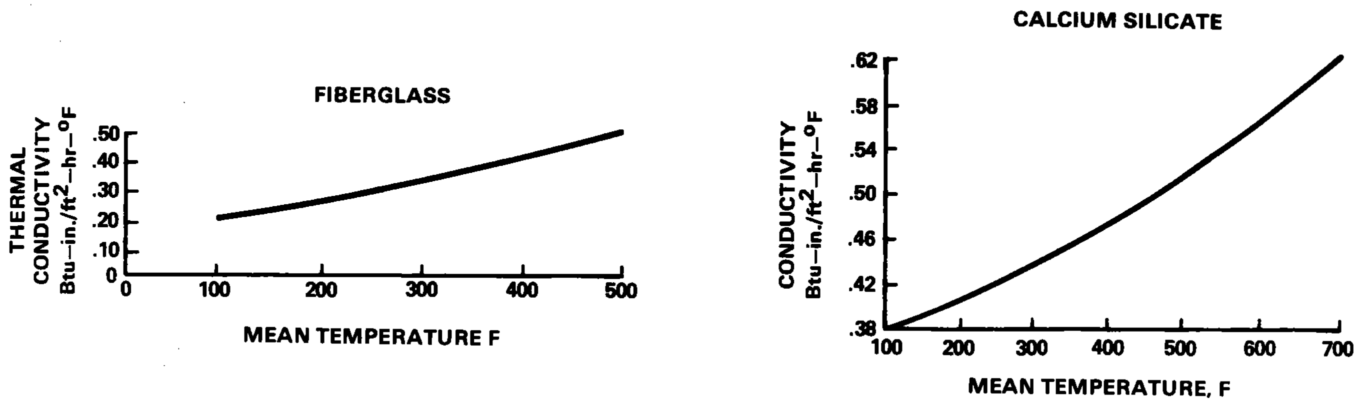


Figure 4.3.2-1. Insulation System Properties

4.3.2.2 High Temperature Storage (HTS) Subsystem

The HTS performance is characterized by the amount of energy extracted at a useable temperature from a charged amount. There are three forms of energy degradation that affect the amount of energy extracted for the trickle oil system: (1) heat losses to the evnironment, (2) unavailable or degraded energy, and (3) inversion temperature degradation.

The heat losses to the environment are estimated at 4 percent of the stored capacity daily from a fully charged tank. On an annual basis, the losses are only 2.5 percent of energy delivered to the storage system.

The second type of energy degradation is the energy stored at temperatures below the turbine inlet minimum requirement of 672° K (685° F). The amount of energy extracted

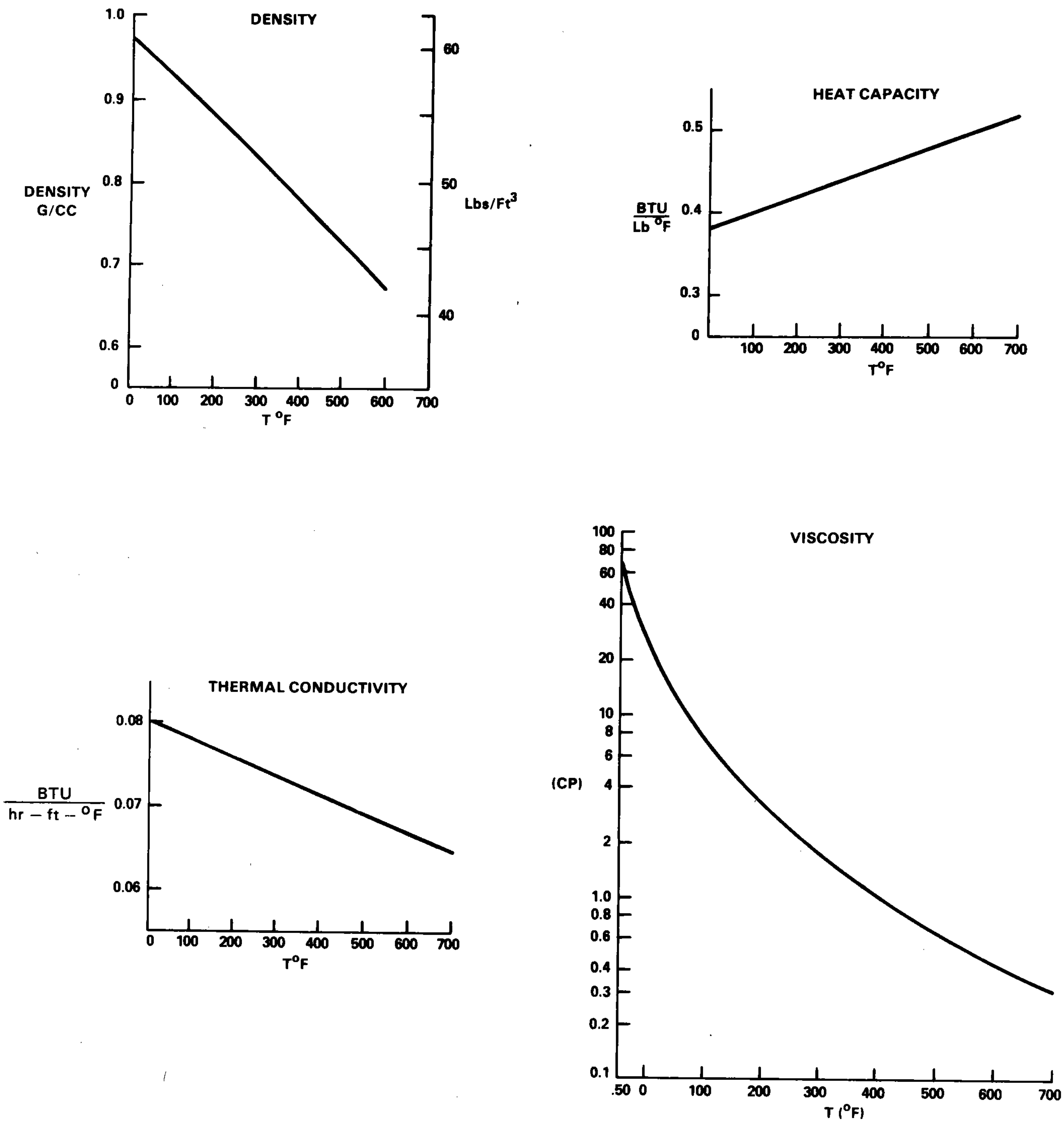
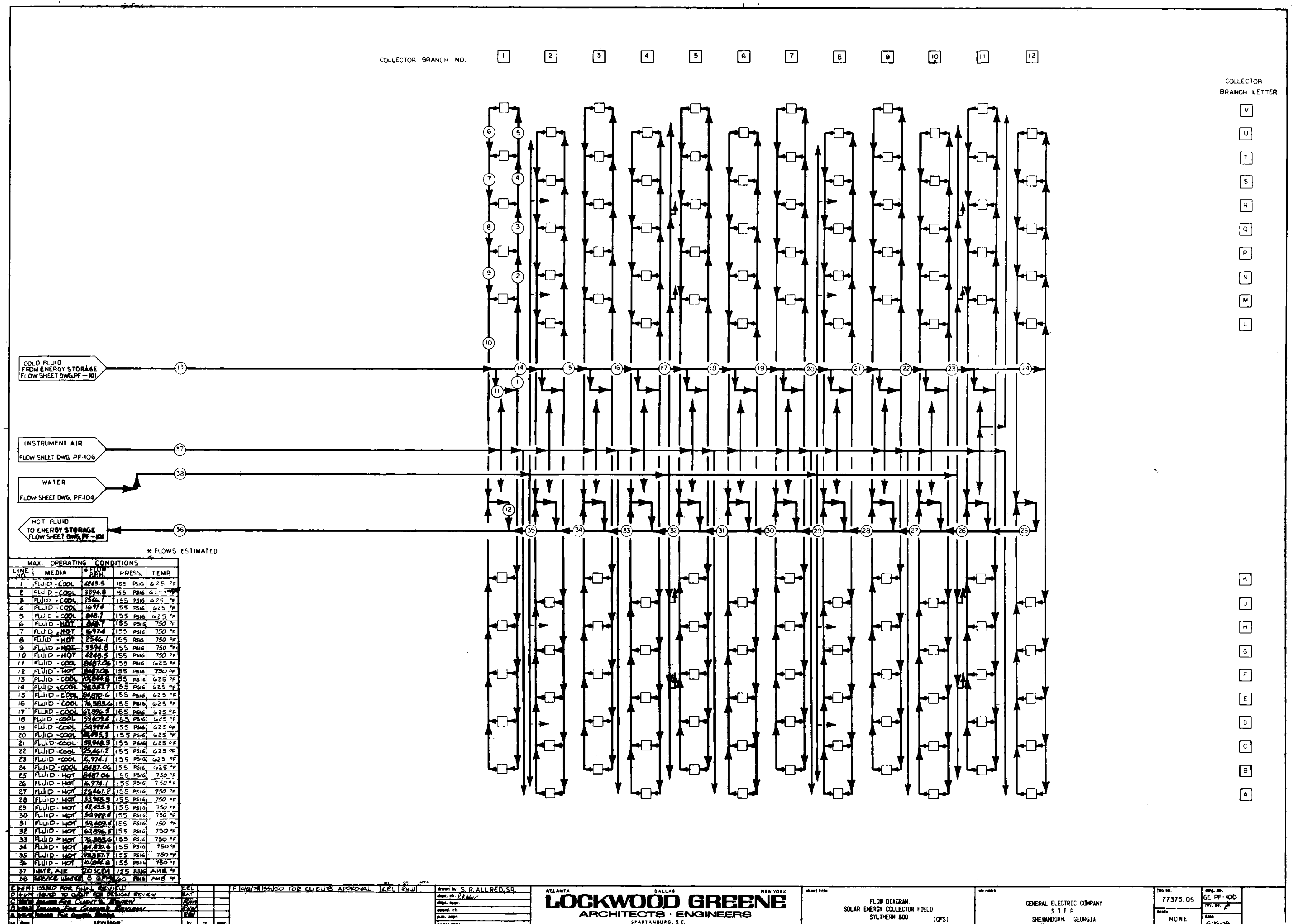


Figure 4.3.2-2. Typical Properties of Dow Corning Syltherm™ 800



MAX. OPERATING CONDITIONS

LINE NO.	MEDIA	* FLOW P.P.H.	PRESS.	TEMP.
1	FLUID - COOL	4243.5	155 PSIG	625 °F
2	FLUID - COOL	3394.8	155 PSIG	625 °F
3	FLUID - COOL	2546.1	155 PSIG	625 °F
4	FLUID - COOL	1697.4	155 PSIG	625 °F
5	FLUID - COOL	848.7	155 PSIG	625 °F
6	FLUID - HOT	848.7	155 PSIG	750 °F
7	FLUID - HOT	1697.4	155 PSIG	750 °F
8	FLUID - HOT	2546.1	155 PSIG	750 °F
9	FLUID - HOT	3394.8	155 PSIG	750 °F
10	FLUID - HOT	4243.5	155 PSIG	750 °F
11	FLUID - COOL	8487.06	155 PSIG	625 °F
12	FLUID - HOT	8487.06	155 PSIG	750 °F
13	FLUID - COOL	101,844.8	155 PSIG	625 °F
14	FLUID - COOL	93,357.7	155 PSIG	625 °F
15	FLUID - COOL	84,870.6	155 PSIG	625 °F
16	FLUID - COOL	76,383.6	155 PSIG	625 °F
17	FLUID - COOL	67,896.5	155 PSIG	625 °F
18	FLUID - COOL	59,409.4	155 PSIG	625 °F
19	FLUID - COOL	50,922.4	155 PSIG	625 °F
20	FLUID - COOL	42,435.3	155 PSIG	625 °F
21	FLUID - COOL	33,948.3	155 PSIG	625 °F
22	FLUID - COOL	25,461.2	155 PSIG	625 °F
23	FLUID - COOL	16,974.1	155 PSIG	625 °F
24	FLUID - COOL	8487.06	155 PSIG	625 °F
25	FLUID - HOT	8487.06	155 PSIG	750 °F
26	FLUID - HOT	16,974.1	155 PSIG	750 °F
27	FLUID - HOT	25,461.2	155 PSIG	750 °F
28	FLUID - HOT	33,948.3	155 PSIG	750 °F
29	FLUID - HOT	42,435.3	155 PSIG	750 °F
30	FLUID - HOT	50,922.4	155 PSIG	750 °F
31	FLUID - HOT	59,409.4	155 PSIG	750 °F
32	FLUID - HOT	67,896.5	155 PSIG	750 °F
33	FLUID - HOT	76,383.6	155 PSIG	750 °F
34	FLUID - HOT	84,870.6	155 PSIG	750 °F
35	FLUID - HOT	93,357.7	155 PSIG	750 °F
36	FLUID - HOT	101,844.8	155 PSIG	750 °F
37	INSTR. AIR	20 SCFM	125 PSIG	AMB. °F
38	SERVICE WATER	8 GPM	60 PSIG	AMB. °F

no.	date	REVISION	by	ck.
E	[illegible]	ISSUED FOR FINAL REVIEW	CRL	
D	[illegible]	ISSUED TO CLIENT FOR DESIGN REVIEW	EAT	
C	[illegible]	Issued For Client's Review	RHW	
B	[illegible]	Issued For Client's Review	RHW	
A	[illegible]	Issued For Client's Review	RHW	

Figure 4.3.2-3. Flow Diagram Solar Energy Collector Field

at a useable temperature is therefore a function of the heat transfer gradient zone slope as it moves through the bed. In the series tank system design, this energy is minimized under a fully charged condition since it occurs only in the last tank. The last tank will receive 75% of a full charge before the fluid exit temperature reaches 547°K (525°F).

For individually discharged tanks, the efficiency of extraction above 658°K (725°F) is 80% for the small tank and 88% for the larger tank.

Typical profiles are shown in Figure 4.3.2-4 for a 254 gpm charge rate and a 165 gpm discharge rate.

The third type of energy degradation occurs as a result of the thermal inversion process which brings a partially charged tank on line for discharge. Since the trickle oil system is discharged by gravity feed, at the end of a solar collection day, a partially charged tank [top portion of the rockbed at 658°K (750°F) and bottom at 533°K (500°F)] can either be held until the next day or thermally inverted with a recirculating flow to move the hot layer to the bottom of the tank. This process results in a slight lowering of the peak temperature 3°K (6°F) and reduction of the energy available or spreading of the temperature profile. The spreading of the profile is not lost energy to the system since, under charging conditions, the bed can be brought up to 672°K (750°F) faster, and the series configuration restricts the spread profile to the last tank. The inversion flow rate is 0.016 m^3/s (254 gpm) to minimize the inversion time. The efficiency for a single large tank inversion is shown in Figure 4.3.2-5 as a function of the initial percent charged condition. The resulting temperature profiles for inversion of a 50 percent initially charged tank is shown in Figure 4.3.2-6. The large tank must have a minimum charge of 70 percent to limit the inversion to one hour, as shown in Figure 4.3.2-7, or the time during which the small tank can supply the demand. If the second tank is charged, the third can be inverted with an initial charge down to 35 percent. Below an initial charge of 35 percent, inversion is not used. The annual system

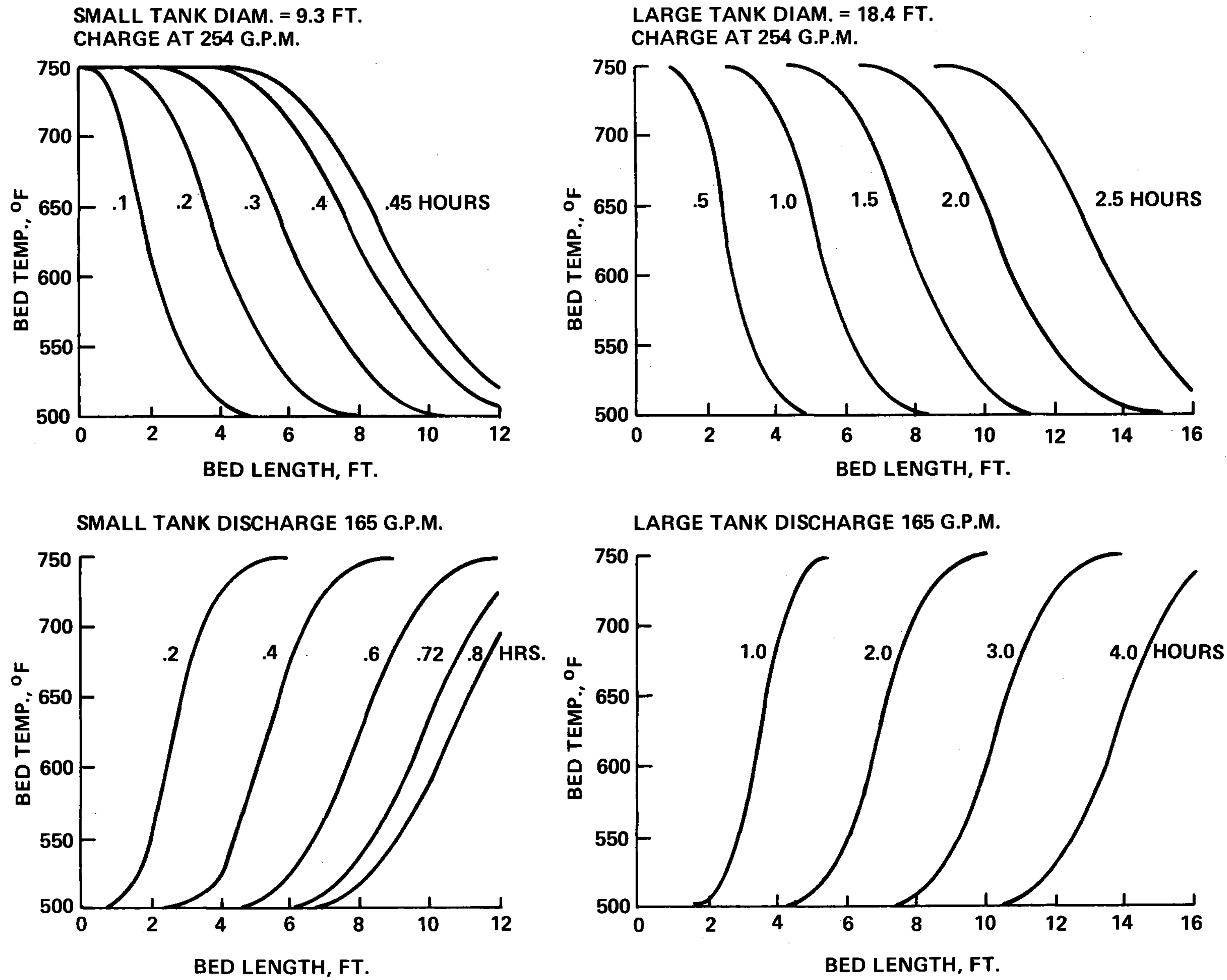


Figure 4. 3. 2-4. HTS Tank Temperature Profiles

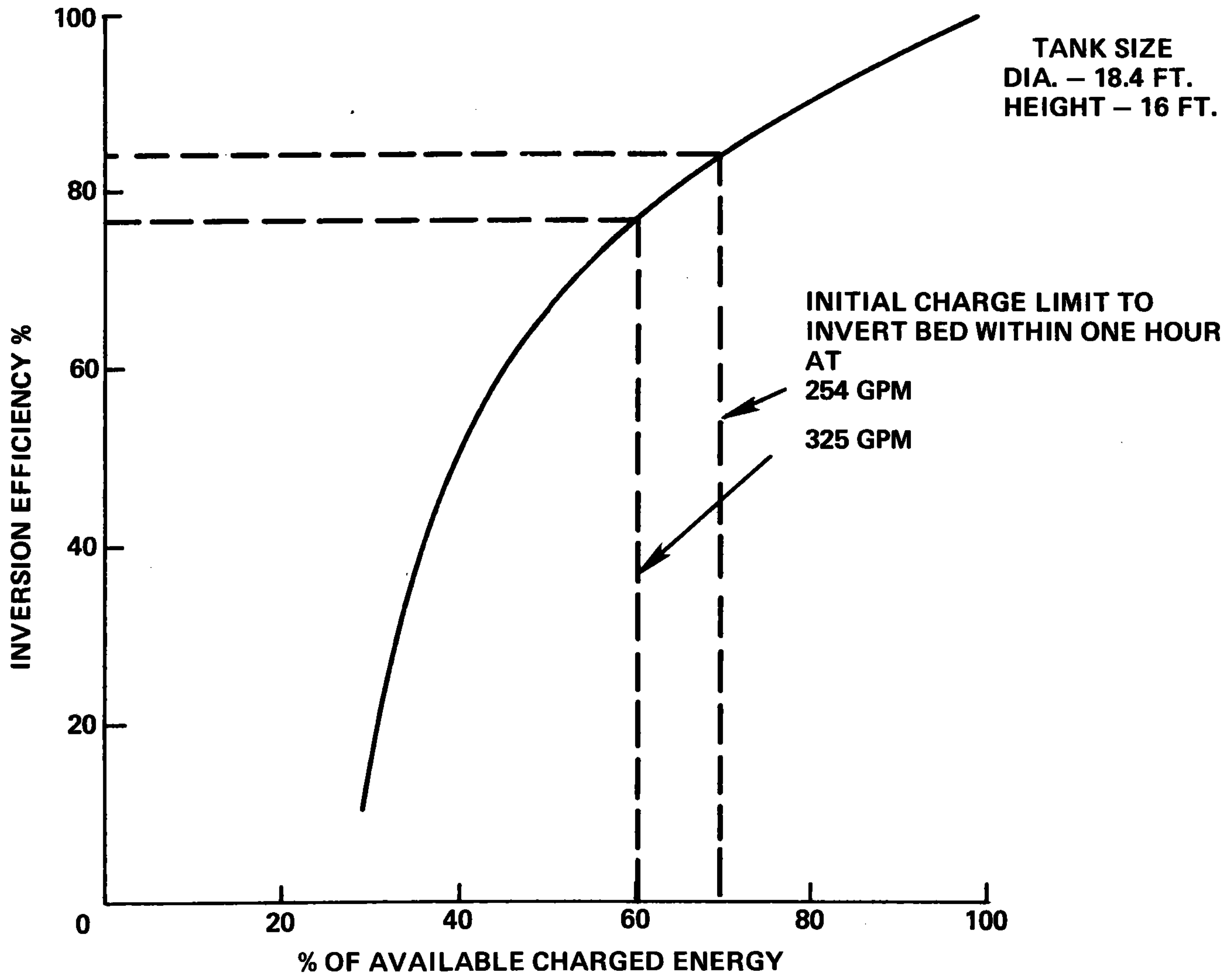


Figure 4. 3. 2-5. HTS Tank Inversion Efficiency

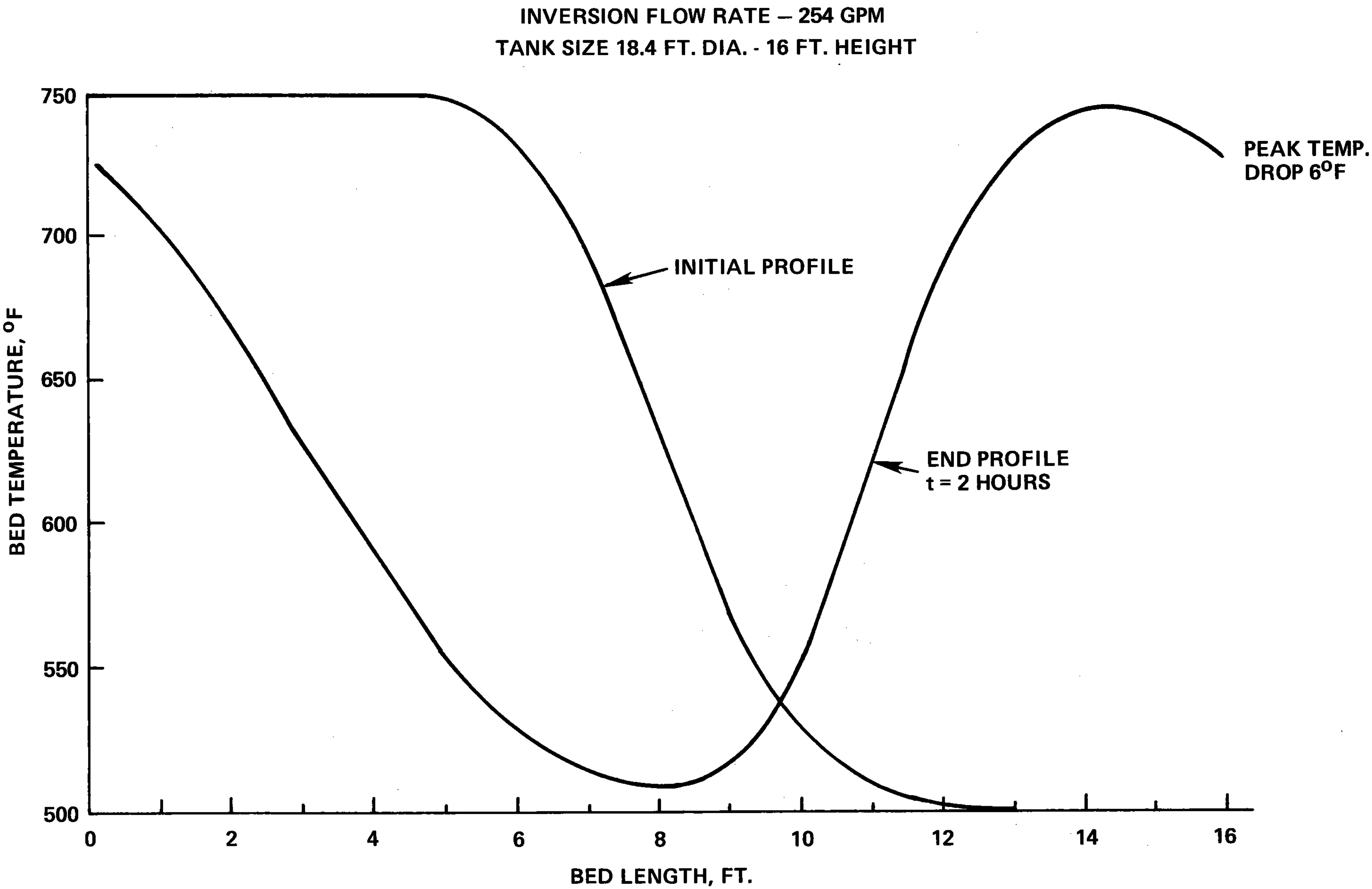


Figure 4.3.2-6. Inversion Temperature Profile

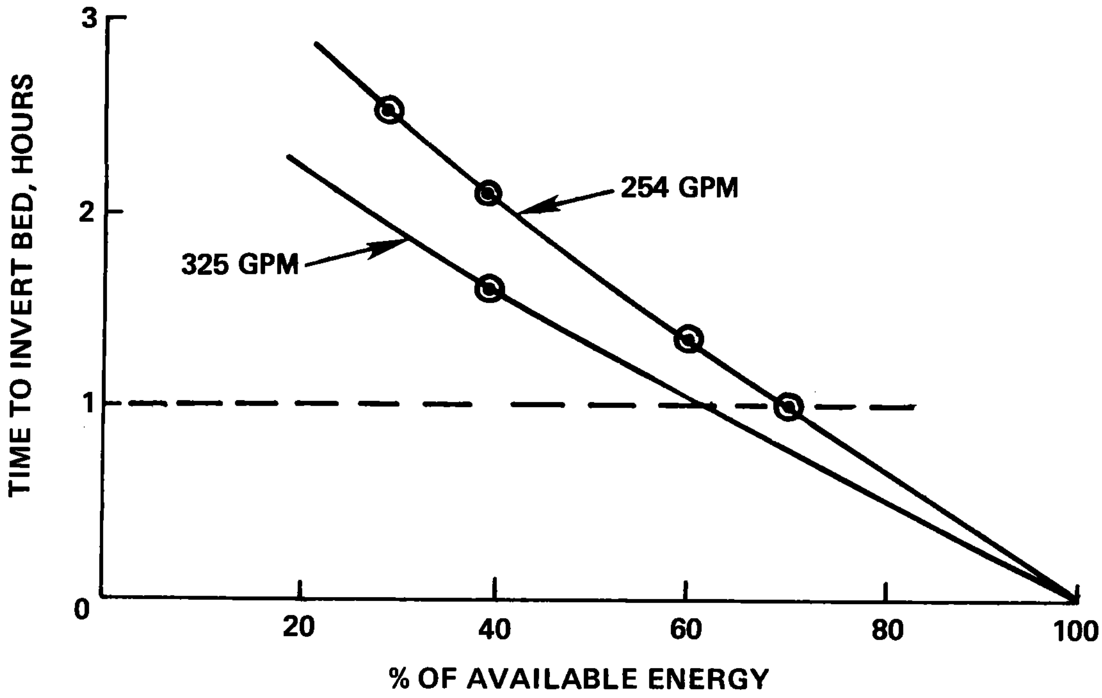


Figure 4.3.2-7. Inversion Time Requirements

performance for the system was shown to be the same with and without tank inversion. This results from the fact that only 7 percent of the total energy delivered to the HTS requires inversion. Design pressures, temperatures, and flow rates for the HTS are shown in Figure 4.3.2-8.

4.3.2.3 Solar Collector Performance

The major component groupings of the collector subsystems are the following:

a) Receiver
b) Dish/Reflector
c) Mount/Drive
d) Control

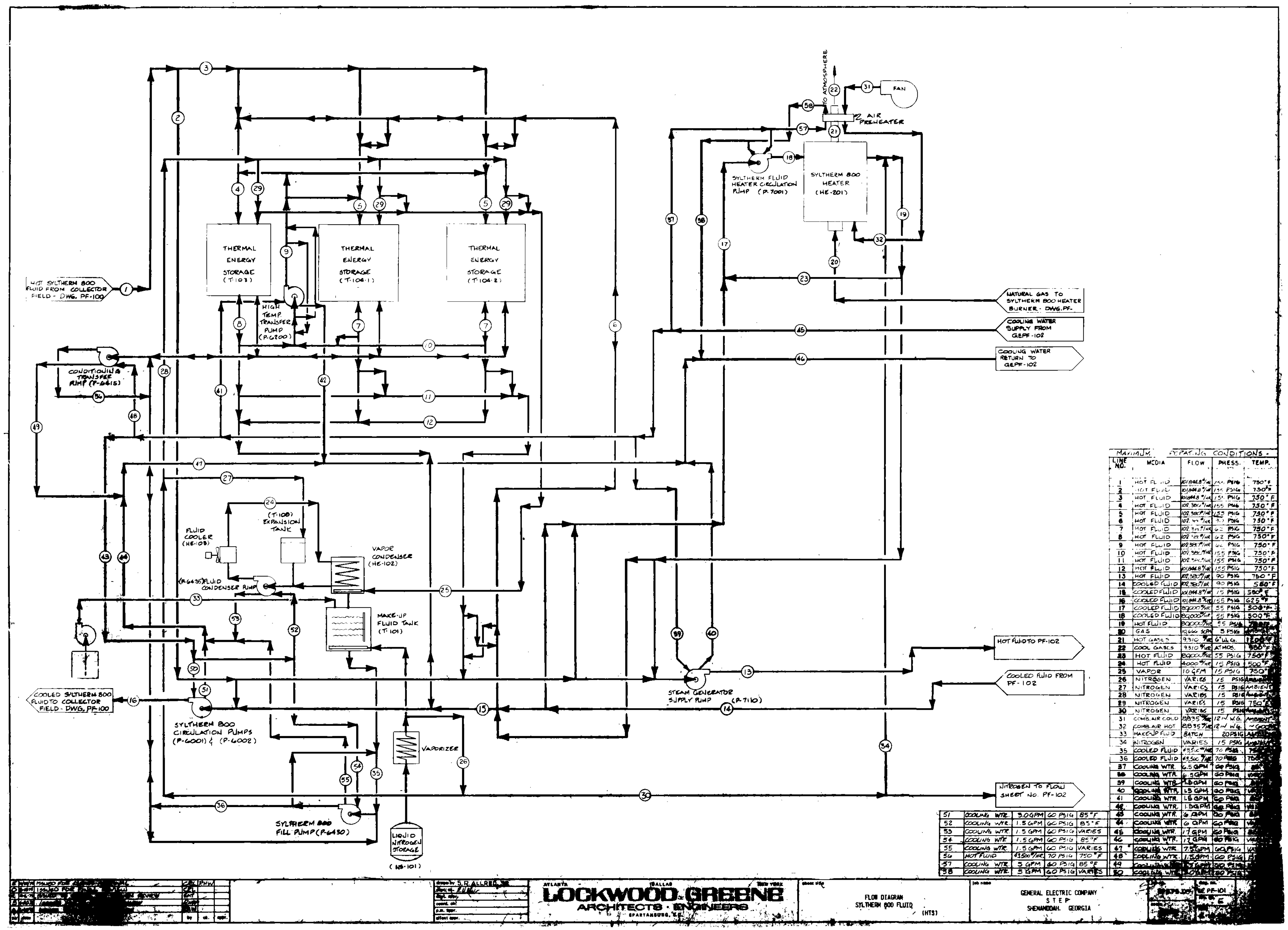


Figure 4.3.2-8. Flow Diagram HTS Subsystem

The function of the collector subsystem is to intercept, concentrate and transfer the incident solar energy into the Syltherm™ 800 heat transfer fluid, raising the temperature of the fluid from an inlet of 533° K to 672° K (500°F to 750°F). Table 4.3.2-1 presents the overall collector performance as a function of the incident solar insolation. Presented are the energy collected, Syltherm™ 800 flow rates, and overall collector efficiency achieved while the collector tracks the sun within specified control limits. It will automatically acquire the sun in the morning and return to stow in the evening. In the case of an emergency, the collector will defocus from the sun upon external command or upon the receiver exceeding an overtemperature set point.

4.3.2.3.1 Receiver Performance

The receiver transfers the concentrated solar energy from the focal plane of the collector to the Syltherm™ 800, heating the fluid from a temperature of 533°K (500°F) to an outlet temperature of 672° K (750° F). The losses for the receiver are a function of the outlet temperature and are tabulated in Table 4.3.2-2.

TABLE 4.3.2-1. COLLECTOR PERFORMANCE

Insolation	Thermal Energy Delivered	Flow Rate		Efficiency
BTU/FT^2	BTU	LBM/HR	GPM	$Q_{thermal}/Q_{sun}$
300	88,900	710	1.967	0.716
250	72,200	578	1.601	0.697
200	55,500	444	1.23	0.670
150	38,800	310	0.86	0.625
100	22,100	177	0.49	0.534
50	5,400	43	0.119	0.260

TABLE 4.3.2-2. RECEIVER THERMAL PERFORMANCE

Outlet Temp ^oF	Thermal Losses			Total Q_{loss} BTU
	Q_{rad} BTU	Q_{conv} BTU	Q_{cond} BTU	
775	8199	4104	963	13266
750	7410	3933	926	12269
725	6676	3762	889	11727
700	5995	3591	853	10439

4.3.2.3.2 Dish/Reflector

It is the function of the dish/reflector to intercept the incident solar energy and reflect and concentrate the energy to the focal plane of the dish. The reflector optical surface has a one sigma specular distribution of less than 8 mrads and a total hemispherical reflectance of 84%. The optical surface has a contour (slope error) accuracy of 1/2° rms and will maintain this slope error under the structural deflections caused by steady state wind loading and varying orientations as it tracks the sun. The surface area is 94 percent active, with six percent being lost by shadowing of the receiver and its support struts and cracks between the petals. The dish has a stowage orientation of -90° polar angle (i.e., due east) and -23 1/2° declination angle (i.e., winter solstice). The dish is in the stowage orientation when not in use or in high wind conditions.

4.3.2.3.3 Tracking/Control

The solar tracker enables the collector to follow the sun within $\pm 1/4^\circ$ both in polar and declination angles during illumination and also to follow the sun within $\pm 1^\circ$ when the sun is obscured by clouds. The polar drive system has a slew rate capability of 0.2°/second or 12°/minute and can return the collector to stow within 20 minutes after shutdown for the day.

4.3.3 MAJOR COMPONENTS

4.3.3.1 Solar Collectors

Figure 4.3.3-1 shows an overall geometry drawing of the collector and defines graphically the major components to be discussed below. The solar collectors receive the direct radiation of the sun and concentrate it to heat the Syltherm™ 800 fluid to a high temperature. In order to satisy the energy requirements of the STEP, the collectors must be capable of converting at least 56 percent of all the direct normal insolation incident upon the collector surface under the design operation conditions into heat supplied to the heated oil. A two-axis tracking, paraboloidal dish was selected to maximize collection efficiency. The mount and drive portions of the collector elevate the dish from the ground and point it at the sun. The dish retains its accurate paraboloidal shape regardless of changes in weight loadings or wind loadings below 13.4 m/s (30 mph). The reflective surface of the collector reflects 86 percent of the incident radiation with a specular dispersion equivalent to eight mrad RMS (root mean square) value. The reflected energy is concentrated in a receiver that converts 82 percent of the energy into useful heat at a design insolation rate of 630 W/m^2 (200 $Btu/hr\text{-}ft^2$) and 87 percent at the maximum insolation rate of 977 W/m^2 (310 $Btu/hr\text{-}ft^2$) by minimizing convection and radiation losses. The heated oil is transported up to and down from the receiver through insulated, nested piping which traverses the two axes of motion through flexible joints.

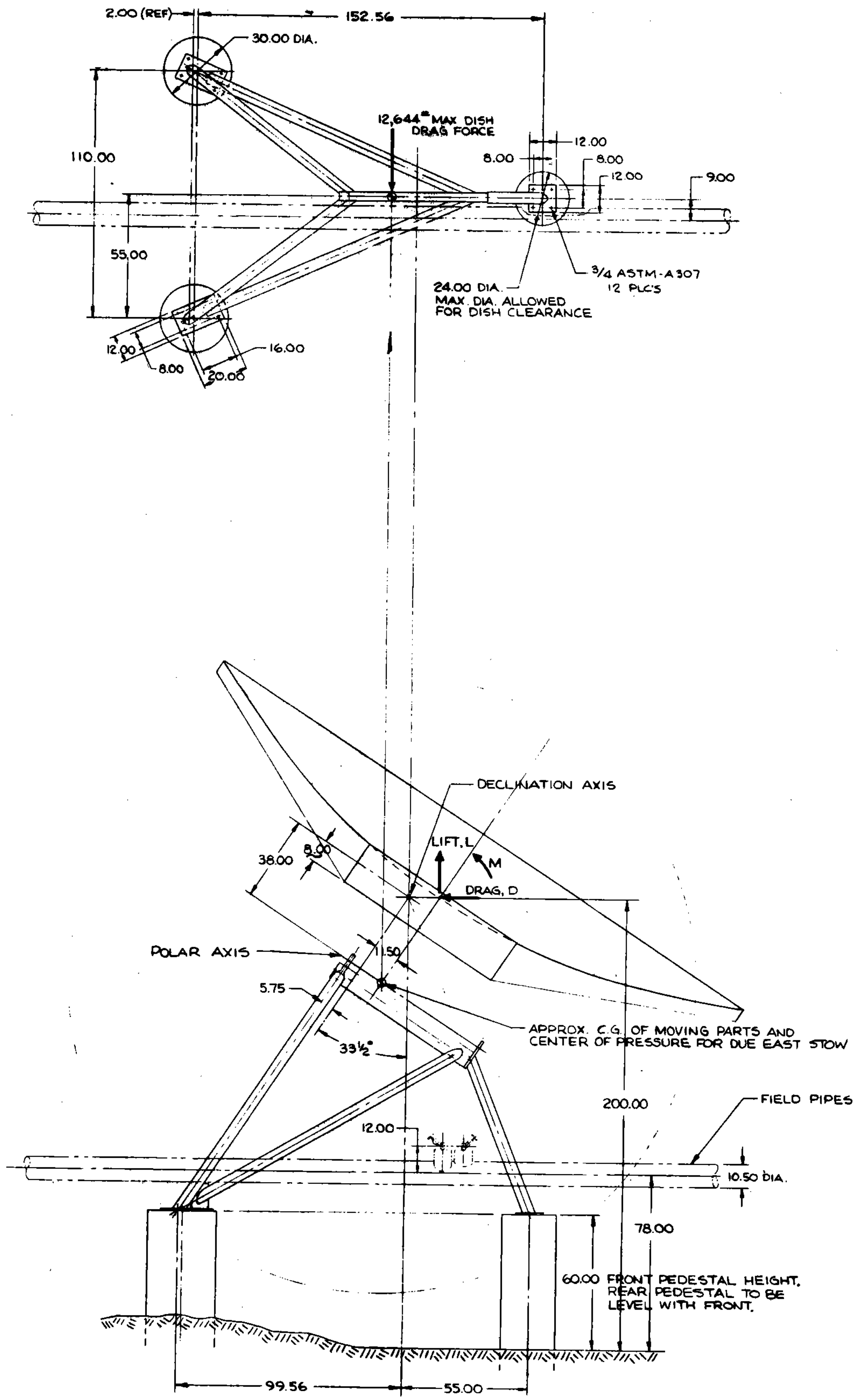


Figure 4.3.3-1. Collector Geometry

4.3.3.1.1 Receiver

The function of the receiver is to transfer the concentrated solar energy at the focal plane of the collector into the working fluid. The receiver is a cavity type with the incident concentrated solar flux impinging upon an absorptive surface enclosed within an insulated cylindrical shell. The aperature of the receiver is positioned in the focal plane of the dish and is 0.475 meter (18 inches) in diameter. The corresponding concentration ratio is 234, and 96 percent of the incident flux is intercepted. Figure 4.3.3-2 shows the design layout of the receiver.

The heat transfer surface is a beehive shaped cylindrical coil. This coil is 0.685 meter (27 inches in diameter (outer) and is constructed of wound Type 409 stainless steel tubes with an O.D. of 0.013 meter (1/2 inch) and a wall thickness of 0.9 MM (0.035 inch)). The total length of tubing is 60.6 meter (199 ft). The receiver interfaces with the up/down tubing external to the receiver. Two RTD's are inserted into

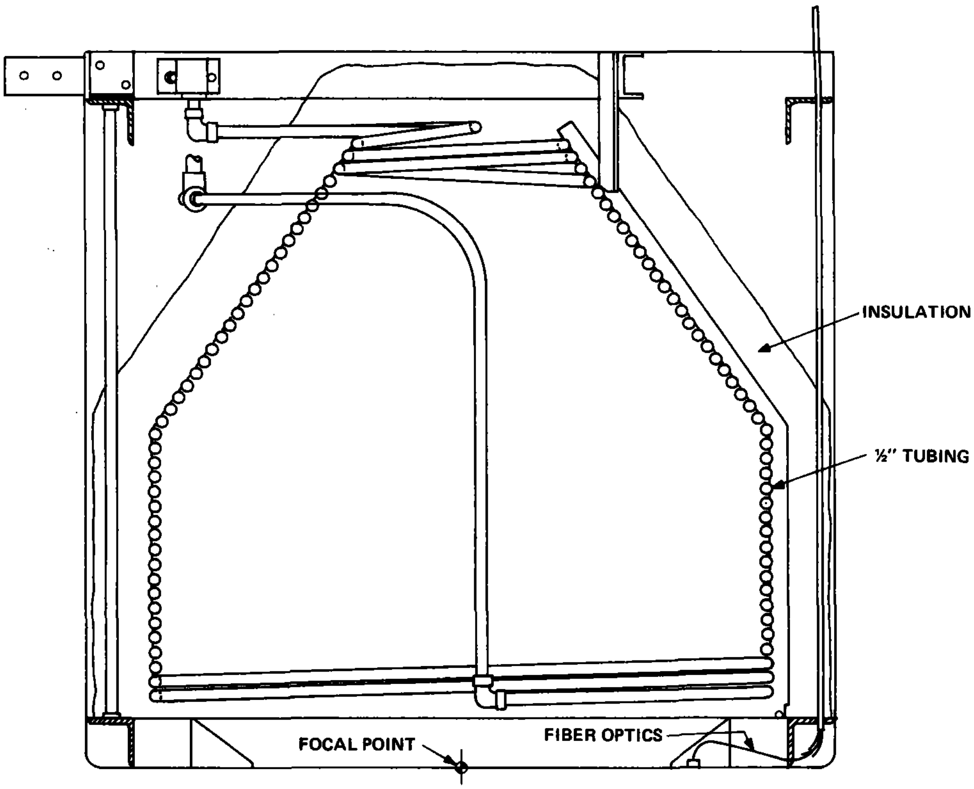


Figure 4.3.3-2. Receiver Configuration

the coil to monitor the flow temperature and provide over-temperature protection. The tubing is coated with a black Pyromark paint to give a high absorbtivity of 0.90 or greater.

Three shaped supports hold the coils in the beehive shape. The supports hang the coil off of a triangular top support frame and the supports are guided into slots at the bottom of the receiver. The outer cylindrical shape is dictated by a top and bottom angle ring. These rings are separated by three struts. The outer shell is also stainless steel with an outside diameter of 0.827 meter (32.56 inches). Between the outer shell and beehive coil is a .051 meter (2 inch) layer of Kaowool-B insulation.

The receiver has a four segment aperature. The outsides of each of the segments is covered by a woven quartz fiber cloth (Astrocloth) which keeps the aperature relatively cool during focus or defocus because of its good reflectivity and high emissivity. The aperature also holds the four fiber optics sensor canes. These canes of borosillicate glass intercept the "tails" of the solar flux pattern at the inner aperature. By equalizing the light the dish tracks the sun's image during the day as explained further in Section 4.3.3.1.3.

4.3.3.1.2 Collector Dish and Reflective Surface

The collector dish with its reflective surface concentrates the incoming solar radiation at the dish's focal point and hence can be thought of as an optical component. The dish must provide a true parabolic surface for the reflective material and hold this shape under various types of loadings such as gravity and wind forces. Typical antenna dishes measure the deviation from the true parabolic surface as an RMS value of the distances measured from a number of points on the dish. For optical reflective error calculations, the surface error is best measured as a slope error. Thus, for a given slope error distribution, the flux profile at the focal plane can be computed rather than assuming that the flux is all located at the theoretical focal point of the dish. This flux profile directly affects the design of the receiver as discussed above, and thus, the required dish slope error distribution is defined by the receiver design. In this case, a dish slope error of 0.5° RMS or less is required.

The diameter of the dish is seven meters. To provide the stiffness required to hold the parabolic shape, the dish is made from 21 stamped aluminum petals which are bolted together. The petals require structural backing to prevent excessive deflections under various loads. Aluminum ribs bolted to the petals are used for this purpose. The dish reflective surfaces and ribs are supported by a hub to which the declination axis pivot supports and one end of the declination actuator is attached for a three-point suspension. The reflective surface should reflect the sun's rays to the focal plane with minimal losses. These reflective losses are determined by measuring the total reflectance and the specular reflectance of the surface. The total reflectance refers to that portion of the solar radiation which is reflected and not absorbed. For this application, its required value is 0.84. The specular reflectance refers to how much a single ray would be dispersed after being reflected. Its required value must be equivalent to an 8 mrads RMS normally distributed specular distribution.

The reflective surface should withstand all expected adverse environmental conditions without serious degradation for the duration of the design life of the collector. Testing requirements for the reflective surface include:

a) Weathering due to wind, rain and humidity
b) Salt spray
c) Ultraviolet degradation
d) Thermal cycling, both daily and seasonal
e) Cleanability requirements including resistance to abrasive scratches

The reflective surface that best meets the design requirements is FEK 244, a 3-M Company acrylic film on 5657 H241 aluminum alloy petals.

4.3.3.1.3 Dish Mount and Drive

The parabolic surface of the collectors must be pointed at the sun in a semi-continuous manner to maximize the amount of heat collected. The tracking need not be continuous since up to 1/4° tracking and bias errors are allowed. This results in the reflected sun image at the receiver not being exactly centered in the cavity at all times, which is acceptable within the angular error prescribed above. This allows the drive system to be under an on-off control. Since the sun's motion is 0.00416°/s (360° day) or 1/4° per minute, the average tracking rate must match this, but need not do so continuously. With one half of the 1/4° RMS error allowed for the tracking error, the nominal position versus time is described in Figure 4.3.3-3. This shows the stepwise responses about the polar axis.

Since, at the time of stepping, the dish trails or leads the sun by 1/8° by design, 1/8° is allowed for other errors, e.g., by the wind loading deflecting the structure or by sun sensor errors. The wind deflection is expected to be the largest contributor to the error. An estimate of the stiffness requirement for the mount and drives has been developed based on known data and by making simplifying assumptions. The system is required to operate in maximum winds of 13.4 m/s (30 mph). The 13.4 m/s wind is not steady but is characterized as having a 10 m/s (22.5 mph) mean with a 3.4 m/s (7.5 mph) varying component. With a total of 6.8 m/s (15 mph) change in wind speed used as the worst case to produce the 1/8° error, the wind torque can be estimated. (Note: the steady wind component is compensated for by the sun sensor tracking approach.) From JPL wind tunnel data for parabolic dishes, this wind can impart a 1000 m-N (740 ft-lb) torque about the polar axis. Thus, the stiffness of the system should exceed 1000 m-N/1/8° = 8000 m-N/deg. (6000 ft-lb/deg). This value is a minimum to allow error contributions from other sources, but since the wind is expected to be the largest contributor, the whole 1/8° is used to calculate a minimum number rather than attempt a more sophisticated probabilistic analysis.

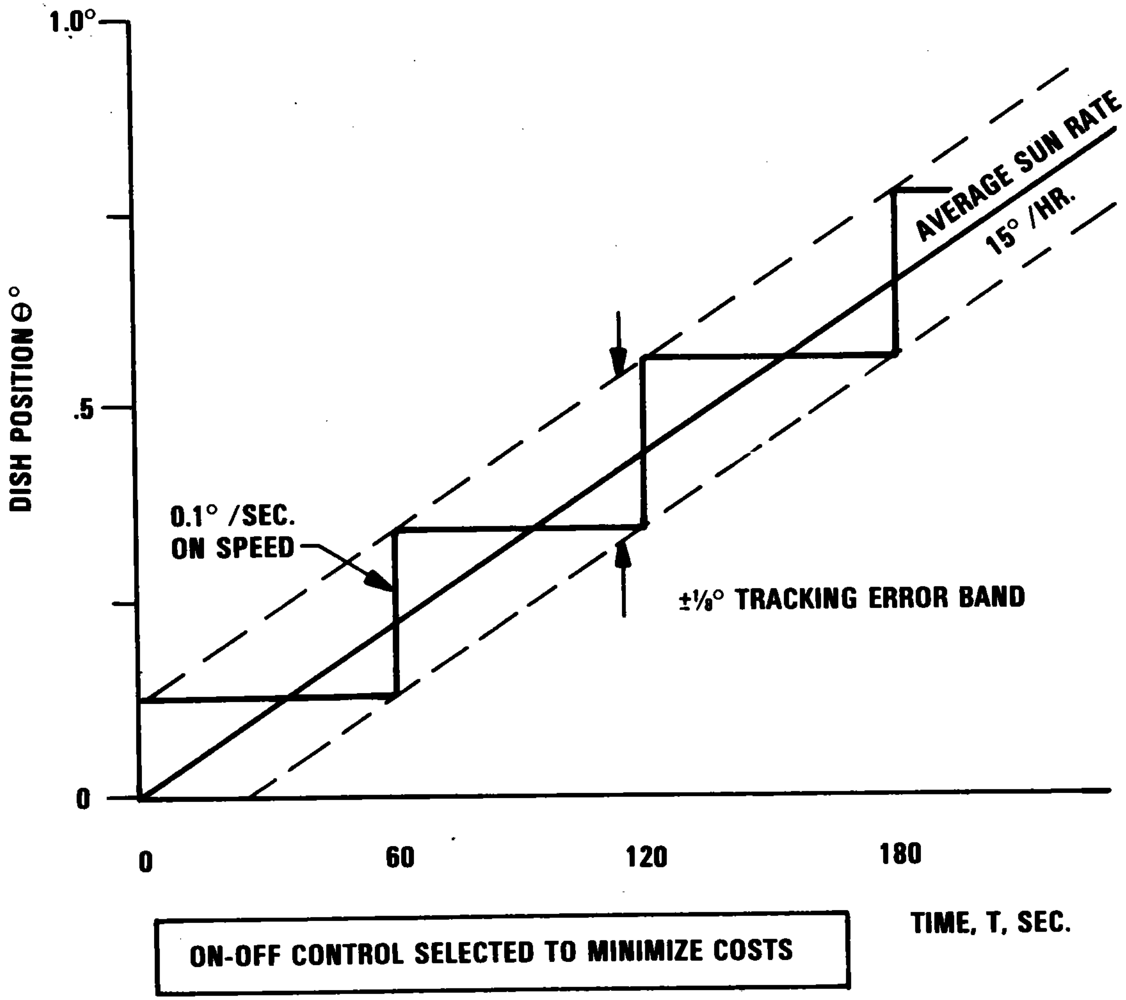


Figure 4.3.3-3. Actuator Speed Selection

This system stiffness limits the types of drive system components that can be used. In general, pneumatics or inexpensive gearing cannot be used because of being too compliant. Hydraulics could be used, but larger cylinders are required to meet the stiffness requirement than those needed to provide the forces and torques required. Inexpensive AC-motor driven jackscrews were selected as the drive elements primarily because of their stiffness at low cost. Because the motors need only 0.1 hp, simple relay control can be used. Two jackscrews are used for the polar motion since 180° motion is difficult to get from one jackscrew. The mount is required to provide ground clearance of the collector dish of about 0.61 meter (2 feet). This minimizes degradation of the reflector surface due to wind-borne heavy particles. The mount should also provide a stow position where the dish is pointed slightly downward. This will provide protection to the reflector surface from hail and also minimize dew collection. The polar/declination axis gimbal drive was chosen over the more conventional azimuth/elevation drive for two reasons. First, angular excursion requirements are smaller to point the dish at the sun during the most useful times, and secondly, the polar drive basically uses only one motion to track; i.e., it does not require the coordination of motions the azimuth/elevation needs.

The design of the mount structure not only requires the stiffest design for the least amount of material (cost) but also must not interfere with the dish motion. The polar axis provides 180° motion and the declination axis $\pm 23\ 1/2^\circ$. Hence, as the dish sweeps out these motions, the structure must not interfere. The mount must sit on a foundation that also does not interfere.

The foundation provides the initial alignment and must support the dish without excessive settling. It, along with the rest of the mount and drive, must be able to withstand the 40.2 m/s (90 mph) maximum wind condition. The mount, drive, and foundation must meet the local building codes. The mount structure and drives are then designed to meet the AISC design requirements in the worst case; that is, the dish is not in the stow position with the actuator retracted.

The outdoor environment requires the components selected to be either inherently weather proof or housed in weather proof containers. Maintenance should be minimized, and replacement of active parts be made easy.

The collector must focus and/or defocus every operating day, so obviously a faster speed than the nominal tracking speed is required. A nominal 0.2° sec speed is obtained by turning on both polar drives which will defocus the receiver in 50 sec or less. The receiver's aperature, as mentioned above, is protected by a quartz fiber cloth to keep the temperatures down. Since the collector must be able to defocus in the event of AC power loss to the field an auxillary generator emergency power supply is provided.

4.3.3.1.4 Control

Each of the collectors has its own Collector Control Unit (CCU), a weather proof enclosure which receives and sends control and command signals. The CCU receives three types of signals from the collector: 1) potentiometers on the polar and declination send position signals 2) Two RTD's mounted in the received send temperature signals and 3) four fiber optic sensors mounted on the aperature send signals which indicate how well the focused spot is centered in the hole. The CCU sends to the collector the motor drive signals and to the various status signals.

Under normal tracking the four fiber optic signals are used to control the collector drives. Usually only polar drive is used. The difference between East and West fiber optic signal indicate the need for a step update as indicated in Figure 4.3.3-3.

If the sun is obscured by clouds, the polar drives are updated by matching the polar potentiometer signal with the calculated position. The potentiometer cannot provide the accuracy of the fiber optics, but will keep the receiver close enough so that when the cloud passes the fiber optics can regain control. The potentiometer signals are also used to control the collectors during the focus and return to stow maneuvers.

4.3.3.2 High Temperature Storage Tanks

4.3.3.2.1 Tanks

The three high temperature storage tanks will be of similar carbon steel construction. The smaller, one hour tank is 3.04 meter (10 feet) in diameter and 3.65 meter (12 feet) high with a capacity of 26.7 cubic meters (7069 gallons). The two larger tanks each are 5.7 meters (19 feet) in diameter and 4.87 meter (16 feet) high with a capacity of 128.8 cubic meters (34023 gallons). Figure 4.3.3-4 shows the tank construction. The tank ends will be preformed domes for maximum strength and economy. The lateral wall is 0.0095 meter (3/8 inch) thick from the bottom to the top of the tank. The main inlet connection is a 0.114 meter (4.5 inch) tube leading to the distribution manifold which will be an integral part of the dome as described in Section 4.3.3.2.2. The dome will also have man-hole ports, for access to the tank interior. The tank will be supported on a 1.2 meter (4 foot) high structure to allow adequate bottom insulation and access to the sump.

4.3.3.2.2 Distribution Manifold

The trickle oil concept requires only one manifold at the top of the packed bed, but a second bottom manifold is included to accommodate the fluid filled back-up design capability. The two manifolds will be of identical construction as shown in Figures 4.3.3-5 and 4.3.3-6. The manifold is a series of interconnecting pipes, .032 meter (1-1/4 inches) in diameter, providing a uniform flow distribution over the packed bed. There will be two holes uniformity distributed along the pipe length, with a hole located on the bottom or top of the pipe for the top and bottom manifolds, respectively. There will be a total of 900 holes each with a .0019 meter (0.074 inch) diameter for a total flow efflux area of .0025 square meters (.026 square feet). The top manifold will be an integral part of the dome attached by stringers at several key points, Figure 4.3.3-5.

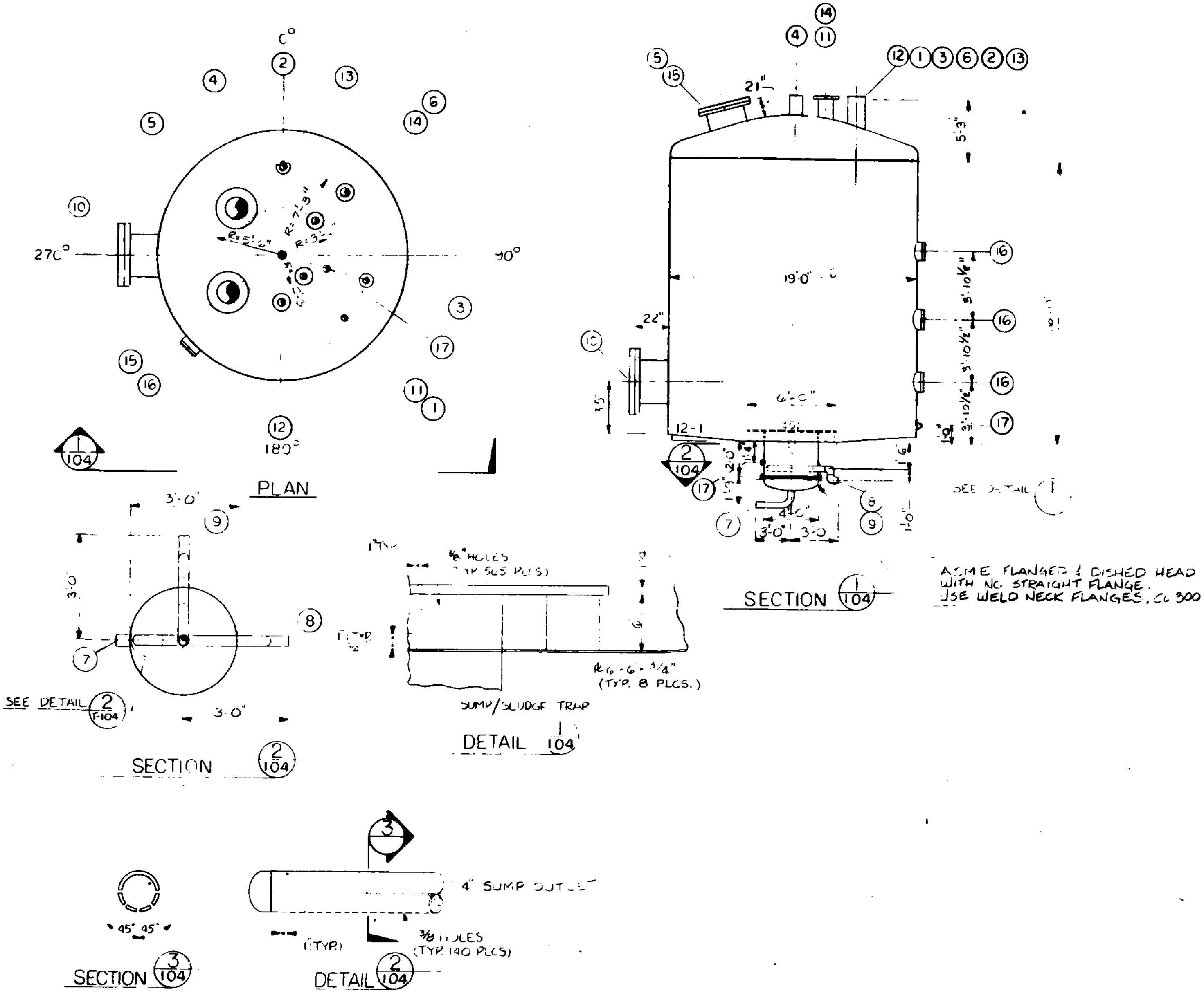
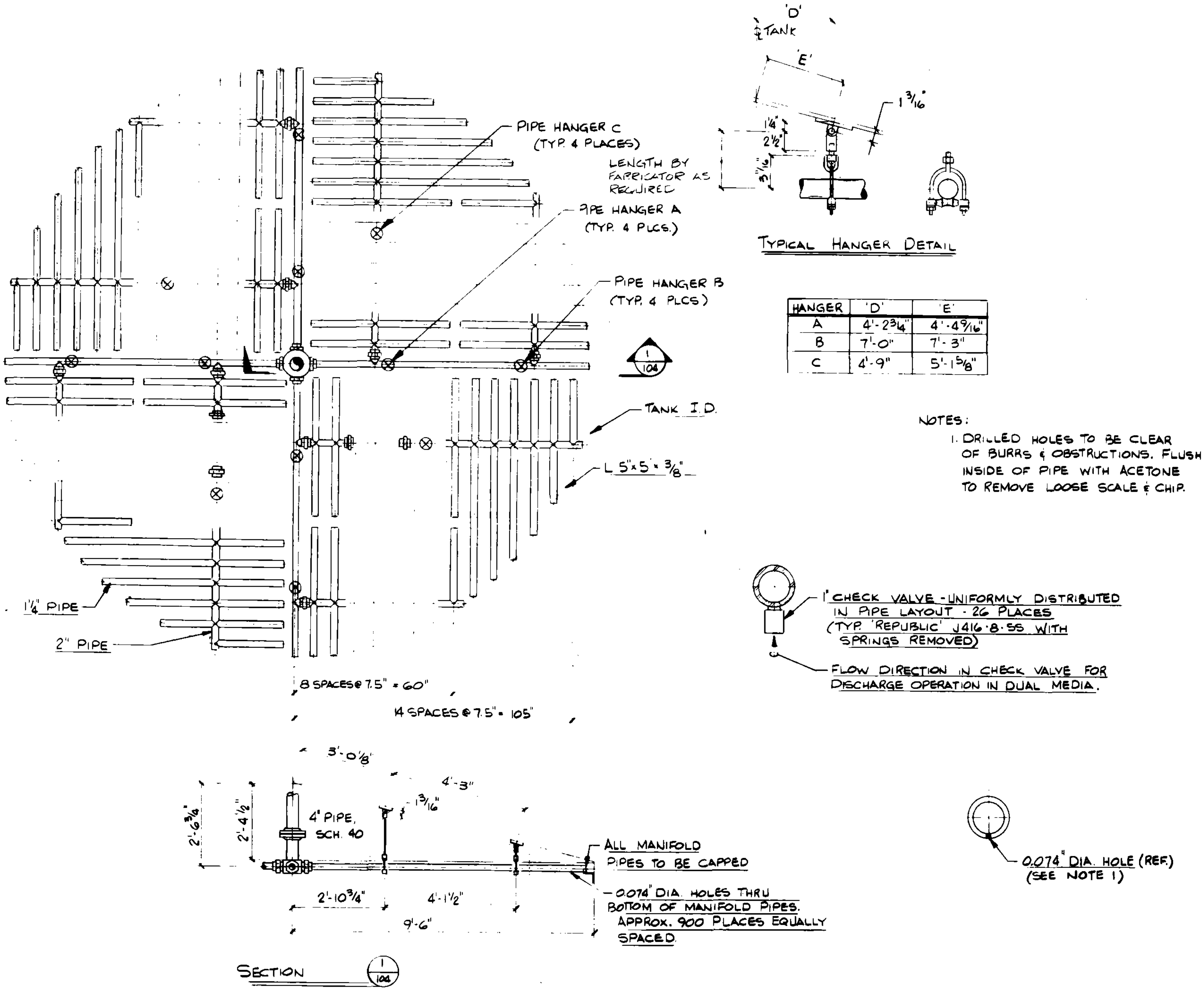


Figure 4.3.3-4. Layout Oil/Storage Medium Tank



HANGER	'D'	'E'
A	4'-2¾"	4'-4 9/16"
B	7'-0"	7'-3"
C	4'-9"	5'-1 5/8"

Figure 4.3.3-5. Tank Inlet Piping Arrangement

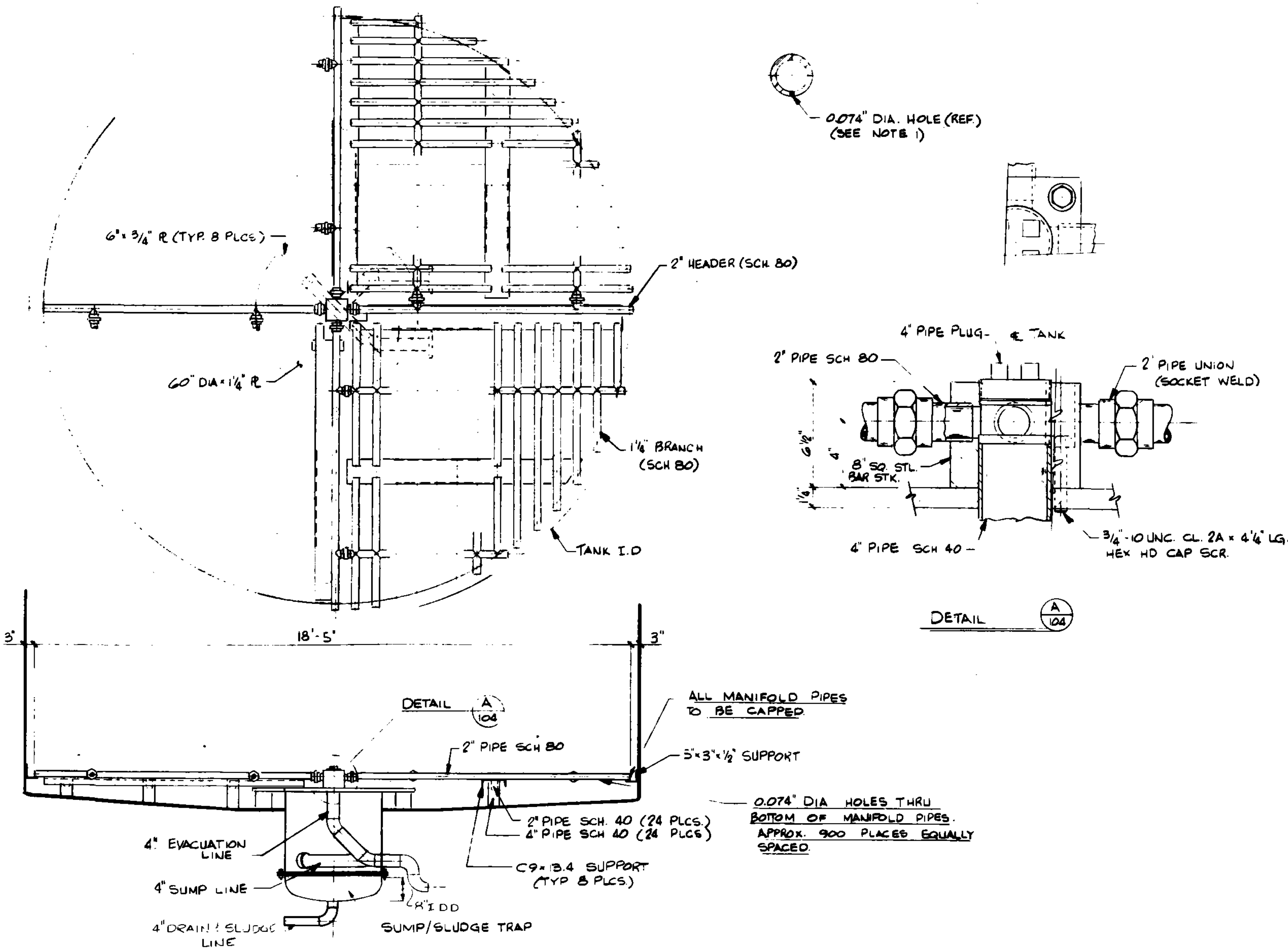


Figure 4.3.3-6. Tank Outlet Piping Arrangement

This design allows unit installation. The bottom manifold is located at the sump level and supported off the domed floor as shown in Figure 4.3.3-6. The bottom manifold will be valved externally to the tank to allow conversion from the trickle oil sump operation to the dual medium manifold.

4.3.3.2.3 Sumps

Each tank will have a separate sump of similar design located at the center of the tank. Each sump will be cylindrical in shape, 0.915 meter (3 feet) in diameter and 0.915 meter (3 feet) deep with a capacity of 0.605 cubic meters (160 gallons).

The bottom of the sump will be sloped toward a drain with a removable cover for sludge cleanout. The outlet pipe will enter from the side of the sump. A .025 meter (1 inch) grid grate is located directly above the pipe to inhibit formation of a large vortex flow which could result in pump cavitation. The outlet pipe will have a capped end with multiple holes on the bottom side also to minimize any strong vortex formation. A solid 1.52 meter (60 inch) flat head will be mounted 0.15 meter (6 inches) above the tank floor and supported by load carrying gussets which distribute the load directly to the support structure. Hole perforations are located around the side of the flat head. This design prevents sludge from falling directly into the sump and allows flat layout of the bottom manifold.

4.3.3.2.4 Iron Ore Storage Medium

Iron Ore is the packed bed storage medium. The iron ore pellets are sphere-like pellets with a nominal size range of .00952-.0159 meter (3/8 - 5/8 inch) in diameter. The bulk density is 2195 kg/m^3 (137 lb/ft^3) and its average specific heat from 533-672°K (500 to 750°F) is 876 kg/°K (.21 Btu/lb-°F). Typical composition of iron ore is:

Fe	62-65%
SiO_2	5-6%
P	.01-.04%

M	.1-.3%
Al_2O_3	.22-.88%
C_aO	.20-.43%
M_gO	.04-.66%
S	.002%
H_2O	1-3%
O_2	Remainder

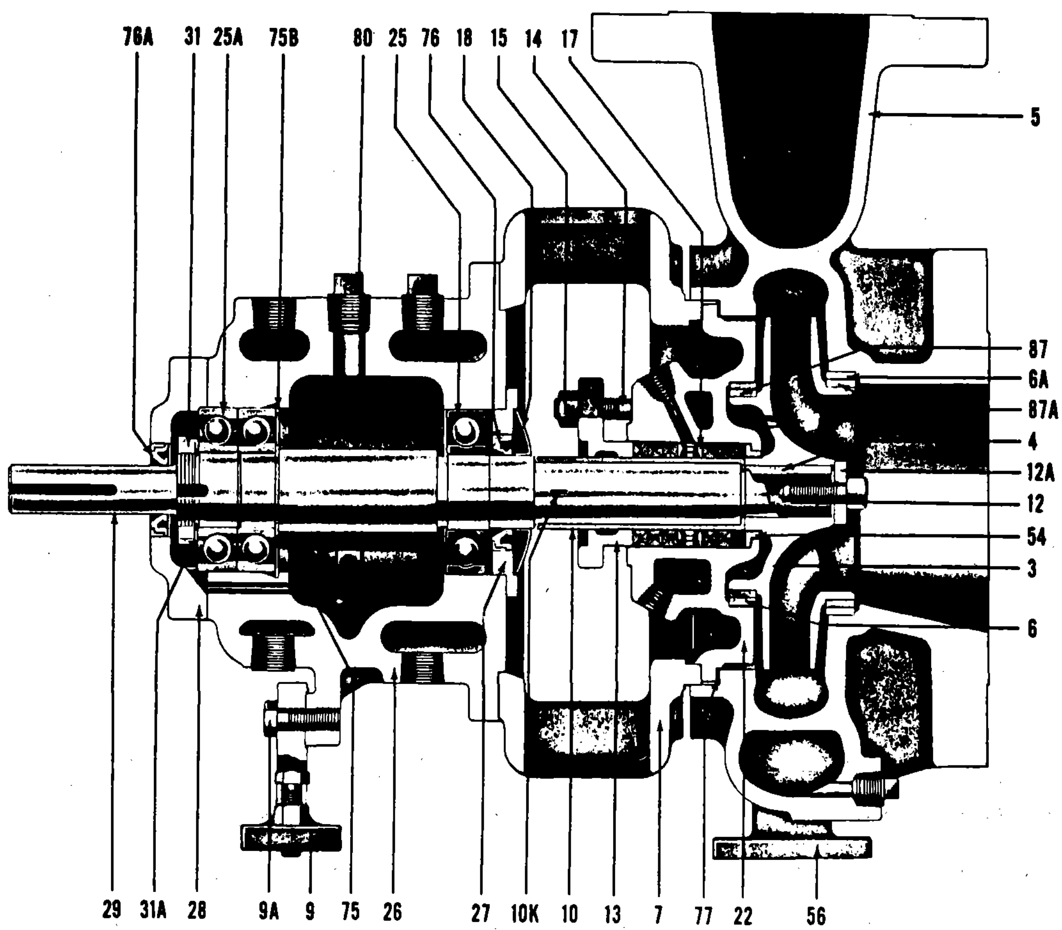
Approximately 5.5 x 10^4 kg (61 tons) of iron will be packed into the one hour tank and 2.7 x 10^5 kg (299 tons) in each of the two larger tanks for a total iron ore weight of 5.4 x 10^5 kg (659 tons). Larger sized pellets will be screened and used as bottom layers in each of the tanks to provide adequate drainage to the sump.

4.3.3.3. SCS Pumps

Pumping power for the entire Solar Collection Subsystem is supplied by high temperature centrifugal pumps which are located in the Mechanical Building. These pumps are designed to operate at 672°K (750°F) and have water cooled stuffing boxes and bearing frames. Totally enclosed, fan cooled, 3 phase motors drive the pumps. The casing of each pump in the SCS is flange connected to the tubing through free flexing expansion joints to minimize axial and lateral displacement loadings during thermal expansion. The pump casing is also insulated. Each pump has isolation valves for maintenance and a pump casing drain. A cross-sectional view of a typical pump along with a list of materials of construction is shown in Figure 4.3.3-7.

4.3.3.3.1 Collector Field Pumps

A set of two centrifugal pumps supply the pumping needs of the Collector Field Subsystem. Each pump is rated for .009 m^3/sec (140 gpm) at 1 x 10^6 N/m^2 (150 PSIG) of head, and when operated together, in parallel, they can provide the maximum collector field flow requirements of 0.018 m^3/sec (280 gpm). This parallel pump design provides greater system reliability and reduced power consumption. Also



PART #	PART NAME	CLASS 40	CLASS 50	PART #	PART NAME	CLASS 40	CLASS 50
STANDARD MATERIALS OF CONSTRUCTION—LISTED BY MATERIAL CLASS							
3	Impeller	C.I. (1)	316 (3)	25	Shaft Bearing—Radial	Stl.	Stl.
4	Impeller Key	Stl. (2)	316 (8)	25A	Shaft Bearing—Thrust	Stl.	Stl.
5	Casing	Stl. (6)	316 (3)	26*	Bearing Housing	C.I. (1)	C.I. (1)
6*	Backhead Ring	Iron (7)	316 (3)	27*	Seal Ring	C.I. (1)	C.I. (1)
6A	Casing Ring	Iron (7)	316 (3)	28	Bearing End Cover	C.I. (1)	C.I. (1)
7	Cradle Spacer	C.I. (1)	C.I. (1)	29*	Pump Shaft	Stl. (10)	316 (8)
9	Bearing Housing Foot	C.I. (1)	C.I. (1)	31	Bearing Lock Nut	Stl.	Stl.
9A*	Brg. Hsg. Ft. Capscrew	Stl. (2)	Stl. (2)	31A	Bearing Lock Nut Washer	Stl.	Stl.
9F*	Brg. Hsg. Ft. Jack Bolt	Stl. (2)	Stl. (2)	54*	Throat Bushing	C.I. (1)	316 (8)
9G*	Brg. Hsg. Ft. Jack Bolt Nut	Stl. (2)	Stl. (2)	56	Casing Foot	C.I. (1)	C.I. (1)
10*	Shaft Sleeve	316 (8)	316 (8)	75	Snap Ring—Inner Shaft	Stl.	Stl.
10K*	Shaft Sleeve Key	304 (9)	304 (9)	75B	Snap Ring—Inner Housing	Stl.	Stl.
12*	Impeller Bolt	Stl. (2)	316 (8)	76	Oil Seal	Buna	Buna
12A*	Impeller Washer	Stl. (2)	316 (8)	76A	Oil Seal	Buna	Buna
13*	Stuffing Box Gland	Stl. (6)	316 (3)	77	Casing Gasket	Asbestos (11)	Asbestos (11)
14*	Stuffing Box Gland Stud	Stl. (4)	304 (9)	77B*	Bearing End Cover Gasket	Paper (12)	Paper (12)
15*	Stuffing Box Gland Stud Nut	Stl. (5)	304 (9)	80	Oil Vent Plug	C.I.	C.I.
17*	Lantern Gland	C.I. (1)	316 (3)	87*	Impeller Ring—Back (Optional)	C.I. (1)	316 (3)
18*	Splash Collar	Stl. (13)	Stl. (13)	87A	Impeller Ring—Front (Optional)	C.I. (1)	316 (3)
22	Backhead	Stl. (6)	316 (3)	*Denotes parts interchangeable in all pump sizes of same type.			

Figure 4.3.3-7. Pump Cross Section and Materials

single pump operation can provide sufficient flow to the collector field for 2/3 of the time during the average day. The second pump is needed only during the peak insolation period each day. With this parallel operation, peak power consumption is less than 40 kW.

Two inline flow meters and temperature transducers are used to measure the flow rate to the collector field and provide pump permissives. Individual flow meter bypass allows maintenance during system operation with no loss of flow data. A loop strainer is installed upstream of the pumping system. Downstream of the pumps is a pneumatically operated throttling value which functions to control the flow delivered to the field.

4.3.3.3.2 HTS Transfer Pumps

A single centrifugal pump supplies the pumping power required to transfer the heated Syltherm TM800 fluid from one HTS tank to another. This pump is rated at 0.0208 m^3/sec (325 gpm) at 6.2 x $10^5 N/m^2$ (90 PSIG). The installation of this pump is similar to that of the CFS pumps except that there is no bypass or redundancy.

4.3.3.3.3 Steam Generator Supply Pump

The steam generator supply pump delivers the heated Syltherm TM800 fluid to the steam generator. This pump is rated for 0.021 m^3/sec (325 gpm) at 31 meters (102 feet) and is capable of providing the maximum flow rate required by the steam generator during all modes of operation. This pump has a modulated bypass to provide flow adjustments to compensate for the pressure drop across the steam generator. A characteristic pump curve for the steam generator supply pump is shown on Figure 4.3.3-11.

4.3.3.3.4 Fossil Heater Booster Pump

The fossil fuel fired Syltherm ^{TM}800 heater has a single centrifugal pump rated for 0.0145 m^3/sec (225 gpm) at 4.8 x 10^5 N/m^2 (70 psig). This pump is part of the Syltherm ^{TM}800 heater package, and it can be used to supply heated fluid to the collector field, to the HTS tanks, or to the steam generator.

4.3.3.4 <u>Fossil Fired Heater</u>

4.3.3.4.1 Design Criteria

a) Sizing Criteria

The fossil fired hot oil heater will be designed to heat 0.0145 m^3/sec (225 gpm) from 533°K to 672°K (500°F to 750°F) for a net output of approximately 8.45 x 10^9 joules/hr (8 x 10^6 BTU/hr) at an efficiency of approximately 80 percent. Natural gas will be the fuel source.

b) Material Compatibility

The unit will be constructed of carbon steel, carbon steel alloy, or stainless steel as dictated by the temperatures of the various components.

c) Electrical Requirements

The electrical requirements will be approximately 11.2 kW (15 hp) for the combustion air fan plus the minimal requirements for instrumentation and controls.

d) Maintenance and Testing Requirements

1) The hot oil heater shall require only a minor amount of servicing. Instruments and controls shall have an annual calibration check. The combustion chamber shall be visually inspected on a semi-annual basis for any indication of fireside corrosion and/or erosion. The manufacturers representative shall make an inspection on an annual basis.

2) The unit's components shall be lubricated and otherwise serviced per the manufacturers printed instructions.

3) The hot oil system fluid shall be sampled and tested at the appropriate intervals as recommended by the manufacturer of the fluid for deterioration or other undesirable properties.

e) Component Special Features

The air inlet and the flue gas outlets ducts will be provided with high quality dampers for sealing the unit and preventing air at ambient temperatures from circulating through the heater, thereby preventing energy losses from the heater.

f) Component Operational Limitations

The hot oil heater will be operated as necessary and in conjunction with the other components of the Solar Collection Subsystem. The fossil fired hot oil heater controls will be furnished by the heater manufacturer and will be interlocked with the subsystem controls to furnish the required thermal energy as required by the STES central computer.

4.3.4 CONTROLS AND INSTRUMENTATION

4.3.4.1 Tracking Control

4.3.4.1.1 Design Criteria

a) Provide automatic closed loop tracking in the declination and polar axes of each collector

b) Provide collector pointing at low insolation levels (cloud cover)

c) Accommodate shadowing effects

d) Provide total pointing error less than $1/4^\circ$

e) Provide a defocus slew rate in excess of 2 deg/sec for at least 10 degrees of travel

f) Provide monitor and control functions at the central computer console

g) Provide for manual and stow positioning controls

h) Provide for sequential collector actuation to minimize power surges

i) Provide instrumentation for performance evaluation

4.3.4.1.2 Control Description

When in the tracking mode, each axis of the collector will operate in one of two modes depending upon the level of solar insolation. During intermittent cloudy periods, pointing angles for each axis are calculated in the computer and provide command angles for closed loop position control. At insolation levels above threshold, sun tracker operation takes over, and each axis is operated by sun tracker developed errors. In this mode, position errors are limited by monitoring the computed positions to establish sun tracker position error thesholds.

After morning start-up, each of the polar axis motors are operated alternately. Further, within a group of collectors, motors are operated sequentially to minimize power surges on the motor power supply system.

The tracking control has the capability to return to the morning start-up position after evening shutdown. Each collector also has the capability to be programmed to a stow position and a maintenance position if different from stow.

Each receiver is provided with an overtemperature sensor and controller. In the event of an overtemperature, this controller is actuated and the collector defocused. Also the controls prevent focusing of the collectors until fluid flow has been established in the receivers.

Collector tracking operation will be tested by operator command at the microprocessor or central computer level. Operation will be monitored at these locations using standard readout equipment.

4.3.4.1.3 Devices

The following components are included in the design of the tracking control.

- Microprocessor
- Analog to digital converters
- Digital to analog converters
- Position potentiometers
- Quadrature sum sensor head
- Analog electronics package
- Control relay assembly
- RTD's (2)

4.3.4.1.4 Alarms

The following alarms are included in the tracking control.

- Overtemperature alarm
- Operational modes/status
  - Track
    - Computer
    - Sun tracker
  - Stow
  - Defocus

4.3.4.2 Field Temperature Control

4.3.4.2.1 Design Criteria

a) Deliver Syltherm 800 fluid to the field return line at 658 to 672°K (725° to 750°F)

b) Maximize the fluid flow within the temperature constraints

c) Accommodate transients due to cloud cover

d) Control branch flow based on maximum collectors per branch

e) Minimize temperature variations between collectors in a branch

f) Provide instrumentation for performance evaluation of the subsystem

4.3.4.2.2 Control Description

The required collector field flow is determined by branch valve positions. The positions are used to adjust the centrifugal pump flow valve so as to provide the correct flow to the collector field. In this way, valve controllability is maintained over the range of flows.

The collector flow paths are paralleled in groups to a branch per design field layout. The flow in each receiver is manually adjusted during initial startup with trim flow valves so that all receivers in a branch will have equal flow at maximum insolation condition. The inlet flow to the branch is controlled by a flow control valve operated by a temperature control loop. The discharge temperature of all receivers is instrumented and the highest used for operating the temperature control so long as it is below the trip out (defocus) temperature for the receiver. If the receiver discharge temperature exceeds the alarm (defocus) temperature, the collector is defocused to reduce the receiver temperature. An audible/visible alarm is provided and manual reset required.

4.3.4.2.3 Devices

The following devices are included in the design of the field temperature control.

Microprocessor
Minicomputer
Operator's console
Valve drivers
RTD's
EMF Comparators
Alarms
High EMF Selector

4.3.4.2.4 Alarms

The following alarms are included in the field temperature control.

Overtemp Alarms (audible/visible)
  each collector
  pipe field locations

Pump On/Off
Flow Loss Alarms
Loss of AC power

4.3.4.3 High Temperature Storage Controls

4.3.4.3.1 Design Criteria

a) Provide capability to charge and discharge storage tanks

b) Activate/deactivate collector field based on insolation and storage requirements

c) Determine tank status whether charged, discharged, or inverted

d) Determine system load requirements

4.3.4.3.2 Control Description

The bottom and top tank temperatures are used to establish the status of each storage tank along with its most recent history of operation. For the trickle oil mode, a tank is charged with hot fluid in the top and discharged with hot fluid exiting the bottom. In the thermocline mode, hot fluid enters and leaves the top of the tank for charge and discharge, respectively.

The control processor will determine when to charge or discharge the tank based on the energy available from the collector field and the energy requirements of the system. The various on/off valves in the system will be operated by the logic to accomplish this.

The processor will determine if sufficient energy can be obtained from the collector field to charge the tanks or operate the system. It will also determine when to discontinue field operation due to low solar insolation or a fully charged HTS.

The processor will also determine the status of all tanks and the system energy requirements. The fossil heater will be actuated if the stored energy level drops below a preselected threshold value.

4.3.4.3.3 Devices

The following devices are included in the design of the HTS controls.

RTD's
Microprocessor
A/D inverters
Solenoid valves
Valve drivers

4.3.4.3.4 Alarms

The following alarms are included in the HTS controls.

Temperature Alarms, high and low
Collector Field Status: on/off, energy rates
Tanks: Charged/Discharged, Level

4.4 SUBSYSTEM OPERATION

4.4.1 NORMAL OPERATION

4.4.1.1 Startup Operation with Storage Depleted

Startup of the SCS with storage depleted begins with the actuation of the fossil fired Syltherm^{TM} 800 heater and pump to provide the energy needed to operate the PCS and the TUS. The steam generator supply pump supplies flow to the steam generator, and the steam generator control valve, responding to the demands of the PCS, provides flow control. During this initial period, the Steam Generator Supply Subsystem is isolated from the collector field. One of the HTS tanks which is open to the suction line of the SGS pump provides thermal expansion capability and sufficient net pump suction head (NPSH).

Activation of the solar collector field includes both initiation of the parabolic dish tracking mechanism as well as startup of the collector field pump and the field flow control valves. The principal activation signal for the field is the solar time, with a direct normal insolation override. If, once the time signal is given, the insolation level exceeds the startup threshold value of approximately 236 W/m^2 (75 $Btu/hr\text{-}ft^2$), solar collection is initiated. The Syltherm 800 recirculates through the field, gradually heating up, while the fossil heater, PCS, and TUS continue to function to provide the Bleyle Plant loads. This mode of recirculation will continue until the outlet from the field reaches approximately 533°K (500°F). At this point, the recirculation is discontinued, and the field flow is directed through the smaller (1 hour) discharged storage tank. During this mode, the collector outlet temperature gradually increases to its normal operating range of 658°K -672°K (725°F-750°F).

When the sump temperature in the one hour storage tank reaches 561°K (550°F), the exiting Syltherm 800 fluid is directed through the next discharged storage tank and back to the collector field. The HTS transfer pump is used to maintain the transfer flow between the tanks. This mode allows the one hour tank to become fully charged without exceeding the 561°K (550°F) field inlet temperature limit.

When the one hour tank is fully charged, the bulk of the hot fluid from the collector field is directed toward the Steam Generator Supply Subsystem where it is used to satisfy the steam generator load. The remainder of the collector field outlet flow is used to continue charging the storage tanks.

4.4.1.2 Startup Operation with Storage Charged

Startup of the SCS with the storage charged proceeds in the same manner as the case with the storage depleted; however, instead of activating the fossil fired heater, the HTS subsystem is placed on line to supply the PCS startup and operating energy. If the one hour storage tank is charged, it is the first tank to be discharged. This assures that the one hour tank will be empty when the approach to operating temperature mode is begun. If the one hour tank is discharged, the next partially discharged or fully charged large tank is placed on line to supply the steam generator.

After the collector field has reached its normal operating temperature, if the HTS subsystem is still close to full, the PCS is ramped up to full power to utilize energy faster and avoid storage excess.

4.4.1.3 Solar Power Operation

In the normal operating mode of the SCS, heated Syltherm™ 800 fluid from the collector field is supplied directly to the steam generator supply pump, then to the steam generator, and back to the field. Only flow from the collector field which is in excess of the PCS demands flows through one of the storage tanks to be charged. Thus, in this mode, the SCS supplies energy directly to the load, with excess energy being stored.

When the Syltherm 800 fluid flow from the collector field is less than the PCS demand, the additional required flow will be made up by discharging a charged storage tank. This additional flow is drawn from and returned to the discharging tank by the steam generator supply pump, which also serves as a booster pump to the direct flow from the collector field.

During evening operation or whenever sufficient solar insolation is unavailable, the demands of the PCS will be supplied by discharging the HTS subsystem until the storage is depleted.

4.4.1.4 Shutdown Operation

In normal operation, Solar Collection Subsystem shutdown occurs through the sequential shutdown of the collector field, the HTS discharge operation, and fossil heater shutdown. Collector field shutdown occurs when the field outlet temperature drops below the 658°K (725°F) minimum. The field pump stops, and the collectors reverse and move to the nightime stow position. Shutdown under these conditions always occurs with the collectors going to the fully stowed (nighttime) position.

HTS shutdown occurs when the supply outlet temperature from the last tank available for discharge drops below the 636°K (685°F) minimum steam generator delivery temperature or there is no longer a sufficient plant electrical demand to require turbine-generator operation. Typically, this condition will occur at the end of the second shift of the plant operating day. The fossil heater will shut down when there is no longer a sufficient plant electrical demand to require turbine-generator operation. The fossil heater and steam generator supply pump are shut down in conjunction with PCS shutdown. During shutdown of the SCS, an inert nitrogen gas cover will be maintained over the entire fluid loop, including HTS tanks, at the design pressure.

4.4.2 OFF-NORMAL OPERATION

Two major off-normal operational modes have been identified for the SCS. The first involves an emergency condition which arises as a result of loss of ac power or fluid flow while the collectors are tracking. If this condition occurs the collectors go into automatic defocus operation. Full stow can then safely be accomplished in a normal fashion under power provided by the Emergency Generator.

A second mode of off-normal operation occurs when the system collects and stores energy in the three large TES tanks without delivery to the steam generator. This condition typically occurs during weekends when the TES tanks are charged, and the PCS is not operating. In this operating mode, each tank is charged until breakthrough and sequential inter-tank transfer is performed to fully charge the total HTS subsystem. After fully charging the subsystem, collector field and HTS shutdown will occur normally as described in Section 4.4.1.4.

SECTION 5

SECTION 5

POWER CONVERSION SUBSYSTEM (PCS)

5.1 SCOPE

5.1.1 FUNCTION

The Power Conversion Subsystem uses the steam generated in the solar steam generator to drive the turbine-generator set. A portion of this steam is extracted at a mid-point in the turbine expansion to provide steam for process use in the Bleyle Plant. At the turbine discharge, steam flows to the condenser which provides the source of heat for the Thermal Utilization Subsystem. The turbine driven generator provides the electrical power required for the operation of the STES and the Bleyle Plant.

5.1.2 SUBSYSTEM CONFIGURATION

The Power Conversion Subsystem Piping and Instrumentation Diagram is shown in Figure 5.1.2-1 and 5.1.2-2. As can be seen from this diagram, the PCS has direct interface connections with various other subsystems. The steam generator serves as the boundary between the PCS and the Solar Collection Subsystem. The condenser forms the boundary between the PCS and the Thermal Utilization Subsystem. The turbine generator set links the PCS with the Electrical Subsystem, and the process steam lines of the PCS connect with the Bleyle Plant steam distribution system. The various input/output devices used throughout the PCS serve as the interface and communications link with the Control and Instrumentation Subsystem.

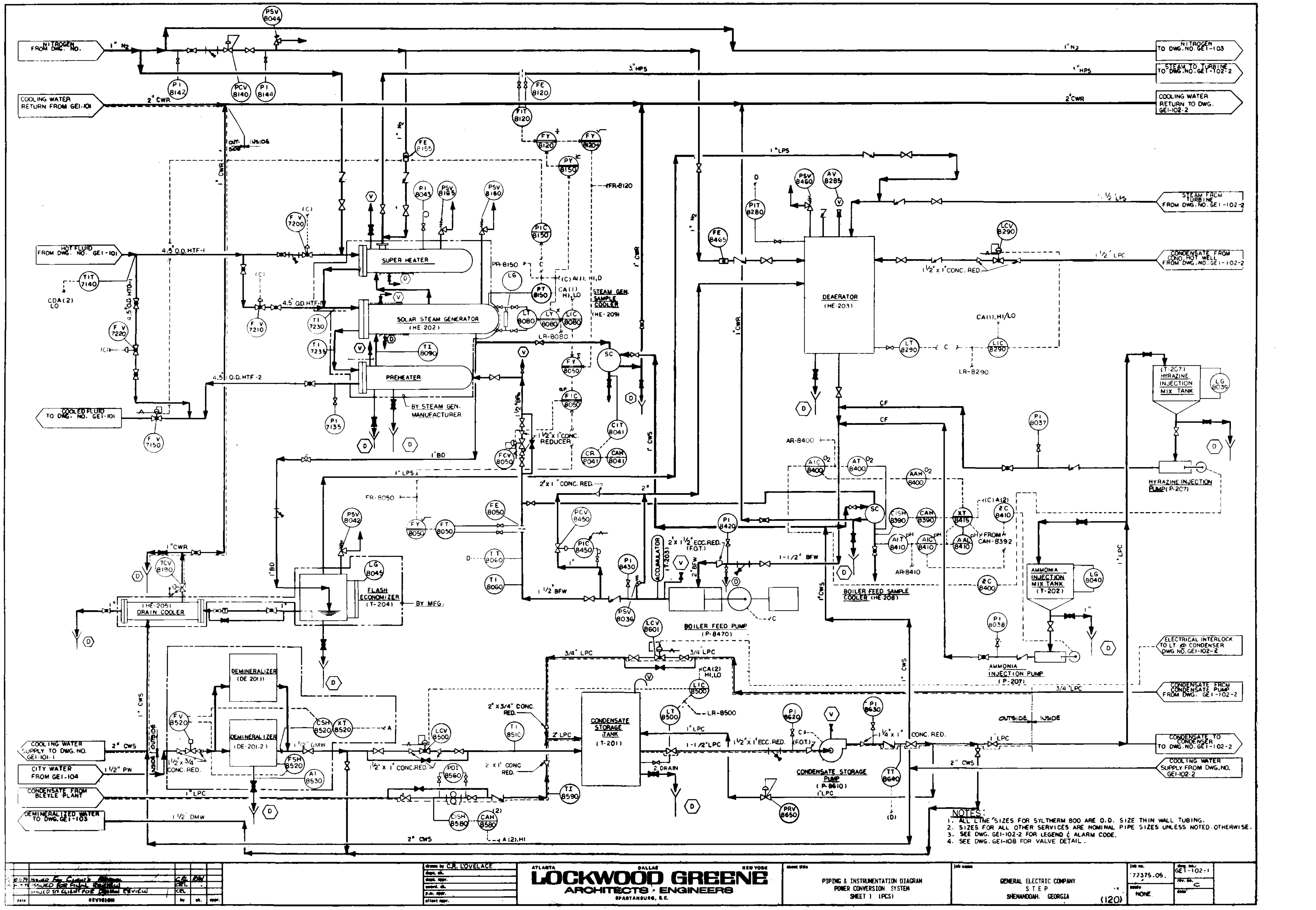


Figure 5.1.2-1. Piping & Instrumentation Diagram Power Conversion Subsystem

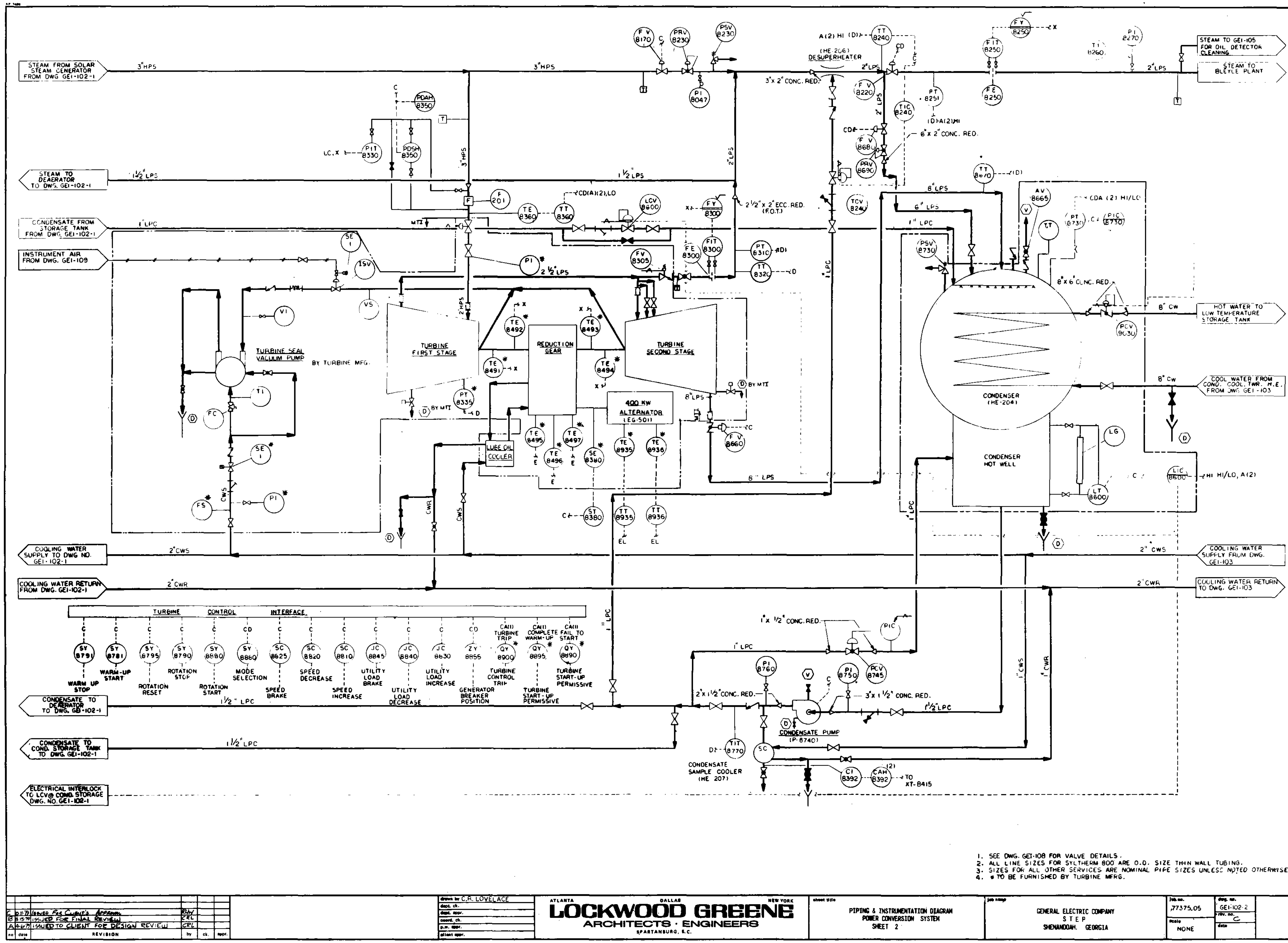


Figure 5.1.2-2. Power Conversion Subsystem P&ID

5.2 DESIGN CRITERIA

5.2.1 PERFORMANCE CRITERIA

5.2.1.1 PCS Steady State Performance Requirements

a) Electric Power Output:	
Range	100-400 kW
Voltage	480V ± 5%
Frequency	60 Hz ± 1/2%
b) Process Steam	
Flow Range	0-0.174 kg/s (0-1380 lbs/hr)
Pressure	$7.24 \times 10^5 N/m^2$ (105 psig) minimum at header to Bleyle Plant
c) Steam Condition at Turbine Inlet:	
Pressure	$4.83 \times 10^6 N/m^2 \pm 1.73 \times 10^5 N/m$ (700 psig ± 25 psi)
Temperature	$655^\circ K \begin{smallmatrix} +14^\circ K \\ -39^\circ K \end{smallmatrix}$ $(720^\circ F \begin{smallmatrix} +25^\circ F \\ -70^\circ F \end{smallmatrix})$
d) Maximum Thermal Input to Steam Generator:	
@ 400 kW & 0.17kg/s (1380 lbs/hr)*	2638 kW†
@ 300 kW & 0.17kg/s (1380 lbs/hr)*	2171 kW†
@ 200 kW & 0.17kg/s (1380 lbs/hr)*	1591 kW†
e) Heat Transfer Fluid Temperature in Steam Generator:	
Inlet Temperature	636-672° K (685° F-750° F)
Minimum Temperature Change	366° K (200° F)
f) Condenser:	
Condensing Pressure	$143,000 N/m^2 \pm 6895 N/m^2$ (20.78 psia ± 1 psi)
Coolant Inlet Temp	355-364° K (180-195° F)
Coolant Outlet Temp	372° K (210° F) minimum
g) Minimum Heat Delivered to Condenser Coolant:	
@ 400 kW & 0.174kg/s (1380 lbs/hr)*	1733 kW†
@ 300 kW & 0.174kg/s (1380 lbs/hr)*	1363 kW†
@ 200 kW & 0.174kg/s (1380 lbs/hr)*	893 kW†
h) Maximum PCS Parasitic Power	20 kW
i) Maximum PCS Heat Loss Chargeable to Input:	15 kW
j) Maximum PCS Heat Loss Chargeable to Output to TUS:	8 kW

*Process steam flow rate

†616° K(650° F) & $4.83 \times 10^6 N/m^2$ (700 psig)

5.2.1.2 PCS Transient Performance Requirements

a)	Maximum Step Increase in Alternator Load:	25 kW
b)	Maximum Rate of Ramp Increase in Alternator Load:	1.67 kW/sec (100 kW/min.)
c)	Maximum Step Increase in Process Steam Demand	0.126kg/sec (1000 lbs/hr)

5.2.2 SUBSYSTEM OPERATIONAL MODES

5.2.2.1 Interconnected Load Following

The PCS will provide electric power in the 100-400 kW range and extracted, desuperheated, process steam in the 0-0.174kg/sec (0-1380 lb/hr) flow range while operating in parallel with the utility and will be controlled to follow the plant load with a constant (±5kW averaged over 15 minutes) input to the plant from the utility. The utility constant input is normally 75 kW in the summer months, and 50 kW in the winter months.

5.2.2.2 Stand Alone Operation

The PCS will have a capability for supplying electric power in the 200-400 kW range and extracted, desuperheated, process steam in the 0-0.174kg/s (0-1380 lb/hr) flow range while operating unconnected from the utility once the STES has been started up. However there is no provision for startup of the STES independent of the utility. The PCS transient performance requirements, as described in Section 5.2.1.2, may not be complied with for T-G operation at outputs less than 200 kW.

5.2.2.3 Bypass Supply of Process Steam and Heat to TUS

The PCS will incorporate a provision for supply of process steam directly from the steam generator discharge to the inlet of the process steam pressure control valve.

The PCS will also provide for supply of throttled, desuperheated steam to the condenser directly from the steam generator discharge. Capacity capability for this operational mode will be in the range of 0-100% of the 0.174kg/s values specified in 5.2.1.1.

5.2.2.4 Daily Start-up/Shutdown

The PCS will have a capability of start-up from a cold condition to full operational status (per 5.2.2.1.1 or 5.2.2.1.2) within a period not to exceed 30 minutes following availability of heating fluid from the Solar Collection Subsystem. Heating fluid will be available at rated temperature at the beginning of the start-up period. Daily shutdown time for the PCS will not exceed 15 minutes.

5.2.2.5 Emergency Shutdown

The PCS will carry out an automatically controlled shutdown following contingency events including:

a) Loss of electrical load (steam supply is bypassed to Bleyle Plant process lines and/or condenser)

b) Component malfunctions detected by monitors (specific malfunctions and related monitors described below for specific components)

5.2.2.6 Backup Features for Minimization of Failure Effects

The PCS will incorporate backup components where necessary to assure reliability/availability goals. These will include:

a) Independent shaft driver and motor driven turbine generator lube pumps

b) Independent main governor and overspeed emergency governor

c) Redundant condensate water quality monitoring instrumentation

5.2.3 INTERFACE REQUIREMENTS

5.2.3.1 Interfacing Subsystem Constraints

5.2.3.1.1 Solar Collection Subsystem

The SCS supplies a flow of heating fluid to the PCS upon demand from the steam pressure control of the PCS. This flow, after being cooled by passage through the steam generator, is returned to the SCS. Instant availability of this flow, subject only to the time delay of the flow control, at a supply temperature within the limits of 5.2.1.1, is required.

5.2.3.1.2 Thermal Utilization Subsystem

The PCS is supplied with a flow of condenser cooling water from the TUS. The flow rate is controlled by the PCS condenser pressure control and is modulated as a function of turbine discharge flow and circulatory water inlet temperature. For maintenance of condenser pressure at the desired level of 143,000 N/M^2 (20.78 psia) the temperature of the circulatory water delivered to the PCS must be maintained in the range of 355 to 364°K (180°F-195°F).

5.2.3.1.3 Process Steam Supply Interface

Process steam at a controlled condition will be delivered to the plant at a rate governed by Bleyle steam press demands from the discharge of the desuperheating station. Process steam condensate to be returned to the PCS will be pumped into the condensate storage tank at a maximum temperature of 361^{o}K (190^{o}F).

5.2.3.1.4 Plant Service Requirements

The PCS will be provided with the following services for its operation:

a) Electric power 480v, 3Ø 60 Hz for PCS auxiliaries.

b) Clean raw water from the plant water supply for cycle make-up and demineralizer regeneration.

c) Filtered, oil free, compressed air for operation of pneumatic controls.

d) Dry nitrogen for extended shutdown overpressure on the steam generator and deaerator.

e) Waste drain for discharge of boiler blowdown and neutralized demineralizer discharges.

5.2.3.1.5 Plant Control Interface - Load Control

Output from a power transducer signalling base load power transferred from the utility to the plant will be required for the interconnected mode PCS load control.

5.2.4 MAINTENANCE AND RELIABILITY REQUIREMENTS

5.2.4.1 Subsystem Availability

The PCS will be designed to meet the following standards of availability.

a)	Forced outage rate	1% (of operating period)
b)	Forced outage hours/year (for maintenance)	45
c)	Planned outage hours/year weekday insolation period	0
	night/weekend	80

5.2.4.2 Routine Maintenance Operations

Routine maintenance operations for the PCS will include the following:

a) Check levels and fill in the chemical injection tanks, the make up demineralizer caustic and acid supply tanks, and the T-G and boiler feed pump lubricant reservoirs (req'd frequency as per vendor Operation and Maintenance Manual).

b) Conduct weekly analysis of water samples taken from condenser hot well, deaerator storage tank, condensate storage tank, and boiler drum.

c) Adjust/replace boiler feed pump packing (interval as per vendor Operation and Maintenance Manual).

d) Adjust/replace boiler feed pumps V belts (interval as per vendor Operation and Maintenance Manual).

e) Replace/clean main steam filter and replace condensate return filter.

5.2.4.3 Maintenance Accessibility

Adequate space will be provided for each component to facilitate independent installation/removal and for such disassembly operations as may be required for planned and contingency maintenance and repair.

5.2.5 TESTING AND INSPECTION REQUIREMENTS

5.2.5.1 Preoperational Testing

PCS/components preoperational testing will include:

a) Hydrostatic test of condensate/feedwater/main stream flow circuit with turbine valved off; check out of installed valves for leak tight integrity/actuation capability.

b) Hydrostatic test of condenser circulating water circuit

c) Turbine mechanical check out

d) Subsystem control valves checkout

e) Water sample analysis following cold flow condensate recirculation

5.2.5.2 Acceptance Testing

PCS/component acceptance tests will include the following.

a) Start up and operate PCS over load range in interconnected mode. Verify proper mechanical operation of all components. Measure thermal inputs and outputs at selected load points.

b) Subject PCS to step function and ramp function load changes and measure response rate and stability characteristics for both interconnected and stand alone operation.

c) Check out bypass steam supply operation of PCS.

d) Simulate contingencies and check out emergency shut down operation.

5.2.5.3 Periodic Performance Testing

Repeat (a), (b), (c), above at six month intervals.

5.2.5.4 Routine Inspections

The following inspections will be conducted on the PCS on a routine basis:

a) Conduct periodic inspections of major components per detailed procedures to be listed in component Operation and Maintenance Manuals.

b) Periodically (frequency TBD) check pressure drop/temperature at steam generator circuitry as check against deposit formation.

c) Periodically (frequency TBD) check out control elements.

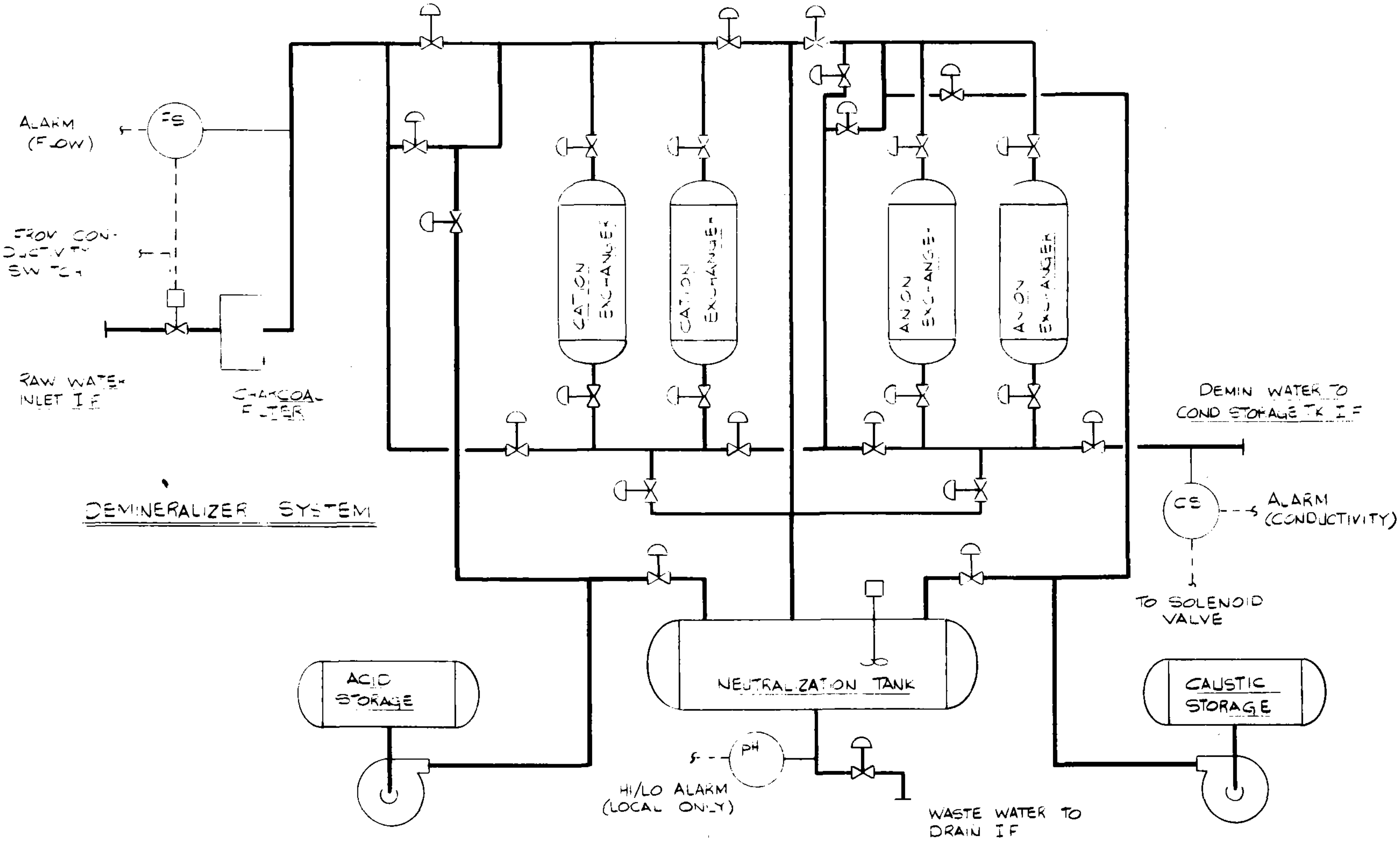
d) Periodically (frequency TBD) check out subsystem alarms.

e) Periodically (frequency TBD) check PCS piping connections for evidence of leaks.

5.3 DESIGN DESCRIPTION

5.3.1 DETAILED SUBSYSTEM DESCRIPTION

The flow circuitry of the Power Conversion Subsystem is illustrated by Figure 5.1.2-1 and 5.1.2-2 Detailed circuitry of the make-up demineralizer unit is indicated in Figure 5.3.1-1.



5.3.1-1. Demineralizer Unit Flow Circuit

Heat energy input to the PCS is supplied through a flow of liquid Syltherm^{TM} 800 at a maximum temperature of 672°K (750°F) from the Solar Collection Subsystem. This flow passes through the tube sides of the steam generator heat exchanger units in which superheated steam at 4.83×10^6 N/m^2 (700 psig), 655°K (720°F) is produced. The steam pressure is controlled by variation of the Syltherm^{TM} 800 flow rate. A small variation of superheat temperature (± 10°F) occurs over the full range of discharge steam flow. During normal operation, steam is admitted to the turbine through the control valves. Combined function stop valve/throttle valves are located upstream of the control valves for start-up/shutdown and emergency shutdown. The 708 rev/s (42480 rpm) turbine drives a 30 rev/s (1800 rpm) synchronous generator through a reduction gear. At a mid point in the turbine expansion, steam is extracted for process use and also for feedwater deaeration/heating. The extraction port pressure is maintained at or above the required process steam delivery pressure throughout the kW_e/ process steam load range. The extracted steam, which has a substantial superheat, is conditioned to the process requirement of 7.55×10^5 N/m^2 (110 psig), saturated, through controlled throttling and desuperheating by spray injection of condensate out of the condenser hot well. At the turbine, discharge steam flows to the condenser through a butterfly valve and a short make-up water preheating passage into which the make-up water from the condensate storage tank is sprayed. The major portion of the condenser thermal load is delivered to the Thermal Utilization Subsystem through a flow of circulating water. This flow is controlled so as to maintain a constant condenser pressure. The design provides for minimum hot well condensate subcooling in order to minimize heat input requirement. Hot well level is controlled by a level control valve in the make-up injection line. There is also a modulating valve through which condensate can be delivered to the condensate storage tank from the condensate pump discharge. The hot well storage capacity is sufficient for five minutes operation at full load. Make-up water needed to replace the process steam flow is admitted to the make-up demineralizer from the plant water supply at a rate controlled by the condensate storage tank level control.

From the condenser hot well, condensate is pumped by the condensate pump to the deaerator. The deaerator has a storage capacity sufficient for two and one half minutes of operation at full load. The deaerator incorporates a storage level control which regulates condensate in-flow. In the deaerator, entering condensate is mixed with extraction steam from the turbine, and the heated condensate leaves in a saturated condition at the deaerator pressure. From the deaerator the heated condensate passes to the boiler feed pump. Near the suction of this pump, hydrazine and ammonia are injected into the feed water by means of metering pumps from which flow is controlled in response to inputs from sensors of dissolved O_2 (hydrazine control) and pH (ammonia control). The boiler feedwater pump discharge pressure is controlled by a recirculation valve which maintains a constant pressure at the steam generator control valve inlet.

In order to implement the requirement for turbine bypass delivery of process steam and of steam to the condenser for use by the Thermal Utilization Subsystem, piping is provided from the steam generator discharge to the process steam pressure control valve and to the condenser, which also has its own pressure reduction valve. For extended bypass mode operation, the steam pressure set point is reduced to the process steam pressure level, and saturated steam is taken directly from the boiler. The turbine inlet and discharge valves are both closed.

The make-up demineralizer is a two tank unit preceded by a carbon filter. Acid is required for regeneration of the cation bed; caustic is required for the anion bed regeneration. Following regeneration, the tanks are rinsed with water, and the acid/caustic solutions are flushed through the neutralizing tank. Additional acid is added to lower the pH of the effluent to an acceptable level for discharge to the sewer.

Serious contamination from condenser circulating water leakage is prevented through the use of demineralized circulating water. Water purity is continuously monitored downstream of the feedwater pump (conductivity, dissolved O_2, and pH) at the make-up demineralizer discharge (conductivity), at the condenser discharge (conductivity), at the boiler blowdown (conductivity), and the steam condensate return (conductivity).

5.3.2 SUBSYSTEM PERFORMANCE CHARACTERISTICS

In Table 5.3.2-1, performance parameters of the Power Conversion Subsystem are tabulated for ranges of gross electric power output and turbine inlet temperature. Design pressures, temperatures, and flow rates for the PCS are shown in Figure 5.3.2-1, the Process Flow Diagram for the PCS.

5.3.3 MAJOR COMPONENTS

The major components of the power conversion subsystems include the following:

a) Steam Generator (or Boiler)
b) Turbine-Generator
c) Condenser
d) Makeup Demineralizer
e) Condensate Pump
f) Deaerating Heater
g) Boiler Feed Pump
h) Condensate Tank
i) Condensate Storage Pump

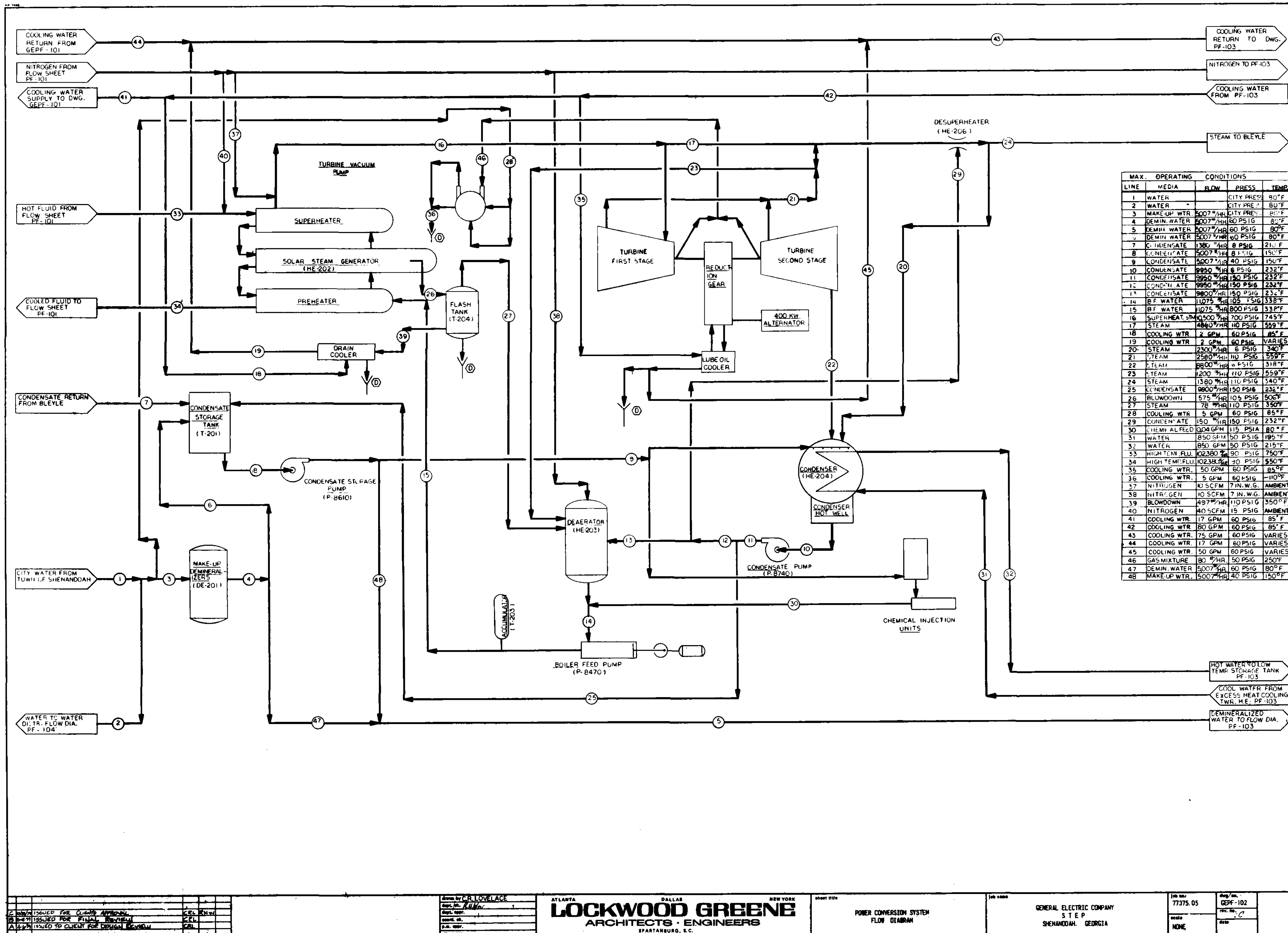
5.3.3.1 Steam Generator

5.3.3.1.1 Design Criteria

a) Sizing Criteria

TABLE 5.3.2-1. POWER CONVERSION SUBSYSTEM PERFORMANCE TABULATION

	(MTI turbine generator)								
Thermal Input kW	2628	2110	1544	2629	2143	1569	2638	2171	1591
Electric Output kW	400	300	200	397	300	200	391	300	200
Process Steam Flow #/hr	1380	1380	1380	1380	1380	1380	1380	1380	1380
Heat Delivered to Condenser Coolant kW	1713	1302	846	1718	1336	871	1733	1363	893
Throttle Pressure psig	700	700	700	700	700	700	700	700	700
Throttle Temp °F	720	720	720	680	680	680	650	650	650
P extr. psig	110	110	110	110	110	110	110	110	110
H in Btu/#	1356	1356	1356	1333	1333	1333	1313	1313	1313
H extr Btu/#	1244	1248	1253	1225	1228	1233	1209	1212	1217
UEEP Btu/#	1152	1158	1164	1135	1143	1149	1122	1129	1135
T cond °F	230	230	230	230	230	230	230	230	230
Throttle Flow #/hr	8591	6897	5049	8789	7165	5245	8995	7402	5423
Extr. Flow to Process #/hr	1308	1304	1298	1333	1329	1323	1354	1350	1343
Extr. Flow to D/A #/hr	936	749	546	976	793	578	1014	832	607
Condenser Flow #/hr	6347	4844	3205	6480	5043	3344	6627	5220	3473



MAX. OPERATING CONDITIONS				
LINE	MEDIA	FLOW	PRESS	TEMP.
1	WATER		CITY PRESS	80°F
2	WATER		CITY PRESS	80°F
3	MAKE-UP WTR.	5007 #/HR	CITY PRESS	80°F
4	DEMIN. WATER	5007 #/HR	60 PSIG	80°F
5	DEMIN WATER	5007 #/HR	60 PSIG	80°F
6	DEMIN WATER	5007 #/HR	60 PSIG	80°F
7	CONDENSATE	1380 #/HR	8 PSIG	210°F
8	CONDENSATE	5007 #/HR	8 PSIG	150°F
9	CONDENSATE	5007 #/HR	40 PSIG	150°F
10	CONDENSATE	9950 #/HR	6 PSIG	232°F
11	CONDENSATE	9950 #/HR	150 PSIG	232°F
12	CONDENSATE	9950 #/HR	150 PSIG	232°F
13	CONDENSATE	9800 #/HR	150 PSIG	232°F
14	B.F. WATER	11075 #/HR	105 PSIG	338°F
15	B.F. WATER	11075 #/HR	800 PSIG	338°F
16	SUPERHEAT. STM	10500 #/HR	700 PSIG	745°F
17	STEAM	4860 #/HR	110 PSIG	559°F
18	COOLING WTR.	2 GPM	60 PSIG	85°F
19	COOLING WTR	2 GPM	60 PSIG	VARIES
20	STEAM	2300 #/HR	6 PSIG	340°F
21	STEAM	2580 #/HR	110 PSIG	559°F
22	STEAM	8800 #/HR	6 PSIG	318°F
23	STEAM	1200 #/HR	110 PSIG	559°F
24	STEAM	1380 #/HR	110 PSIG	340°F
25	CONDENSATE	9800 #/HR	150 PSIG	232°F
26	BLOWDOWN	575 #/HR	105 PSIG	506°F
27	STEAM	78 #/HR	110 PSIG	350°F
28	COOLING WTR	5 GPM	60 PSIG	85°F
29	CONDENSATE	150 #/HR	150 PSIG	232°F
30	CHEMICAL FEED	0.04 GPH	115 PSIA	80°F
31	WATER	850 GPM	50 PSIG	195°F
32	WATER	850 GPM	50 PSIG	215°F
33	HIGH TEMP. FLU.	102380 #/HR	90 PSIG	750°F
34	HIGH TEMP. FLU.	102380 #/HR	90 PSIG	550°F
35	COOLING WTR.	50 GPM	60 PSIG	85°F
36	COOLING WTR.	5 GPM	60 PSIG	~110°F
37	NITROGEN	10 SCFM	7 IN. W.G.	AMBIENT
38	NITROGEN	10 SCFM	7 IN. W.G.	AMBIENT
39	BLOWDOWN	497 #/HR	110 PSIG	350°F
40	NITROGEN	40 SCFM	15 PSIG	AMBIENT
41	COOLING WTR.	17 GPM	60 PSIG	85°F
42	COOLING WTR.	80 GPM	60 PSIG	85°F
43	COOLING WTR.	75 GPM	60 PSIG	VARIES
44	COOLING WTR.	17 GPM	60 PSIG	VARIES
45	COOLING WTR.	50 GPM	60 PSIG	VARIES
46	GAS MIXTURE	80 #/HR.	50 PSIG	250°F
47	DEMIN. WATER	5007 #/HR.	60 PSIG	80°F
48	MAKE-UP WTR.	5007 #/HR	40 PSIG	150°F

Figure 5.3.2-1. Process Flow Diagram Power Conversion System

The steam generator is sized to deliver the maximum load steam flow rate indicated in Table 5.3.2-1 above at 655°K (720°F), 4.83×10^6 N/m^2 (700 psig) steam outlet conditions. Feedwater inlet enthalphy is 8.55×10^5 J/kg (368 Btu/lb) at full load. The Syltherm 800 inlet temperature is 672°K (750°F), and the flow rate is 12.3 kg/s (97,200 lb/Hr). The skid mounted steam generator unit incorporates three heat exchangers: a counterflow preheater, a drum type pool boiler, and a counterflow superheater. These are enclosed in separate shells.

b) Material Compatibility

Material for the Syltherm 800 containment tubing and for the heat exchanger pressure vessels is carbon steel. This material is compatible with Syltherm 800 and is also well proven in steam generator service at the required pressure/temperature conditions.

c) Maintenance and Testing Requirements

The steam generator will be designed for 20 years life without maintenance subject to the requirement that feedwater and Syltherm 800 purity requirements are met. The component will be subjected to a hydrostatic test of the tube side and shell side leak tight integrity-prior to installation and at intervals of approximately 1 year. In all of the steam generator heat exchangers, the tubes can be removed for external (water side) cleaning if this should become necessary.

d) Operational Limitations

The principal operational limitation of the steam generator is that the blowdown water flow rate must be sufficient to meet maximum dissolved solid limits for the boiler water. In particular, the steam total solids carryover must be limited to 1 ppm.

5.3.3.1.2 Design Description

The steam generator is a skid mounted assemblage of three heat exchangers: a counter-flow preheater, a drum type pool boiler with immersed heater tubes, and a counterflow superheater. The Syltherm^{TM}800 flow is on the tube side in all heat exchangers. Feed-water is admitted to the preheater through a control valve which operates to maintain the boiler drum level. The preheater discharges water into the boiler drum. Immersed in this drum are Syltherm^{TM}800 tubes which enter and leave at one end. Saturated steam leaves the drum and passes to the superheater from which it flows to the turbine. Approximate dimensions of the heat exchanger shells are: preheater, 0.30 m. dia x 3.66 m. long (1 ft. dia. x 12 ft. long); boiler, 0.61 m. dia x 4.57 m. long (2 ft. dia. x 15 ft. long); superheater, 0.30 m. dia. x 3.05 m. long (1 ft. dia x 10 ft. long).

Water is continually bled from the boiler drum through a blowdown valve from which it is passed to a flash tank operating at deaerator pressure. Steam formed in the flash tank is passed to the deaerator, and the water is passed through a trap to a second (atmospheric pressure) flash tank is which both water and steam are cooled and condensed to a maximum temperature of 300°K (80°F) by a controlled flow of cooling water for discharge to the sewer.

5.3.3.2 Turbine-Generator

5.3.3.2.1 Design Criteria

a) The steam turbine generator flow/head capacity is selected to meet the maximum throttle flow and inlet/exit steam pressure/temperature conditions indicated in Table 5.2.3-1. Because of the importance of power conversion efficiency to the STES, a high speed 708 rev/sec (42,480 rpm) multistage geared turbine generator unit is employed. The turbine-generator is designed to comply with both steady-state and transient performance requirements, as listed in Section 5.2.1.1 and 5.2.1.2, respectively. However, due to rotor inertial restraints, the T-G may not comply with the transient requirements when operating under 200 KW. Should frequency or voltage deviations occur which could be determental to Bleyle plant operation, provisions within the GPC switchgear will remove the T-G from the line.

b) Material Compatibility

The four turbine wheels are made of 17-4 Ph stainless steel which is compatible with the contaminates in the condensate flow circuit. The turbine casing is also stainless steel and may be subjected to air during shutdown without concern of corrosion.

c) Electrical Requirements

Three phase, 480 V, 60 Hz power is required for the auxiliary lube pump, the seal vacuum pump and for controls.

d) Maintenance and Testing Requirements

The turbine-generator is a high-speed high-efficiency unit developed by Mechanical Technology Inc. (MTI) for the Shenandoah Project and provided as GFE. As such, major maintenance requirements will be as defined in the manufacturer's Operation and Maintenance Manual, and maintenance performed under the supervision of a manufacturer's and/or DOE appointed representative. Routine maintenance is also as described in the Operation and Maintenance Manual; typical operations are as follows:

1) Lubricate external pivots of governor system. Replenish grease in lever systems bearings (once per month).
2) Check oil level in hydraulic system (once per month).
3) Check out overspeed trip (once per month). Once per week lubricate outside moving parts of trip throttle valve and control valves.
4) Test oil neutralization number, flash point, viscosity etc. (every six months).
5) Maintain oil levels.
6) Check temperature drop through oil cooler. Clean cooler when necessary.

5.3.3.2.2 Design Description

The turbine-generator unit consists of two high speed axial flow turbines coupled through reduction gearing to a 30 rev/s (1800 rpm) synchronous alternator. An extraction port is provided at an interstage point in the turbine for removal of steam for process use and for supply to a deaerating feedwater heater. The pressure level at this port is above the required process steam pressure level of $7.55 \times 10^5 N/m^2$ (110 psig) throughout the operating range of 100-400 kW electrical load.

Construction features of the turbine include the following:

a) Upstream stop/throttle and modulating valve
b) First stage 180° arc partial admission, three admission arcs, on/off valve control
c) Third stage 360° arc admission, three admission arcs, modulating valve control
d) Pressure compounded stages
e) Speed/load control system which provides synchronized and independent operation, and automatic extraction.
f) Remote automatic start/stop interface with local contrd panel, local safeguards/annunciaturs including emergency overspeed trip
g) Two stage reduction gearbox
h) Mounting skid complete with self-contained lube oil system
i) Vacuum steam seal subsystem

5.3.3.3 Condenser

5.3.3.3.1 Design Criteria

a) Sizing Criteria

The condenser is sized to transfer the maximum thermal load to the TUS which is $8.87 \times 10^6 J$ (8.4×10^6 BTU), corresponding to 400 kW T-G operation with no process steam. This thermal duty is carried out by the condenser heat exchanger tubes. For this duty the maximum condenser coolant inlet temperature is 36°K (195°F), and the minimum coolant discharge temperature is 375°K (215°F). The maximum condensing pressure is 41,300N/m^2 (6 psig). In addition to the heat transferred to the TUS, heat is also absorbed by a make-up heating spray injected into the neck section of the condenser immediately downstream of the turbine outlet valve. The flow rate of this spray is nominally equal to the process steam flow which is returned as make up from the condensate storage tank. The hot well of the condenser is sized to provide a condensate storage volume for five minutes operation at full power/process steam load.

b) Material Compatibility

The condenser tubes and water boxes will be fabricated from 304 stainless steel. The shell and tube sheets are carbon steel.

c) Electrical Requirements

Single phase, 120 V, 60 Hz AC and 24 VDC is available for controls

d) Maintenance and Testing Requirements

The condenser will be designed for 20 years life. The unit will be subjected to a hydrostatic test of the shell and of the tubes prior to installation, and the tube leak tight integrity will be checked at intervals of not less than six months. Tube leaks will be repaired as required. Controls for main coolant flow will be calibrated over the power/process steam load range. Hot well level controls will also be calibrated. These calibrations will be performed during initial checkout running of the unit and periodically at intervals of not less than six months. At the same time, the unit thermal performance will be checked against minimum requirements.

5.3.3.3.2 Design Description

The condenser unit comprises a two pass heat exchanger contained in an approximately 0.61 meter (two foot) diameter cylindrical shell. Water coolant tubes extend approximately 4.88 meters (16 feet) between tube sheets, supported by two intermediate support plates. Tubes are expanded into the tube sheets and are slightly bowed upward for drainage and accommodation of differential expansion between the shell and the tubes. Dished heads enclose water boxes at both ends of the shell. The condenser is joined to the turbine discharge valve flange through a make up inlet spray passage discharging into the shell at an upper location. A bellows joint is employed at the turbine discharge valve connection. The shell is suspended from the turbine skid. Opposite the desuperheating passage at the bottom of the shell is the hot well. At each side of the shell near the bottom, a small group of tubes is shrouded from the main steam flow in order to subcool uncondensed vapor containing concentrated air which is vented from the shell. Air vents guarded by thermostatic valves are located at each side of the shell.

The hot well level is controlled during normal operation by variation of the rate of make-up water injection. For reduction of PCS water inventory during startup and establishment of normal steam generator operation, condensate is pumped back to the condensate tank.

5.3.3.4 <u>Make Up Demineralizer</u>

5.3.3.4.1 Design Criteria

a) Sizing Criteria

The make-up demineralizer is sized to meet the water inlet/discharge quality requirements shown in Table 5.3.3-1 with a minimum operating time at the flow rate of $6.3x10^{-4} m^3/sec$ (10 GPM) for 24 hours. Maximum temperature of the raw water supplied to the unit is 300°K (80°F).

TABLE 5.3.3-1. INLET/DISCHARGE WATER QUALITY SPECIFICATIONS FOR MAKE UP DEMINERALIZER

Water Chemistry Constituent	Raw Make up Water	Demineralizer Discharge Water
Total Solids	200	1
Silica as SiO_2	12	0.3
Total Hardness	48	0
Iron (Fe^{++})	1	0.16
Sodium (Na^{+})	6	0.03
Calcium (Ca^{++})	17	0
Magnesium (Mg^{++})	2	0
Potassium (K^{+})	3	0.001
Carbonate ($CO_3^{=}$)	15	0
Bicarbonate (HCO_3^{-})	12	0
Sulfate ($SO_4^{=}$)	14	0'
Nitrate (NO^{-}_3)	0.2	0
Chloride (C1)	7	0.03
pH	9.0	9.2

b) Material Compatibility

Demineralizer tanks will be coated with PVC, with the exception of the concentrated acid and caustic tanks which will be unlined carbon steel. All piping, fittings, and other containing surfaces will be PVC lined.

c) Electrical Requirements

Single phase, 120 V, 60 Hz AC power is required for electrical pumps and controls.

d) Maintenance and Testing Requirements

The make up demineralizer is designed for semi-automatically sequenced resin regeneration initiated by a manual signal. Water discharge quality is continuously monitored. At intervals of two days during night shutdown, this will be required. Caustic and acid tanks must be kept full. Resin replacement will be required approximately once per year. Acceptance testing of the make-up demineralizer will be carried out during plant check out operation.

5.3.3.4.2 Design Description

The make-up demineralizer is a skid mounted unit including cation and anion resin tanks, caustic and acid regeneration tanks with pumps, and a neutralizing tank. An activated carbon inlet filter is also included to insure uniform discharge water quality under non constant flow.

5.3.3.5 Condensate Pump

5.3.3.5.1 Design Criteria

a) Sizing Criteria

The condensate pump is sized to handle the maximum flow rate requirements of $12.6x10^{-4} m^3/sec$ (20 GPM). The pump discharge pressure is $1.21x10^6 N/m^2$ (176 psia) at this flow. The minimum NPSH requirement is 1.1 m(3 Ft), and the maximum condensate temperature 384°K (232°F).

b) Material Compatibility

The condensate pump casing is cast iron, and the impeller bronze. These are compatible with the condensate water chemistry at this temperature.

c) Electrical Requirements

Three phase, 480 V, 60 Hz AC power is provided to meet the 4.75 kW pump drive motor requirement.

d) Maintenance and Testing Requirements

The pump is designed for long term continuous service. Bearings are grease packed and require only an annual lubricant replenishment. Seal replecement will not be required at less than five year intervals.

At initial plant check out, the pump will be tested for flow/head/power characteristics. A semiannual check will be made for seal packing leakage.

5.3.3.5.2 Design Description

The condensate pump is a regenerative (turbine) type pump. This pump receives flow from the condenser hot well and discharges to the deaerator and to the process steam desuperheater. There is also a discharge connection to the condensate storage tank. Discharge pressure is controlled by a pressure relief valve through which water recirculates to the hot well. The pump is directly driven by a 29.2 rev/sec (1750 rpm) induction motor.

5.3.3.6 Deaerating Heater

5.3.3.6.1 Design Criteria

a) Sizing Criteria

The deaerating heater is sized for a maximum condensate flow rate of 1.24 kg/s (9800 #/hr). The full load pressure level is $.72 \times 10^6$ (105 psig) with a heating steam flow of 0.151kg/s (1200 #/hr) at an enthalpy of 2.9×10^6 J/kg (1250 Btu/#). The feedwater storage capacity is .188 m^3 (50 gallons) minimum which will supply the steam generator for two and one half minutes at full load.

b) Material Compatibility

The deaerating heater with shell and internal parts, including trays, will be stainless steel. The outer shell is carbon steel.

c) Maintenance and Testing Requirements

The deaerator will be hydrostatically tested prior to initial system start-up for leak tight integrity of the shell, steam and condensate piping, and vent condenser circuit. This test will be repeated during normal shutdown periods at six month intervals. Free actuation of the level control valve and operating mechanism will be periodically checked.

5.3.3.6.2 Design Description

The deaerator is an open feedwater heater in which condensate is spread in thin sheets over successive layers of air separating trays where it is raised to saturation temperature through contact with injected steam. In this process the steam is desuperheated and condensed, adding to the quantity of saturated deareated water which is delivered to the storage volume in the lower part of the shell. Residual steam and entrained air are passed from the shell to the vent condenser which is cooled by the incoming condensate before being vented to the atmosphere.

5.3.3.7 Condensate Storage Tank

5.3.3.7.1 Design Criteria

a) Sizing Criteria

The condensate storage tank is sized for 15.14m^3 (4000 Gal), which is sufficient capacity to provide the design PCS make-up rate for 16 hour day.

b) Material Compatibility

The condensate storage tank will be fabricated from carbon steel, ASTM A-285 GR C, which is compatible with condensate/make-up water chemistry at the operating temperature of 328°K (130°F).

c) Maintenance and Testing

The tank will be hydrostatically tested according to the ASME Boiler and Pressure Code, Section VIII. Free actuation of the level control valve and operating mechanism will be periodically checked.

5.3.3.7.2 Design Description

The condensate storage tank is a vertical, shop-built, atmospheric tank which will be used to store steam condensate and demineralized make-up in an outdoor environment.

5.3.3.8 Condensate Storage Pump

5.3.3.8.1 Design Criteria

a) Sizing Criteria

The condensate storage pump is sized to provide 5.7×10^{-4} m^3/s (9 GPM) at $4 \times 10^5 N/m^2$ (58 psia), assuming a minimum of 6m (20 ft) of NPSH available. This flow is adequate to provide design PCS and TUS make-up requirements.

b) Material Compatibility

The pump casing will be cast iron, and the impeller bronze, these materials are selected for compatibility with the condensate at the 328°K (130°F) operating temperature.

c) Electrical Requirements

Three phase 480 V, 60 Hz AC power is provided the meet the .5 kW motor requirements.

d) Maintenance and Testing Requirements

The pump is designed for long term 16 hour per day duty. At yearly intervals the mechanical seal will be checked/adjusted as is required.

5.3.3.8.2 Design Description

The condensate storage pump is a close-coupled, turbine-type pump. The pump is provided with a pressure relief valve and recirculation loop to the condensate storage tank to allow continued operation under all flow conditions.

5.5.3.9 Boiler Feed Pump

5.3.3.9.1 Design Criteria

a) Sizing Criteria

The boiler feed pump is a triplex pump with a flow/head capacity of 1.4kg/s (11075 lb/hr) at $5.96 \times 10^6 N/m^2$ (865 psia). NPSH is available is 3.05 m (10 ft.) minimum.

b) Material Compatibility

Operating plungers, and the cylinder block are forged chrome steel, while the valves will be fabricated from stainless steel.

c) Electrical Requirements

The boiler feed pump is belt driven by an induction motor requiring 3 phase, 60 Hz AC power at 480 volts.

d) Maintenance and Testing Requirements

The pump is designed for long term 16 hour per day duty. Lubricant is sealed in and requires only a level check at six month intervals. At yearly intervals the plunger packing will require a sealing check and possible adjustment. Packing should be replaced annually.

At initial plant check out, the pump will be tested for flow/head/power performance over the required flow range. A check will be made for packing leakage.

5.3.3.9.2 Design Description

The boiler feed pump is a three cylinder, horizontal plunger pump driven from a crankshaft through a connecting rod-cross head mechanism. Main bearings at the ends of the crankshaft are tapered roller type. Valves are mounted in replaceable bushings. The plungers are externally sealed with packing. The pump is driven at 6.67 rev/s (400 rpm) through a V belt drive from an 29.2 rev/s (1750 rpm) induction motor.

5.3.4 CONTROL AND INSTRUMENTATION

5.3.4.1 Design Criteria

a) Control functions required by the Power Conversion Subsystem include the following:

1) Turbine load control - this is an automatic, multi-loop, centralized control
2) Steam Generator pressure/level control - this is local automatic control
3) Condenser pressure/level control - this is a local automatic control
4) Process steam temperature control - this is a local automatic control
5) Level controls for condenser hot well, condensate storage tank, deaerator storage volume
6) Chemical injection control - this is a local automatic control
7) Sequencing of special operations: bypass supply of process steam/heat, subsystem start-up, subsystem shutdown, and demineralizer regeneration. These are automatic controls or manually initiated automatic sequencing controls

b) The following parameters will be continuously monitored, either locally or remotely:

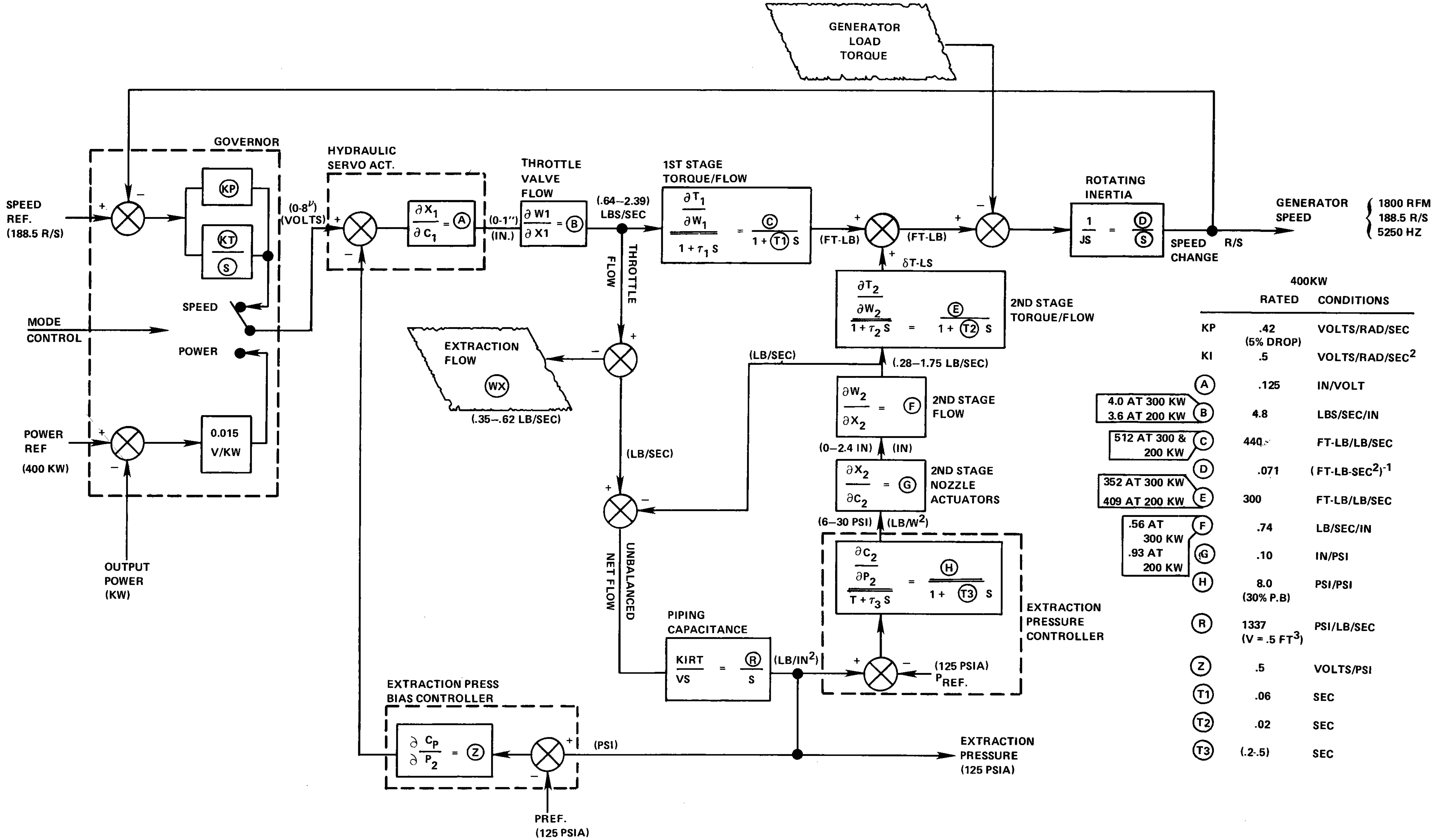
- Steam throttle temperature
- Steam throttle pressure
- Alternator output power
- Alternator voltage and frequency
- Turbine shell pressure downstream of extraction port
- S800 temp at steam generator inlet
- Condenser pressure
- Water quality
  - Feedwater
    - conductivity
    - O_2
    - Ph
  - Condensate
    - conductivity
- Make up demineralizer discharge
  - Conductivity
- Blowdown
  - Conductivity
- Steam Condensate
  - Conductivity
- Turbine rotor vibration level
- Lubricant temperature

5.3.4.2 Control Description

5.3.4.2.1 Turbine Control

A block diagram of the Turbine speed/load control is shown in Figure 5.3.4-1. As indicated by these diagrams, the turbine load is controlled by regulation of the utility load to a constant value for interconnected operation, and for independent operation, the speed is regulated to a constant value as load varies. In addition to the operational controls described by the block diagram, the turbine is subject to trip-out controls initiated by contingency events:

a) loss of electrical load



		400KW RATED	CONDITIONS
KP		.42 (5% DROP)	VOLTS/RAD/SEC
KI		.5	VOLTS/RAD/SEC^2
(A)		.125	IN/VOLT
(B)	4.0 AT 300 KW; 3.6 AT 200 KW	4.8	LBS/SEC/IN
(C)	512 AT 300 & 200 KW	440	FT-LB/LB/SEC
(D)		.071	(FT-LB-SEC^2)$^{-1}$
(E)	352 AT 300 KW; 409 AT 200 KW	300	FT-LB/LB/SEC
(F)	.56 AT 300 KW	.74	LB/SEC/IN
(G)	.93 AT 200 KW	.10	IN/PSI
(H)		8.0 (30% P.B)	PSI/PSI
(R)		1337 (V = .5 FT^3)	PSI/LB/SEC
(Z)		.5	VOLTS/PSI
(T1)		.06	SEC
(T2)		.02	SEC
(T3)		(.2-.5)	SEC

Figure 5.3.4-1. Turbine-Generator Speed/Load Governor Control (For Both Interconnected and Independent Operation)

b) Subsystem or T-G internal equipment malfunctions as indicated by out of limit signals from monitored parameters.

c) Subsystem external (SGS, TUS, instrument air, cooling water, etc.) failures

5.3.4.2.2 Control Actuators:

Provision for control equipment test and check out.

5.3.4.3 Devices

Instrumentation required for the Power Conversion Subsystem is summarized in Table 5.3.4-1.

5.3.4.4 Alarms

Alarms are to occur whenever parameters in Table 5.3.4-1 are out of limits by amounts specified for the individual parameters.

5.4 SUBSYSTEM OPERATION

5.4.1 NORMAL OPERATION

Normal operation of the STES includes both the interconnected and independent operating modes. During normal operation, Syltherm^{TM} 800 and feedwater from the boiler feed pump are supplied to the steam generator from which superheated steam flows to the turbine at $4.83 \times 10^6 N/m^2$ and 655°K (700 psig/720°F). Steam is extracted from the turbine at an interstage port. A portion of the extraction steam flows to the deaerating heater, and another portion flows to the desuperheating station from which process steam is supplied to the plant at a $7.24 \times 10^5 N/m^2$ (105 psig) saturation condition.

TABLE 5.3.4-1. PCS INSTRUMENTATION SET POINTS

Variable to be Measured	Location	Range	Set Point
Steam Temp	Steam generator Disch.	100-800°F	720°F
Steam Pressure	Steam generator Disch	25-750 psi	700 psig
S-800 Temp	Steam generator Outlet	100-800°F	750°F
Steam Temp	Process steam delivery header	100-500°F	340°F
Steam Pressure	Process steam delivery header	50-150 psi	105 psig
Steam Pressure	Condenser	1-25 psi	6 psig
Steam Pressure	1st stg. shell	500-750 psig	NA
Circulating water temp	Condenser inlet	100°F-250°F	190°F
Circulating water temp	Condenser disch	100°F-250°F	210°F
Condensate Conductivity	Make up device outlet	.01 to .1 umas/cm	.05
Condensate conductivity	Unit pump disch	.01 to .1 umas/cm	.05
Condensate conductivity	BFP disch	.01 to .1 umas/cm	.05
Dissolved O_2 Conc.	BFD disch	.001-1ppm	.005ppm
Condensate ph	BFP disch	7.0-10	9.5
Alternate or Frequency		59-61 Hz	60Hz
Alternate or Voltage		470-490V	480V

Desuperheating water is supplied from the condensate pump discharge. The turbine exhausts to the condenser which operates at a pressure of 1.43×10^5 N/m^2 (20.8 psia). Demineralized make-up water at 300°K (80°F) is sprayed into the neck section of the condenser at a rate controlled by the hot well liquid level. Condenser pressure is controlled by the circulating water flow rate. The make-up demineralizer receives raw water from the plant water supply and delivers demineralized water to the condensate storage tank at a rate controlled by the level in this tank. From the condenser hot well, condensate is pumped to the deaerator. The deaerator incorporates a storage tank and a level control which governs the rate of flow into the unit. Air removal from the condensate is expelled from the deaerator vent condenser.

From the deaerator, condensate is pumped to the steam generator by the boiler feed pump. Hydrazine and ammonia are injected by a proportioning pump into the boiler feed pump suction flow. Hydrazine injection is controlled in response to a dissolved oxygen analyzer and ammonia injection regulated in response to a pH meter.

5.4.2 OFF-NORMAL OPERATION

Off normal operation of the PCS includes turbine bypass operation, start-up, and shutdown.

5.4.2.1 Turbine Bypass Operation

The STES may be operated in the turbine bypass mode. The turbine stop valve and the turbine discharge butterfly valves are closed. The steam generator is operated at a reduced pressure setting, and saturated steam is taken directly from the boiler without superheat.

In this mode steam is passed through the turbine bypass line to the process steam supply line and/or to the condenser. For the turbine bypass operating mode, steam is also supplied to the deaerator.

5.4.2.2 Start-up Operation

Start-up of the Power Conversion Subsystem involves numerous sequential operations. First, with the turbine stop valve and discharge butterfly valve closed, the boiler drum, deaerator storage, and hot well storage are brought to operating levels. A flow of Syltherm 800 is initiated through the steam generator. When the set point pressure is reached, the turbine discharge valve is opened. The stop/throttle valves are opened, the turbine is rolled, and accelerated to full speed. The automatic synchronizer then closes the generator breaker, and the generator load is ramped to the desired power level.

5.4.2.3 Shutdown

Shutdown operations begin with ramping down the turbine-generator load and termination of heat supply to the steam generator. The turbine-generator is then shutdown (tripped), and PCS pumps deactivated to put the system into normal (nightly) shutdown. For extended shutdown, N_2 is provided to the steam generator and deaerator when the steam pressure in these vessels drops to atmospheric to prevent oxygen contamination.

SECTION 6

SECTION 6

THERMAL UTILIZATION SUBSYSTEM (TUS)

6.1 SCOPE

6.1.1 FUNCTION

The Thermal Utilization Subsystem serves as the condensing medium for the steam condenser and the heat source for the heating and cooling of the Bleyle Plant and the Mechanical Building. The exhaust heat from the steam turbine provides the heat input to the TUS. When the turbine is out of service, steam will be provided directly to the condenser. A low temperature storage (LTS) tank is included in the TUS for the storage of thermal energy, and any excess energy is dissipated through a cooling tower. Chilled and heated water are pumped to the Bleyle Plant and the Mechanical Building for cooling and heating purposes.

6.1.2 SUBSYSTEM CONFIGURATION

The Thermal Utilization Subsystem Piping and Instrumentation Drawing (P&ID) is shown in Figure 6.1.2-1. The steam condenser acts as the boundary between the TUS and the Power Conversion Subsystem. The chilled and heated water lines of the TUS connect with the HVAC distribution system in the Bleyle Plant and the Mechanical Building.

6.2 DESIGN CRITERIA

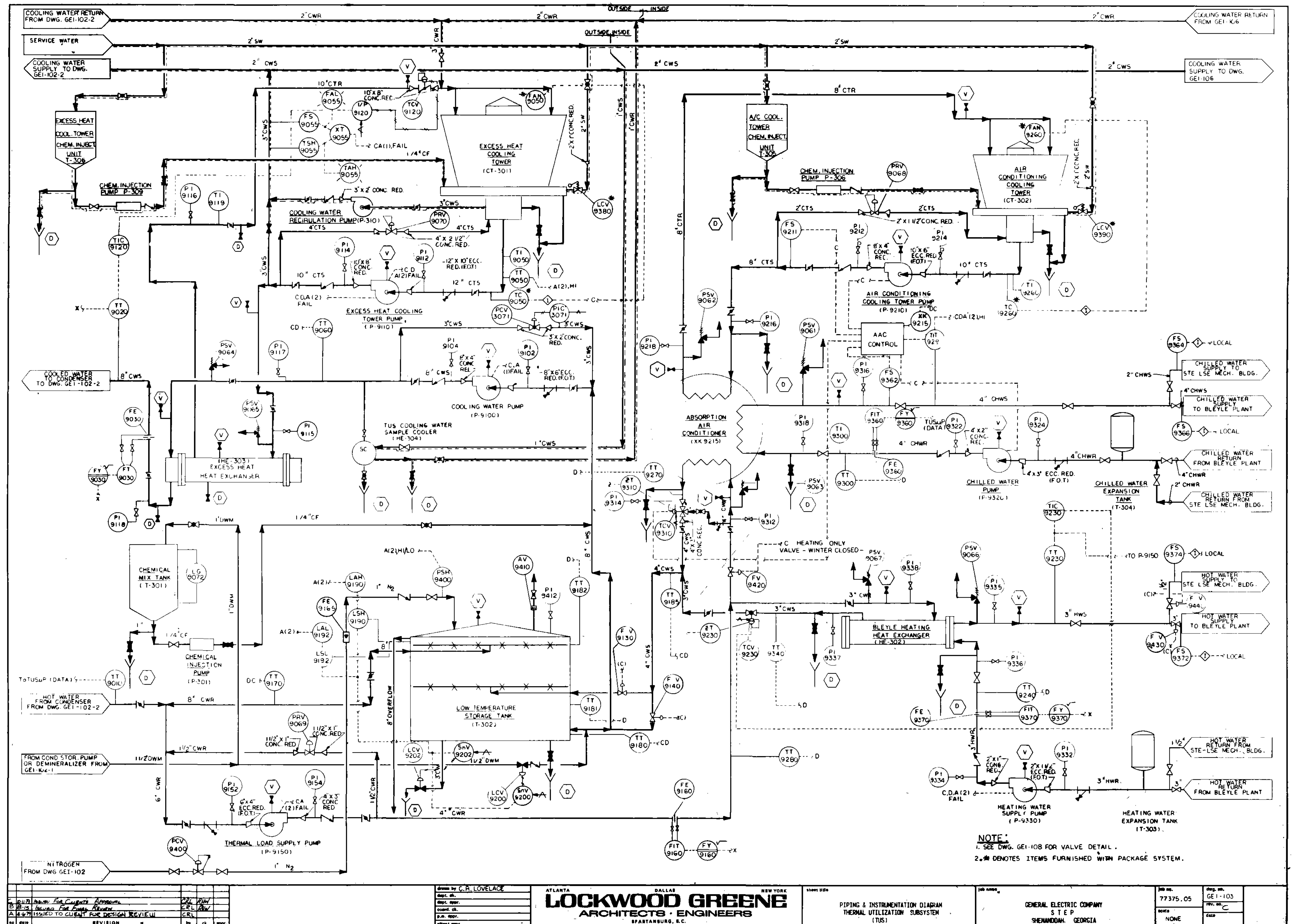


Figure 6.1.2-1 Piping & Instrumentation Diagram Thermal Utilization Subsystem

6.2.1 PERFORMANCE CRITERIA

a) The absorption air conditioning (AAC) subsystem in the TUS shall have maximum cooling capacity of 4.68×10^5 J/s (133 tons) when supplied with condenser cooling water at an outlet temperature of 372^{o} (210^{o}F). This capacity is sufficient to handle the maximum combined cooling load of the Bleyle Plant and the Mechanical Building.

b) The hot water coil heating subsystem in the TUS shall be capable of satisfying a maximum heat load of 1.04×10^5 J/s (356×10^3 Btu/hr) when supplied with consenser cooling water at an outlet temperature of 372^{o}K (210^{o}F).

c) The low temperature TES subsystem shall be sized for a maximum storage capacity of 1.05×10^{10} joules (10×10^6 Btu).

d) The condenser cooling tower will be a 2.45×10^6 J/s (700 ton) capacity tower at 299^{o}K (78^{o}F) wet bulb temperature.

e) The AAC cooling tower will be a 1.1×10^6 J/s (323 ton) capacity tower at 299^{o}K (78^{o}F) wet bulb temperature.

6.2.2 SYSTEM OPERATIONAL REQUIREMENTS

Both the heating and air conditioning subsystems of the TUS shall have multiple zone distributibution systems.

6.2.3 INTERFACE REQUIREMENTS

The Bleyle Plant has been designed to accept the STES heating and cooling water sybsystems.

6.2.4 MAINTENANCE AND RELIABILITY REQUIREMENTS

Maintenance on pumps or cooling towers will require shutdown of that particular piece of equipment. Single pumps and cooling towers are installed. Spare pumps will be purchased and maintained in storage for quick replacement. Chemical feed systems are provided for the cooling towers and the closed water systems to reduce corrosion on piping and wetted equipment.

6.2.5 TESTING AND INSPECTION REQUIREMENT

No special provisions are provided for testing and inspection. Room has been provided for pulling tubes on all heat exchangers.

6.3 DESIGN DESCRIPTION

6.3.1 DETAILED SUBSYSTEM DESCRIPTION

The Thermal Utilization Subsystem is shown on the Piping and Instrument Drawing, Figure 6.1.2-1. Using this figure as a guide, water is circulated through the condenser by using the discharge of the cooling water pump. The heated water from the condenser may then be placed in the low temperature storage tank. The hot water will enter in the top of the low temperature storage tank and relatively cold water will be removed from the bottom of the tank to the suction of the cooling water pump. In the event of excess thermal energy (low temperature storage tank full), the excess heat cooling tower may be used to cool the condenser circulating water discharging from the low temperature storage tank. Water is routed from the cooling tower by excess heat cooling tower pumps to the heat exchanger and then back to the cooling tower.

A hot water pump is provided. It takes suction from the hot water line leaving the steam condenser. The pump discharges either to the heat exchanger supplying Bleyle heating or to the absorption air conditioner. The heat exchanger is used to extract the heat from the hot water pump discharge and to transfer this to the water supply for heating the Bleyle plant.

The hot water from the discharge of the hot water pumps is routed through the absorption air conditioner. The heat from the water is used as the heating source in the absorption air conditioner. The chilling power generated in the AAC is used to cool the cooling water supply to the Bleyle Plant. The water pumped by the hot water pump leaves the absorption air conditioner and then may go to the middle of the low temperature storage tank, if heat is still available in the water, or may flow to the suction of the low temperature storage pump.

6.3.2 SUBSYSTEM PERFORMANCE CHARACTERISTICS

Design pressures, temperatures, and flows for the Thermal Utilization Subsystems are shown on Figure 6.3.2-1, the Process Flow Diagram.

6.3.3 MAJOR COMPONENTS

6.3.3.1 Low Temperature Storage Tank

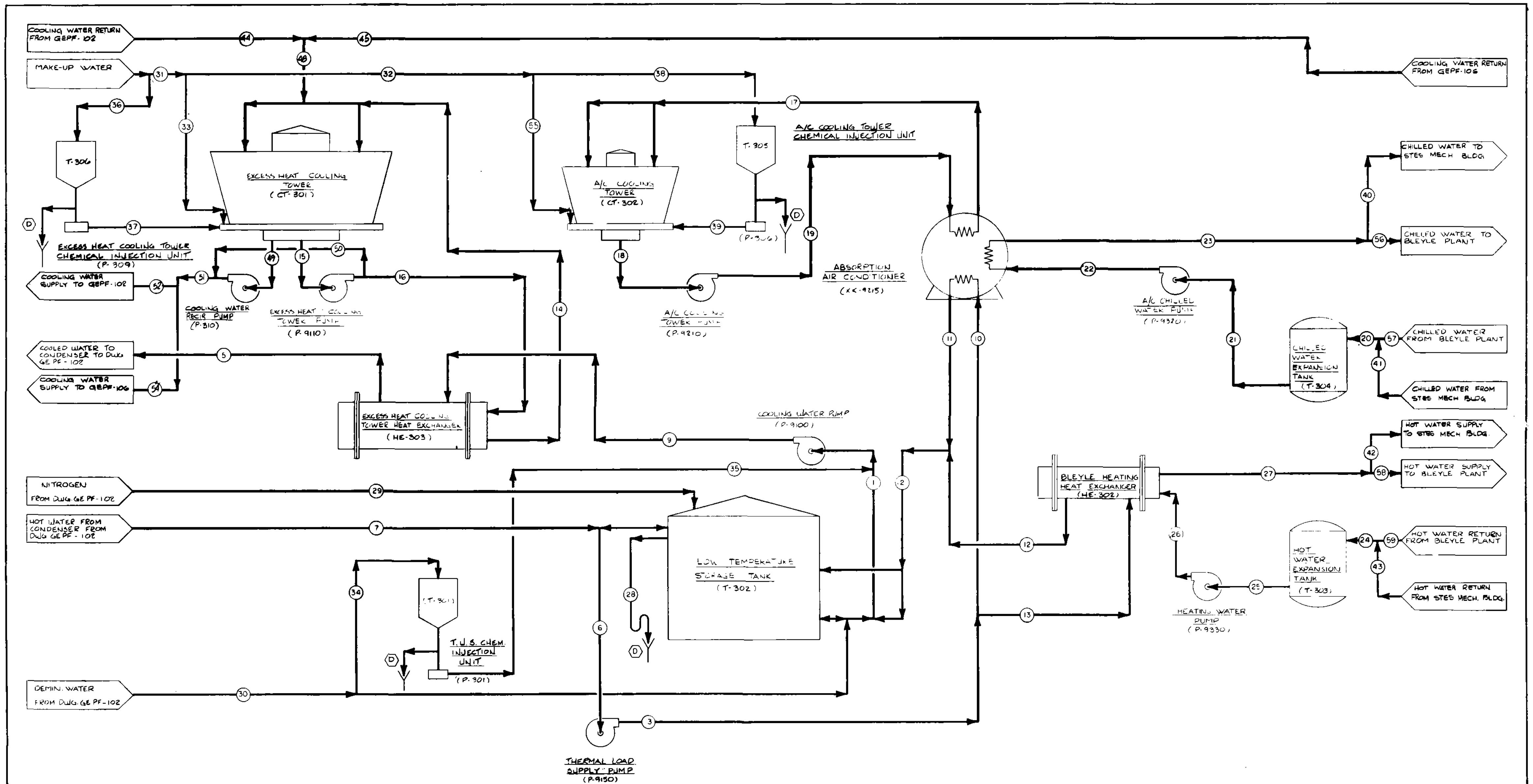
A 235 cubic meter (62,000 gallon) storage tank is provided for stratified storage of thermal energy. The storage tank is used to store heated water in the top and cool water in water in the bottom. There are three water connections on the tank.

A. Top connection - Hot water can enter the tank from the condenser or can be drawn from the tank with the hot water pump.

B. Middle connection - Cooled water can enter the middle connection from the Bleyle heating heat exchanger of from the absorption air conditioner.

C. Bottom connection - Provides suction (cool water) to the low temperature storage pump.

The tank is provided with a drain, overflow (safety) pipe, automatic vent, and a nitrogen supply. The tank is sized to accommodate thermal expansion for the system.



MAXIMUM OPERATING CONDITIONS				
LINE NO.	MEDIA	FLOW	PRESS.	TEMP.
1	WATER	850 GPM	6 PSIG	215°F
2	WATER	284 GPM	33 PSIG	215°F
3	WATER	284 GPM	33 PSIG	215°F
4				
5	WATER	850 GPM	50 PSIG	195°F
6	WATER	284 GPM	6 PSIG	215°F
7	WATER	850 GPM	50 PSIG	215°F
8				
9	WATER	850 GPM	50 PSIG	215°F
10	WATER	230 GPM	33 PSIG	215°F
11	WATER	230 GPM	33 PSIG	185°F
12	WATER	54 GPM	33 PSIG	195°F
13	WATER	54 GPM	33 PSIG	215°F
14	COOLING WATER	1700 GPM	35 PSIG	95°F
15	COOLING WATER	1700 GPM	FLOODED SUCTION	85°F
16	COOLING WATER	1700 GPM	35 PSIG	85°F
17	COOLING WATER	780 GPM	55 PSIG	95°F
18	COOLING WATER	780 GPM	FLOODED SUCTION	85°F
19	COOLING WATER	780 GPM	55 PSIG	85°F
20	CHILLED WATER	320 GPM	75 PSIG	55 F
21	CHILLED WATER	320 GPM	1 PSIG	55 F
22	CHILLED WATER	320 GPM	75 PSIG	55 F
23	CHILLED WATER	320 GPM	75 PSIG	45°F
24	HOT WATER	135 GPM	32 PSIG	142°F
25	HOT WATER	135 GPM	1 PSIG	142°F
26	HOT WATER	135 GPM	32 PSIG	142°F
27	HOT WATER	135 GPM	32 PSIG	150°F
28	OVERFLOW	850 GPM	2 PSIG	215°F
29	NITROGEN	50 SCFM	5 PSIG	AMB.
30	DEMIN. WATER	10 GPM	60 PSIG	80°F
31	WATER	85 GPM	60 PSIG	80°F
32	WATER	10 GPM	60 PSIG	80°F
33	WATER	80 GPM	60 PSIG	80°F
34	DEMIN. WATER	4.5 GPM	60 PSIG	80°F
35	CHEM. INJECT.	0.04 GPH	150 PSIG	80°F
36	WATER	15 GPM	60 PSIG	80°F
37	CHEM. INJECT.	0.04 GPH	150 PSIG	80°F
38	WATER	15 GPM	60 PSIG	80°F
39	CHEM. INJECT.	0.04 GPH	150 PSIG	80°F
40	CHILLED WATER	48 GPM	75 PSIG	45°F
41	CHILLED WATER	48 GPM	75 PSIG	55°F
42	HOT WATER	27 GPM	32 PSIG	150°F
43	HOT WATER	27 GPM	32 PSIG	142°F
44	COOLING WTR.	75 GPM	35 PSIG	95°F
45	COOLING WTR.	10 GPM	35 PSIG	95°F
46				
47				
48	COOLING WTR.	85 GPM	35 PSIG	95°F
49	COOLING WTR.	90 GPM	FLOODED SUCTION	85°F
50	COOLING WTR	90 GPM	35 PSIG	85°F
51	COOLING WTR.	96 GPM	25 PSIG	85°F
52	COOLING WTR	80 GPM	35 PSIG	86°F
53				
54	COOLING WTR	10 GPM	35 PSIG	85°F
55	MAKE-UP WTR.	35 GPM	60 PSIG	80°F
56	CHILLED WTR.	272 GPM	75 PSIG	45°F
57	CHILLED WTR	272 GPM	75 PSIG	55°F
58	HOT WATER	108 GPM	36 PSIG	150°F
59	HOT WATER	108 GPM	36 PSIG	142°F

no	date	REVISION	by	ch.	app.
C	[illegible]	ISSUED FOR CLIENTS APPROVAL	CRL	RHW	
B	[illegible]	ISSUED FOR FINAL REVIEW	CRL		
A	[illegible]	(REDRAWN) ISSUED TO CLIENT FOR DESIGN REVIEW	EAT		

drawn by C.R.LOVELACE
dept. ck. R.H.W.
dept. appr.
coord. ck.
p.m. appr.
client appr.

ATLANTA DALLAS NEW YORK
LOCKWOOD GREENE
ARCHITECTS · ENGINEERS
SPARTANBURG, S.C.

sheet title: PROCESS FLOW DIAGRAM THERMAL UTILIZATION SUBSYSTEM

job name: GENERAL ELECTRIC COMPANY STEP SHENANDOAH, GEORGIA

job no. 77375.05 | dwg. no. GEPF-103 | rev. no. C | scale NONE | date

Figure 6.3.2-1. TUS Process Flow Diagram

Drain and make-up controls are provided. The tank is located outdoors in the Mechanical Area. It will be 7.1 meters (23 feet) in diameter and 6 meters (20 feet) high, insulated and weather proofed.

6.3.3.2 Absorption Air Conditioning Unit

A .9 x 10^6 J/s (256 ton) absorption air conditioner (AAC) is provided inside the Mechanical Building. The packaged absorption air conditioner will consist of a 5.6 kW (7 1/2 hp)/sealed pump, a 190 watt (1/4 hp) purge pump, an absorber, evaporator, concentrator, condenser, and a heat exchanger. Thermal energy is provided to the AAC by 0.018 m^3/s (284 gpm) water at a nominal temperature of 372°K (210°F).

Cooling tower water is provided to the AAC at 302°K (85°F) and 0.049 m^3/s (780gpm). The water leaves the AAC at 309°K (95°F). Chilled water at 280°K (45°F) will be supplied to Bleyle at a flow rate of 0.020 m^3/s (320 gpm). The water will be returned from Bleyle at 286°K (55°F).

The AAC utilizes the proven lithium bromide-water, absorption refrigeration cycle. This cycle takes place in a sealed hermetic shell from which essentially all air has been removed. Consequently, the pressures within the shell are the vapor pressures of the liquids used in the cycle at their respective temperatures. In operation, the pressure in the absorber and the evaporator section is about 1000 N/m^2 (1/100th of an atmosphere). Pressure in the concentrator and condenser sections is about 1 x 10^4 N/m^2 (1/10th of an atmosphere). In the operating cycle, distilled water is used as the refrigerant and lithium bromide as the absorbent.

6.3.3.3 Cooling Towers

Two cooling towers are being provided. The AAC cooling tower is a nominal 1.1 x10^6 J/s (323 ton) double flow unit. It will be provided with a fan driven thru a gear reducer.

The tower is capable of operating thru a range of 0.012 to 0.049 m^3/s (190 to 780 gpm) of cooling tower water flow. It will be provided with an overflow, make-up system and chemical treatment system. Construction of baffles for water droplet dispersion will be PVC. Casing and louvers will be corrugated asbestos. An access ladder will be provided to the fan.

The condenser cooling tower is 2.45 x 10^6 J/s (700 nominal ton) double flow unit. It will be provided with a fan driven through a gear reducer. The tower is capable of operating through a range of 0.038 to 0.107 m^3/s (600 to 1700 gpm) cooling water flow. Construction materilas will be similar to the AAC cooling tower.

6.3.3.4 Condenser Cooling Tower Heat Exchanger

The condenser cooling tower heat exchanger shall be capable of cooling 0.054 m^3/s (850 gpm) of water at 375°K to 364°K (215°F to 195°F). It will give up its heat to the condenser cooling tower water that will flow at 0.107 m^3/s (1700 gpm) at 302°K (85°F) and return at 308°K (95°F). The hot water will flow through the shell. The cool water will be on the tube side.

6.3.3.5 Pumps

The following pumps will be used in the Thermal Utilization Subsystem. All pumps will be driven by 480V, 3 phase motors with local and remote start-stop controls:

- The cooling water pump will be capable of pumping .054 m^3/s (850 gpm) at 4.2 x 10^5 N/m^2 (61 psia).
- The excess heat cooling tower pump will be capable of pumping 0.107 m^3/s (1700 gpm) at 2.45 x 10^5 N/m^2 (35.7 psia).
- The air conditioning cooling tower pump will be capable of pumping 0.049 m^3/s (780 gpm) at 4.1 x 10^5 N/m^2 (59.7 psia).

- The thermal load supply pump will be capable of pumping .016 m^3/s (284 gpm) at 3.3 x 10^5 N/m^2 (48 psia).
- The chilled water pump will be capable of pumping 0.026 m^3/s (320 gpm) at 5 x 10^5 N/m^2 (74 psia).
- The heating water supply pump will be capable of pumping .008 m^3/s (135 gpm) at 2.2 x 10^5 N/m^2 (32 psia).

6.3.3.6 Piping Valves and Insulation

The piping and valve material specifications for the Thermal Utilization Subsystem require use of ASTM A-53 Grade A Schedule 40 welded or seamless pipe. Pipe connections will be welded except for valves and pumps that may be flanged. Standard 57 kg (125 lb.) vlaves will be used. Insulation will be installed on the tanks and piping to minimize heat loss and to prevent sweating where necessary.

6.3.4 CONTROLS AND INSTRUMENTATION

6.3.4.1 Design Criteria

Control functions required by the Thermal Utilization Sybsystem include the following

1. Low temperature storage tank level control - This control will admit make-up water and operate the drain valve. A Nitrogen blanket is also provided, and an overflow pipe with a loop seal.
2. Cooling towers - Level controls are provided for control of make-up. Fan speed controls will be provided for temperature maintneance.
3. Heating and cooling controls - Hot water may be routed to the AAC or the Bleyle heating heat exchanger. The AAC is provided with a local control panel, and a temperature controller is provided for the Bleyle heating heat exchanger.
4. Chemical injection - This will be controlled semi-automatically.

6.3.4.2 Alarms

Alarms are provided for controlled variable deviations (temperature and pressure) and for status failures (pumps and valves).

6.4 SUBSYSTEM OPERATION

Operation of the TUS will occur when either the PCS is operating or there is a heating or cooling demand from the Bleyle Plant.

6.4.1 NORMAL OPERATION

6.4.1.1 Operation With PCS Operating

When the PCS is operating, the TUS cooling loop takes heat from the PCS condenser and delivers energy by way of the low temperature storage pump to the low temperature storage tank or, if there is a heating or cooling load at the Bleyle Plant or Mechanical Building, directly to the heat exchanger (for space heating) or to the absorption air conditioner generator. The absorption air conditioner will control internal flows to match the load and maintain the required chilled water temperature and condenser/absorber temperatures. Excess thermal energy above that required for heating or cooling is stored in the LTS. When the LTS is fully charged, additional excess heat is dissipated through activation of the cooling tower loop.

6.4.1.2 Operation Without PCS Operating

In this mode of operation, the LTS stored energy is used to supply either the absorption air conditioner generator or heating heat exchanger directly to satisfy Bleyle Plant cooling or heating loads, respectively. This mode continues until either the loads are supplied or PCS operation begins.

6.4.2 OFF NORMAL OPERATION

Off normal operation will occur when there is no heating or cooling required for prolonged periods or the absorption air conditioner is not operating. In this mode, the PCS will continue to operate at design backpressure, and the heat to the TUS will be dissipated through the excess heat cooling tower. If cooling is required by the plant, it will be supplied by the vapor compression air conditioning rooftop units at the Bleyle Plant.

SECTION 7

SECTION 7

CONTROL AND INSTRUMENTATION SUBSYSTEM (CAIS)

7.1 SCOPE

7.1.1 FUNCTION

The Control and Instrumentation Subsystem provides: the controls and monitors for all interfacing subsystems, the selection of the system operational mode, provisions for monitoring critical parameters of the various subsystems, alarms and logic for protection of the subsystem components, and integration of the operation of the system as a whole.

7.1.2 SUBSYSTEM CONFIGURATION

The Control and Instrumentation functions are provided via the central control console the central mini computer and peripherals, and two microprocessor control units. These units (The Energy Utilization Processor and the Buffer Control Unit) interact directly with the individual STEP subsystems. They contain conditioning circuitry to convert the digital computer outputs to signals usable by the control actuators and to transform sensor outputs to digital format for scrutiny and recording by the micro- and as necessary mini-computers. Control units will act autonomously where possible and will interact with the central processor in a distributed control approach as necessary. The control console and computer terminal will provide input-output control and monitor capability to the operator.

7.2 DESIGN CRITERIA

7.2.1 PERFORMANCE REQUIREMENTS

a) The design of the CAIS shall make use of standard control devices and functions and existing computer hardware and software. The design shall not be dependent upon the development of new control devices.

b) The design of the CAIS shall incorporate sufficient controls and monitoring devices to detect and identify system faults and malfunctions, provide appropriate warnings and alarms, and automatically initiate appropriate actions to prevent damage to system components.

c) The design of the CAIS shall include data archiving for monitoring and recording system performance parameters during experimental and normal operating modes.

7.2.2 SYSTEM OPERATIONAL REQUIREMENTS

a) The computer architecture of the CAIS shall have sufficient flexibility to be adaptable to experimental modes of operation as well as anticipated commercial operational modes.

b) The design of the CAIS shall incorporate provisions for manually overriding control set points and automatic operational modes.

c) The CAIS shall be capable of automatic start-up and shut-down operations.

7.2.2.1 Solar Collection Subsystem

The collector field control units must provide tracking control as outlined in Section 4.3.4.1 and field temperature control as outlined in Section 4.3.4.2.

These requirements necessitate interactive processing capabilities between collector field control units and central control console in addition to the input of data from sensors that are located in the thermal energy subsystem to execute the various operating modes of the field.

7.2.2.2 High Temperature Storage Subsystem

Requirements for the High Temperature Storage Subsystem control are summarized in Section 4.3.4.3. In order to manage the referenced tasking effectively, this equipment monitors a number of temperature, flow and pressure variables within its own environment and additionally defines basic operating modes based on data interactively acquired from outside its system boundaries. The various major modes and sub-modes of operation are executed via appropriate binary or proportional controls within the local system.

7.2.2.3 Power Conversion Subsystem

The power conversion subsystem control is required to provide the applicable functions defined in Section 5.3.4.1. While the internal management functions are as defined in the referenced sections, these tasks are dynamically reconfigured and optimized in direct response not only to the steady state operating protocol but also to changes in load requirements present at the utility and plant interfaces by closed loop feedback to provide the required system response speed and stability.

7.2.2.4 Thermal Utilization Subsystem

Management of low grade energy, assigned to the Thermal Utilization Subsystem control is functionally described in Section 6.3.4.1. Operating modes may be reduced to sequential control algorithms providing modal stability as a function of action/response criteria set for various temperature, pressure, and/or flow transducer outputs within the system. Major modes of operation are defined and modified in response to inputs from various linear transducers within the output environment as modified by the state of operating conditions within the TUS.

7.2.3 INTERFACE REQUIREMENTS

The Control and Instrumentation Subsystem interfaces may be broadly divided into three main categories:

1) Power requirements - the central control complex, Buffer Control Unit and Energy Utilization Processor are designed to operate from 120V AC, 60 Hz as the primary power source. Certain elements of the system may require capability to operate for the period of time necessary to effect orderly shutdown in the event of loss of main power.

2) Subsystem inputs - micro-processor control units shall be capable of interfacing with a variety of ranges of analog and digital signals via signal conditioning circuitry. Typical sources are temperature, pressure, and flow transducers; binary status indicators; voltage, power (both real and reactive), and frequency; and various digitally formatted input parameters.

3) Subsystem outputs - the micro-processors shall incorporate signal conditioning to output digital and/or analog signals of the appropriate format, scale, and precision to drive the various controls (both binary and analog) resident within that micro-processor's environment.

7.2.3.1 Solar Collection Subsystem

7.2.3.1.1 Collector Field Subsystem (CFS)

The Control and Instrumentation Subsystem will interface with the CFS by means of sensors providing the Syltherm^{TM} 800 temperature at each collector and the collector pointing position to within $\pm 0.25^\circ$. The CAIS will provide the collectors with signals to permit tracking of the sun to within $\pm 1.0^\circ$ and to adjust the Syltherm^{TM} 800 flow to optimize the field temperature to a maximum of 672°K (750°F). Signals will also be provided to permit emergency defocusing of collectors as well as startup-shutdown sequences.

7.2.3.1.2 High Temperature Storage Subsystem

The Control and Instrumentation Subsystem will be provided with inputs monitoring the state of charge or discharge of the storage tanks and the interconnecting valve positions. Outputs to the HTS will set the valves for maximum charging during charge cycle and control the discharge during discharge cycle. Outputs to control the fossil fired heater will also be provided.

7.2.3.2 Power Conversion Subsystem

The Control and Instrumentation Subsystem will send signals to control the PCS steam generator to maintain the steam temperature and pressure required by the PCS turbine-generator and process steam demands. Automatic startup and shutdown sequences will also be executed under the direction of the CAIS.

7.2.3.3 Thermal Utilization Subsystem

The Control and Instrumentation Subsystem will provide signals to maintain the proper flow rate and temperature of coolant into the steam condenser. The CAIS will also control the charge/discharge of the low temperature storage tank and select between and control absorption air conditioner or space heating. The Control and Instrumentation Subsystem will also interface with the Bleyle Plant to provide recording of selected factory instrumentation.

7.2.4 ON-SITE MAINTENANCE

7.2.4.1 General STES Considerations

Design of the Control and Instrumentation Subsystem requires that major STES operating criteria be routinely interrogated not only to generate the appropriate control signals for the various subsystems but also to ascertain that the prerequisite response has occurred either in that subsystem or between hydraulically interconnected subsystems. As such these action/response algorithms are, in themselves, a general system maintenance tool. Responses which do not occur in the predicted manner cause detected instabilities within any particular operating protocol and are brought to the attention of the operator so that appropriate fault isolation and servicing may be initiated.

7.2.5 TESTING AND INSPECTION REQUIREMENTS

a) Testing of computer hardware will be accomplished by means of standard, vendor supplied, diagnostic programs.

b) Testing of individual software modules will be performed during the fabrication phase. Each module, as it is developed, will be tested by test programs which will exercise all features within the software module.

c) The Control and Instrumentation Subsystem will be tested against a customer approved acceptance test procedure. Proper response and control during normal operation and abnormal situations will be demonstrated using test equipment which simulates these conditions.

7.2.6 SUBSYSTEM SPECIAL FEATURES

Due to the evolutionary nature of this project, the Control and Instrumentation Subsystem has been designed to permit, as an inherent feature, system flexibility.

The Subsystem may be considered to be a software driven rather than a hardware-oriented tool. The subsystem may be reconfigured by changes in programs at the computer console rather than by change-out or by time consuming calibration of hardware modules at remote locations. Micro-processors may be operationally reconfigured by down loading software via the mini-computer and its associated serial stream data links. Mode changes, operating set-points, archiving requirements, and fail-safing all may be changed through software techniques with a minimum need to effect remote hardware changes.

7.3 DESIGN DESCRIPTION

7.3.1 DETAILED SUBSYSTEM DESCRIPTION

Implementation of the varius control functions of the STES has been partitioned into distinct areas of device responsibility. Architecturally, the mini-computer is the master system controlling element. Reporting to the mini-computer (Digital Equipment Corporation PDP 11/34) are the various input/output devices (used for archiving, program storage, operator displays, and operator input devices) generally termed peripherals. The mini has minimal control over the operating characteristics of the peripherals.

The flexibility of the total control subsystem resides in the relationship that exists between the mini-computer master controller and the two micro-computer-driven control units which are physically resident in the control room. Whereas the mini-computer has minimal influence over the operating characteristics of the peripherals, it has highly flexible control via software reconfiguration of the techniques that the individual micro-processors use to interpret data and execute control over the various transducers and control devices that are resident in their individual domain.

The basic concept is depicted in Figure 7.3.1-1. The mini-computer is in a position to analyze inputs from each unit reporting to it for inconsistencies that may indicate improper operation and initiate appropriate reactions (alert operator, make ready to initiate fail-safe sequencing, etc.) depending on the class of failure detected.

Part of the task load of the control subsystem is the acquisition of data from the various subsystems under its control in order to execute the appropriate control algorithms and to create a data base to serve as an archieve for optimization and experimentation. At the analog input interfaces of the micro-computers, the various raw transducer outputs are conditioned and presented to analog multiplexers for conversion by analog-to-digital converters into formatted digital data for linearization and incorporation into control routines and also for archiving.

Control routines may also incorporate binary status indicators to effect proper control. To execute control the micro-computer generates two types of signals:

1) Binary (on/off) for control of valves, motors, etc.
2) Analog, by means of digital-to-analog converters, for control of proportional control elements

In addition to archive control, the mini-computer supervises and checks data flow from the individual micro-computers, down loads software to effect mode changes in either a

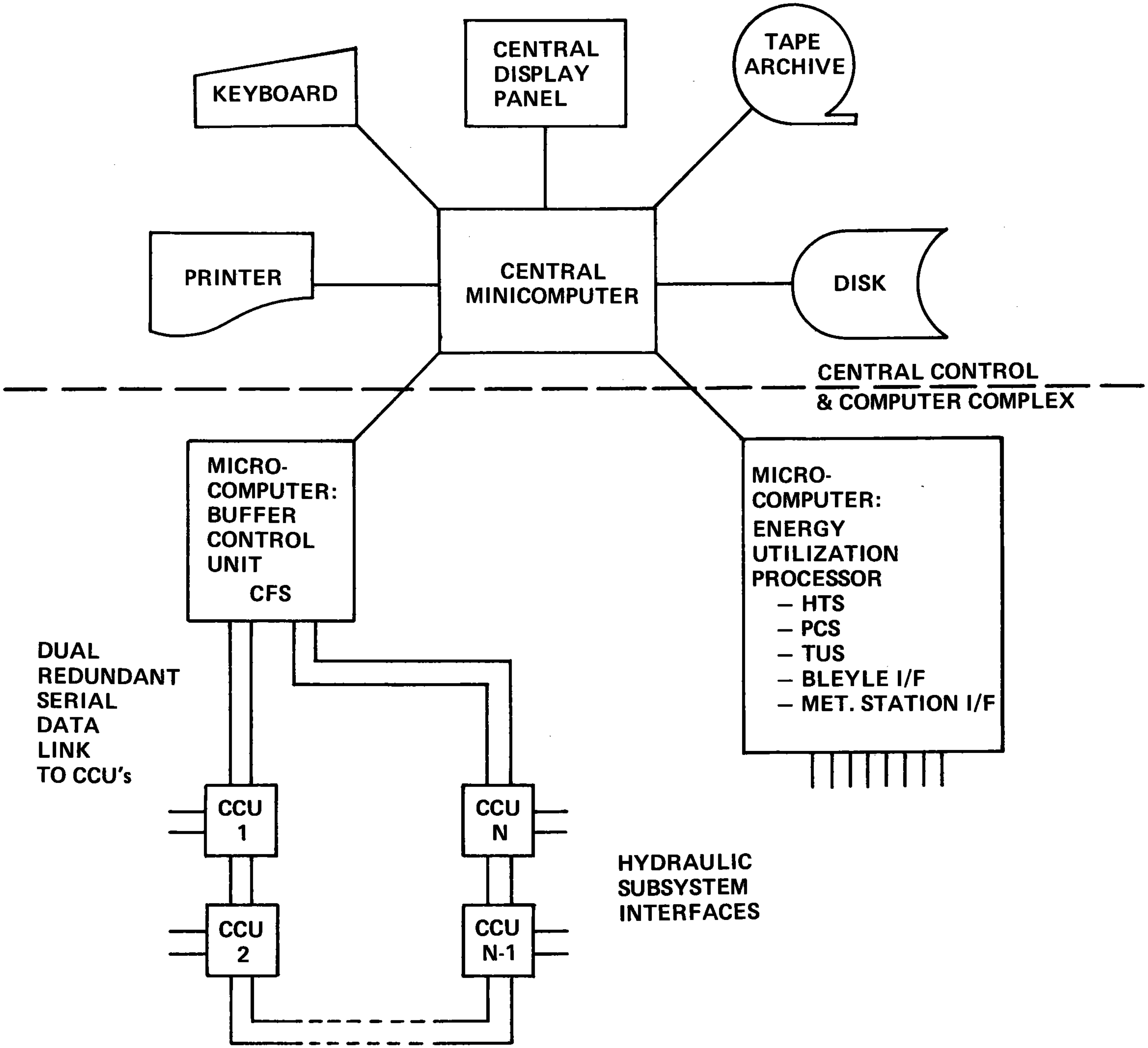


Figure 7.3.1-1. Computer Architecture

pre-programmed or an on-demand manner, serves via the keyboard or control console as the input mode for human interface, accepts software revision/update, and performs general system housekeeping tasks.

7.3.2 MAJOR COMPONENTS

The major components of the control system are the central control console, the central mini-computer, The Buffer Control Unit and The Energy Utilization Processor. A hardware selection analysis resulted in selection of Digital Equipment Corporation (DEC) computers. Specifically, the PDP-11/34 is selected for the central mini-computer, and the LSI-11/02 for the micro-computers

A distinguishing characteristic of the DEC family is its common physical architecture arising primarily from the patented DEC Unibus, a single high-speed asynchronous, bidirectional communications path to which all system components (CPU, memories, and I/O controllers) are connected. This common bus structure enables all functional elements to communicate with one another independently of the CPU. This ability reduces the time spent by the CPU in supervising I/O operations and allows it to devote more time to actual data processing.

A second salient feature of the DEC family is that all models, from the smallest LSI-11/02 to the largest 11/70, use the same basic instruction set, thus allowing great flexibility in software development and transferability. Additional descriptions of the selected models are given below.

7.3.2.1 Central Minicomputer

The PDP-11/34 is a systems level computer that includes increased memory expansion to 124K words, memory relocation and protection, faster processing speeds, and hardware multiply and divide instructions. The PDP-11/34 processor is prewired to accept additional memory (parity core or MOS) and standard peripheral device controllers including communications interfaces, mass storage controllers, etc.

7.3.2.2 Microcomputers

The LSI-11/02 is a 16-bit micro-computer with the speed and instruction set of a mini-computer. The LSI-11 has the following features.

400 Plus Instruction Set

More than 400 instructions make up the LSI-11's extensive instruction set. This instruction set (also used by the PDP-11/34) permits the user to take advantage of standard PDP-11 software.

Extensive Computer Power and Small Processor Size

The processor module is built around a set of four N-channel metal oxide semi-conductor (MOS) chips, which include control and data elements as well as two microcoded read-only memories (microms). The latter are programmed to emulate the powerful PDP-11/35, 40 instruction set, along with routines for on-line debugging techniques (ODT) operator interfacing, and boot-strap loader capability. The processor also contains a 16-bit buffered parallel input/output (I/O) bus, a 4096-word MOS random-access memory (RAM), a real-time clock input, priority interrupt control logic, power-fail, auto restart, and other features to provide stand-alone operation. The entire processor plus all of the above mentioned features are contained on one 0.216 by 0.254 meter (8.5 by 10 inch) printed circuit board.

Modularity

The process, memory, device interfaces, backplane, and interconnecting hardware are all modular in design. Modular selection, such as the type and size of memory and device interfaces, enable custom tailoring to meet specific application requirements.

Serial and Parallel I/O Modules

Serial and parallel I/O modules are available for interfacing the processor bus with external devices. These modules simplify connection to peripherals when and if required and also facilitate assembly of prototype systems without penalizing later development of customized interfaces.

Power Fail/Auto Restart

Whenever DC power sequencing signals indicate an impending AC power loss, micro-coded power fail sequence is initiated. When power is restored, the processor can automatically return to the run state. Four options are available for power-up sequencing.

7.3.2.3 Control Console

The Central Control Console with its two color graphic CRT/keyboards is the operator interface with the STEP control system. The console itself has a minimum set of dedicated control and monitoring devices to provide the operator with a top level status of the system in a glance, and those controls enabling immediate safety action. More detailed monitor and control activity is exercised through the minicomputer. The STEP control system is designed to operate in a supervisory control manner. It will operate unattended, or an operator may interact and take control at any time. The console also has a custom work surface and desk type storage drawers for operator convenience.

7.3.2.4 Buffer Control Unit

The Buffer Control Unit (BCU) is a microprocessor whose chief function is to interface the Collector Field System (CFS) to the central control complex. It also performs supervisory control functions for the CFS. The actual interface is via a dual redundant serial data link to each Collector Control Unit (CCU) as depicted in Figure 7.3.1-1. A CCU is mounted on each collector and performs tracking and hydraulic subsystem functions. Each CCU has several multifunctional parts which control or monitor the various transducers and instruments in the collector field.

7.3.2.5 Energy Utilization Processor

The Energy Utilization Processor (EUP) interfaces with all other subsystems (PCS, HTS, TUS) as well as the Bleyle plant and meterological station. The EUP performs supervisory control over these subsystems and interfaces with the central minicomputer. All data and control signals enter/exit the EUP via portable signal lines. Signals are of a standard signal set and are conditioned in the EUP using signal conditioning circuitry for proper formatting of data with the minicomputer.

7.4 SUBSYSTEM OPERATION

The subparagraphs of this section describe in a general manner the various modes of operation of the four subsystems that comprise the STES. All control functions are incorporated into a software operating hierarchy that permits a multi -moded operation as the STES cycles through start-up/run/shut-down with the constant need to assess and modify as needed subsystem modes in response to the presence of a typical operating conditions.

7.4.1 CFS CONTROL

Control of the collector field is executed via the Buffer Control Unit (BCU) micro and serial data link to the Collector Control Units (CCU) mounted on the collectors themselves. These perform two types of control simultaneously and interactively; solar tracking and temperature control.

The tracking control is based on time of day and inputs from the autotracker. Coarse tracking control, typically ±1° is derived from time of day. When outputs from the solar autotracker are available, these are used to refine tracking commands to ±0.25°. Therefore, the collectors track the sun to within ±1/4° when the sun is shining, but during temporary obscurations due to cloud passage, coarse tracking and associated accuracy is resumed. Coarse tracking control also provides for collector stowage at the end of the day or in the case of rain, and will reset each morning. Manual intervention will permit stowage for maintenance.

Syltherm™ 800 temperature in the collector field is controlled on a branch line basis, with appropriate logic to maximize the temperature from each branch while also protecting each collector from overtempeature. This is performed by controlling the field circulation pump for approximate temperature control based on insolation conditions, with finer adjustment provided by proportional branch control valves. The temperature control interacts with the tracking control by allowing rapid emergency defocus of the collectors in the event of overtemperature.

7.4.2 HTS CONTROL

The HTS control logic consists of first identifying the state of charge or discharge of each of the storage tanks. Discrete valves in the supply and return lines of each tank can be set to permit each tank to discharge if it is identified to be in a charged state, or to be charged if it is identified to be in a discharged state. Thus, each tank is prepared to accept energy from the field should it be available and to deliver energy to the steam generator on demand.

Note that since the trickle tank concept being employed is rather innovative, considerable monitoring must be performed to verify proper operation. This is accomplished by a large number of RTD's imbedded in the tanks.

7.4.3 PCS CONTROL

The control of the electrical output of the turbine-generator, i.e., speed (frequency) and voltage control is obtained from analog devices which are an integral part of the turbine-generator set. The computer system provides the T-G load requirement, operating mode, and activates the startup/shutdown sequences.

PCS steam generator control consists of monitoring the steam demand from the turbine and process steam system. Flow of Syltherm^{TM}800 into the steam generator is regulated to maintain output steam temperature, and flow of water into the boiler is regulated to control output steam pressure. The Syltherm^{TM}800 input temperature is monitored and the fossil fuel heater is controlled to supply supplementary energy when required.

7.4.4 TUS CONTROL

The primary function of the TUS control is to maintain water flow and temperature to the steam condenser for proper condenser pressure. The control system then sets the valve configuration for the AAC, space heater, cooling tower and storage tank to meet factory demands for air conditioning or heating and to store excess energy while maintaining a suitable condenser input water temperature.

SECTION 8

SECTION 8

ELECTRICAL SUBSYSTEM (ES)

8.1 SCOPE

8.1.1 FUNCTION

The Electrical Subsystem provides for the distribution of the electrical power from the PCS generator to the components of the STES and to the parallel electrical connection with the Georgia Power Company and the Bleyle Plant. The ES also provides the backup power supply for collector defocus in the event of loss of normal electrical power. In addition, the ES contains a grounding system to prevent damage to the collector field in the event of lightning strikes.

8.1.2 SUBSYSTEM CONFIGURATION

The Electrical Subsystem is shown in Figure 8.1.2-1. The ES interfaces with all subsystems in the STES since it supplies electrical power to all electrical components and control devices. The primary ES boundary connection with the Georgia Power Company occurs at the air circuit breaker which connects the two systems in parallel. The turbine driven generator serves as the link between the ES and the PCS.

8.2 DESIGN CRITERIA

8.2.1 UTILITY REQUIREMENTS

The Georgia Power Company requires that the STES electrical system, which connects to both their system and to the Bleyle plant, not interfere with the operation of either GPC or the Bleyle Plant nor cause degradation or interruption of service. Specifically,

a) The existence and/or operation of the STES shall not cause an interruption in the GPC system

b) The existence and/or operation of the STES shall not cause any degradation of electrical service to the Bleyle Plant

c) The STES electrical output will operate in parallel with the GPC 480 Y277 volt bus supplying Bleyle in order to enhance voltage and frequency regulation

d) For STES operation alone to serve the Bleyle plant, power quality requirements are:

   1) Voltage regulation
      480 volts ±5%, normal operation
      480 volts ±7%, with ±10% load transient

   2) Frequency regulation (any conditions)
      60 hertz ±0.5%
      (±0.3 hertz)

   3) Voltage Waveform Distortion
      5% maximum

   4) Net output at Bleyle Bus
      161 kilowatts, 0.8 power factor (estimate)

8.2.2 STES SYSTEM REQUIREMENTS

a) Supply STES parasitic electrical loads of 137 kilowatts, 0.8pf (includes margin)

b) Provide supervisory control capability of electrical system

c) Provide transducers for monitoring and recording of electrical parameters

d) Provide a backup power source for critical systems and controls to allow for safe shutdown in the event of primary power failure

e) Interconnect power and instrumentation devices

f) Provide safety and lightning grounding means

g) Design for a lightning strike of

   1) 100,000 amperes peak

   2) 1.0 microsecond rise time

   3) 100 coulomb charge transfer tin 0.3 seconds

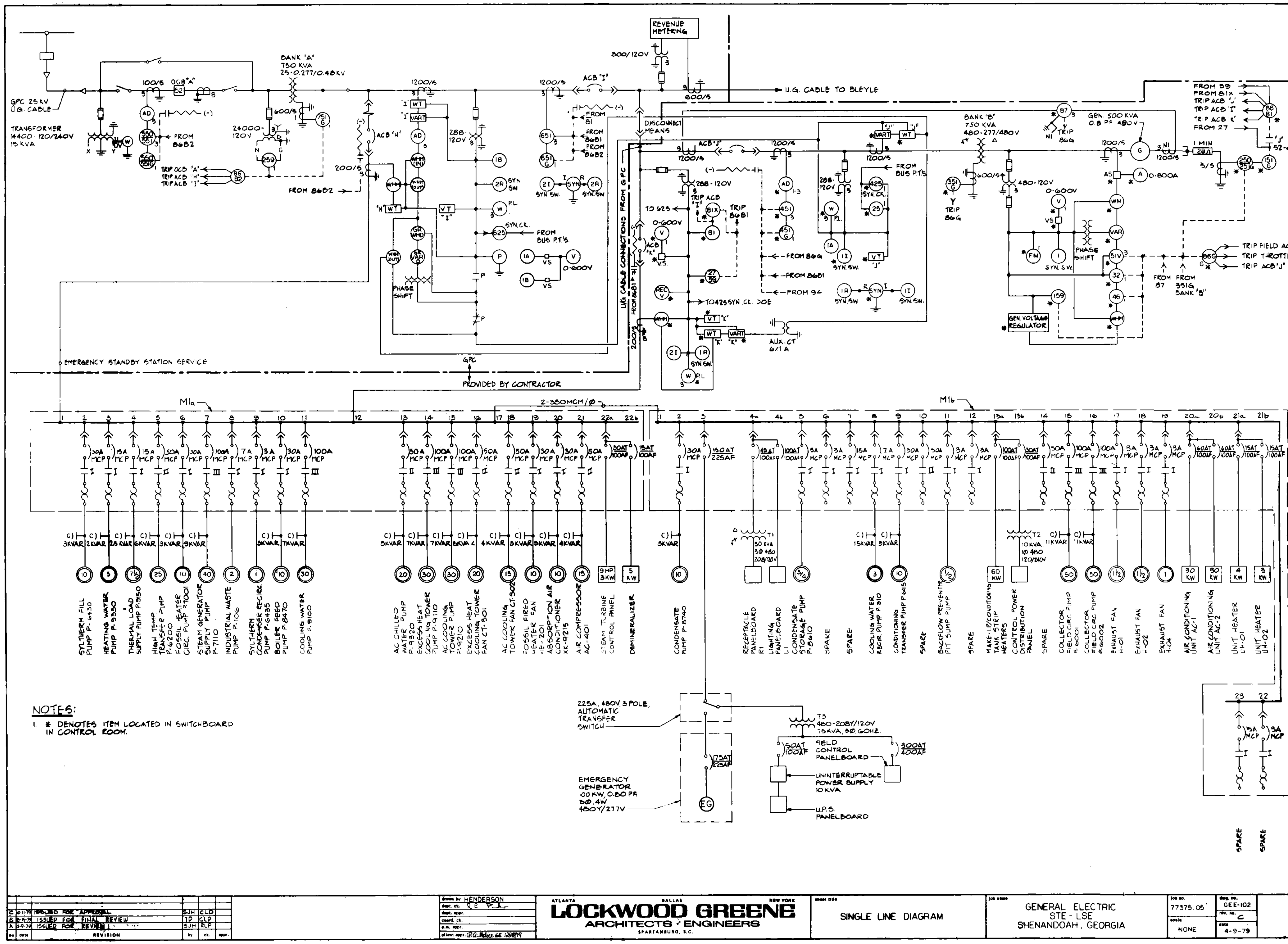


Figure 8.1.2-1. Electrical Subsystem

8.2.3 INTERFACE REQUIREMENTS

a) The STES 480Y277 volt system will connect to the GPC-Bleyle substation by underground cable. A disconnect device will be provided by GPC.

b) An emergency 480Y277 volt connection will be provided by GPC for STES startup and temporary operation if the GPC-Bleyle bus is not energized.

c) Control and instrumentation circuits between GPC and the STES system shall consist of:

   1) Instrument transformer secondary circuits from current and potential transformers

   2) Trip and close circuit contacts for circuit breakers transfer, trip and control

   3) GPC power transducer circuit for load following control of turbine

d) Control and instrumentation circuits to the PCS and GFE turbine generator are as follows:

   1) Power transducer interface to set turbine electrical power demand

   2) Mode select for parallel or stand alone operation

   3) Start-up and shutdown sequencing including emergencies

   4) Instrumentation list for control, evaluation, and monitoring

e) Control and instrumentation circuits to the SCS shall be as provided in Section 4.

f) Auxiliary power circuits shall be circuit breaker or fusible disconnect protected and switchable.

g) Circuits subject to lightning interference or contact between instrumentation and power circuits shall be provided with surge arrestors.

h) STES service power at 480/277/208/120 volts, 60 hertz will be provided from the STES auxiliary power distribution system which is paralleled to the GPC-Bleyle bus with an emergency connection available as described in b) above.

8.2.4 MAINTENANCE AND RELIABILITY

8.2.4.1 Availability

a) Auxiliary power is subject to the GPC system availability with an estimated forced outage rate of (TBD) hours per year.

b) STES electrical output availability is determined by the PCS subsystem discussed in Section 5.2.4

c) Standard electrical equipment will be utilized to maximize STES power distribution system availability

8.2.4.2 Routine Maintenance

a) Inspect and clean external ventilation openings on enclosed switchgear and electrical apparatus.

b) Tap meter faces and observe indicating meter readings.

8.2.4.3 Periodic Maintenance and Inspection

a) Check calibration of protective relaying utilizing external test circuit devices at (TBD) intervals.

b) Check operation and lubricate operating mechanism of circuit breakers every 500 operations or 12 months per manufacturers instructions.

c) Check and tighten terminal board connections and megger test (high voltage insulation resistance test) wire insulation after 12 months.

d) Every 5000 operations, perform manufacturers recommended major maintenance on circuit breakers.

8.2.4.4 Accessibility

Adequate space for door opening and circuit breaker drawout and transport shall be provided. All accessible electrical equipment shall be suitably interlocked with the power circuits to prevent contact with energized parts during maintenance operations.

8.2.5 TESTING

8.2.5.1 Preoperational Tests

a) Megger all circuits at 500 volts for insulation resistance greater than 100 megohms. Disconnect or isolate sensitive electronics before meggering.

b) Megger generator and transformer insulation per the manufacturers recommendations.

c) Operate circuit breakers in test position to check functional control circuit and mechanism performance.

d) Check phase sequence of main, auxiliary, and emergency circuits.

e) Check emergency power system batteries for full charge state and for correct operation of charging circuit.

8.2.5.2 Acceptance Testing

No special tests are planned for electrical subsystem acceptance. Exercise of the CFS, HTS, PCS, and TUS subsystems will demonstrate acceptable Electrical Subsystem operation.

8.3 DESIGN DESCRIPTION

8.3.1 DETAILED SUBSYSTEM DESCRIPTION

The Electrical Subsystem (ES) shown in Figure 8.1.2-1 consists of the electrical portions of the STES from the PCS generator through the protective relaying, transformer, and circuit breaker switchgear assemblies to the parallel electrical connection with the GPC-Bleyle 480/277 volt bus. Within the Mechanical Building, the ES also includes the auxiliary power distribution to the CAIS and portions of the other STES subsystems, such as motor starter circuits.

Collector field SCS power distribution consists of 208/120 volt service through panelboard circuit breakers located at a field enclosure. Each collector has an individually fused power circuit breaker. The collector field will have a ground grid installation consisting of driven rods and bonded cable.

The backup power supply for collector defocus is provided by a natural gas fueled auxiliary AC generator.

Control and serial data link cables to each collector will consist of multi-conductor shielded cable terminating at the collector control units.

8.3.2 SUBSYSTEM PERFORMANCE CHARACTERISTICS

Performance characteristics of the ES are tabulated in the major components sections beginning at 8.3.3.

8.3.3 MAJOR COMPONENTS

8.3.3.1 Generator and Exciter

A turbine driven generator with shaft mounted, brushless exciter is provided to generate the electrical portion of the total energy output of the STES. The generator has the following characteristics for specification purposes.

Rating	500	KVA
Power Factor	0.8	
Speed	1800	RPM
Connection	WYE	4 Leads Out
Distortion	5	Percent, Maximum
Voltage	480	Volts, Line to Line, 3 Phase
Overspeed	25	Percent, Standard
Frame	OPEN	Dripproof
Exciter	2.5	Per Unit, Forcing Capability
Shaft	Keyed	Standard extension

Additionally, an oversized connection box will be supplied to house lightning arrestors, surge capacitors, and current transformers. The windings and bearings will have RTD detectors for operational and experimental temperature measurement.

8.3.3.2 Transformer

An isolation transformer will be connected in DELTA-WYE at the generator output to prevent harmonics from reaching the Bleyle Plant or Georgia Power systems. The transformer KVA rating will be the same or slightly more than that of the generator. An air insulated unit enclosed in the same metal-clad enclosure as the circuit breakers will be utilized to avoid any fire risk which could arise from the use of an oil insulated construction. The WYE connected Bleyle side will have a solidly grounded neutral with a current transformer on the neutral to detect ground fault currents.

8.3.3.3 Paralleling Circuit Breaker

An air circuit breaker will be used to connect the STES electrical system in parallel with the Georgia Power system to supply the Bleyle Plant load. The circuit breaker ratings will be:

Voltage	480	Volts, L-L, 3 Phase
Current	600	Amperes, continuous
Short Circuit	(TBD)	MVA, symmetrical
Operations	5000	Minimum, before major maintenance
Control	125	Volts DC, close and trip circuits
Construction	Drawout	NEMA 12 enclosure

Closing control of the paralleling circuit breaker will be by manual or automatic synchronizing. Tripping control will be manual, automatic, or normal shutdown and through generator or bus lockout relays in cases of protective relay operation. A cable connection serves Bleyle by paralleling with GPC at their substation through this circuit breaker.

8.3.3.4 Auxiliary Circuit Breaker

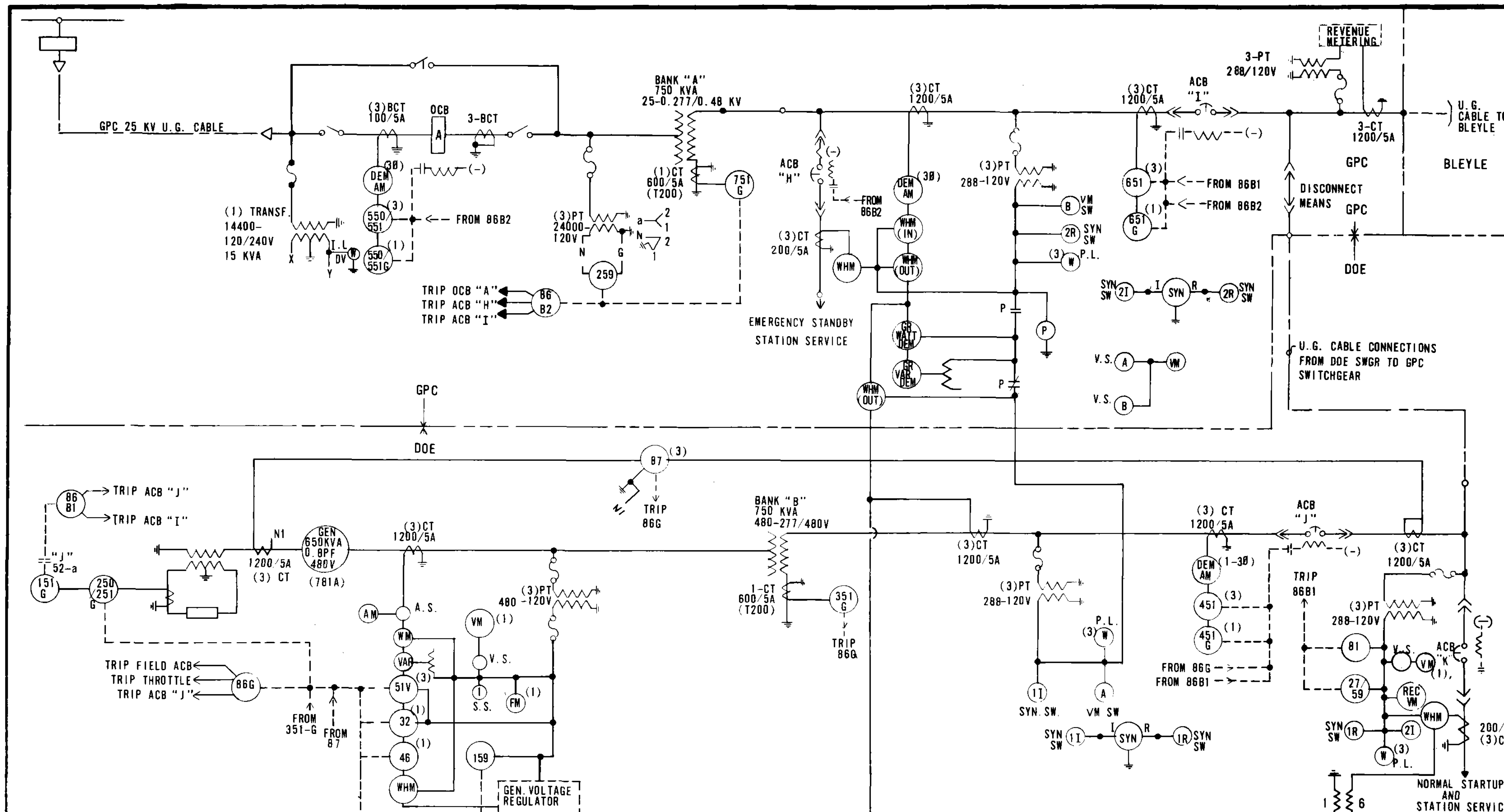
An air circuit breaker will be used to connect and provide short circuit protection to the STES station service loads. This auxiliary circuit breaker will have the same ratings as the paralleling circuit breaker and be mounted in the same enclosure structure with it and the transformer.

8.3.3.5 Protective Relaying

The STES output electrical system is protected from faults and some forms of equipment malfunction by a group of utility type relays. These devices operate from voltage and current signals through instrument transformers on the main 480 volt circuit. The instrument transformers will be installed in the enclosure housing the isolation transformer and circuit breakers, and the relays will be mounted in a separate, but similar and adjacent, NEMA 12 switchboard.

The relaying utilized operates as follows. Interface drawing E-3, Figure 8.3.3-1, has the connection points and model number of the devices

ANSI Number	Function
27/59	Detect whether paralleling bus voltage is excessively low or high as indicative of a voltage regulator malfunction and open paralleling breaker.
32	Detect power flow towards generator or motoring as indicative of a problem with the turbine control and open breakers plus shutdown turbine.
46	Detect phase unbalance as indicative of excessive unbalanced load or loss of a phase and open breakers plus shutdown turbine.
51V	Detect phase overcurrent as indicative of a line to line fault with greater sensitivity to close voltage reducing faults and open breakers plus shutdown turbine.



RELAY LIST

DEVICE NO.	QUAN.	MODEL NO. AND RANGE	FUNCTION
550/551	3	WHSE CAT #CO-9H1111N(1-12T)(6-144I)	H.S. BUOC BANK A
550/551-G	1	WHSE CAT #CO-9H1111N(1-12T)(6-144I)	H.S. BU GND BANK A
259	1	GE MOD #12IAV51D1A(16-64V)	H.S. OV RELAY
751-G	1	WHSE CAT #CO-9H1101N(1-12T)	L.S. BU GND BANK A
651	3	WHSE CAT #CO-9H1101N(1-12T)	PHASE O.C. -ACB "I"
651-G	1	WHSE CAT #CO-9H1101N(1-12T)	GND O.C. -ACB "I"
86B2	1	GE MOD #12HEA61B236(6-NO.4-NC)	AUX. LOCKOUT RELAY
27/59	1	GE MOD #12IAV69A1A(55-140V)	UNDER- & OVER-VOLTAGE
32	1	GE MOD #12GGP53B1A(0.025-3A)(1.5-30 SEC)	ANTI-MOTORING RELAY
46	1	GE MOD #12INC77B3A(WITH ALARM UNIT)	NEG. SEQUENCE RELAY
51V	3	GE MOD #12IJCV51A18A(2-8T)	VOLT RESTR PHASE O.C.
86B1	1	GE MOD #12HEA61B236(6-NO,4-NC)	AUX. LOCKOUT RELAY
86G	1	GE MOD #12HEA61B236(6-NO,4-NC)	AUX. LOCKOUT RELAY
87	3	WHSE STY #HU- #290B346A21(HU-2REST.)	UNIT DIFFERENTIAL
81	1	GE MOD #12SFF21A1A(4-80 CY)	UNDERFREQUENCY
151-G	1	WHSE CAT #CO-9L1101N(0.5-2.5T)	GEN GND -B.F. "J"
159	1	GE MOD #12IAV51A1A(55-140V)	GEN OVERVOLTAGE
250/251-G	1	WHSE CAT #CO-9L1111N(0.5-2.5T)(2-48)	GEN. GROUND
351-G	1	WHSE CAT #CO-9H1101N(1-12T)	L.S. B.U. GND-BANK B
451	3	WHSE CAT #CO-9H1101N(1-12T)	PHASE O.C.-ACB "J"
451-G	1	WHSE CAT #CO-9H1101N(1-12T)	GND O.C.-ACB "J"

SINGLE LINE ELECTRICAL LOAD INTERCONNECTION

NOTES:

1) ALL CURRENT TRANSFORMERS USED FOR RELAYING SHALL BE RATED "C" OR T200 OR BETTER.

2) STES GENERATOR AND TRANSFORMER SIZES MAY BE CHANGED SUBJECT TO GPC REQUIREMENTS. DETAILED ON DRAWING E-4.

BLEYLE MANUFACTURING PLANT, SHENANDOAH, GEORGIA

STES INTERFACE DEFINITION AND CONTROL DRAWINGS

SINGLE LINE ELECTRICAL LOAD INTERCONNECTION

date 10/20/77 | 1/25/78 | 2/8/78 | 4/7/78 | 5/1/78

HEERY & HEERY

E-3

Figure 8.3.3-1. Single Line Electrical Load Interconnection

ANSI Number	Function
86G/86B1	Lockout relays to require manual intervention after protective relay operation.
81	Detect low bus frequency as indicative of islanded system or loss of turbine control and initiate system shutdown.
87	Detect differential current across generator, transformer, and main breaker indicative of ground or phase fault and initiate system shutdown.
151G	Backup ground fault detection in case of main breaker failure. Retrips main breaker and GPC tie breaker.
159	Detect generator terminal overvoltage indicative of voltage regulator malfunction prior to synchronization plus backup on 59. Causes system shutdown on operation.
250/250G	Detect generator ground fault by level of neutral to ground current and cause system shutdown.
351G	Detect bus ground fault on Bleyle side of isolation transformer by level of neutral current and cause system shutdown. Backup 451G.
451	Detect phase overcurrent on the STES 480 volt system and cause system shutdown.
451G	Detect ground faults on bus or badly unbalanced load and cause system shutdown.

In addition to these relays, the GPC electrical system has a suitable complement of protective devices that are not part of the STES.

8.3.3.6 Auxiliary Power Distribution

A motor control center consisting of a factory assembled NEMA 12 enclosure with plug-in type combination motor starters and feeder circuit breakers will be utilized to distribute and control 480 volt auxiliary loads. Motors of greater than 373 watts

(1/2 horsepower) rating will be run at 3 phase 480 volts, and motors of 373 watts (1/2 horsepower) or less or equivalent loads will be powered at 120 volts, single phase through a step down transducer to 208/120 volts.

At least two stepdown transformers will be required: one for Mechanical Building loads and a second for collector field supply to control boxes, convenience outlets, and collector drives. Air insulated units in stand alone enclosures or core and coil units mounted inside a throat connected compartment next to the motor control center will be used.

In the collector field, the three phase circuit will connect to panelboards at the two field control boxes. Heating and cooling requirements of the electronics in these boxes and the electronics themselves will be fed 120V, 60 hertz power through separate small circuit breakers on the panelboard. Each half branch of collectors will also be single phase circuit breaker protected in order to trip only a small section of the field for electrical shorts anywhere in the system.

From the panelboards, single phase 120 volt circuits will be laid in below-grade wireway and elevated conduit to the collectors. Convenience outlets will be provided at the collector control boxes for the use of maintenance personnel. Separate fused protection for the collector control and for the outlets is provided. Collector field area lighting will be supplied by a circuit separate from the main field circuit but running in the same wireways.

8.3.3.7 Backup Power Source

The preliminary requirement for the backup power source is safe shutdown of the STES system. Rapid defocus of the entire field in the event of an AC power outage, requires a short time, instant response capability of about 129 KVA with 860 watts per collector ignoring inrush requirements. To accomplish this an auxiliary generator will provide the necessary power to drive the collector motors. This generator will have a 100 KW capacity and is connected to the collector drive motors via a transfer switch upon an AC power outage. Remote reset of the defocus circuit is required, thereby eliminating a hydraulic dump, manually set system as utilized on the Engineering Prototype Collector.

8.3.3.8 Field Control and Signal Wiring

Each collector will be connected to its field control box by a multi-conductor, shielded pair cable. The branch flow control valves will have a similar cable connection with fewer pairs. Industrial plug connectors will be used on both ends of each control cable. Cable routing is in the same wireway as, but separated from, the power cables.

The high speed serial data interface connection between the field control boxes and the main control minicomputer will utilize twisted pair shielded cable. All electronic connections will require transient protection from induced surges due to nearby lightning ground strokes.

8.3.3.9 Grounding and Lightning Protection

Grounding rods and interconnection to establish a field earth-to-ground resistance of less than five ohms will be provided to conduct any field lightning strikes to earth in a controlled manner.

These grounding rods will be copperclad steel of 3/4" in diameter and 10 feet in length. They will be located along the perimeter of the site, mechanical building and collector field. Also, grounding rods will be located within the collector field. All grounding rods will be interconnected forming a ground grid network. Major equipment and storage tanks in the mechanical room will be connected to the ground grid network. All perimeter collectors and selected interior collectors will be grounded via the gird network.

RETURN ORIGINAL TO E. J. NEY BLDG 260 2ND FLOOR

"TELECOPY TO R. W. HINKE" - 505-264-8847 SANDIA LABS DIVISION 4725

PAGES 1068 or 7091 VERIFICATION 3917

PHONE CHARGE - 017-4007-035

SOLAR TOTAL ENERGY PLANT ESTIMATE

NOTES AND ASSUMPTIONS

The cost estimate for the Solar Total Energy Plant was prepared from input by the Georgia Power Company Solar Energy Team. A Code of Accounts was established for estimate and schedule presentation. The method of preparation will allow for a smooth interaction with the computerized Cost System.

The following assumptions form the basis for the estimate:

A. Design will be complete when construction begins and equipment will be delivered to conform to the construction schedule need dates.

B. Construction is to begin in October, 1979.

C. For the purposes of the estimate, the Phase III Preliminary Design Report is the base document.

D. For the purposes of the estimate, construction work will be by a union prime contractor. (Atlanta base union rates)

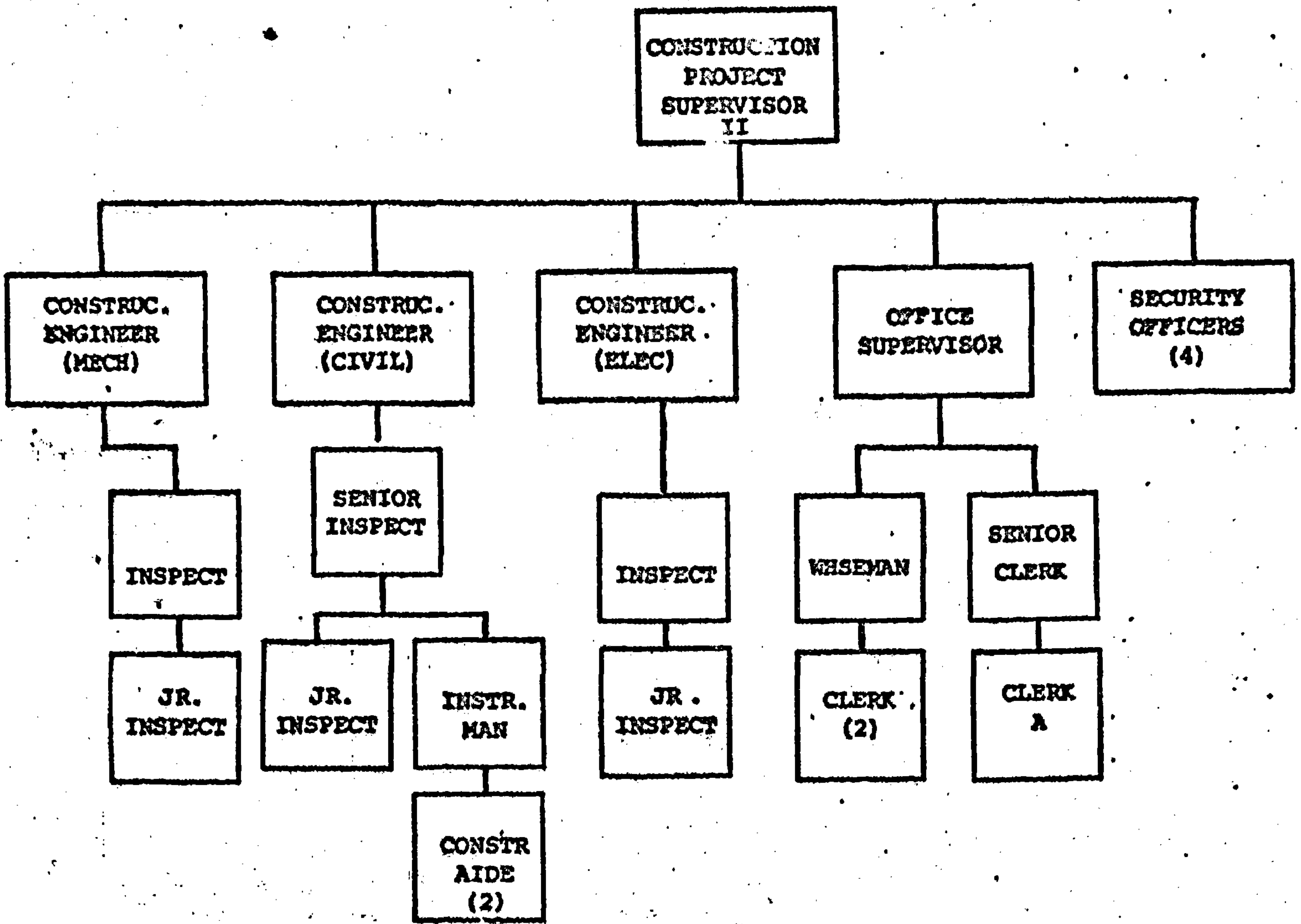
E. Construction equipment will be provided by Georgia Power Company. Concrete will be brought in by truck.

F. Commercial operation will be March, 1981. This means the 15 week checkout proposed by General Electric should be complete by that date.

G. Two year operational testing will begin in March, 1981.

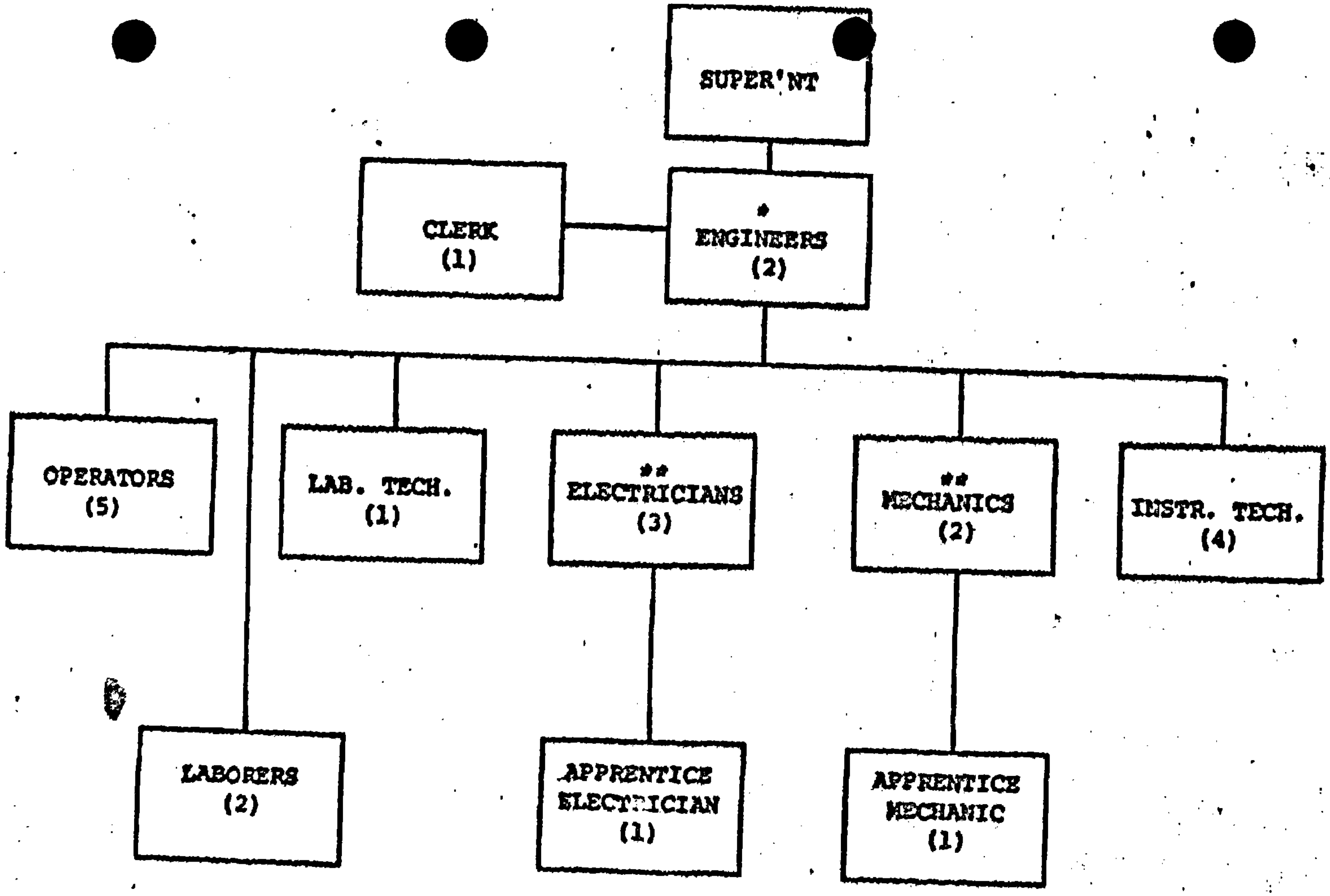
The following cost items are not included in the estimate:

A. Engineering
B. Land cost
C. Rough grading with catch basins
D. Initial grassing
E. Temporary services up to the property line.
F. AFUDC (not required due to payment plan)
G. Ad valorem tax (not required due to Georgia constitutional amendment.)



SOLAR ENERGY PLANT

CONSTRUCTION ORGANIZATION



* *Will function as shift supervisors*

** *Only one will be required after start-up*

SOLAR ENERGY PLANT START-UP AND POWER GENERATION ORGANIZATION

MARCH, 1979

SOLAR TOTAL ENERGY PLANT
COST ESTIMATE

SUMMARY

Shipping – 104,610
GA Matslo 228400
CONST. MAN. 388,207
TEMP FAC 95,505
SPARES 97,548
914,270

SYSTEM	DESCRIPTION	DOLLARS 1979	1980	1981	1982	1983	TOTAL
00	Construction Clearing Accounts	1,910,000	1,587,600	1,287,400	1,196,200	202,800	6,184,000
10	Site Work	151,600	121,500			* 579,135	273,100
20	Mechanical Building	25,900	187,900			122,189	~~187,900~~ 213,800
25	Control Room		15,300			—	15,300
30	Power Conversion System	16,100	940,300			717,675	956,400
40	Solar Energy Collection System	177,000	4,120,400			4,838,940	4,297,400
50	Thermal Utilization System	7,700	456,000			217,675	463,700
60	High Temp. Storage System	81,300	1,416,200			1,074,038	1,497,500
70	Electrical System	4,000	781,700			323,833	781,700
80	Control System		701,800			657,339	701,800
	TOTAL WITHOUT CONTINGENCY	2,373,600	10,328,700	1,287,400	1,196,200	202,800	15,388,700
00	Contingency	246,000	1,164,000				1,410,000
	TOTAL SOLAR TOTAL ENERGY PLANT	2,619,600	11,492,700	1,287,400	1,196,200	202,800	16,798,700

* HAND NUMBERS FROM GE COSTS.

ARCH, 1979

SOLAR TOTAL ENERGY PLANT
COST ESTIMATE

STEM	SAC	DESCRIPTION	1979	1980	1981	1982	1983	TOTAL
					DOLLARS			
00	--	Construction Clearing Accounts						
	000010	Contingency						
		Spare Parts		150,000				150,0
	002000	Contract Costs						
		Contractor Fee	117,800	309,500	8,400			435,7
		Management Fee	90,000	360,000	360,000	360,000	60 ,000	1,230,0
	004500	Production Operation			669,800	831,600	142 ,000	1,643,4
	004700	Production Start-up	20,300	274,000	112,400			406,7
	010400	Warehouse Operation	14,400	43,000	5,400			62,8
	012100	Construction Office	53,000	(40,000)				13,0
	012200	Construction Warehouse	170,100	(120,000)				50,1
	016000	Site & Bldg Maintenance	6,900	27,900				34,8
	006000	Construction Equipment	983,500	(753,700)				229,8
	008000	Small Tools	66,900	133,800				200,7
	Various	Temporary Services	83,700	334,400				418,1
	022100	Guard Services	29,600	52,800	9,400			91,8
	025100	Project Management	109,700	193,200	61,700			364,6
	028000	Outside Engineering	24,900	25,100				50,0
	030100	Field Supervision	123,600	342,300	55,500			521,

SYSTEM	SAC	DESCRIPTION	1979	1980	1981	1982	1983	TOTAL
00	--	Construction Clearing Accounts (continued)						
	036000	Construction Insurance	3,400	200,000				203,400
	048100	General Administration	12,200	55,300	4,800	4,600	800	77,700
*00	--	Subtotal/Construction Clearing Accounts	1,910,000	1,587,600	1,287,400	1,196,200	202,800	6,184,000

SYSTEM

00 Construction Clearing Accounts

These accounts are provided to cover the field and overhead expenses for the construction of the Solar Total Energy Plant. Included are expenses for production, field supervision, temporary facilities contract costs and administration.

Contingency (000010)

5% Scope Contingency
5% Budget Contingency
2.5% Spare Parts Contingency (calculated on all equip. includes 4 spare collectors)

Contract Costs (002000)

10% Fee on labor and contractor supplied materials
-- Management Fee — 9%

Production Operation (004500)

4 Staff personnel for 2 years
19 Operations personnel for 2 years
10,260 Gal make-up Syltherm 800 oil
Utilities for 2 years

Production Plant Start-up Test (004700)

14 People for 15 weeks to perform the following start-up tests:

004701 - DC Battery
004702 - Starting Station Service
004703 - Service Water Supply
004704 - Service and Control Air
004705 - Computer and Control Console
004706 - Nitrogen System
004707 - High Temperature Storage
004708 - Fossil Fired Heater
004709 - Steam Generator Supply
004710 - Solar Collector Field
004711 - Demineralizer and Condensate Make-up
004712 - Condensate System
004713 - Feedwater System
004714 - Steam Generator
004715 - Process Steam System
004716 - Thermal Utilization Subsystem
004717 - Steam Turbine Generator

4 Staff personnel for 1 year

Warehouse Operation (010400)

4 Warehouse persons for 18 months

SYSTEM

00 Construction Clearing Accounts (continued)

Construction Office (012100)

2 ea - 24 X 60 double wide trailers (3,000 sf) including HVAC, lighting, furniture, various appurtenances and concrete anchors.

53
-40

Construction Warehouse (012200)

7,500 sf - Prefab structure including heating, roll-up door and various appurtances.
186 cy - Concrete slab

170
-120

Site and Building Maintenance (016000)

2 People for 15 months

Construction Equipment (006000)

Buy: 4 ea - Pick-up trucks
1 ea - 10 ton forklift
2 ea - 2½ ton flatbed dump truck
1 ea - Mechanics tool truck
1 ea - 18 ton hydraulic crane
1 ea - Front-end loader
1 ea - 50 ton crane (rubber-tired with 100 ft boom)
1 ea - Hydraulic backhoe (track mounted)
1 ea - Hughes LL caisson drill rig

220

Maintenance: 3 men for 15 months

Small Tools (008000)

To support contractor requirements

200,000

Temporary Services, including:

Temporary Welding (018200)
Temporary Communications (018300)
Temporary Power (018400)
Temporary Air (020200)
Temporary Water ((020300)
Temporary Sewage (020400)

400,000
35000
misc based on experience

SYSTEM

00 Construction Clearing Accounts (continued)

Guard Services and Equipment (022100)

91,800

4 people for 20 months
1 ea 10 X 10 guard house

Project Management Salaries and Expenses (025100)

6 People for 20 months:

364,600

Project Manager (1)
Assistant (1)
Procurement (1)
Cost and Scheduling (1)
Clerk/Steno (2)

Outside Engineering (028000)

50,000

Concrete testing consultant

Field Supervision and Expenses (030100)

20 People for 18 months:

521,200

Construction Manager (1)
Disciplines (14)
Planning & Budget (1)
Field Office (3)
Quality Control (1)

Construction Insurance (036000)

Wrap-up and all-risk insurance

General Administration (048100)

Allocation by Georgia Power Accounting

GENERAL ELECTRIC

GENERAL ELECTRIC COMPANY . . . . VALLEY FORGE SPACE CENTER
KING OF PRUSSIA PARK, P.O. BOX 8661, PHILADELPHIA, PENNA. 19101. . .TEL (215) 962-2000

SPACE DIVISION

SPACE SYSTEMS OPERATIONS

In reply please refer to
Ref No. 78-STE-0149

October 2, 1978

To : Recipient on Controlled Distribution

Subject : Transmittal of Document No. 78SDS4234

Enclosed for your use and maintenance is a controlled copy of the original issue of the System Description Document (General Electric Space Division Document No. 78SDS4234, dated July 10, 1978) for the Solar Total Energy System for the Large Scale Experiment at Shenandoah, Georgia. Document recipients on controlled distribution are listed on page iii of the document. As changes are made to the contents of the document, alteration pages and/or sections will be sent to each recipient on the controlled distribution list.

Please contact me if you have any questions etc. on this Document. Also, if you do not want changes to the controlled distribution list, or want to transfer your copy, please let me know.

Sincerely yours,

A. J. Poche, Program Manager
Solar Total Energy-Large Scale Experiment
at Shenandoah, Georgia
Rm. 7246, CC&F 7
(215) 962-4934

encl.

DOCUMENT NO. 78SDS4234
DATE: JULY 10, 1978
ORIGINAL ISSUE

SOLAR TOTAL ENERGY - LARGE SCALE EXPERIMENT AT SHENANDOAH, GEORGIA

SYSTEM DESCRIPTION

DEPARTMENT OF ENERGY
CONTRACT NUMBER EG77-C-04-3985

GENERAL ELECTRIC
SPACE DIVISION

System Description Document
Document No. 78SDS4234

Revision Record

Rev.	Date	Changes	Pages Affected	Approval

Controlled Distribution - External to Valley Forge

Organization	Location	Attention	No. of Copies
U.S. Department of Energy	Germantown, Md.	J. Rannels M. Resner	1 1
U.S. Department of Energy (Albuquerque Operations Office)	Albuquerque, N.M.	D. K. Nowlin G. N. Pappas	1 1
Sandia Laboratories	Albuquerque, N.M.	R. W. Hunke (5722) G. S. Kinoshita (5722) J. C. Zimmerman (5722) Tech. Library Systems and Reference Division (3144)	1 1 1 1
Georgia Power Company	Atlanta, Ga.	W. Hensley	1
Heery and Heery, Architects and Engineers	Atlanta, Ga.	B. Cruickshank	1
General Electric Company - Ground Systems Department	Daytona Beach, Fla.	D. Zubas	1
General Electric Company - MATSCO	King of Prussia, Pa.	M. Bongiovanni	1
General Electric Company - Energy Systems Programs Department	Schenectady, N.Y.	A. Schnacke	1
Lockwood-Greene, Architects and Engineers	Atlanta, Ga.	R. Bercik	1
General Electric Company - Advanced Energy Programs	Evendale, Ohio	M. Marvin	1

PREFACE

The Solar Total Energy Program (STEP) is a separate activity of the National Solar Electric Applications Program and is supported by the U.S. Department of Energy. During the program, a series of solar total energy systems is planned which will be designed, constructed, and operated to provide electricity and thermal energy to localized users such as Government and institutional facilities, apartment houses, shopping centers, and industrial and commercial plants, buildings, and complexes. The overall purpose of these energy systems is to demonstrate the high potential that solar energy offers for total energy systems, to develop a solar-oriented technology compatible with the high temperature demands of electric power conversion via thermodynamic cycles, and to provide the stimulus required so that private industry will aggressively participate, both as manufacturers and users.

The first industrial application of the solar total energy concept has been initiated as a cooperative venture of the U.S. Department of Energy and the Georgia Power Company. The Solar Total Energy - Large Scale Experiment (STE-LSE) project consists of the design, construction, operation, and technical evaluation of a solar total energy system providing power to a knitwear factory operated by Bleyle of America, Inc. The preliminary design phase of the project is currently underway, with the final design to be completed in the third quarter of 1979. The factory, initially equipped with its own independent (conventional) energy source, will derive greater than 60 percent of its annual energy needs from the sun when the solar energy system becomes operational in the first quarter of 1981.

The site for the STE-LSE is located in the industrial park of Shenandoah, Georgia, which is about 25 miles south of the Atlanta airport on U.S. highway I-85. The land has been provided by Shenandoah Development, Inc., and exclusive use of the land will remain with the U.S. Government for the term of the agreement. The General Electric Company/Space Division has been selected as the designer of the DOE funded and owned solar total energy system. Sandia Laboratories is the DOE technical manager for the STE-LSE project.

The objectives of the Large Scale Experiment at Shenandoah include the following:

- To obtain experience with hardware on large scale solar energy systems.
- To establish an industrial engineering capability for subsequent large scale solar total energy demonstration projects.
- To reduce the uncertainty of cost and performance estimates for large solar projects.
- To disseminate information on solar total energy systems.

- To design a system large enough to encounter the problems of a full-scale demonstration and to be scalable to higher power levels.

- To utilize all collected solar energy in a cost-effective manner.

Under terms of the cooperative agreement, the Georgia Power Company and DOE share site costs on a 50-50 basis for those activities of common interest. Additional services are provided to DOE by Georgia Power and their participants on a reimbursable basis. Member organizations of the Georgia Power team and their activities include:

- Shenandoah Development, Inc.
  Developer and factory building owner

- Georgia Institute of Technology
  Solar consultation to Georgia Power

- Heery and Heery, Inc.
  Site architectural and engineering liaison services

- Owners - Corning Fiberglass
  Energy conservation services

- Westinghouse Electric Corp.
  Site liaison.

The General Electric Company, Space Division (GE/SD) was selected by DOE following a competitive conceptual design phase as the subcontractor to design, fabricate, install and operate the DOE funded and owned STES for the Shenandoah Large Scale Experiment. GE/SD has engaged the following organizations as members of the STES team:

- GE Energy Systems Technology Division
  Steam system analysis and component selection

- GE Management and Technical Services Company (MATSCO)
  Hardware procurement and site construction management

- GE Ground Systems Department
  Control system design and analysis

- Lockwood-Greene
  Engineering and architectural design.

Sandia Laboratories, Albuquerque, N.M., is DOE's technical manager for the STE-LSE. This Large Scale Experiment is an outgrowth of research started in 1972 by Sandia.

TABLE OF CONTENTS

TABLE OF CONTENTS (Continued)

TABLE OF CONTENTS (Continued)

TABLE OF CONTENTS (Continued)

TABLE OF CONTENTS (Continued)

TABLE OF CONTENTS (Continued)

TABLE OF CONTENTS (Continued)

LIST OF ILLUSTRATIONS

LIST OF ILLUSTRATIONS (Continued)

LIST OF TABLES

LIST OF ACRONYMS

ACRONYM	DEFINITION	FIRST SECTION
A/D	Analog to Digital (Converter)	4.3.4.3.3
AAC	Absorption Air Conditioner (or Conditioning)	6.2.1
AISC	American Institute of Steel Construction	3.11.1
ANSI	American National Standards Institute	3.11.1
ASME	American Society of Mechanical Engineers	3.11.1
ASHRAE	American Society of Heating Refrigeration and Air Conditioning Engineers	2.1.1
BIL	Base Insulation Level	8.3.3.9
CFR	Code of Federal Regulations	3.11.1
CFS	Collector Field Subsystem	7.2.3.1.1
CIS	Control and Instrumentation Subystem	2.1.2.4.1
CPU	Central Processing Unit	7.3.3
DEC	Digital Equipment Cooperation	7.3.1
DMA	Direct Memory Access	7.3.31
EMF	Electromotive Force (Voltage)	4.3.4.2.3
ES	Electrical Subsystem	8.0
GFE	Government Furnished Equipment	2.1.2.2
GPC	Georgia Power Company	3.1
HTS	High Temperature Storage	2.1.2.1
HUD	Housing and Urban Development (Administration)	2.2
HVAC	Heating, Ventilating and Air Conditioning	2.1.1
ICD	Interface Control Drawing	3.4.2
IES	Independent Energy Sources	3.2
I/O	Input/Output	7.3.3
LTS	Low Temperature Storage	6.1.1
MEA	Mechanical Equipment Area	2.1.2.1
MOS	Metal Oxide Semiconductor	7.3.3.1
MSY	Mean Solar Year	Fig. 4.3.3-8

LIST OF ACRONYMS (Continued)

ACRONYM	DEFINITION	FIRST SECTION
NEMA	National Electrical Manufacturers Association	3.11.1
NFPA	National Fire Protection Association	3.11.1
NPSH	Net Pump Suction Head	4.4.1.1
ODT	On-Line Debugging Technique	7.3.3.2
OSHA	Occupational Safety and Health Administration	3.11.1
PCS	Power Conversion Subsystem	2.1
P&ID	Piping & Instrumentation Diagram	6.1.2
PSW	Processor Status Word	7.3.3.2
RAM	Random Access Memory	7.3.3.2
RMS	Root-Mean-Square	4.3.3.1
ROM	Read Only Memory	7.3.3.2
RTD	Resistance Temperature Detector	4.2.5.3
SCS	Solar Collection Subsystem	2.1
SDI	Shenandoah Development Incorporated	2.2
SGS	Steam Generator Supply (Subsystem)	4.3.1.3
STE-LSE	Solar Total Energy - Large Scale Experiment	Preface
STEP	Solar Total Energy Program	Preface
STES	Solar Total Energy System	2.1
TBD	To Be Determined	
TEMA	Tubular Exchanger Manufacturers Association	3.11.2
TES	Thermal Energy Storage	2.1.2.4.1
TIG	Tungsten Inert Gas	4.3.1.1
TUS	Thermal Utilization Subsystem	2.1

SECTION 1

SECTION 1

INTRODUCTION

This document presents the description of the preliminary design for the Solar Total Energy System (STES) to be installed at the Shenandoah, Georgia, site for utilization by the Bleyle knitwear plant. Thus, the document is intended to be a comprehensive technical manual that explicitly defines the requirements and the design features and characteristics of the individual subsystems and components which comprise the Solar Total Energy System for the Large Scale Experiment.

While this first issue of the document presents the preliminary design of the STES, the document will be updated periodically to reflect changes in the design along with associated subsystem and component characteristics as the design progresses to and includes the final system configuration. To facilitate the record of the changes made and to identify the current revision in effect, a Revision Record page is included after the title page. Pages or sections will be updated as appropriate to the design status, and copies of the revised pages will be distributed to the recipients of the document (i.e., those individuals on the controlled distribution list for STE-LSE, Shenandoah).

Section 2 of the document first presents a general description of the energy system along with the location and site description. The Large Scale Experiment objectives are listed also. The system design criteria and requirements are presented next in Section 3. Included in this section are the performance criteria and operating requirements; environmental conditions of operation; interface requirements with the Bleyle plant and the Georgia Power Company lines; maintenance, reliability, and testing requirements; health and safety requirements; and other applicable ordnances and codes. The remaining sections of the document describe the major subsystems of the STES. Section 4 presents the Solar Collection Subsystem (SCS), Section 5, the Power Conversion Subsystem (PCS), and Section 6, the Thermal Utilization Subsystem (TUS). The Control and Instrumentation Subsystem (CIS) is described in Section 7, and the Electrical Subsystem (ES), in Section 8. Each of these sections include design criteria and operational requirements specific to the subsystem, including interface requirements with the other subsystems, maintenance and reliability requirements, and testing and acceptance criteria. The detailed description of the subsystem is presented along with pertinent performance characteristics. Major components of each subsystem are described in more detail. Specific features of the control and instrumentation provisions for the subsystem are discussed, and subsystem operational modes are described.

SECTION 2

SECTION 2

SYSTEM DEFINITION

2.1 SCOPE

A Solar Total Energy System (STES) is defined as an energy system which uses collected solar energy to supply high grade (electrical/mechanical) and low grade (thermal) energy needs for selected applications. The basic function of the STES at Shenandoah is to supply the electric power, process steam, and heating and cooling demands of the expanded 3900 square meters (42,000 ft^2) Bleyle Plant.

Figure 2.1-1 presents an artist's concept of the Shenandoah LSE site and system. The STES design is essentially composed of three hydraulic loops or subsystems which transfer the collected solar energy into the appropriate energy forms required by the Bleyle Plant and a central control subsystem which monitors and controls the overall system operation.

The Solar Collection Subsystem (SCS) utilizes a series of hydraulic circuits which transport the collected solar energy from the collector field either to the high temperature storage or directly to the steam generator to the Power Conversion Subsystem (PCS). In the PCS, electrical power is produced by a dual steam turbine-generator, while steam for process use is extracted from the rear of the first turbine to simulate operation of an extraction turbine likely to be used in larger commercial-size applications. The Thermal Utilization Subsystem (TUS) utilizes another series of hydraulic circuits to transport the heat rejection energy from the PCS to the low temperature storage or directly to the space heating and cooling units.

2.1.1 SITE LOADS

As a total energy system, the STES has been designed to serve all of the loads on the site and sized to supply at least 60 percent of the expanded 3900 square meter (42,000 square foot) Bleyle Plant loads with solar energy consistent with the overall experiment objectives stated in the Preface. The site loads include the Bleyle Plant electric loads and STES operating power and power for the STES Mechanical Building, process steam to the Bleyle Plant used for pressing fabric, and heating and cooling for both the Bleyle Plant and the STES Mechanical Building. The design electric loads used to size the STES generator are summarized in Table 2.1.1-1. In normal operation, the site electric load will not exceed 400 kW. To accommodate load fluctuations and to provide a better match with the site thermal loads, the STES operates with a 100 kW base load from the utility, and electric load follows between 200-300 kW in normal operation. Except for lunch and shift breaks, the plant electric load profile is relatively constant over the two shift operation as shown in Figure 2.1.1-1.

The plant's process steam demand is currently supplied by a natural gas fired boiler. Process steam at saturated conditions is required during all working hours, with the design profile shown in Figure 2.1.1-2.

The design cooling loads, based on ASHRAE design conditions, are summarized for the Bleyle plant and STES Mechanical Building in Table 2.1.1-2. The cooling loads consist primarily of internal heat generated by the process and building lighting and are relatively constant during plant operating hours. However, the plant heating, ventilating, and air conditioning (HVAC) system incorporates an economizer cycle which supplies a major portion of the internally generated cooling load from December to February. To provide a more optimum site thermal-to-electric load ratio for the STES, the cooling loads are served by a chilled water system supplied by an absorption chiller.

The maximum site heating load is 1.64×10^5 J/s (559×10^3 Btu/hr) which would occur if the design outdoor ambient temperature occurred when the plant was not in operation and with the system supplying maximum ventilation to the Bleyle plant.

2.1.2 OVERALL SYSTEM DESCRIPTION

The system is a fully cascaded total energy system design as shown in the Figure 2.1.2-1 schematic, featuring high temperature paraboloidal dish solar collectors with a 235 concentration ratio, a steam Rankine cycle power conversion system capable of supplying 200-400 kW(e) output with an intermediate process steam take-off point, and a back pressure condenser for heating and cooling. The design also includes an integrated control system employing the supervisory control concept to allow maximum experimental flexibility.

2.1.2.1 Solar Collection Subsystem

The Solar Collection Subsystem consists of an array of 192 seven-meter diameter, parabolic dish collectors, which provide a 139°K (250°F) temperature rise to a flow of Syltherm 800 fluid through each collector in a series/parallel arranged, closed, hydraulic circuit. The design collector output temperature is 672°K (750°F). The receiver is a cavity type with the incident concentrated solar flux impinging upon an absorptive surface enclosed within an insulated cylindrical shell. The parabolic dish design, Figure 2.1.2-2, is based on a low-cost five meter antenna which Scientific-Atlanta supplies for communication/Earth station applications. As seen from the figure, the dish is made up of individual petals which are die-stamped aluminum, and the entire assembly is field assembled. The aluminum is polished, and a weather surface is applied to allow maintenance of reflectance in the range of 0.88. The unit tracks individually in polar and declination axes.

The field piping network consists of field welded steel tubing covered with high temperature insulation. The parabolic dish collectors are arrayed on the Shenandoah collector field in a repeating diamond pattern (Figure 3.1.2-3). The spacing is optimized to provide maximum annual field energy output from the 20,016 square meter (4.95 acre) site for the collector field and Mechanical Equipment Area (MEA).

The trickle oil concept was selected for the High Temperature Storage subsystem (HTS). This concept offers a low-cost solid storage medium for essentially all heat storage, thus reducing to a minimum the inventory of high-cost heat transfer oil. Sand is not necessary to fill voids between the solid medium pieces to reduce the fluid volume, so the filtration and cleaning of sand throughout the system is not required. Figure 2.1.2-4 presents a schematic diagram that shows the major components of a large trickle oil storage tank. The system includes manifolds for the backup dual-media approach.

Storage heat is either charged or discharged by trickling oil over a cold or hot storage bed, and the heat is transferred by a thin film of oil trickling over the taconite solid medium. A drain plate is used to collect the oil into a sump area at the bottom of the tank. The preliminary design for the STE-LSE at Shenandoah has $1.0^5 \times 10^{11}$ joule (100 MBtu) capacity stored in four tanks, one to provide one hour of system operation at full load, 4 meters in diameter and 3.7 meters high (13 feet in diameter, 12 feet high) and the remaining three together to provide a storage capacity adequate for holding the energy collected in the summer over the weekend, 6.3 meters in diameter and 4.9 meters high (20.6 feet in diameter, 16 feet high). During operation of the trickle oil storage system, flow is always into the top of each compartment, whether charging or discharging. A series of flow control valves and thermal switches direct the flow to the desired tanks.

The Solar Collection Subsystem also includes a fossil fired heater capable of supplying the full PCS heat input requirement when the HTES is depleted.

2.1.2.2 Power Conversion Subsystem

The Power Conversion Subsystem consists of a three piece pool-type boiler with preheater, boiler, and superheater, a steam turbine-generator set rated at 400 kW(e) supplied by Mechanical Technology, Inc as Government Furnished Equipment (GFE), a condenser and condensate storage tank, make-up demineralizer, deaerating heater, and boiler feed pump. The components are shown schematically in Figure 2.1.2-5. In normal operation, steam at 655°K (720°F) and 4.8×10^6 N/m^2 (700 psig) is generated in the boiler-superheater, heated by Syltherm 800, and delivered to the turbine inlet. The turbine generator set consists of two high speed (42,450 rpm) turbines coupled to a gearbox which reduces the speed to the 30 rev/s (1800 rpm), 60 Hz alternator. The back of the first turbine has a take-off for process steam and steam for regenerative feed water heating. The second turbine operates into a condenser at 383°K (230°F) to provide 372°K (210°F) water to the Thermal Utilization Subsystem. Steam make-up is preheated to 383°K (230°F) by being introduced as a spray into the condenser.

2.1.2.3 Thermal Utilization Subsystem

The Thermal Utilization Subsystem major components include a 2.1×10^{10} joule (20 MBtu) capacity sensible heat low temperature water storage system, a 12.5×10^5 J/s (354 ton) absorption chiller derated to provide 6.1×10^5 J/s (173 tons) with inlet hot water at 372°K (210°F), and two separate cooling towers for heat rejection from both the absorption chiller and the PCS condenser. The storage system is available to supply heating or cooling loads when the PCS is not operating such as at night or on weekends. The full system capacity, sized for a 11°K (20°F) temperature differential, is contained in a single tank 9.8 meter (32 feet) in diameter by 6.1 meter (20 feet) high. The absorption chiller and cooling towers are standard off-the-shelf items which will not require design modifications. The absorption chiller has self contained controls to sense load variations and will supply chilled water directly to the Bleyle Plant piping system. The system will have the capability to supply heating to the office areas and cooling to the plant process areas simultaneously.

2.1.2.4 System Operation & Control

2.1.2.4.1 Basic Operating Philosophy

The Control and Instrumentation Subsystem (CIS) design allows maximum operational flexibility of the LSE system. Six modes of operation are defined

- Normal
- Experimental
- Diagnostic
- Fail Safe
- Degraded
- Maintenance

In the normal mode of operation, the control system will initiate collector tracking, energy storage, electrical power generation, and auxiliary air conditioning or heating. The electrical requirements of the Bleyle Plant will be monitored and sufficient power generated to supplement the base load supplied by Georgia Power Company. On weekends and during periods of lower power demand, energy will be stored for later use.

A switch to alternate modes will allow the operator to initiate solar collection experiments, monitoring, and recording experimental data as needed. The operator may initiate computer stored diagnostic routines in the event of a malfunction. The critical components of the system are fail-safed to prevent damage during power or primary control failures or over temperature conditions. Finally, the system will be operational in a degraded mode when certain components, such as a collector branch, are not available due to routine maintenance or component failures.

Control of the solar collectors will be achieved via four micro-processor control units in the collector field. Coarse solar tracking will be provided by a computer stored algorithm during start-up and coast, with fine tracking provided by an optical feedback control loop. The temperature of the fluid at each receiver will be monitored and branch fluid flow rate adjusted to achieve the desired fluid temperature. Automatic defocus will activate should the fluid in any collector receiver exceed a safe temperature. Automatic stowing will actuate if necessary to protect a collector under adverse climatic conditions.

The high temperature thermal energy storage (TES) subsystem will be carefully monitored with level and temperature sensors to determine charge and discharge readiness. The Sylthem 800 fluid will be routed according to the TES status. Additionally, if the system is fully charged and no additional energy can be handled, collector stowage will automatically occur to prevent fluid over-temperature. A micro-processor control unit will be dedicated to the TES to interface with the central control console.

The Power Conversion Subsystem incorporates the steam generation plant (boiler) and the steam turbine/generator. This subsystem is also under control of a dedicated micro-processor. Automatic start-up/shut-down sequences as well as built-in protection functions are an inherent part of this equipment. The electrical requirements of the knitwear factory will be monitored and generator output moderated according to need.

Heat to the Thermal Utilization Subsystem is provided by means of a fluid coolant loop from the PCS condenser. The control system will provide coolant flow and temperature control to maintain the PCS condenser pressure and temperature. The absorption air conditioning and hot water heating system will respond to the requirements of the Bleyle Plant as well as the STES Mechanical Building. A micro-processor control unit will provide control and monitor functions for this system.

2.1.2.4.2 Control System Design

The Control and Instrumentation Subsystem is comprised of a central control console, the central mini-computer, and seven micro-processor control units. The operator shall have the capability to monitor and control basic system functions from the control panel. All other detailed monitored and controlled functions will be via the computer keyboard and CRT (Cathode Ray Tube) interface. Monitored data will be recorded from experiments, alarms, and normal operation on magnetic tape storage and in hard copy form on the computer line printer. Signal conditioning circuitry will be provided as needed in the remote control units. The remote micro-processor will be programmable from the central mini-computer to allow a high degree of system control and monitor flexibility.

2.1.3 SYSTEM PERFORMANCE

For the system design of 192 seven-meter diameter dishes and $1.0^{5} \times 10^{11}$ joule (100 MBtu) of high temperature storage capacity, direct solar contribution to the plant loads includes an estimated 33 percent of the annual electrical energy requirements, 62 percent of the process steam required, and 89 percent of the energy required to drive the absorption air conditioning system. If air conditioning is considered as part of the electric load, then STES provides fifty percent of the plant non-thermal loads while on solar operation. This results in an annual solar replacement of 65 percent. Remaining low grade 372°K (210°F) thermal energy may be used to supply part of the hot water requirements for other nearby applications. On cloudy days, after solar energy is expended, the total energy sytem can be operated on the fossil heater. The system thus has the capability to supply the full plant loads on-site.

2.2 LOCATION AND SITE DESCRIPTION

The proposed Solar Total Energy - Large Scale Experiment will be located in Shenandoah, Georgia. Shenandoah is a new town near Newnan, Georgia about 40 kilometers (25 miles) southwest of Atlanta as shown in Figure 2.2-1. This new community is being developed by Shenandoah Development Incorporated (SDI) which was established in 1969 by Unioamerica-Incorporated. Approximately 30 square kilometers (7,400 acres) are currently being developed by SDI.

The site that was made available by SDI for the proposed total energy facility is defined in Figure 2.2-2 (Plat I). It consists of approximately 23,150 square meters (5.72 acres) of gently sloping land. As depicted in Figure 2.2-3, the site is near the intersections of Interstate 85 and Georgia Highway 34. The site is connected to Newnan by Georgia Highway 34 and Atlanta by Interstate 85. The Bleyle knitwear plant is located along the west property line of the development.

Access to the Bleyle facilities will be via Amlajack Boulevard. The property adjacent to the north boundaries of the Bleyle facility/STES site is neither owned nor controlled by SDI. Located near the northeast corner of the collector tract is a parcel of land measuring 15 meters by 44 meters (50 feet x 143 feet). This property is owned by the Housing and Urban Development Administration (HUD) and is designated as a green area. Green areas are intended to be land which will never be developed. However, the HUD property can be modified to control erosion at the STES site, if required.

Positioned directly south of the site on a parcel of land with a peak elevation of 296 meters (970 feet) is a 3785 cubic meter (1,000,000 gallon) water tower. The height of the water tower is approximately 51 meters (166 feet). SDI owns and operates the water facility.

Located on the STES site itself are two man made structures. The first is a meteorological station on a 6 meter by 6 meter (20 ft. by 20 ft.) concrete pad. This station will eventually be dismantled and repositioned on top of the STE-LSE mechanical building to record data in conjunction with STE-LSE operations. The second structure is a 0.2 meter (8 inch) concrete sanitary sewer line. The concrete pipe is located approximately 2.7 meters (9 feet) below the existing grade elevation. Service to the sewer is via two manholes located on Figure 2.2-2. It should be noted that the sanitary sewer has a three meter (10 feet) easement and that manhole elevations will need to be adjusted to any changes in surrounding ground elevations.

All other lands that adjoin the collector boundary line are owned by SDI. SDI has plans to install a road southeast of the site to provide access to Amlajack Boulevard. Since the region between the collector field and Amlajack Boulevard has not been assigned to a third party by SDI, the exact position of the road is not final. The land in this area will be graded in conjunction with STE-LSE site preparation. This will reduce the potential for shadowing the solar collector field and thus enhance system performance.

2.3 EXPERIMENT OBJECTIVES

Specifically stated, the experiment objectives are to:

a) Develop within industry the engineering and development experience on large scale solar total energy systems for subsequent demonstration projects.

b) Assess the interaction of solar energy technology with the application environment.

c) Narrow the prediction uncertainty of the cost and performance of solar total energy systems.

d) Expand solar engineering capability and experience with large-scale hardware systems.

e) Disseminate information on solar total energy.

TABLE 2.1.1-1. DESIGN ELECTRIC LOADS

Bleyle Plant		STES Operation	
Process Machinery	83	Collection Subsystem	38
Lighting	80	Power Conversion Subsystem	20
Air Handling Equipment	59	Thermal Utilization Subsystem	66
Process Equipment	32	STES Mechanical Bldg.	10
Miscellaneous	16		
Total	270 kW	Total	134 kW

TABLE 2.1.1-2. DESIGN COOLING LOADS

Load Source	Load (Tons)
Bleyle Plant	143
Loading/Storage Area	20
STES Mechanical Building	10
Total	173

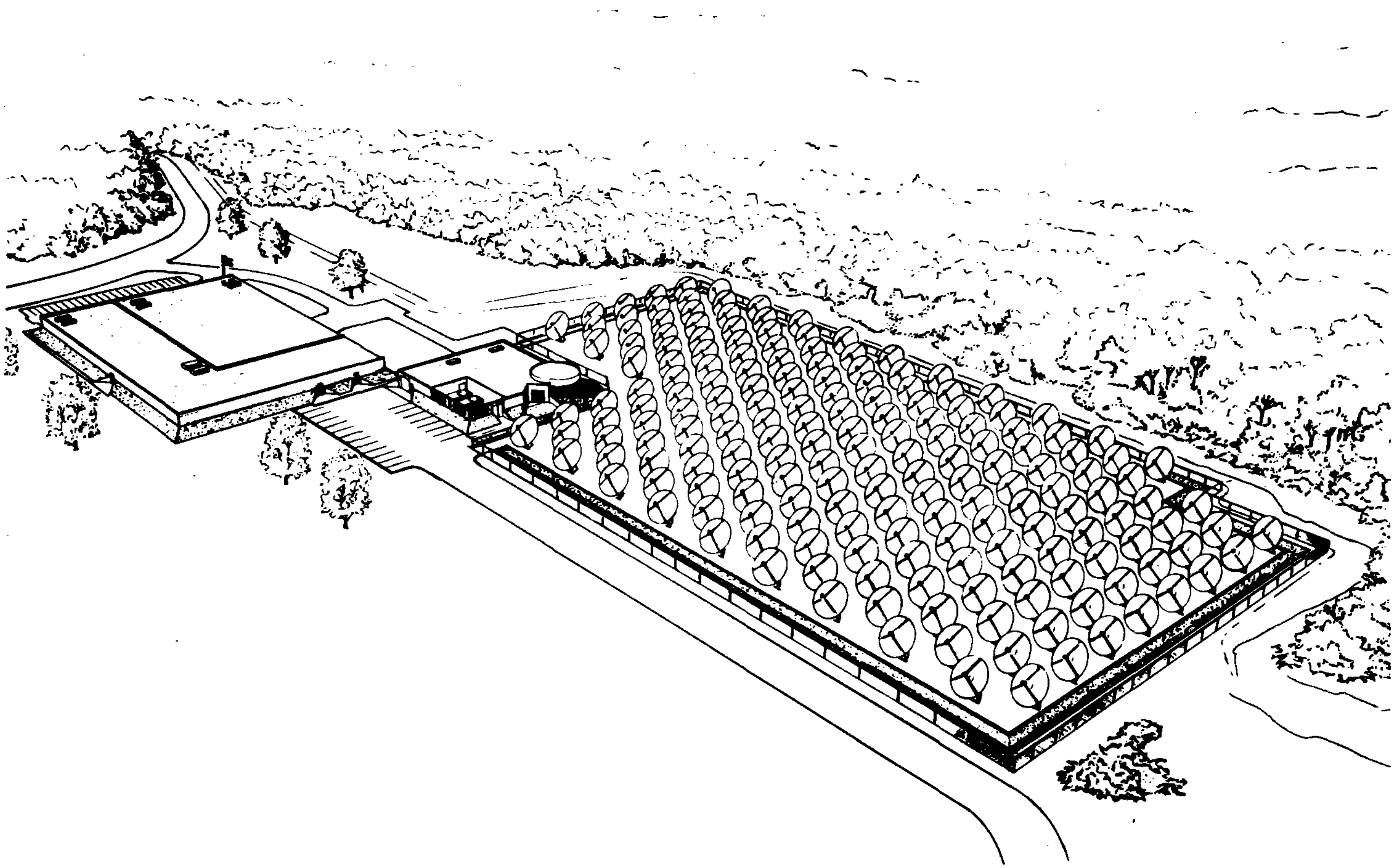


Figure 2.1-1. Solar Total Energy-Large Scale Experiment at Shenandoah, Georgia

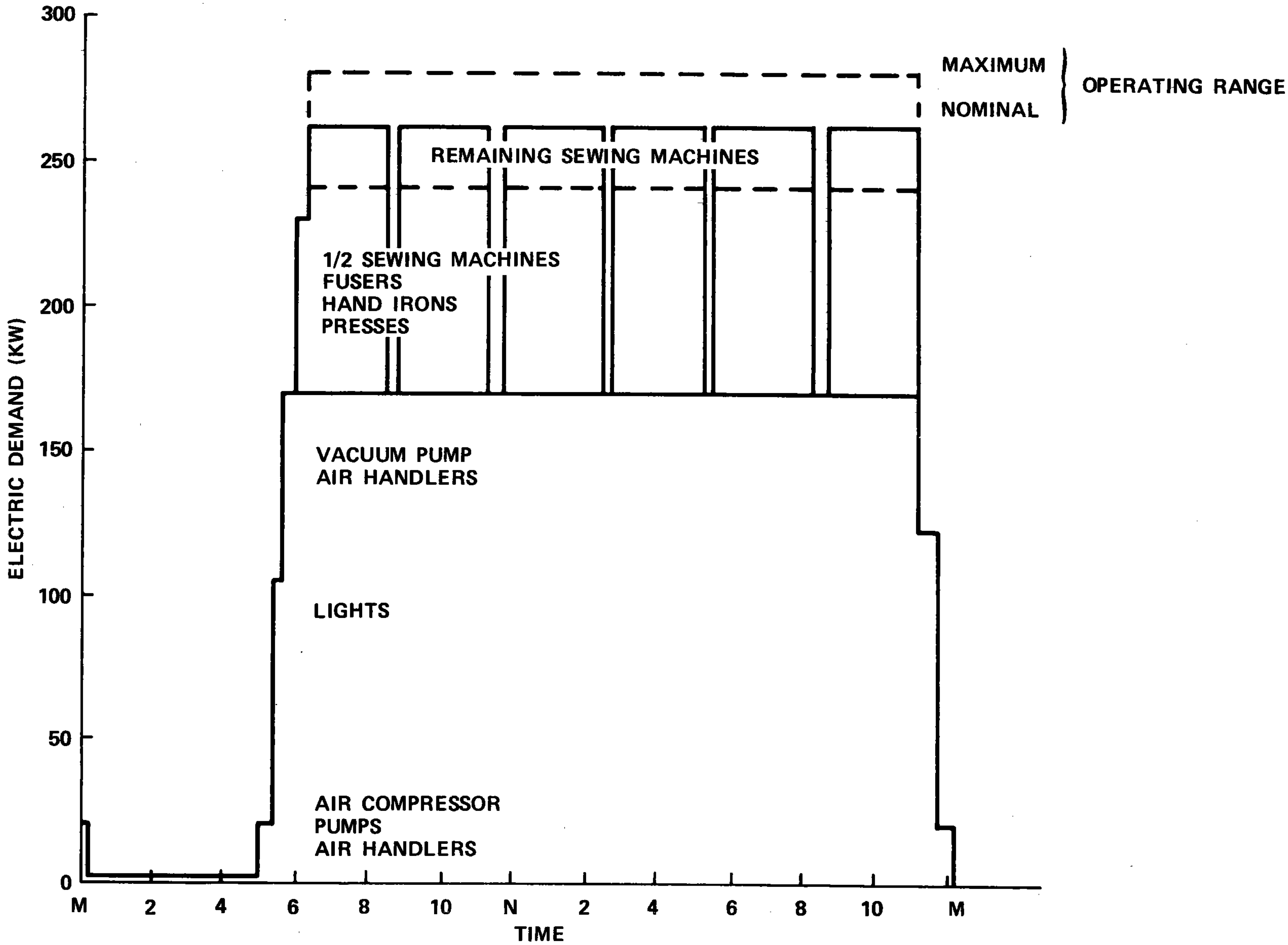


Figure 2.1.1-1. Bleyle Plant Electric Loads

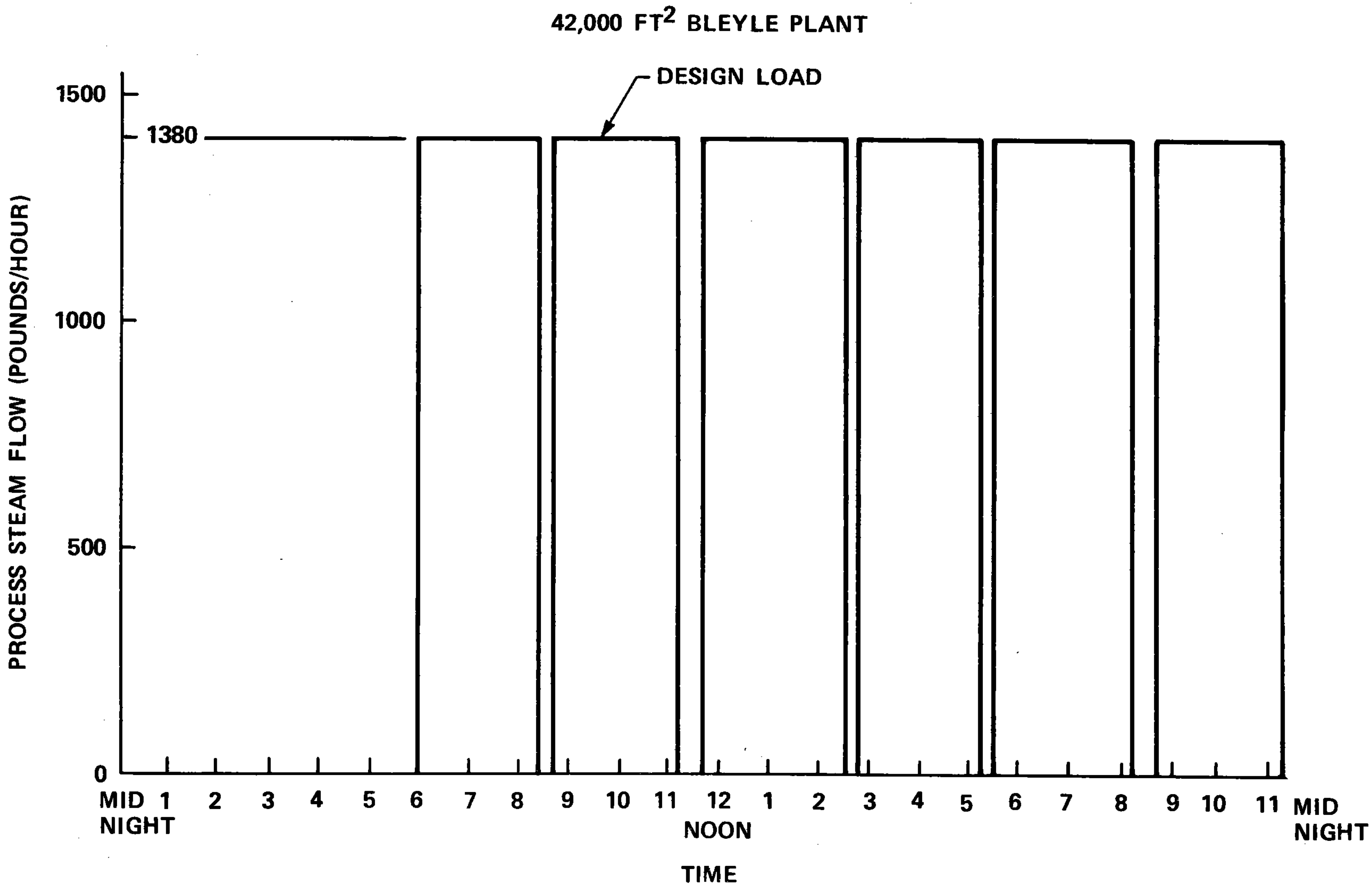


Figure 2.1.1-2. Process Steam Demand

Figure 2.1.2-1. Shenandoah System Schematic

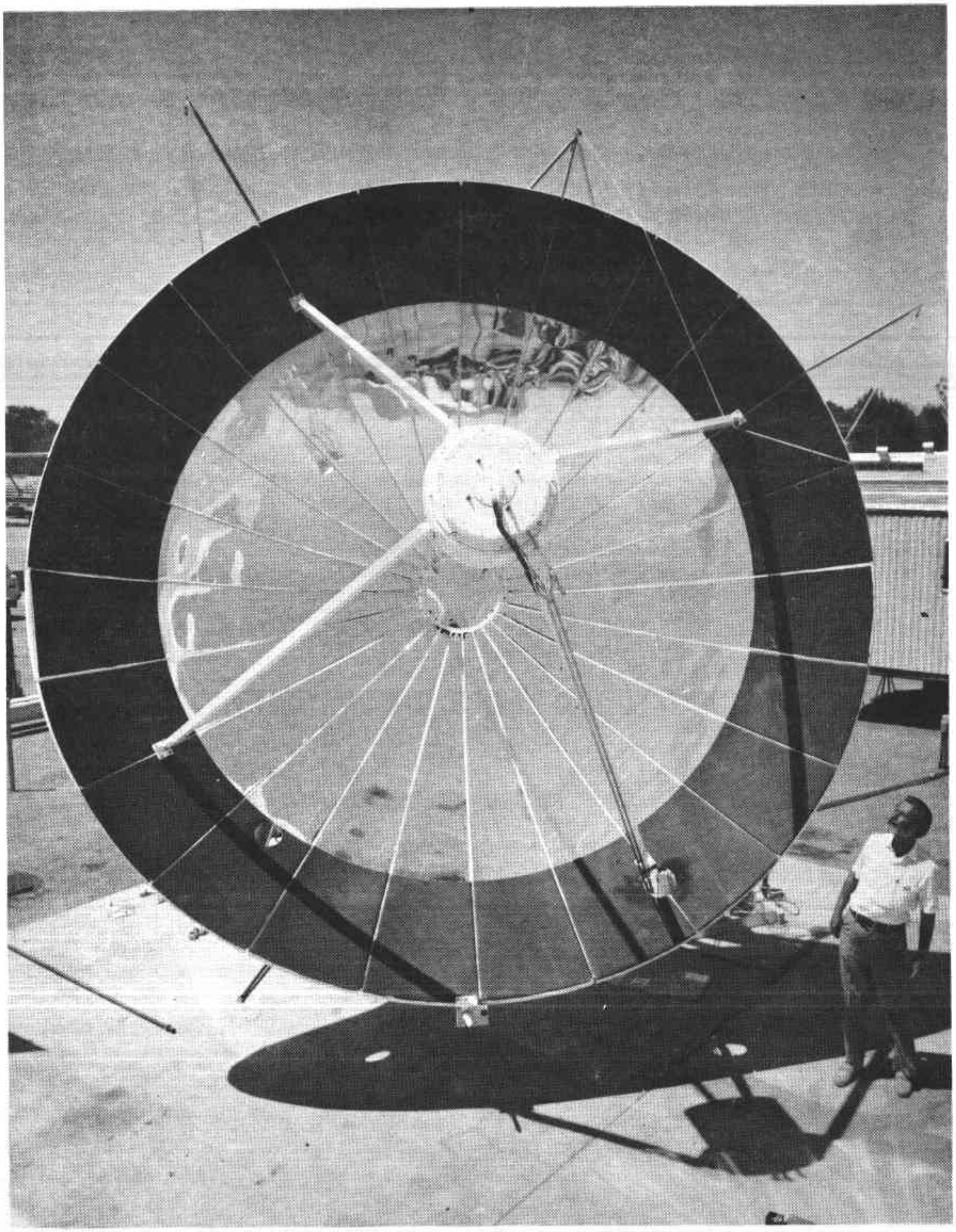


Figure 2.1.2-2. Engineering Prototype Collector

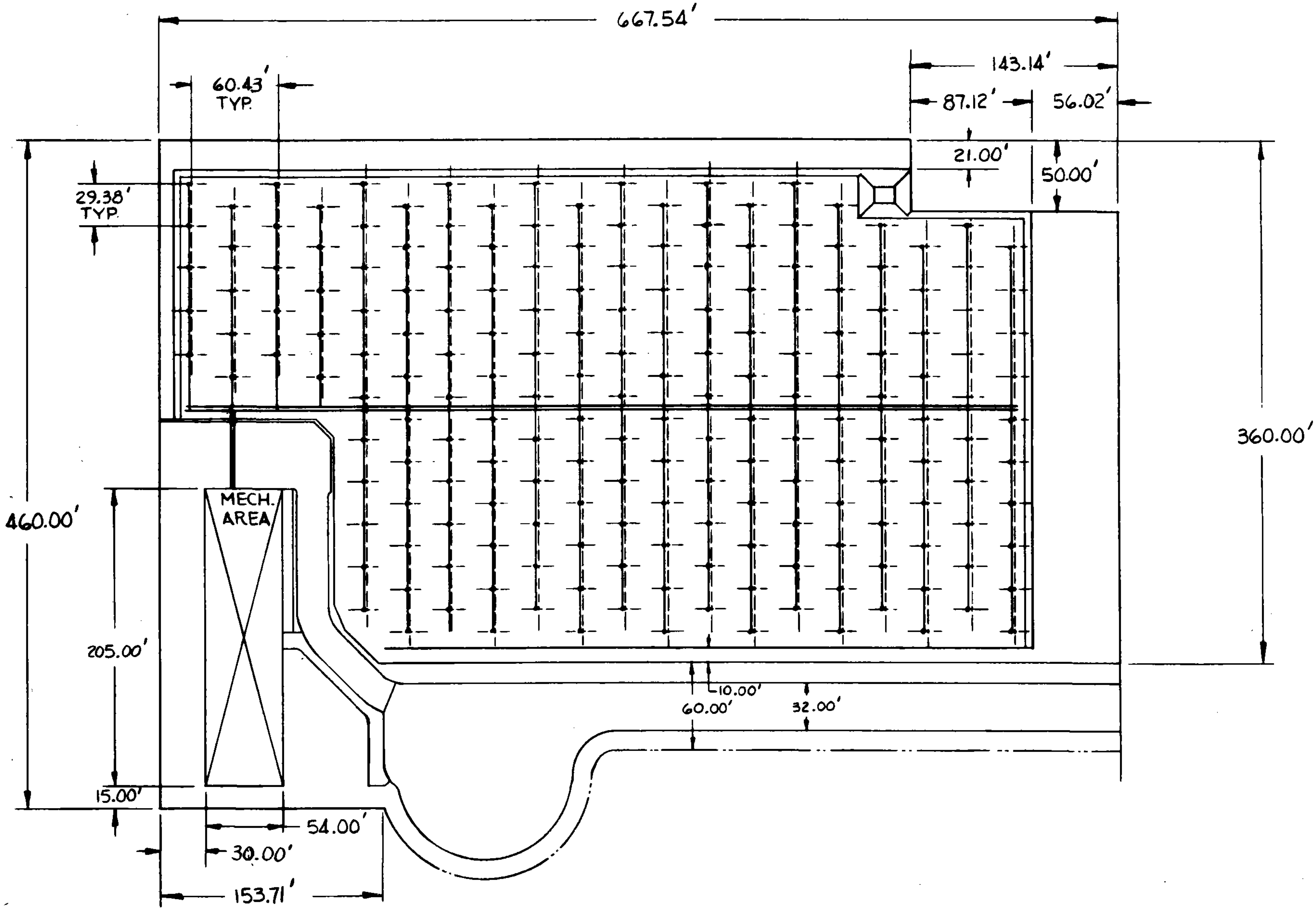
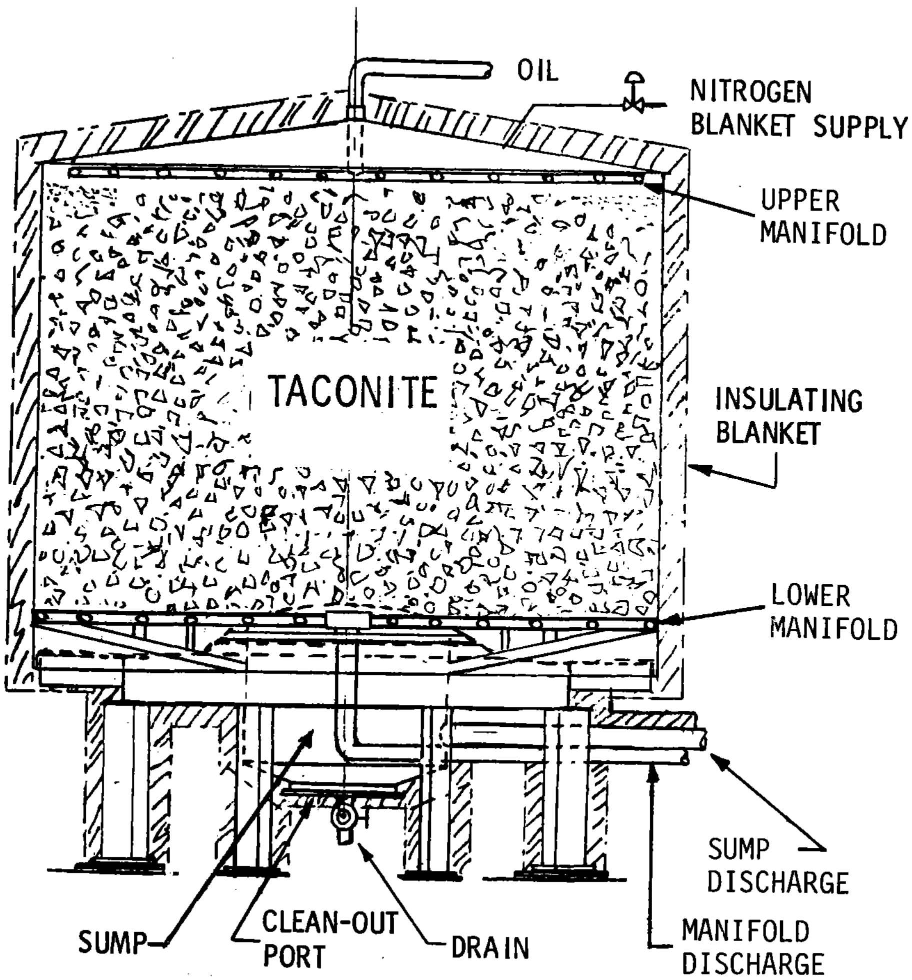


Figure 2.1.2-3. STE-LSE Site Layout



SIZE: LARGE TANK -

20'6" DIA X 16' HIGH
(LESS COVER)
(40,065 GAL/348 TONS TACONITE)

SMALL TANK -

13' DIA X 12' HIGH
(LESS COVER)
(11,860 GAL/103 TONS TACONITE)

Figure 2.1.2-4. Trickle Oil TES Tank

Legend:

─▷◁─	Gate Valve	STV	Stop/Throttle Valve	L	Level Indicator	N_2	Nitrogen Supply
─▷|─	Check Valve	PCV	Pressure Control Valve	F	Flow Sensor	C	Conductivity Meter
	Relief Valve	T	Temperature Sensor	pH	pH (acidity) Indicator	PD	Pulsation Dampener
CV	Control Valve	P	Pressure Sensor	O_2	Oxygen Analyzer	M	Motor

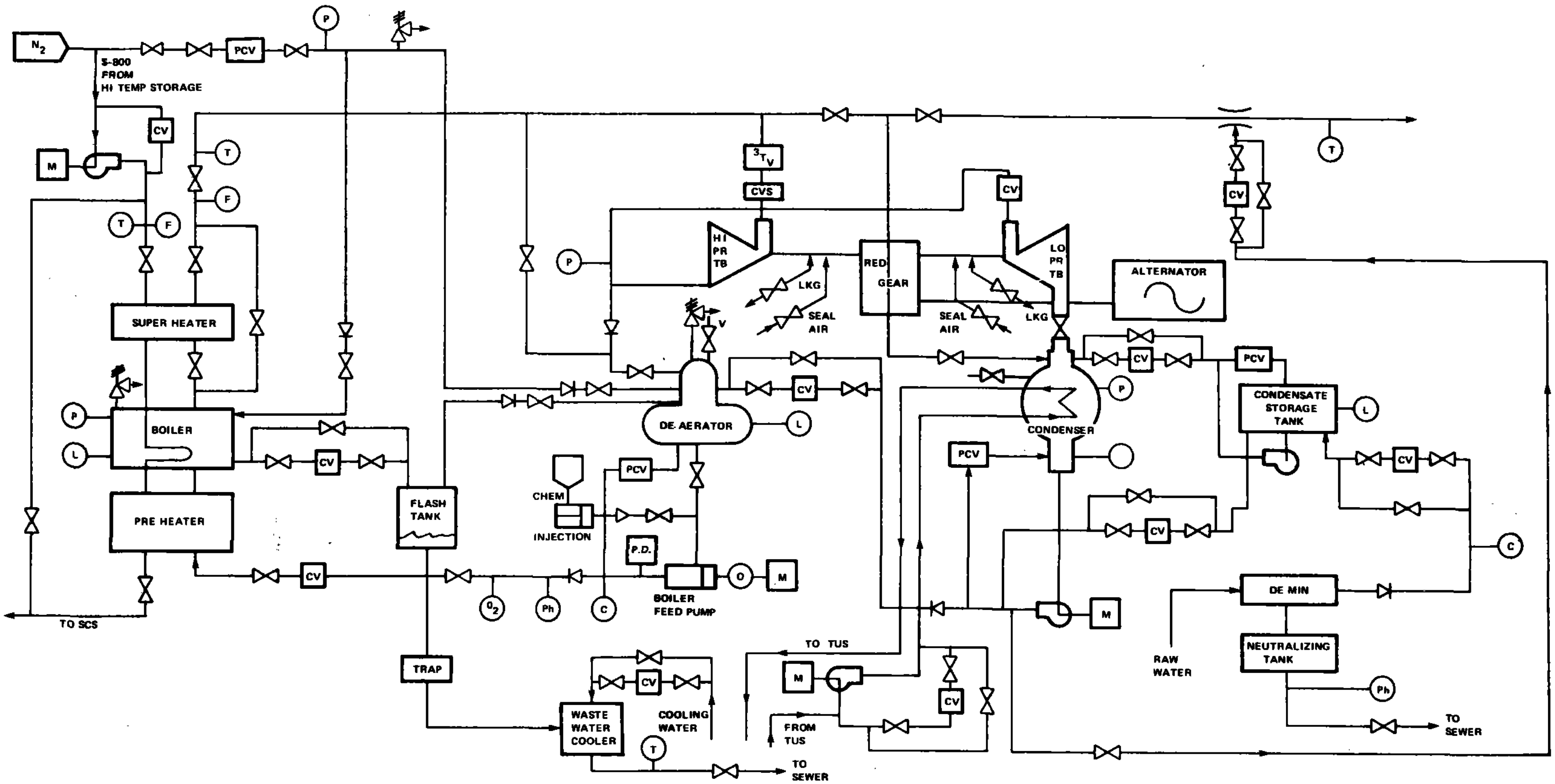


Figure 2.1.2-5 Power Conversion Subsystem Flow Circuit

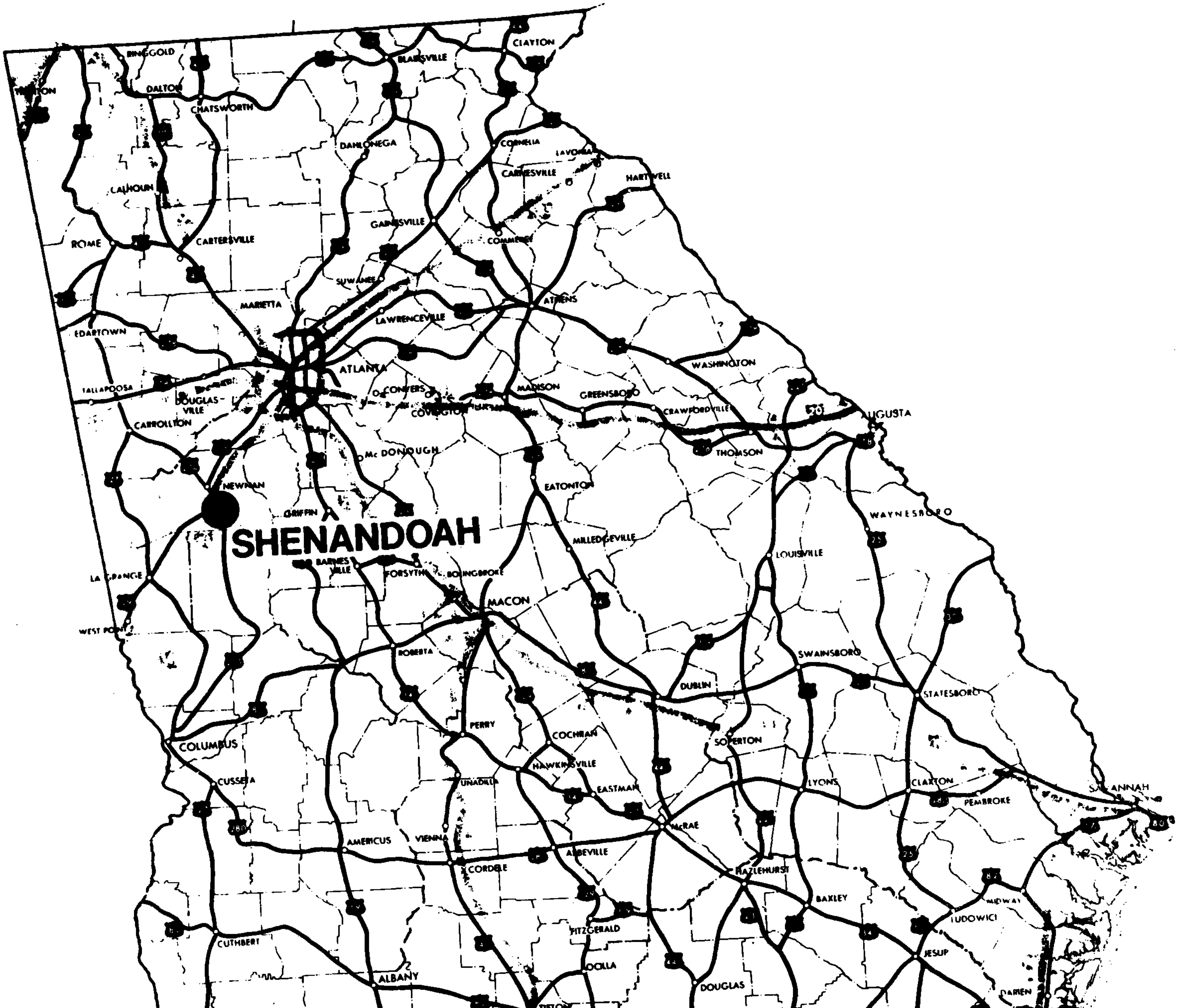


Figure 2.2-1. Location Map

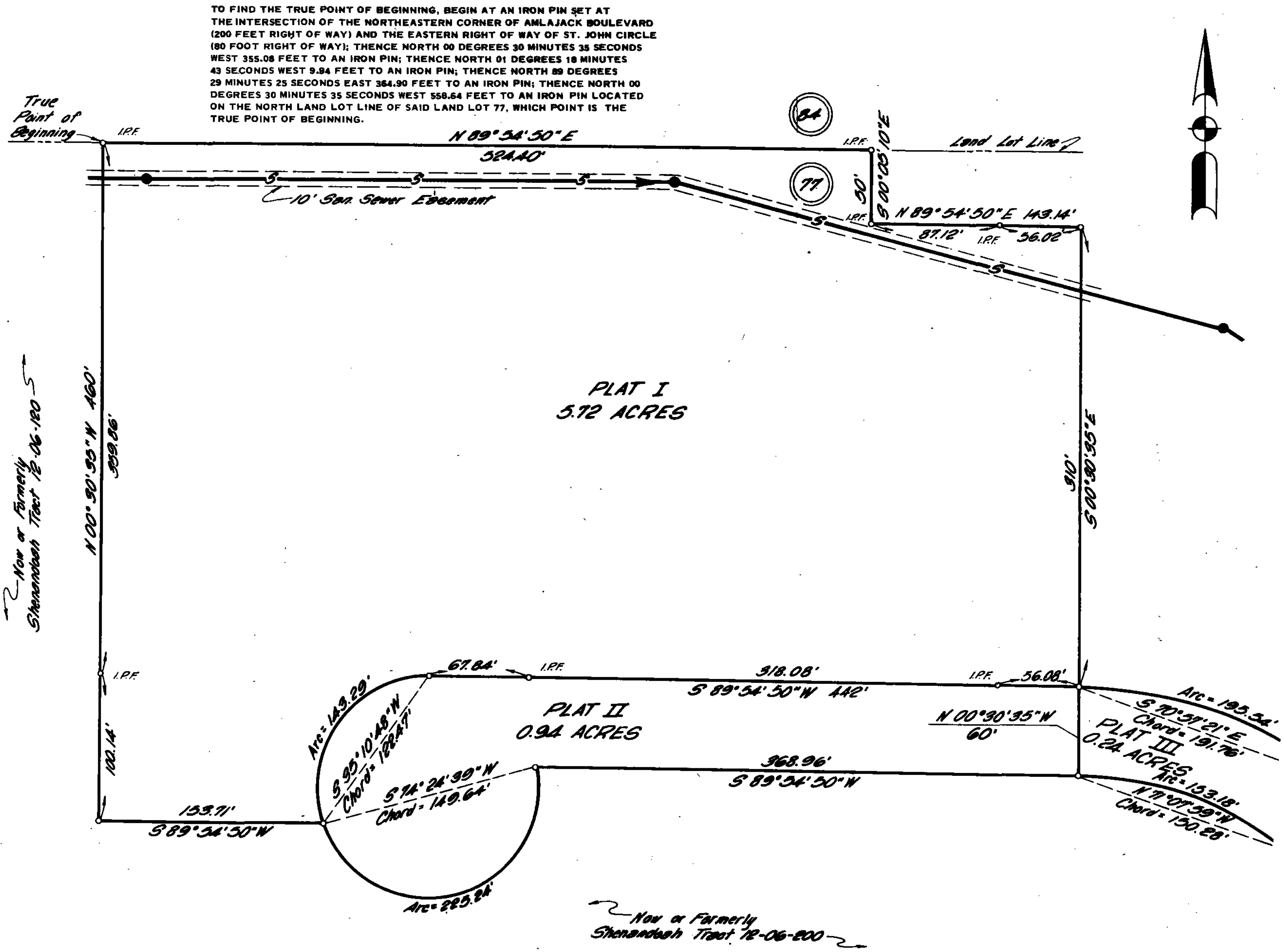


Figure 2.2-2. The Plot Plan (5.72 Acre Plot)

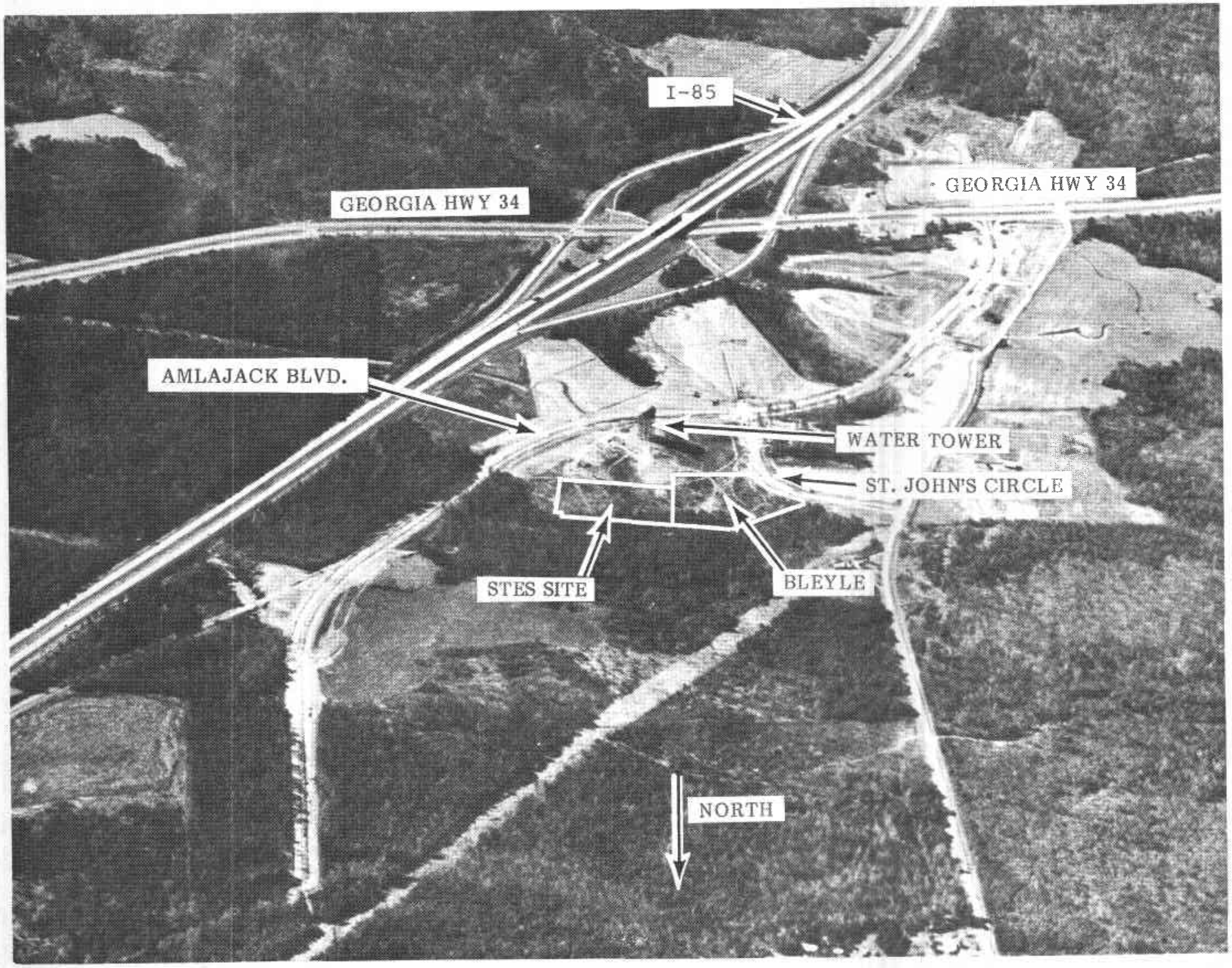


Figure 2.2-3. Aerial Photograph - Looking South

SECTION 3

SECTION 3

SYSTEM DESIGN CRITERIA

3.1 PERFORMANCE CRITERIA

a) The STES shall be designed to supply at least 60% of the annual energy requirements (combined thermal and electric) of the LSE.

b) The quality of the electric power generated by the STES must fall within the limits established by the Georgia Power Company (GPC):

Voltage: 480v $\pm$ 5%

Frequency: 60Hz $\pm$ 1/2%

Maximum Voltage Waveform Distortion: 5%

c) The quality of the process steam supplied at the Bleyle Plant interface from the STES must satisfy the following process requirements:

At min. flow rate of 0.029 kg/s (230 lbs/hr) - steam at 7.93×10^5 N/m^2 and 443°K (115 psia/338°F)

At max. flow rate of 0.174 kg/s (1380 lbs/hr) - steam at 7.93×10^5 N/m^2 and 466°K (115 psia/379°F)

3.2 SYSTEM OPERATIONAL REQUIREMENTS

a) The STES shall be capable of operating in parallel with the independent energy sources (IES) on a daily basis.

b) The STES shall be capable of supplying electrical power to the GPC grid network.

c) The STES shall be capable of being completely disconnected from the Bleyle Plant.

d) The STES shall be capable of operating as a peak shaving system, i.e., supplying peak electric loads while a base load is supplied by the electric utility.

e) The STES shall have stand alone operational capability, i.e., be capable of supplying all the Bleyle Plant energy requirements independent of the IES during selected experimental operating conditions.

f) A high temperature thermal energy storage subsystem (TES) shall be included in the design of the STES to store excess energy collected during system operation and to extend its operational capability during periods of no insolation.

g) A standby fossil fuel heater shall be included in the design of the STES to provide system operational capability at its total energy output independent of solar insolation and stored energy.

3.3 ENVIRONMENTAL CONDITIONS

Ambient Temperatures

Maximum	313^oK (104^oF)
Minimum	254^oK (-3^oF)

Wind

Design operating speed	13.4m/s (30 mph)
Design survival speed	31.3m/s (70 mph) (sustained)
	40.2m/s (90 mph) (gusts)

Hail

Survive damage to structural and mechanical mechanisms - Design diameter	.015m (0.6 inch)

Lightning

Survive damage due to lightning strike having characteristics:

Peak discharge current	100,000 amps
Rise time	1 micro sec

(These numbers account for over 98 percent of recorded lightning strikes.)

3.4 INTERFACE REQUIREMENTS

3.4.1 SITE

a) The entire STES, including solar system components and the STES Mechanical Building, shall be constructed within the boundaries of the 23,150 square meters (5.72 acres) tract specified as Plat I on Figure 2.2-2. No portion of the system shall extend beyond these boundaries.

b) An access road to the STES shall be provided and constructed within the boundaries of the tracts specified as Plat II and Plat III of the site as shown on Figure 2.2-2.

c) In accordance with the terms of the Solar Easement Agreement between Shenandoah, Ltd. and the Georgia Power Company, the allowed maximum height of any improvement located on the land adjacent to the STES site shall not be exceeded.

d) Access for all utility connections and easements shall be provided.

e) A meteorology station shall also be located within the site boundaries.

3.4.2 MECHANICAL

All interconnections between the STES mechanical systems (steam, heating and cooling) and the Bleyle Plant shall be compatible with the Bleyle Plant piping as indicated on Heery & Heery's STES Interface Control Drawing (ICD) No. M-4, Figure 3.4.2-1.

3.4.3 ELECTRICAL

a) The existence and/or operation of the STES shall not cause any interruption of service in the GPC system.

b) The existence and/or operation of the STES shall not cause any degradation of electrical service to the Bleyle Plant.

3.5 CONTROL & INSTRUMENTATION REQUIREMENTS

a) All control systems of the STES shall be capable of operation within the full range of the expected seasonal and diurnal variations in their control parameters.

b) The control and instrumentation system of the STES shall have the capability of being placed in a supervisory control mode, where an individual operator can assume direct control over the system and/or selected components via the computer terminal.

c) All control systems of the STES shall be capable of monitoring, reporting, and recording those parameters essential in evaluating the system and subsystem performance.

3.6 STES MECHANICAL BUILDING REQUIREMENTS

a) The STES Mechanical Building and ancillary equipment shall be located entirely within the site boundaries of the STES tract.

b) The location of the Mechanical Building and ancillary equipment shall satisfy the minimum setback requirements established to prevent shadowing of the collector field.

3.7 MAINTENANCE AND RELIABILITY REQUIREMENTS

a) The STES shall be designed with the goal of achieving a system operating life of 20 years with normal maintenance.

b) A primary and secondary (backup) power system shall be provided to all critical systems and controls to allow for the safe shutdown of the STES.

c) To maximize the availability of the STES, no scheduled maintenance shutdowns will occur during the operating day. Normal maintenance will be accomplished during the evening for the solar collectors and during the early morning hours for the remainder of the power plant.

d) The STES shall be designed for an operating availability of 95 percent or greater based on an overall system reliability analysis.

3.8 TESTING REQUIREMENTS

a) Sensors, measuring, and monitoring devices shall be incorporated into the design of the STES to permit the collection of engineering data for evaluation of the system design, performance, and operational characteristics. Specific sensors and locations will be defined in the Test and Evaluation Plan for the STES (to be published later).

b) The quantity and type of all energy sources displaced by the STES shall be carefully monitored and recorded.

c) Data shall be obtained during both normal and experimental operating modes in accordance with the procedures described in the Test and Evaluation Plan for the STES.

3.9 HEALTH & SAFETY REQUIREMENTS

a) The STES shall be designed to prevent injury to personnel and damage to structures resulting from exposure to concentrated solar beams.

b) The STES shall be designed to prevent the exposure of personnel to high temperatures by providing sufficient insulation around all high temperature components.

c) The STES shall be designed to reduce fire and burn hazards.

d) Adequate precautions shall be incorporated into the design of the STES to reduce the hazards of exposure to high voltage, superheated steam, and equipment-generated high noise levels.

e) The design of the STES and its components shall comply with the requirements of the General Electric Company Organization and Policy Guides related to product safety matters:

Policy 1.1 - Participation in Hazardous Business
Policy 3.4 - Product Service
Policy 20.9 - Product Quality
Policy 20.12 - Product Safety
Policy 20.13 - Environmental Protection

f) All efforts shall be taken to minimize the potential adverse environmental effects resulting from the construction and operation of the STES.

3.10 LAWS & ORDINANCES

3.10.1 FEDERAL REGULATIONS

a) Clean Air Act

b) Noise Control Act

c) National Environmental Policy Act

d) Federal Water Pollution Control Act

e) Solid Waste Disposal and Resource Recovery Act

f) Toxic Substance Control Act

3.10.2 STATE & LOCAL REGULATIONS

a) Georgia Water Quality Control Act of 1964

b) Georgia Erosion & Sedimentation Control Act of 1975

c) Georgia Dept. of Natural Resources, Environmental Protection Division

   1) Chapter 391-3-1, Air Quality Control

   2) Chapter 391-3-4, Solid Waste Management

d) Southern Standard Building Code - 1973

e) Building Codes of the County of Coweta

f) Shenandoah Development Incorporated

   1) Development Guidelines

   2) Technical Specifications

g) Building Code Requirements for Minimum Design Loads in Buildings and Other Structures

3.11 CODES & STANDARDS

3.11.1 SYSTEMS

a) Occupational Safety and Health Administration (OSHA)

   1) 29 CFR Part 1910 - Occupational Safety and Health Standards

   2) 29 CFR Part 1926 - Safety and Health Regulations for Construction

b) National Fire Protection Association (NFPA) National Fire Codes - 1977

   1) NFPA 70-1975 National Electrical Code

   2) NFPA 101-1976 Life Safety Code

   3) Other National Fire Codes - 1977 (Vol. 1-16) as applicable

c) American National Standards Institute (ANSI)

1) ANSI C2-1973 National Electrical Safety Code

2) Other ANSI Standards for Safety as applicable

d) American Society of Mechanical Engineers (ASME) Boiler & Pressure Vessel Code

1) Section II-Materials Specification

2) Section V-Nondestructive Examination

3) Section IX-Welding & Brazing Qual.

e) National Electrical Manufacturers Association (NEMA)-Applicable Standards

f) American Institute of Steel Construction (AISC)-Steel Construction Manual

g) American Concrete Institute-Applicable Standards

h) American Petroleum Institute-Applicable Standards

3.11.2 COMPONENTS

a) Pumps

Hydraulic Institute Standards for Rotary, Reciprocating, and Centrifugal Pumps

b) Heat Exchangers

Tubular Exchanger Manufacturers Association (TEMA)-Applicable standards

c) Tanks

ASME Code, Section VIII - Unfired Pressure Vessels

d) Piping

ANSI B31.1-1977, Power Piping

ANSI B31.3-1976, Chemical Plant and Petroleum Refinery Piping

3.12 GENERAL DESIGN GUIDELINES

a. "Facilities General Design Criteria" (Handbook) ERDA Manual Appendix 6301, March 25, 1977 - Sections as applicable.

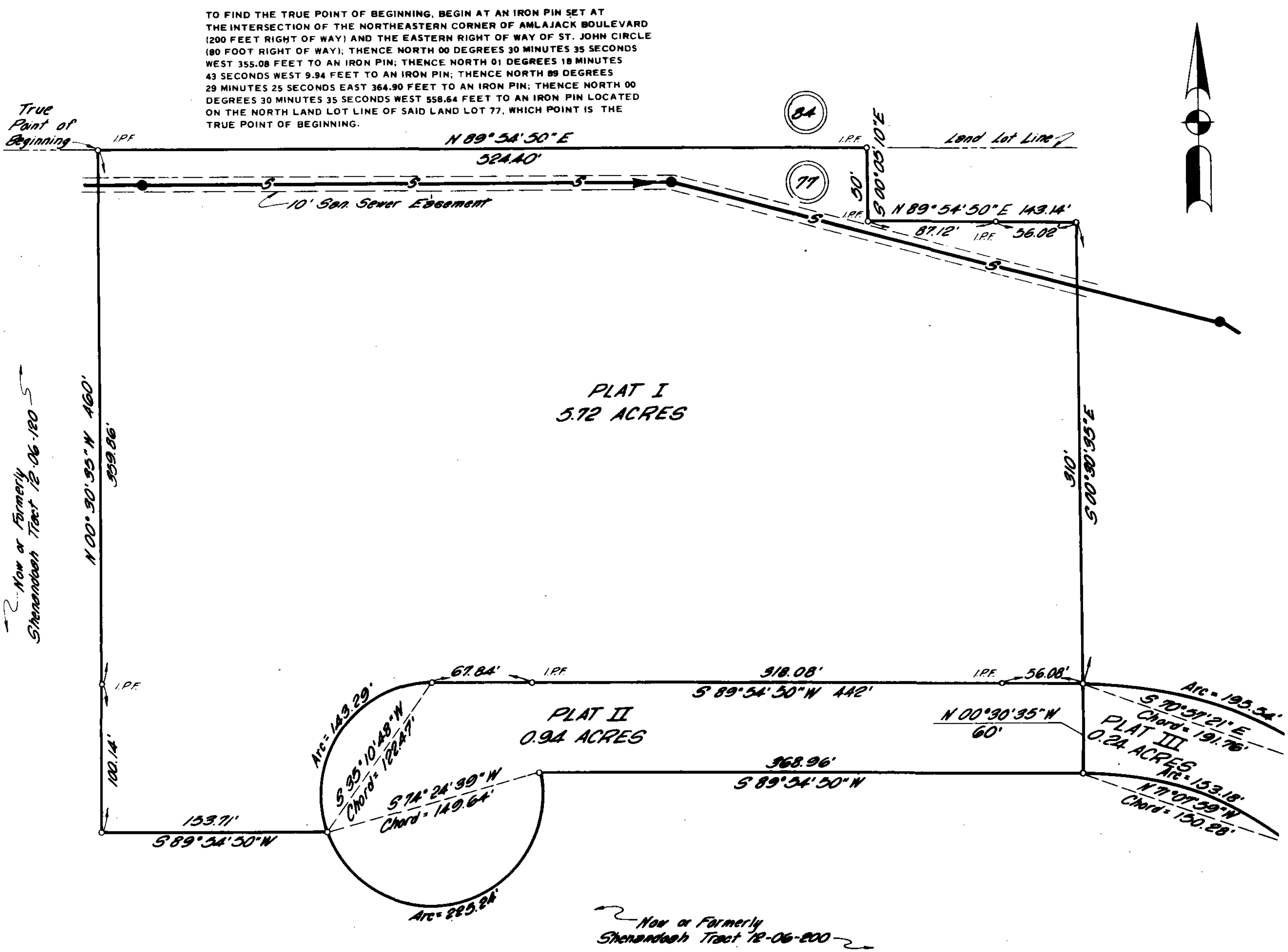


Figure 3.4.1-1 The Plot Plan (5.72 Acre Plot)

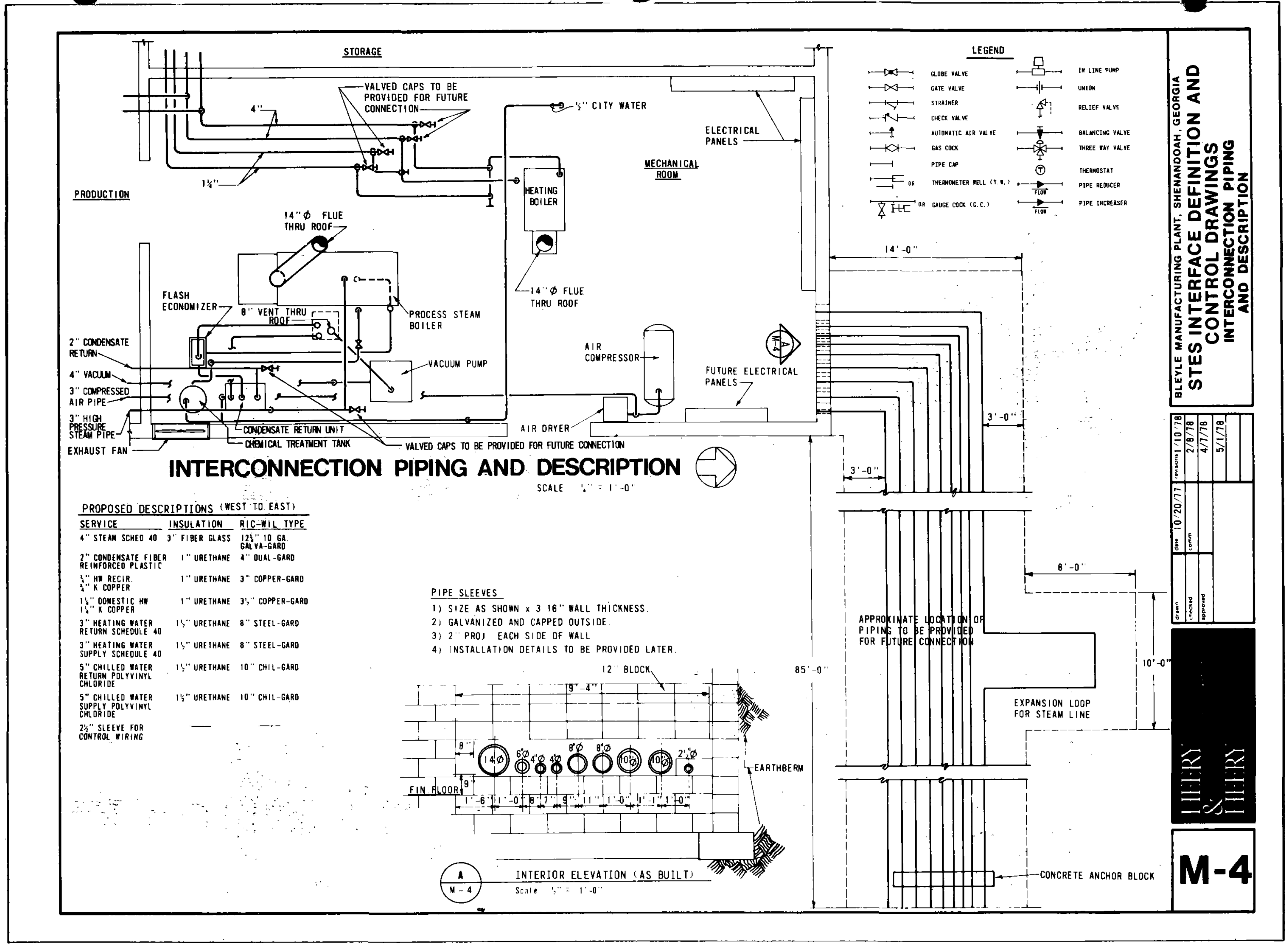


Figure 3.4.2-1 Interconnection Piping and Description

SECTION 4

SECTION 4

SOLAR COLLECTION SUBSYSTEM (SCS)

4.1 SCOPE

4.1.1 FUNCTION

The Solar Collection Subsystem uses the sun's energy to heat the Syltherm 800 fluid flowing through the collector field. This heated fluid is then transported to the steam generator where its heat energy is used to produce steam for the Power Conversion Subsystem. A high temperature thermal energy storage subsystem is provided in the SCS to store excess solar energy. This storage subsystem supplies heated Syltherm 800 fluid to the steam generator during evening operation and periods of low solar insolation. A fossil fuel fired Syltherm 800 heater is also provided in the SCS to supply heat energy during system startup operations and whenever the thermal energy storage is depleted.

4.1.2 SUBSYSTEM CONFIGURATION

The Solar Collection Subsystem is divided into three subloops (or subsystems) as shown in Figure 4.1.2-1. Each of these subloops is named for the function it performs within the SCS. The Collector Field Subsystem (CFS) contains the solar collectors and the collector field supply pumps. This subsystem can deliver the solar heated Syltherm 800 fluid to either the High Temperature Storage Subsystem or to the Steam Generator Supply Subsystem. The piping diagram of the CFS is shown in Figure 4.1.2-2.

The High Temperature Storage (HTS) Subsystem contains the storage tanks for the heated Syltherm 800 and the HTS transfer pump which is used in charging these storage tanks. The system piping diagram for the HTS subsystem is shown in Figure 4.1.2-3.

The Steam Generator Supply (SGS) Subsystem contains the steam generator supply pumps along with the Syltherm 800 fossil fired heater and its associated booster pump. This subsystem supplies the heated fluid from either the CFS or the HTS subsystem to the steam generator. The steam generator itself serves as the system boundary between the Solar Collection Subsystem and the Power Conversion Subsystem. The various input/output devices used throughout the SCS serve as the system interface and communication link with the Control and Instrumentation Subsystem.

4.2 DESIGN CRITERIA

4.2.1 PERFORMANCE CRITERIA

a) The SCS shall be designed to collect an average annual amount of solar energy equal to approximately 2.2×10^{13} joules (21×10^9 Btu).

b) The high temperature TES system shall be sized for weekend energy collection having a storage capacity of 1.1×10^{11} joules (100×10^6 Btu).

c) The standby fossil fuel heater shall be capable of supplying the thermal energy equivalent of the collected solar energy. It will have a heating capacity of 2.9×10^6 joules/sec (10×10^6 Btu/hr).

d) The collector field shall be designed for a temperature rise of 139 °K (250 °F) in the heat transfer fluid with a minimum field return temperature of 658 °K (725 °F) during normal operation.

e) The collector field shall be designed to accommodate a maximum flow rate of .0246 m^3/s (390 gpm).

4.2.2 SYSTEM OPERATIONAL REQUIREMENTS

a) The minimum required level of solar insolation for system operation shall be 236 W/m^2 (75 Btu/ft^2-hr). The solar collectors shall be capable of acquiring the sun at 6:00 AM solar time and tracking the sun until 6:00 PM solar time under all levels of insolation. In the event that insolation levels are below minimum requirements for operation, the collectors shall be capable of continued tracking for a specified time period under computer control and then acquire and optically track the sun when the insolation level reaches the minimum required value.

b) A minimum of 9.5×10^9 joules (9×10^6 Btu) must be stored in the high temperature TES subsystem before the SCS can begin normal operation in the solar total energy mode.

c) The SCS shall be capable of detecting abnormal operating conditions (over-temperature, control malfunctions, power failures) and, in conjunction with the system controls, taking protective action:

    1) The collector will have the capability to defocus to protect the collector fluid components (receiver, piping, etc.) from conditions where over-temperature, loss of fluid flow, or other malfunctions may lead to excessive temperatures in the operating fluid and/or the collector components.

    2) The collector will be capable of moving to the defocus position under system emergency power when the normal power supply to the collector controls and other electrically powered components have failed.

d) Each collector shall be capable of being stowed in a position which minimizes the danger of damage to the collector resulting from the extremes of wind, hail, rain, and other natural hazards.

e) Individual manual control valves and isolation valves shall be provided for each solar collector in the piping field. Automatic control and isolation valves shall be provided for the major branch connections in the field.

f) The design of the High Temperature Storage Subsystem shall contain an adequate space allowance for the thermal expansion of the heat transfer fluid without degrading system performance.

4.2.3 INTERFACE REQUIREMENTS

a) 110 volt electrical power shall be provided for the collector field pumps, motorized valves, collector drives, controls, and sensors.

b) An adequate quantity of bottled nitrogen gas shall be provided to supply and maintain a nitrogen atmosphere in the high temperature storage tanks.

c) Acceptable grade tap water will be provided in the collector field for the periodic washing of collectors. The number of outlets, size of pipe, etc. shall be adequate to support the maintenance requirements for periodic cleaning of the collector reflector surfaces.

d) Filtered, oil free, compressed air will be provided for operation of pneumatic controls.

4.2.4 MAINTENANCE & RELIABILITY REQUIREMENTS

a) The design of the SCS shall incorporate adequate provisions for the filling and draining of the collector field and all interconnecting piping.

b) The following components of the solar collector shall be field replaceable in order to maintain a high component operation availability:

Reflector petal
Receiver
Drive components (motor, screwjacks, bearings)
Piping components (tubing, insulation, protective jackets)
Instrumentation and control units (valves, thermocouples, sun tracker, switches)

Component replacement and maintenance operations shall be accomplished using standard tools and fixtures and shall minimize the use of special equipment.

c) The entire piping network of the SCS shall be assembled using welded pipe connections to minimize leakage. Flanged connections should only be used where major component removal is required.

d) Periodic cleaning of the collector reflector surface is required. Normal cleaning procedures will include a water spray wash and wiping with special detergents utilized under extreme dirt build-up conditions.

e) Provisions for periodic optical alignment of the collectors and calibration of the control sensors shall be required. Alignment and calibration procedures shall be accomplished using standard tools and fixtures where possible.

f) Periodic measurement and calibration of position indicators along with lubrication of screwjack drives, valve motor drives, and other components will be conducted as part of a regular maintenance program.

4.2.5 TESTING AND INSPECTION REQUIREMENTS

4.2.5.1 Acceptance Testing

Acceptance testing for the collector will consist of assembly fit-checks and inspection and functional checkout prior to pre-operational testing. Acceptance testing of the as-received components for the collector will include dimensional and fit checks on the mount assembly, reflector components, receiver, drive components, and control sensors. After assembly, functional checkout of the drive operating mechanism, control position/command control calibration, checkout operation for the defocus/protective component operations, and functional checks of the isolation and/or control valves shall be conducted. The functional checkout testing shall verify that the normal operational motion of the collector performs according to normal operational requirements and that all safety and hazard avoidance components and operations are functional.

4.2.5.2 Pre-Operational Testing

After completion of plumbing connections of the receiver, piping flexible joints, and valves to the field piping, the collector piping shall be isolated and hydrostatically tested to detect leaks. After the collector is filled with coolant from the pipe field, collector control checkout will proceed with the collector in full operational status at maximum insolation levels required for checkout testing. Performance testing to establish the standards shall be conducted, with operational performance within tolerance bands, prior to connection of the collector to power plant central control.

4.2.5.3 Periodic Performance Testing

Periodic performance monitoring utilizing operational thermocouples, resistance temperature detectors (RTD), and system controls will be used to verify that collector performance is within operating tolerance bands. Such periodic performance determinations will not be highly precise measurements due to a lack of individual collector flow measurements. Flows will be estimated to a particular collector through a knowledge of the flow control valve and the up-stream pressure. Flow through an individual collector is determined by assuming the division of flow is in accordance with the hydraulic flow model.

Mass flow rate through a collector, a knowledge of the instantaneous insolation, and a measurement of the outlet temperature yield specific collector performance. Correlation of a representative number of individual collectors performance with overall field performance over a long period is expected. The lack of such correspondence may indicate degradation (or improvement) of the pipe field insulation performance.

4.2.5.4 Periodic Inspection

Periodic visual inspection of drive jacks, declination and polar position indicators, emergency release/protective devices, joints and seals, valves and other dynamic components, and those subject to potential leaking shall be conducted at regular intervals. Visual inspection of receiver coatings for discoloration, cracking, peeling, etc. shall also be conducted. Visual inspection of reflector coatings and insulation and insulation jackets shall be conducted at regular intervals.

4.2.6 SPECIAL FEATURES

4.2.6.1 Collector Field Spacing Requirements

The geometry of the collector field including collector positioning and spacing has been selected to maximize the annual collection of solar energy consistent with costs, area limitations, and thermal output requirements. See Figure 2.1.2-3.

4.2.6.2 Optical Hazards

Provisions to limit access to unauthorized and/or untrained personnel within the defined optical hazard areas of the collector field shall be provided. Provisions for limiting access to extreme optical hazards areas shall also be provided for operating and maintenance personnel. Appropriate barriers, warnings, and safety equipment shall be provided to these personnel when they are within the extreme hazard areas.

4.3 DESIGN DESCRIPTION

4.3.1 DETAILED SUBSYSTEM DESCRIPTION

4.3.1.1 Collector Field Subsystem

The collector field subsystem consists of the collector field supply pumps and the heat Transfer Fluid Supply and return lines to the solar collectors. The main supply and return lines to the collector field run in the east-west direction, while the branch lines to and from the individual collectors run in the north-south direction. The collector field piping configuration is shown in Figure 4.1.2-2. These supply and return lines are constructed of seamless carbon steel tubing which complies with the requirements of ASTM A192.

The main supply and return lines consist of tubes of different diameters which have been reduced by steps to maintain a relatively constant flow velocity of approximately 2.4 m/s (8 ft/sec) throughout the collector field. The size of the lines entering and leaving the Mechanical Building are 0.114 meter (4.5 inches) O.D. with a .0032 meter (0.125 inch) wall thickness. The branch lines are also tapered to maintain a constant flow velocity. The lines running up to and down from the receiver are of different diameters. The down or hot side has a slightly smaller diameter than the cold side to decrease temperature drop during low flow conditions. Pipe supports for both the main headers and the branch lines (Table 4.3.1-1) are installed in accordance with ANSI B31.1 Power Piping Codes.

Under design conditions, Syltherm 800 is pumped to the collectors at a supply temperature of 533° K (500° F) and returns from the field at 658° K (725° F). The main supply and return lines are covered with insulation whose thickness is based upon the tube temperature (500° F or 750° F) and diameter. The recommended insulation materials and thicknesses are shown in Table 4.3.1-2. This insulation is covered with a 16 gage aluminum jacket which is sealed at the joints with a mastic. The branch lines are nested within a similar type of insulation jacket. This nesting of the two fluid lines with the same insulation jacket results in a net heat loss savings of between 35 to 40% over singly insulated tubes. A schematic representation of this nesting technique is shown in Figure 4.3.1-1. The individual collectors are also joined to the branch lines via nested tubing up to and down from the receiver.

Forged carbon steel, manually operated, Y pattern globe valves are installed in the supply and return lines of each individual collector to allow isolation for maintenance and provide thermal trim potential. Thermal trim is accomplished only during initial system startup to give temperature balance between collectors in a branch. Fluid flow control to each branch is provided by pneumatically actuated flow control valves which operate in response to the maximum collector output temperature in the branch. A schematic representation of the branch line valve arrangement is shown in Figure 4.3.1-2. Two pneumatically operated globe valves are required; one, a modulating valve for flow control and the other, an on-off valve for branch isolation. A picture of a typical pneumatic control valve for this application is shown in Figure 4.3.1-3. Due to the weight of the control valve actuation mechanism, each control valve is separately supported.

Due to the low viscosity and surface tension of Syltherm 800 at operating temperatures, the entire field piping network is completely welded. Tungsten Inert Gas (TIG) welding will be used throughout. All valves and fittings in sizes 0.051 meter (2 inches) and smaller will be socket welded. Butt welds will be used for all sizes greater than two inches. Loads resulting from thermal expansion will be controlled by the use of inline, externally pressurized compensators placed in the branch lines. A typical compensator of this type is pictured in Figure 4.3.1-4. The external surface of the insulation will be guided to prevent lateral instabilities.

4.3.1.2 High Temperature Storage (HTS) Subsystem

The HTS subsystem consists of the four HTS tanks and the HTS transfer pump along with the interconnecting piping and valves and associated instrumentation and controls. Interconnecting flow paths throughout the HTS subsystem allow for the transfer of hot Syltherm 800 fluid from the collector field to the HTS tanks, from one HTS tank to another, and from the HTS tanks to the Steam Generator Supply subsystem. The HTS piping configuration is shown in Figure 4.1.2-3.

The subsystem is designed for a trickle oil mode of operation. The design includes the capability for operation in a fluid filled or dual media storage mode. The subsystem utilizes a packed bed of taconite as the solid storage medium operating over a temperature range of 533 to 672° K (500 to 750° F).

In the trickle oil mode, heat transfer is accomplished by a gravity fed trickle oil flow through the bed. The taconite thermal capacity storage medium provides a thermal capacity of 1.06×10^{11} joules (100 MBtu) when all tanks are fully charged. Both the outlet from the collectors (charge flow) and the return from the solar steam generator (discharge flow) enter the top manifold over the bed and are returned from the bottom of the bed. The gravity flow thus requires that the bed be fully charged before it can be discharged, or at least the bottom of the bed be at the delivery temperature for discharge (672° K or 750° F). A sump is required beneath the tank to collect the fluid. No bottom manifold, however, is required to maintain a thermocline at the bottom of the bed.

In the dual media approach, the combined heat capacity of the taconite and the Syltherm 800 fluid is 1.35×10^{11} joules (128 MBtu), assuming 30% fluid filled voids. An additional manifold is required at the bottom of the bed to maintain thermocline stability. The dual media operation provides hot flow entering and leaving the top of the tank, and cold flow entering and leaving the bottom of the tank.

The first tank is sized to provide approximately one hour of energy delivery to the solar steam generator at peak design conditions. The remaining three tanks are sized equally to provide the remaining thermal capacity.

Seamless carbon steel tubing which complies with the requirements of ASTM A192 is used throughout the HTS subsystem. The standard tube size used is 0.114 meter (4.5 inches) O.D. with a .0032 meter (0.125 inch) wall thickness. These tubes are insulated as specified in Table 4.3.1-2. The subsystem is completely welded except for the flanged connections to the HTS transfer pump. Thermal expansion of the piping system is controlled by inline, free flex bellows, expansion points. Pipe supports and lateral restraints are installed in accordance with ANSI B31.1 Power Piping Codes.

4.3.1.3 Steam Generator Supply (SGS) Subsystem

The Steam Generator Supply subsystem consists of the steam generator supply pump, the Syltherm 800 fossil fired heater (FFH), and the fossil heater booster pump. The steam generator supply pump delivers heated Syltherm 800 fluid to the steam generator at a rate controlled by the steam demand of the PCS. This 672° K (750° F) fluid is supplied either directly from the collector field or from the HTS tanks during normal operations. During startup and when solar insolation levels are below minimum requirements, the fossil fired heater is used to provide the heated Syltherm 800 to the steam generator.

The fluid lines in the SGS subsystem are constructed of seamless carbon steel tubing which complies with the requirements of ASTM A192. All joints are TIG welded except for flanged connections to the system pumps. Tubes having a 0.114 meter (4.5 inch) O.D. with a .0032 meter (0.125 inch) wall thickness are used throughout the subsystem. The tubing is covered with insulation per Table 4.3.1-2, and 16 gauge aluminum jacketing covers the insulation. Free flex expansion joints are installed to compensate for thermal expansion. The SGS piping configuration appears on Figure 4.1.2-3.

The stop valves used throughout the SGS subsystem are pneumatically operated globe valves rated for 672° K (750° F) operation. These valves are butt welded in place and covered by an insulation jacket. Valve stems will be mounted horizontally or below horizontal to prevent insulation contamination in the event of a seal leak. This mounting configuration is identical to that used in the collector field and High Temperature Storage subsystem.

4.3.2 SUBSYSTEM PERFORMANCE CHARACTERISTICS

4.3.2.1 Collector Field Subsystem

The table given below is based on the pipe field layout defined in Figure 4.1.2-2.

Collector Field

Collector Loop Heat Loss	216,100 J/S (738,000 Btu/hr)
Thermal Capacity	6.03×10^9 J (5,707,000 Btu)
Fluid Capacity	4.5 m^3 (1184.0 gal)
Supply Line Temperature	533° K (500° F)
Return Line Temperature	658° K (725° F) min.

Mech Bldg.

Thermal Energy Storage:	
-Piping Steady State Heat Loss	10,960 J/S (37,422 Btu/hr)
-Thermal Capacity	9.5×10^8 J (900,154 Btu)
-Fluid Capacity	3.3 m^3 (884 gal)
-Field Supply Line Temp	533° K (500° F)
-Field Return Line Temp	658°K (725° F) min.

Performance data for the field and Mechanical Building was calculated using material property data given in Figures 4.3.2-1 and 4.3.2-2. Pressures, temperatures, and flow rates for the Collector Field Subsystem are shown on Figure 4.3.2-3.

4.3.2.2 High Temperature Storage (HTS) Subsystem

The HTS performance is characterized by the amount of energy extracted at a useable temperature from a charged amount. There are three forms of energy degradation or loss that affect the amount of energy extracted for the trickle oil system: (1) heat losses to the environment, (2) unavailable or degraded energy, and (3) inversion temperature degradation.

The heat losses to the environment are estimated at 4 percent of the stored capacity daily from a fully charged tank. On an annual basis, the losses are only 2.5 percent of energy delivered to the storage system since the stored energy is used each weeknight, and more than 24-hour holding periods for fully charged tanks occur only on weekends or the early part of the week.

The second type of energy loss is the energy stored at temperatures below the turbine inlet minimum requirement of 658° K (725° F). The amount of energy extracted at a useable temperature is therefore a function of the heat transfer gradient zone velicity and slope as it moves through the bed. In the series tank system design, this energy is minimized under a fully charged condition since it occurs only in the last tank. For individually discharged tanks, the efficiency of energy extraction above 658° K (725° F) is 87 percent for the one hour tank, 89 percent for the larger tank, or 96 percent for a completely charged system. Typical profiles are shown in Figure 4.3.2-4 for 0.0032 m^3/s (50 gpm) flow condition through the taconite bed.

The third type of energy degradation occurs as a result of the thermal inversion process which brings a partially charged tank on line for discharge. Since the trickle oil system is discharged by gravity feed, at the end of a solar collection day, a partially charged tank [top portion of the rockbed at 658° K (750° F) and bottom at 533° K (500° F)] can either be held until the next day or thermally inverted with a recirculating flow to move the hot layer to the bottom of the tank. This process results in a slight lowering of the peak temperature 1 to 1.7° K (2 to 3° F) and reduction of the energy available or spreading of the temperature profile. The spreading of the profile is not lost energy to the system since, under charging conditions, the bed can be brought up to 672° K (750° F) faster, and the series configuration restricts the spread profile to the last tank. The inversion flow rate is 0.24 m^3/s (387 gpm) to minimize the inversion time. The efficiency for a single large tank inversion is shown in Figure 4.3.2-5 as a function of the initial percent charged condition. The resulting temperature profiles for inversion of a 62 percent initially charged tank is shown in Figure 4.3.2-6. The second tank must have a minimum charge of 50 percent to limit the inversion to one hour, or the time during which the one hour tank can supply the demand. If the second tank is charged, the third or fourth tank can be inverted with an initial charge down to 25 percent. Below an initial charge of 25 percent, inversion is not used. The annual system performance for the system was shown to be the same with and without tank inversion. This results from the fact that only 7 percent of the total energy delivered to the TES requires inversion. Therefore the overall utility of tank thermal inversion is minimal.

4.3.2.3 Solar Collector Performance

The major component groupings of the collector subsystem are the following:

a) Receiver

b) Dish/Reflector

c) Mount/Drive

d) Control

The function of collector subsystem is to intercept, concentrate and transfer the incident solar energy into the Syltherm 800 heat transfer fluid, raising the temperature of the fluid from an inlet of 533° K to 672° K (500° F to 750° F). Table 4.3.2-1 presents the overall collector performance as a function of the incident solar insolation. Presented are the energy collected, Syltherm 800 flow rates, and overall collector efficiency achieved while the collector tracks the sun within specified control limits. The collector will track the sun with a tracking accuracy of ±1/4°. It will automatically acquire the sun in the morning and return to stow in the evening. In the case of an emergency, the collector will defocus from the sun upon external command.

4.3.2.3.1 Receiver Performance

The receiver transfers the concentrated solar energy from the focal plane of the collector to the Syltherm 800, heating the fluid from a temperature of 533° K (500° F) to an outlet temperature of 672° K (750° F). The losses for the receiver are a function of the outlet temperature and are tabulated in Table 4.3.2-2.

4.3.2.3.2 Dish/Reflector

It is the function of the dish/reflector to intercept the incident solar energy and reflect and concentrate the energy to the focal plane of the dish. The reflector optical surface has a one sigma specular distribution of less than 8 mrads and a total hemispherical reflectance of 88%. The optical surface has a contour (slope error) accuracy of 1/2° rms and will maintain this slope error under the structural deflections caused by steady state wind loading and varying orientations as it tracks the sun. The surface area is 97 percent active, with three percent being shadowed by the receiver and its support struts. The dish has a stowage orientation of -90° polar angle (i.e. due east) and -23 1/2° declination angle (i.e. winter solstice). The dish is in the stowage orientation when not in use or in high wind conditions.

4.3.2.3.3 Tracking/Control

The solar tracker enables the collector to follow the sun within ±1/4° both in polar and declination angles during illumination and also to follow the sun within ±1° when the sun is obscured by clouds. The polar drive system has a slew rate capability of 0.2°/second or 12°/minute and can return the collector to stow within 20 minutes after shutdown for the day.

4.3.3 MAJOR COMPONENTS

4.3.3.1 Solar Collectors

Figure 4.3.3-1 shows an overall geometry drawing of the collector and defines graphically the major components to be discussed below. The solar collectors receive the direct radiation of the sun and concentrate it to heat the Syltherm 800 fluid to a high temperature. In order to satisfy the energy requirements of the STES, the collectors must be capable of converting at least 65 percent of the direct normal insolation incident upon the collector surface into heat supplied to the heated oil. A two-axis tracking, paraboloidal dish was selected to maximize collection efficiency. The amount and drive portions of the collector elevate the

61

dish from the ground and point it at the sun. The dish retains its paraboloidal shape regardless of changes in weight loadings or wind loadings below 13.4 m/s (30 mph). The reflective surface of the collector reflects 86 percent of the incident radiation with a specular dispersion equivalent to eight mrad RMS (root mean square) value. The reflected energy is concentrated in a receiver that converts 82 percent of the energy into useful heat at a design insolation rate of 630 W/m^2 (200 $Btu/hr\text{-}ft^2$) and 87 percent at the maximum insolation rate of 977 W/m^2 (310 $Btu/hr\text{-}ft^2$) by minimizing convection and radiation losses. The heated oil is transported up to and down from the receiver through insulated, nested piping which traverses the two axes of motion through flexible joints.

4.3.3.1.1 Receiver

The function of the receiver is to transfer the concentrated solar energy at the focal plane of the collector into the working fluid. The receiver is a cavity type with the incident concentrated solar flux impinging upon an absorptive surface enclosed within an insulated cylindrical shell. The aperature of the receiver is positioned in the focal plane of the dish and is 0.475 meter (18 inches) in diameter. The corresponding concentration ratio is 250, and 96 percent of the incident flux is intercepted. Figure 4.3.3-2 shows the design layout of the receiver.

The cylindrical insulation shell has an outside diameter of 0.85 meter (33.5 inches) and a height of 0.89 meter (35 inches) with .051 meter (2 inches) of high temperature insulation. The inner wall of the shell is 0.75 meter (29.5 inches) in diameter. The shell outer wall is constructed of a thin wall, low carbon steel sheet wrapped around a rigid frame and coated on both sides with a high temperature paint. The shell inner wall is constructed of low carbon steel sheet and is porcelainized with a base coat on both sides and a prime, diffusely reflective coat on the cavity side. The top plate of the cavity and the face plate of the receiver shell also have the porcelain diffusely reflective coating. The porcelain coating has a reflectance of 0.9 and an emissivity of 0.8.

The heat transfer surface is a coil wrapped into a cylinder with a domed top. This coil is 0.685 meter (27 inches) in diameter and is constructed of two parallel wound, low carbon steel tubes with an O.D. of 0.013 meter (1/2 inch) and a wall thickness of 0.0015 meter (.058 inch). The total length of tubing is 64 meter (210 ft), 32 meters (105 ft) for each tube. The cold feed tube and hot exit tube are joined to the coil with a header fitting. The tubing is treated to give a high absorbtivity of 0.90. Four shaped supports hold the coil in position with the legs being guided into slots in the bottom of the receiver shell. The top of the supports are rigidly attached to the top of the shell. The coil is fastened to the support with clips. The overall dry weight of the receiver is 75 kg (165 lbs.).

4.3.3.1.2 Collector Dish and Reflective Surface

The collector dish with its reflective surface concentrates the incoming solar radiation at the dish's focal point and hence can be thought of as an optical component. The dish must provide a true parabolic surface for the reflective material and hold this shape under various types of loadings such as gravity and wind forces. Typical antenna dishes measure the deviation from the true parabolic surface as an RMS value of the distances measured from a number of points on the dish. For optical reflective error calculations, the surface error is best measured as a slope error. Thus, for a given slope error distribution, the flux profile at the focal plane can be computed rather than assuming that the flux is all located at the theoretical focal point of the dish. This flux profile directly effects the design of the receiver as discussed above, and thus, the required dish slope error distribution is defined by the receiver design. In this case, a dish slope error of 0.5° RMS or less is required.

The diameter of the dish is seven meters. To provide the stiffness required to hold the parabolic shape, the dish is made from stamped aluminum petals which are bolted together. The petals require structural backing to prevent excessive deflections under various loads. Aluminum ribs bolted to the petals are used for this purpose. The dish reflective surfaces and ribs are supported at the center by a support ring to which the declination axis pivot supports and one end of the declination actuator is attached for a three-point suspension. To expedite the manufacturing process and reduce the costs involved, the aluminum petals are not full sized, being 2.44 meters (8 feet) in length. A center dish of approximately 2.29 meters (90 inches) in diameter, which is made from a spinning, is used to complete the reflective surface in the center of the dish.

The reflective surface should reflect the sun's rays to the focal plane with minimal losses. These reflective losses are determined by measuring the total reflectance and the specular reflectance of the surface. The total reflectance refers to that portion of the solar radiation which is reflected and not absorbed. For this application, its required value is 0.86. The specular reflectance refers to how much a single ray would be dispersed after being reflected. Its required value must be equivalent to an 8 mrads RMS normally distributed specular distribution.

The reflective surface should withstand all expected adverse environmental conditions without serious degradation for the duration of the 20 years design life goal of the collector. Testing requirements for the reflective surface include:

a) Weathering due to wind, rain and humidity

b) Salt spray

c) Ultraviolet degradation

d) Thermal cycling, both daily and seasonal

e) Cleanability requirements including resistance to abrasive scratches

The reflective surface that best meets the design requirements is chemically brightened 5657 aluminum alloy coated with RTV 670.

4.3.3.1.3 Dish Mount and Drive

The parabolic surface of the collectors must be pointed at the sun in a semi-continuous manner to maximize the amount of heat collected. The tracking need not be continuous since up to $1/4^{\circ}$ tracking and bias errors are allowed. This results in the reflected sun image at the receiver not being exactly centered in the cavity at all times, which is acceptable within the angular error prescribed above. This allows the drive system to be under an on-off control. Since the sun's motion is 0.00416^o/s (360^o/day) or $1/4^o$ per minute, the average tracking rate must match this, but need not do so continuously. With one half of the $1/4^o$ RMS error allowed for the tracking error, the nominal position versus time is described in Figure 4.3.3-3. This shows the stepwise responses about the polar axis.

Since, at the time of stepping, the dish trails or leads the sun by $1/8^o$ by design, $1/8^o$ is allowed for other errors, e.g. by the wind loading deflecting the structure or by sun sensor errors. The wind deflection is expected to be the largest contributor to the error. An estimate of the stiffness requirement for the mount and drives has been developed based on known data and by making simplifying assumptions. The system is required to operate in maximum winds of 13.4 m/s (30 mph). The 13.4 m/s wind is not steady but is characterized as having a 10 m/s (22.5 mph) mean with a 3.4 m/s (7.5 mph) varying component. With a total 6.8 m/s (15 mph) change in wind speed used as the worst case to produce the $1/8^o$ error, the wind torque can be estimated. (Note: the steady wind component is compensated for by the sun sensor tracking approach.) From JPL wind tunnel data for parabolic dishes, this wind can impart a 1000 m-N (740 ft-lb) torque about the polar axis. Thus, the stiffness of the system should exceed 1000 m-N/$1/8^o$ = 8000 m-N/deg. (6000 ft-lb/deg). This value is a minimum to allow error contributions from other sources, but since the wind is expected to be the largest contributor, the whole $1/8^o$ is used to calculate a minimum number rather than attempt a more sophisticated probabilistic analysis.

This system stiffness limits the types of drive system components that can be used. In general, pneumatics or inexpensive gearing cannot be used because of being too compliant. Hydraulics could be used, but larger cylinders are required to meet the stiffness requirement than those needed to provide the forces and torques required.

The mount is required to provide ground clearance of the collector dish of about 0.61 meter (2 feet). This minimizes degradation of the reflector surface due to wind-borne heavy particles. The mount should also provide a stow position where the dish is pointed slightly downward. This will provide protection to the reflector surface from hail and also minimize dew collection. The polar/declination axis gimbal drive was chosen over the more conventional azimuth/elevation drive for two reasons. First, angular excursion requirements are smaller to point the dish at the sun during the most useful times, and secondly, the polar drive basically uses only one motion to track; i.e., it does not require the coordination of motions the azimuth/elevation needs.

The design of the mount structure not only requires the stiffest design for the least amount of material (cost) but also must not interfere with the dish motion. The polar axis provides 180^o motion and the declination axis $\pm 23\ 1/2^o$. Hence, as the dish sweeps out these motions, the structure must not interfere. The mount must sit on a foundation that also does not interfere.

The foundation provides the initial alignment and must support the dish without excessive settling. It, along with the rest of the mount and drive, must be able to withstand the 40.2 m/s (90 mph) maximum wind condition. The mount, drive, and foundation must meet the local building codes. The mount structure and drives are then designed to meet the AISC design requirements in the worst case; that is, the dish is not in the stow position with the actuator retracted.

The outdoor environment requires the components selected to be either inherently weather proof or housed in weather proof containers. Maintenance should be minimized, and replacement of active parts be made easy.

To provide for certain emergency conditions, the drive should be able to defocus the collector at a rate of 2^{o}/sec. This requirement is met by providing a higher horsepower drive on one of the polar drive actuators. Since it should operate with possible field power loss, its own emergency battery is provided. Also to focus the collector during the day, the collector should catch up to the sun by at least an order of magnitude faster than the $1/240^{o}$/sec ($1/4^{o}$/min) sun rate. The rate used is about $1/10^{o}$/sec (6^{o}/min) which is provided by turning on continuously both polar axis drives. This minimizes the heating up of the receiver aperature as the sun's image wipes across the receiver face. The $1/10^{o}$/sec (6^{o}/min) rate can also be used to position the dish for maintenance purposes.

4.3.3.2 <u>High Temperature Storage Tanks</u>

4.3.3.2.1 Tanks

The four high temperature storage tanks will be of similar carbon steel construction. The smaller, one hour tank is 3.96 meter (13 feet) in diameter and 3.66 meter (12 feet) high with a capacity of 44.9 cubic meters (11,860 gallons). The three larger tanks each are 6.28 meters (20.5 feet) in diameter and 4.87 meter (16 feet) high with a capacity of 152 cubic meters (40,065 gallons). Figure 4.3.3-4 shows the tank construction for the 6.28 meter (20.5 foot) diameter tank. The dome will be conical in shape consisting of 12 flat plate (pie-shaped sectors) bent to conform to the cone radius. The sections will mutually reinforce each other to provide a rigid structure. Some bracing will be required at the truncation of the sectors. The lateral wall is 0.0095 meter (3/8 inch) thick from the bottom to the top of the tank. The main inlet connection is a 0.114 meter (4.5 inch) tube leading to the distribution manifold which will be an integral part of the dome as described in Section 4.3.3.2.2. The dome will also have a man-hole port for access to the tank interior. The bottom of the tank will have a 12 to 1 sloped internal base to provide good drainage to the sump described in Section 4.3.3.2.3. The tank will be supported on a 1.2 meter (4 foot) high structure to allow adequate bottom insulation and access to the sump.

4.3.3.2.2 Distribution Manifold

The trickle oil concept requires only one manifold at the top of the packed bed, but a second bottom manifold is included to accommodate the fluid filled back-up design capability. The two manifolds will be of identical construction as shown in Figures 4.3.3-5 and 4.3.3-6. The manifold is a series of interconnecting pipes, .032 meter (1-1/4 inches) in diameter, providing a uniform flow distribution over the packed bed. There will be two holes at 0.102 meter (4 inch) intervals along the pipe length, with a hole located on both sides of the pipe at a 30^{o} angle from the bottom or top of the pipe for the top and bottom manifolds, respectively. There will be a total of 1424 holes each with a .00159 meter (1/16 inch) diameter for a total flow efflux area of .0028 square meters (.0303 square feet). The top manifold will be an integral part of the dome attached by stringers at several key points, Figure 4.3.3-5. This design allows unit installation. The bottom manifold is located at the sump level and supported off the sloped floor as shown in Figure 4.3.3-6. The bottom manifold will be valved externally to the tank to allow conversion from the trickle oil sump operation to the dual medium manifold.

4.3.3.2.3 Sumps

Each tank will have a separate sump of similar design located at the center of the tank. Each sump will be cylindrical in shape, 0.915 meter (3 feet) in diameter and 0.915 meter (3 feet) deep with a capacity of 0.605 cubic meters (160 gallons) - see Figure 4.3.3-7.

The bottom of the sump will be sloped toward a drain with a removable cover for sludge cleanout. The outlet pipe will enter from the side of the sump. A .025 meter (1 inch) grid grate is located directly above the pipe to inhibit formation of a large vortex flow which could result in pump cavitation. The outlet pipe will have a capped end with multiple holes on the bottom side also to minimize any strong vortex formation. A solid 1.52 meter (60 inch) flat head will be mounted 0.15 meter (6 inches) above the tank floor and supported by load carrying gussets which distribute the load directly to the support structure. Hole perforations are located around the side of the flat head. This design prevents sludge from falling directly into the sump and allows flat layout of the bottom manifold.

4.3.3.2.4 Taconite Storage Medium

Taconite is the packed bed storage medium. The taconite pellets are sphere-like pellets with a nominal size range of .00952-.0175 meter (3/8 - 11/16 inch) in diameter. The bulk density is 1760-2030 kg/m^3 (110-130 lb/ft^3) and its average specific heat from 273-644° K (0 to 700° F) is 793J/kg-°K) (0.19 Btu/lb-°F). Typical composition of taconite is:

Fe	62-65%
SiO_2	5-6%
P	.01-.04%
M	.1-.3%
Al_2O_3	.22-.88%
C_aO	.20-.43%
M_gO	.04-.66%
S	.002%
H_2O	1-3%
O_2	Remainder

Approximately 9.36 x 10^4 kg (103 tons) of taconite will be packed into the one hour tank and 3.16 x 10^5 kg (348 tons) in each of the three larger tanks for a total taconite weight of 1.04 x 10^6 kg (1147 tons). Larger sized pellets will be screened and used as bottom layers in each of the tanks to provide adequate drainage to the sump.

4.3.3.3 SCS Pumps

Pumping power for the entire Solar Collection Subsystem is supplied by high temperature centrifugal pumps which are located in the Mechanical Building. These pumps are designed to operate at 672° K (750° F) and have water cooled stuffing boxes and bearing frames. Totally enclosed, fan cooled, 3 phase motors drive the pumps. The casing of each pump in the SCS is flange connected to the tubing through free flexing expansion joints to minimize axial and lateral displacement loadings during thermal expansion. The pump casing is also insulated. Each pump has isolation valves for maintenance and a pump casing drain. A cross-sectional view of a typical pump along with a list of materials of construction is shown in Figure 4.3.3-8.

4.3.3.3.1 Collector Field Pumps

A set of two centrifugal pumps supply the pumping needs of the Collector Field Subsystem. Each pump is rated for 0.020 m^3/sec (320 gpm) at 49 m (160 ft) of head, and when operated together, in parallel, they can provide the maximum collector field flow requirements of 0.025 m^3/sec (390 gpm) at 67 m (220 ft) of head. This parallel pump design provides greater system reliability and reduced power consumption. As indicated on Figure 4.3.3-9, single pump operation can provide sufficient flow to the collector field for 2/3 of the time during the average day. The second pump is needed only during the peak insolation period each day. With this parallel operation, peak power consumption is less than 30 kW. A characteristic pump curve for the CFS pumps is shown in Figure 4.3.3-10.

Two inline flow meters and pressure transducers are used to measure the flow rate to the collector field and provide pump permissives. Individual flow meter bypass allows maintenance during system operation with no loss of flow data. A loop strainer is installed upstream of the pumping system. Downstream of the pumps is a pneumatically operated throttling valve whose position is preset according to the time of day to control the maximum flow delivered to the field.

4.3.3.3.2 HTS Transfer Pumps

A single centrifugal pump supplies the pumping power required to transfer the heated Syltherm 800 fluid from one HTS tank to another. This pump is rated at 0.025 m^3/sec (390 gpm) at a head of 25 m (81 ft). The installation of this pump is similar to that of the CFS pumps except that there is no bypass or redundancy. A characteristic pump curve is shown in Figure 4.3.3-11.

4.3.3.3.3 Steam Generator Supply Pump

The steam generator supply pump delivers the heated Syltherm 800 fluid to the steam generator. This pump is rated for 0.021 m^3/sec (325 gpm) at 31 meters (102 feet) and is capable of providing the maximum flow rate required by the steam generator during all modes of operation. This pump has a modulated bypass to provide flow adjustments to compensate for the pressure drop across the steam generator. A characteristic pump curve for the steam generator supply pump is shown on Figure 4.3.3-11.

4.3.3.3.4 Fossil Heater Booster Pump

The fossil fuel fired Syltherm 800 heater has a single centrifugal pump rated for 0.021 m^3/sec (325 gpm) at 31 meters (102 feet) of head. This pump is part of the Syltherm 800 heater package, and it can be used to supply heated fluid to the collector field, to the HTS tanks, or to the steam generator.

4.3.3.4 Fossil Fired Heater

4.3.3.4.1 Design Criteria

a) Sizing Criteria

The fossil fired hot oil heater will be designed to heat 0.021 m^3/sec (325 gpm) or 15.4 kg/s (122,070 pounds per hour) from 533°K to 672°K (500°F to 750°F) for a net output of approximately 1.7 x 10^4 joules (16 Btu) at an efficiency of approximately 85 percent. Natural gas will be the fuel source.

b) Material Compatibility

The unit will be constructed of carbon steel, carbon steel alloy, or stainless steel as dictated by the temperatures of the various components.

c) Electrical Requirements

The electrical requirements will be approximately 11.2 kW (15 hp) for the combustion air fan plus the minimal requirements for instrumentation and controls.

d) Maintenance and Testing Requirements

1) The hot oil heater should require only a minor amount of servicing. Instruments and controls should have an annual calibration check. The combustion chamber should be visually inspected on a semi-annual basis for any indication of fireside corrosion and/or erosion. The manufacturers representative should make an inspection on an annual basis.

2) The unit's components should be lubricated and otherwise serviced per the manufacturers printed instructions.

3) The hot oil system fluid should be sampled and tested at the appropriate intervals as recommended by the manufacturer of the fluid for deterioration or other undesirable properties.

e) Component Special Features

The hot oil heater will be equipped with a combustion air preheater for recovery of waste heat from the flue gases. The air inlet and the flue gas outlets ducts will be provided with high quality dampers for sealing the unit and preventing air at ambient temperatures from circulating through the heater, thereby preventing energy losses from the heater.

f) Component Operational Limitations

The hot oil heater will be operated as necessary and in conjunction with the other components of the Solar Collection Subsystem. The fossil fired hot oil heater controls will be furnished by the heater manufacturer and will be interlocked with the subsystem controls to furnish the required thermal energy as required by the STES central computer.

4.3.4 CONTROLS AND INSTRUMENTATION

4.3.4.1 Tracking Control

4.3.4.1.1 Design Criteria

a) Provide automatic closed loop tracking in the declination and polar axes of each collector

b) Provide collector pointing at low insolation levels (cloud cover)

c) Accommodate shadowing effects

d) Provide total pointing error less than $1/4^{o}$

e) Provide a defocus slew rate in excess of 2 deg/sec for at least 10 degrees of travel

f) Provide monitor and control functions at the central computer console

g) Provide for manual and stow positioning controls

h) Provide for sequential collector actuation to minimize power surges

i) Provide instrumentation for performance evaluation

4.3.4.1.2 Control Description

When in the tracking mode, each axis of the collector will operate in one of two modes depending upon the level of solar insolation. During intermittent cloudy periods, pointing angles for each axis are calculated in the computer and provide command angles for closed loop position control. At insolation levels above threshold, sun tracker operation takes over, and each axis is operated by sun tracker developed errors. In this mode, position errors are limited by monitoring the computed positions to establish sun tracker position error thresholds.

After morning start-up, each of the polar axis motors are operated alternately. Further, within a group of collectors, motors are operated sequentially to minimize power surges on the motor power supply system.

The tracking control has the capability to return to the morning start-up position after evening shutdown. The polar motors are operated sequentially, as are the collectors within the group. Each collector also has the capability to be programmed to a stow position and a maintenance position if different from stow.

Each receiver is provided with an overtemperature sensor and controller. In the event of an overtemperature, this controller is actuated and the collector defocused by operation of the polar dc motor. Rotation will be toward the morning position. An alarm is provided with an emergency power supply. Upon the loss of the ac bus, the dc motor will defocus the collector on emergency power. Also the controls prevent focusing of the collectors until fluid flow has been established in the receivers.

Collector tracking operation will be tested by operator command at the micro-processor or central computer level. Operation will be monitored at these locations using standard readout equipment.

4.3.4.1.3 Devices

The following components are included in the design of the tracking control.

Microprocessor
Analog to digital converters
Digital to analog converters
Position potentiometers
Quadrature sum sensor head
Analog electronics package
Control relay assembly
Thermocouple
Temperature reference on controller

4.3.4.1.4 Alarms

The following alarms are included in the tracking control.

- Overtemperature alarm
- Operational modes/status
  - Track
    - Computer
    - Sun tracker
  - Stow
  - Defocus

4.3.4.2 Field Temperature Control

4.3.4.2.1 Design Criteria

a) Deliver Syltherm 800 fluid to the field return line at 658 to 672°K (725° to 750°F)

b) Maximize the fluid flow within the temperature constraints

c) Accommodate transients due to cloud cover

d) Control branch flow based on maximum collectors per branch

e) Minimize temperature variations between collectors in a branch

f) Provide instrumentation for performance evaluation of the subsystem

4.3.4.2.2 Control Description

The required collector field flow is calculated from solar insolation, shading factor, and other pertinent parameters. The calculated value is then used to adjust the centrifugal pump bypass flow so as to provide the correct flow to the collector field. In this way, operation of the pump is held near a fixed point for maximizing its efficiency.

The collector flow paths are paralleled in groups to a branch per design field layout. The flow in each receiver is manually adjusted during initial startup with trim flow valves so that all receivers in a branch will have equal flow at maximum insolation condition. The inlet flow to the branch is controlled by a flow control valve operated by a temperature controller. The discharge temperature of all receivers is instrumented and the highest used for operating the temperature controller so long as it is below the trip out (defocus) temperature for the receiver. If the receiver discharge temperature exceeds the alarm (defocus) temperature, the collector is defocused to reduce the receiver temperature. An audible/visible alarm is provided and manual reset required.

4.3.4.2.3 Devices

The following devices are included in the design of the field temperature control.

Microprocessor
Minicomputer
Operator's console
Valve drivers
Thermocouples and RTD's
EMF Comparators
Alarms
High EMF Selector
Temperature Controller (three mode)

4.3.4.2.4 Alarms

The following alarms are included in the field temperature control.

Overtemp Alarms (audible/visible)
  each collector
  pipe field locations

Pump On/Off
Flow Loss Alarms
  Branch
  Header
  Pump
  Bypass
Loss of AC power

4.3.4.3 <u>Thermal Energy Storage Controls</u>

4.3.4.3.1 Design Criteria

a) Provide capability to charge and discharge storage tanks

b) Activate/deactivate collector field based on insolation and storage requirements

c) Determine tank status whether charged, discharged, or inverted

d) Determine system load requirements

4.3.4.3.2 Control Description

The bottom and top tank temperatures are used to establish the status of each storage tank along with its most recent history of operation. For the trickle oil mode, a tank is charged with hot fluid in the top and discharged with hot fluid exiting the bottom. In the thermocline mode, hot fluid enters and leaves the top of the tank for charge and discharge, respectively.

The control processor will determine when to charge or discharge the tank based on the energy available from the collector field and the energy requirements of the system. The various on/off valves in the system will be operated by the logic to accomplish this.

The processor will determine if sufficient energy can be obtained from the collector field to charge the tanks or operate the system. It will also determine when to discontinue field operation due to low solar insolation or a fully charged TES.

The processor will also determine the status of all tanks and the system energy requirements. The fossil heater will be actuated if the stored energy level drops below a preselected threshold value.

4.3.4.3.3 Devices

The following devices are included in the design of the TES controls.

Thermocouples
Temperature references
Microprocessor
A/D inverters
Solenoid valves
Valve drivers

4.3.4.3.4 Alarms

The following alarms are included in the TES controls.

Temperature Alarms, high and low
Collector Field Status: on/off, energy rates
Tanks: Charged/Discharged

4.4 SUBSYSTEM OPERATION

4.4.1 NORMAL OPERATION

4.4.1.1 Startup Operation with Storage Depleted

Startup of the SCS with storage depleted begins with the actuation of the fossil fired Syltherm 800 heater and pump to provide the energy needed to operate the PCS and the TUS. The steam generator supply pump supplies flow to the steam generator, and the steam generator control valve, responding to the demands of the PCS, provides flow control. During this initial period, the Steam Generator Supply Subsystem is isolated from the collector field. One of the HTS tanks which is open to the suction line of the SGS pump provides thermal expansion capability and sufficient net pump suction head (NPSH).

Activation of the solar collector field includes both initiation of the parabolic dish tracking mechanism as well as startup of the collector field pump and the field flow control valves. The principal activation signal for the field is the integrated direct normal insolation. If the insolation level exceeds the startup threshold value of approximately 236 W/m^2 (75 Btu/hr-ft^2), solar collection is initiated. The Syltherm 800 recirculates through the field, gradually heating up, while the fossil heater, PCS, and TUS continue to function to provide the Bleyle Plant loads. This mode of recirculation will continue until the outlet from the field reaches approximately 533°K (500°F). At this point, the recirculation is discontinued, and the field flow is directed through the smaller (1 hour) discharged storage tank. During this mode, the collector outlet temperature gradually increases to its normal operating range of 658°K (725°F-750°F).

When the sump temperature in the one hour storage tank reaches 561°K (550°F), the exiting Syltherm 800 fluid is directed through the next discharged storage tank and back to the collector field. The HTS transfer pump is used to maintain the transfer flow between the tanks. This mode allows the one hour tank to become fully charged without exceeding the 561°K (550°F) field inlet temperature limit.

When the one hour tank is fully charged, the bulk of the hot fluid from the collector field is directed toward the Steam Generator Supply Subsystem where it is used to satisfy the steam generator load. The remainder of the collector field outlet flow is used to continue charging the storage tanks.

4.4.1.2 Startup Operation with Storage Charged

Startup of the SCS with the storage charged proceeds in the same manner as the case with the storage depleted; however, instead of activating the fossil fired heater, the HTS subsystem is placed on line to supply the PCS startup and operating energy. If the one hour storage tank is charged, it is the first tank to be discharged. This assures that the one hour tank will be empty when the approach to operating temperature mode is begun. If the one hour tank is discharged, the next partially discharged or fully charged large tank is placed on line to supply the steam generator.

After the collector field has reached its normal operating temperature, if the HTS subsystem is still greater than 60 percent charged, some cutback of flow to the collector field may necessary. This situation would occur if the full flow field output exceeded the PCS demands and the available storage capacity.

4.4.1.3 Solar Power Operation

In the normal operating mode of the SCS, heated Syltherm 800 fluid from the collector field is supplied directly to the steam generator supply pump, then to the steam generator, and back to the field. Only flow from the collector field which is in excess of the PCS demands flows through one of the storage tanks to be charged. Thus, in this mode, the SCS supplies energy directly to the load, with excess energy being stored.

When the Syltherm 800 fluid flow from the collector field is less than the PCS demand, the additional required flow will be made up by discharging a charged storage tank. This additional flow is drawn from and returned to the discharging tank by the steam generator supply pump, which also serves as a booster pump to the direct flow from the collector field.

During evening operation or whenever sufficient solar insolation is unavailable, the demands of the PCS will be supplied by discharging the HTS subsystem until the storage is depleted.

4.4.1.4 Shutdown Operation

In normal operation, Solar Collection Subsystem shutdown occurs through the sequential shutdown of the collector field, the HTS discharge operation, and fossil heater shutdown. Collector field shutdown occurs when the field outlet temperature drops below the 658°K (725°F) minimum. The field pump stops, and the collectors reverse and move to the nighttime stow position. If the integrating pyrheliometer signal drops below 236 W/m^2 (75 $Btu/hr\text{-}ft^2$) even though the field outlet temperature may be above 658°K (725°F), the collectors will be stowed unless the integrated signal has changed due to an increase in the insolation level (i.e., a break in the clouds occurs). Shutdown under these conditions always occurs with the collectors going to the fully stowed (nighttime) position.

HTS shutdown occurs when the supply outlet temperature from the last tank available for discharge drops below the 658°K (725°F) minimum steam generator delivery temperature or there is no longer a sufficient plant electrical demand to require turbine-generator operation. Typically, this condition will occur at the end of the second shift of the plant operating day. The fossil heater will shut down when there is no longer a sufficient plant electrical demand to require turbine-generator operation. The fossil heater and steam generator supply pump are shut down in conjunction with PCS shutdown. During shutdown of the SCS, an inert nitrogen gas cover will be maintained over the entire fluid loop, including TES tanks, at the design pressure.

4.4.2 Off-Normal Operation

Two major off-normal operational modes have been identified for the SCS. The first involves an emergency condition which arises as a result of loss of ac power or fluid flow while the collectors are tracking. If this condition occurs the collectors go into automatic defocus operation in which individual polar dc motors drive the collectors toward the east. Full stow can then safely be accomplished in a normal fashion after power is returned to the field.

A second mode of off-normal operation occurs when the system collects and stores energy in the three large TES tanks without delivery to the steam generator. This condition typically occurs during weekends when the TES tanks are charged, and the PCS is not operating. In this operating mode, each tank is charged until breakthrough and sequential inter-tank transfer is performed to fully charge the total HTS subsystem. After fully charging the subsystem, collector field and HTS shutdown will occur normally as described in Section 4.4.1.4.

TABLE 4.3.1-1. SUGGESTED PIPE SUPPORT SPACING

Nominal Pipe Size Inches	Suggested Maximum Span			
	Water Service*		Steam, Gas, or Air Service	
	Feet	m	Feet	m
1	7	2.1	9	2.7
2	10	3.0	13	4.0
3	12	3.7	15	4.6
4	14	4.3	17	5.2
6	17	5.2	21	6.4
8	19	5.8	24	7.3
12	23	7.0	30	9.1
16	27	8.2	35	10.7
20	30	9.1	39	11.9
24	32	9.8	42	12.8

Note 1. Suggested maximum spacing between pipe supports for horizontal straight runs of standard and heavier pipe at maximum operating temperature of 672°K (750°F)

Note 2. Does not apply where span calculations are made or where there are contrated loads between supports such as flanges, valves, specialties, etc.

Note 3. The spacing is based on a maximum combined bending and shear stress of 1035 MPa (1500 psi) and insulated pipe filled with water or the equivalent weight of steel pipe for steam, gas or air service, and the pitch of the line is such that a sag of 0.0025m (0.1 in.) between supports is permissible.

*Applicable also to oil service pipes.

Table 4.3.1-2. Tubing Insulation Schedule*

Tube Outer Dia. - Inches	533°K (500°F)		672°K (750°F)	
	Thickness (inches)	Material	Thickness (inches)	Material
1/2 x 3/4 up and down nested	4.0	Certainteed 850	4.0	Certainteed 850
5/8 nested	4.0	Certainteed 850	4.0	Certainteed 850
3/4 nested	4.0	Certainteed 850	4.0	Certainteed 850
1.0 nested	4.0	Certainteed 850	4.0	Certainteed 850
1.5 single	3.0	Certainteed 850	4.0	Certainteed 850
2.0 single	3.5	Certainteed 850	4.5	Thermo 12
2.5 single	3.5	Certainteed 850	5.0	Thermo 12
3.5 single	4.0	Certainteed 850	5.5	Thermo 12
4.5 single	4.5	Certainteed 850	6.0	Thermo 12

*All Insulation Multilayer

Table 4.3.2-1. Collector Performance

Insolation BTU/FT^2	Thermal Energy Delivered BTU	Flow Rate LBM/HR	Flow Rate GPM	Efficiency $Q_{thermal}/Q_{sun}$
300	88,900	710	1.967	0.716
250	72,200	578	1.601	0.697
200	55,500	444	1.23	0.670
150	38,800	310	0.86	0.625
100	22,100	177	0.49	0.534
50	5,400	43	0.119	0.260

Table 4.3.2-2. Receiver Thermal Performance

Outlet Temp °F	Thermal Losses			Total Q_{loss} BTU
	Q_{rad} BTU	Q_{conv} BTU	Q_{cond} BTU	
775	8199	4104	963	13266
750	7410	3933	926	12269
725	6676	3762	889	11727
700	5995	3591	853	10439

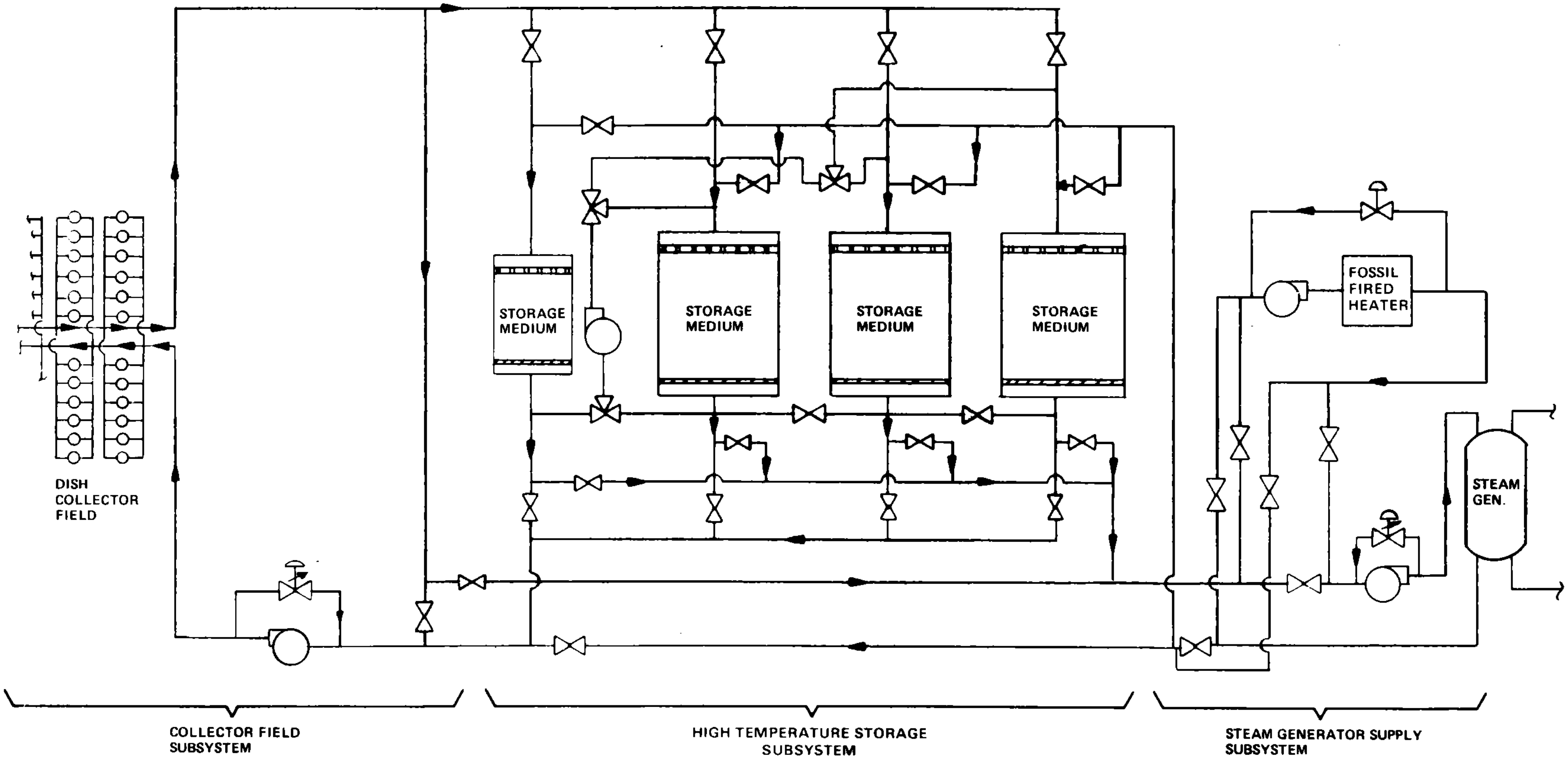


Figure 4.1.2-1. Solar Collection Subsystem

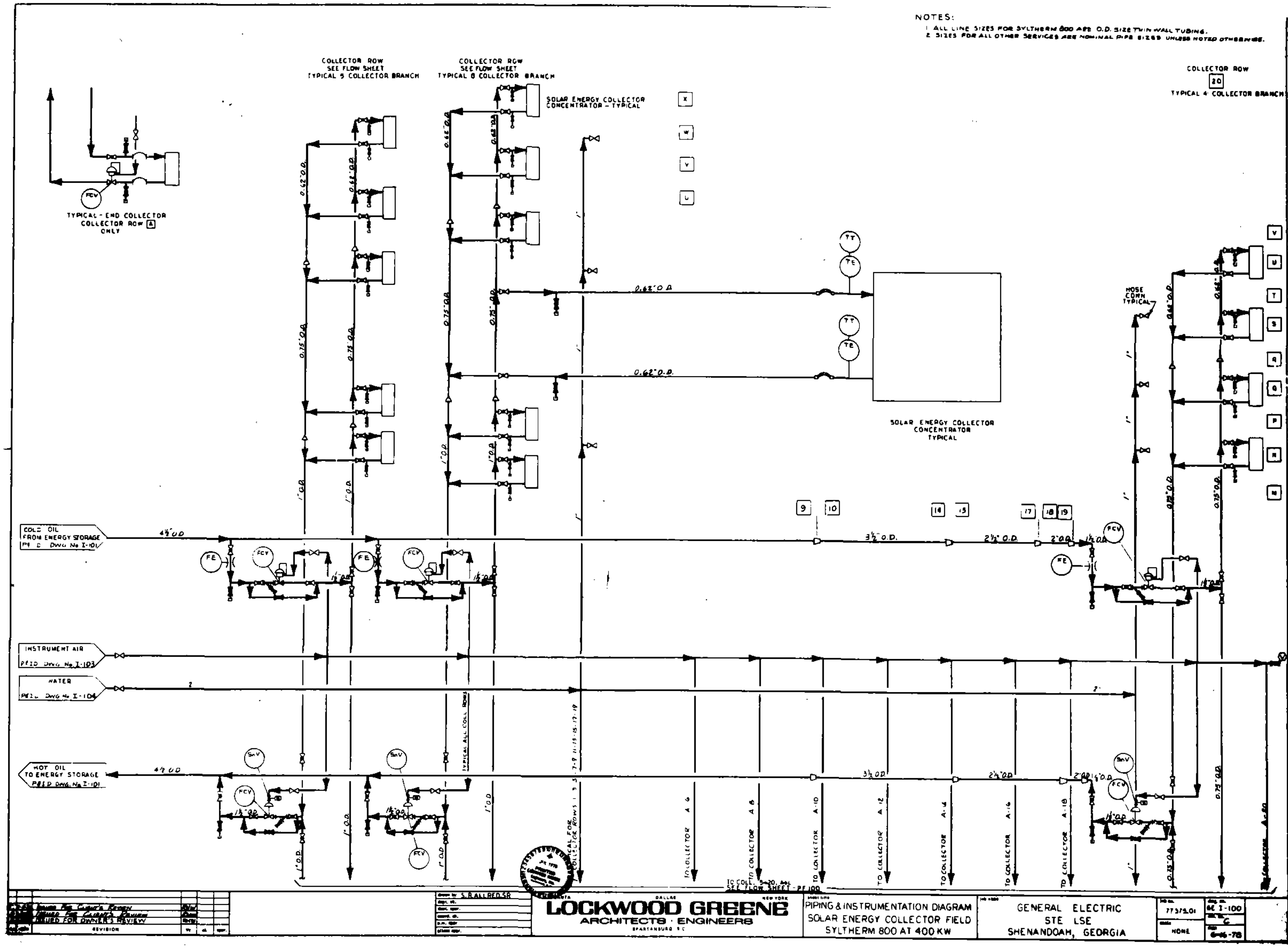


Figure 4.1.2-2. Piping & Instrumentation Diagram Solar Energy Collector Field Syltherm 800 at 400 kW.

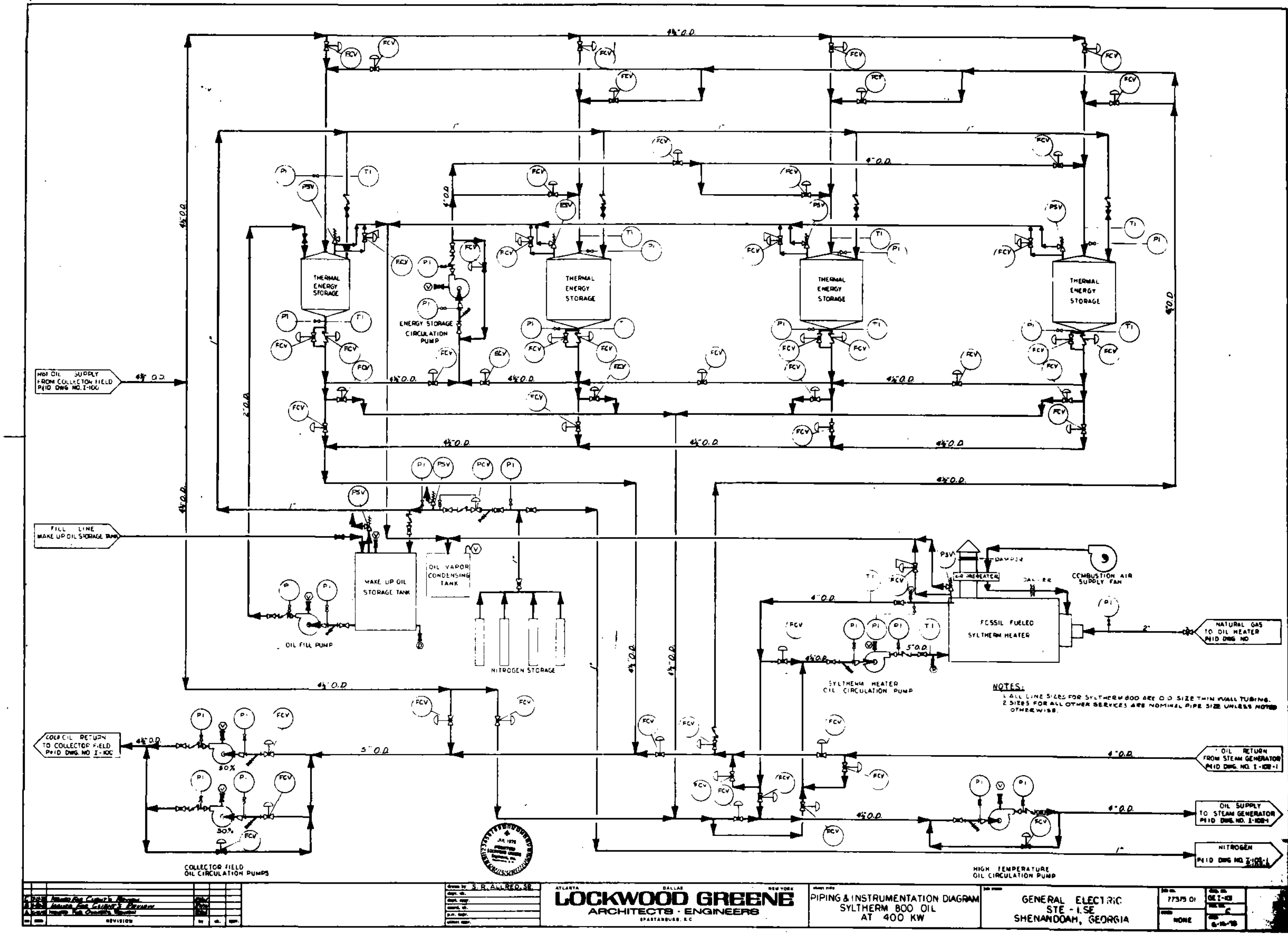
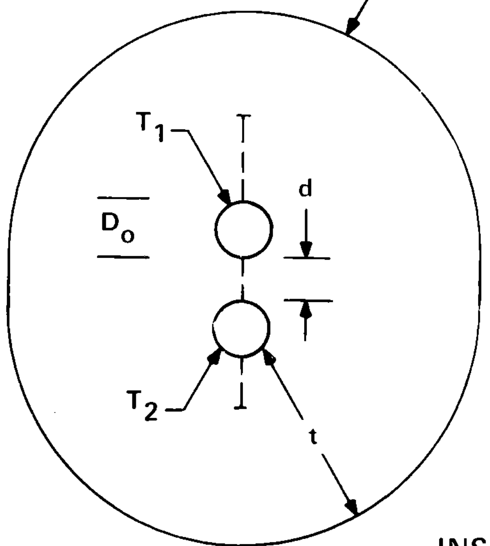


Figure 4.1.2-3. Piping and Instrumentation Diagram for the HTS Subsystem

h = 4.0 BTU/HR-FT^2-$^\circ$F



$T_{AMB} = 60^\circ F$

T_1 = HOT PIPE SURFACE TEMPERATURE – $^\circ$F
T_2 = COLD PIPE SURFACE TEMPERATURE – $^\circ$F
d = TUBE OR PIPE SEPARATION – IN.
D_o = TUBE OUTSIDE DIAMETER – IN.
t = INSULATION THICKNESS

INSULATION MATERIAL EQUIVALENT TO CERTAINTEED 850

k @ $T_{avg} = 400^\circ F$ IS $\frac{.42 \text{ BTU IN.}}{\text{HR–FT}^2\text{–}^\circ\text{F}}$

$\rho = 5.25$ LBS/FT^3 $\quad C_p = \frac{.2 \text{ BTU}}{\text{LB–}^\circ\text{F}}$

Figure 4.3.1-1. Nested Pipe Analysis

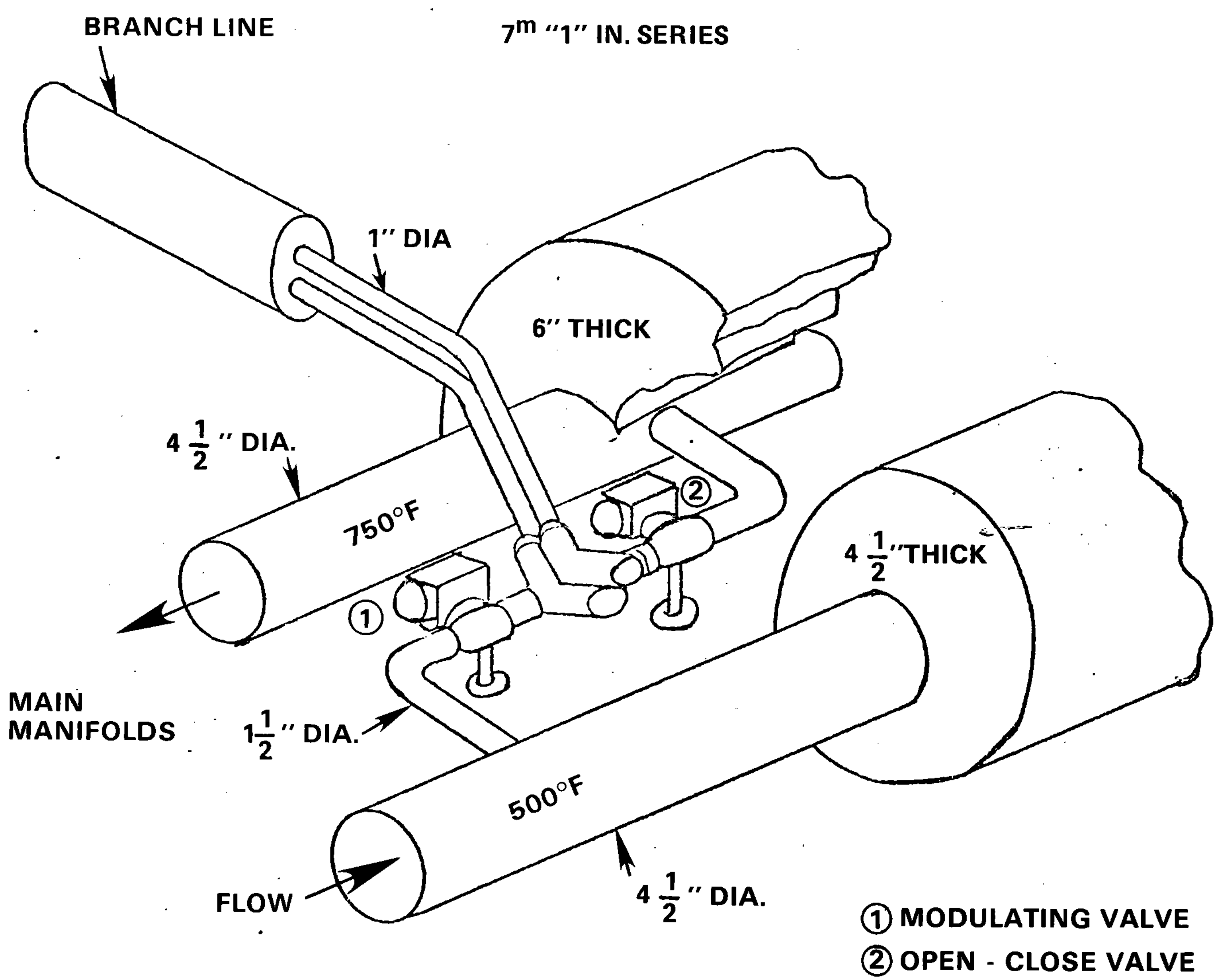
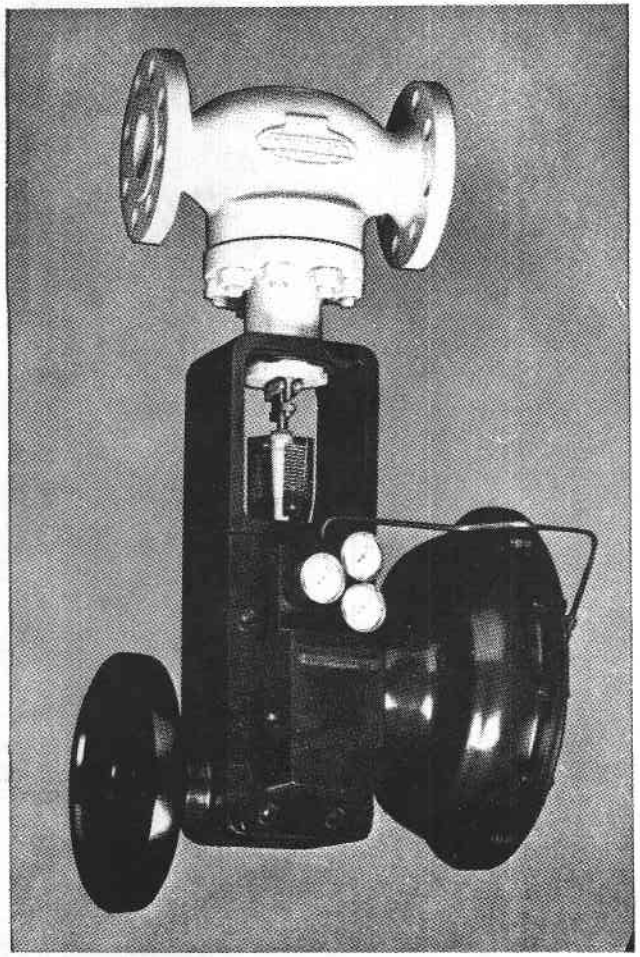
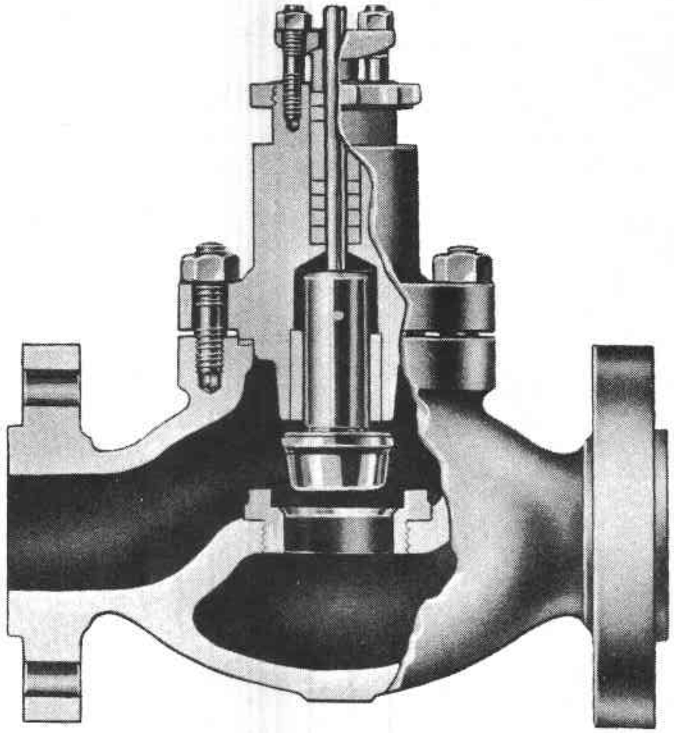


Figure 4.3.1-2. Branch Isolation and Control





Full Capacity Trim

Figure 4.3.1-3. Pneumatic Control Valves

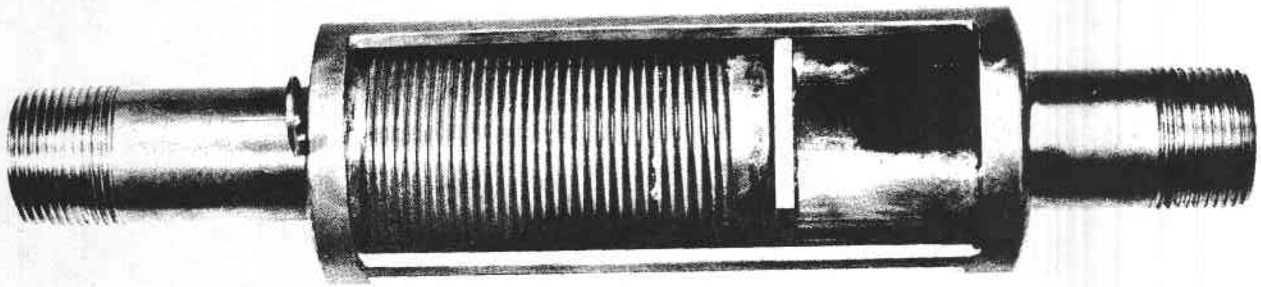
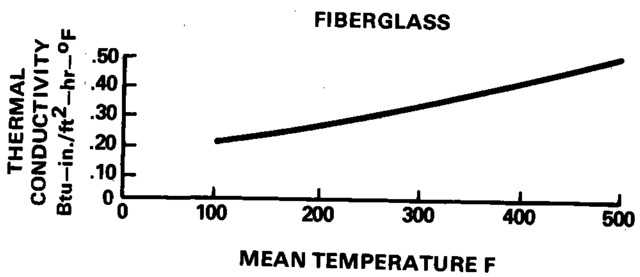


Figure 4.3.1-4. Thermal Expansion Compensator Linear Type



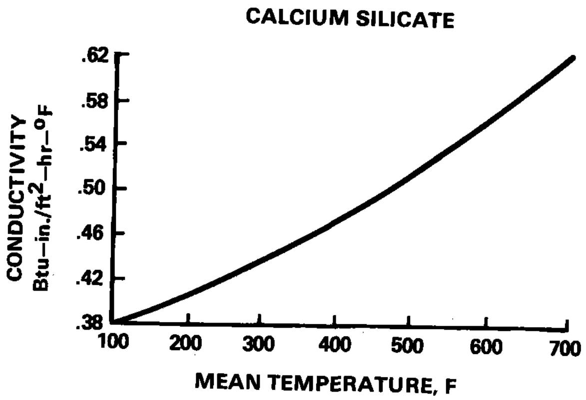


Figure 4.3.2-1. Insulation System Properties

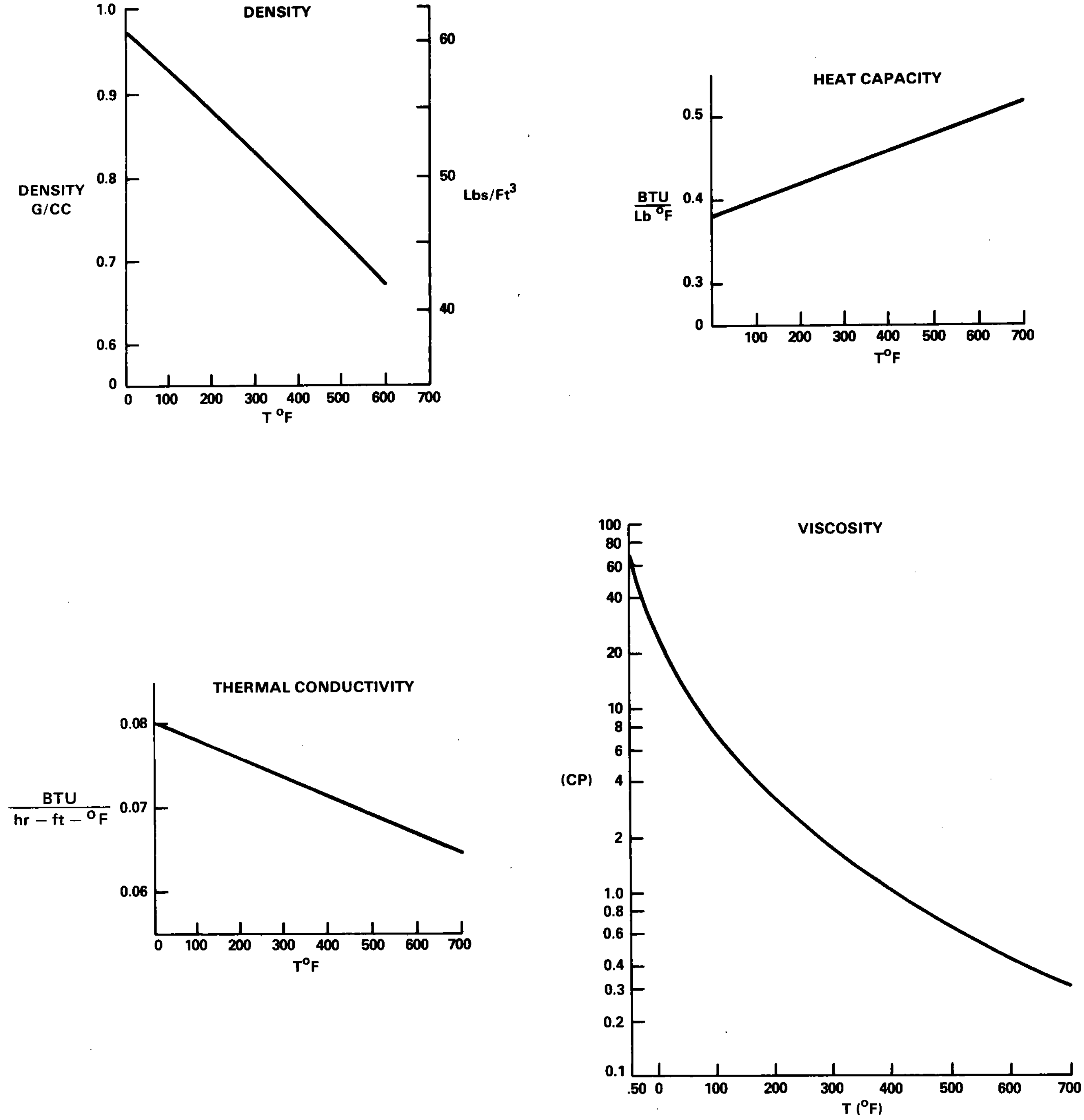
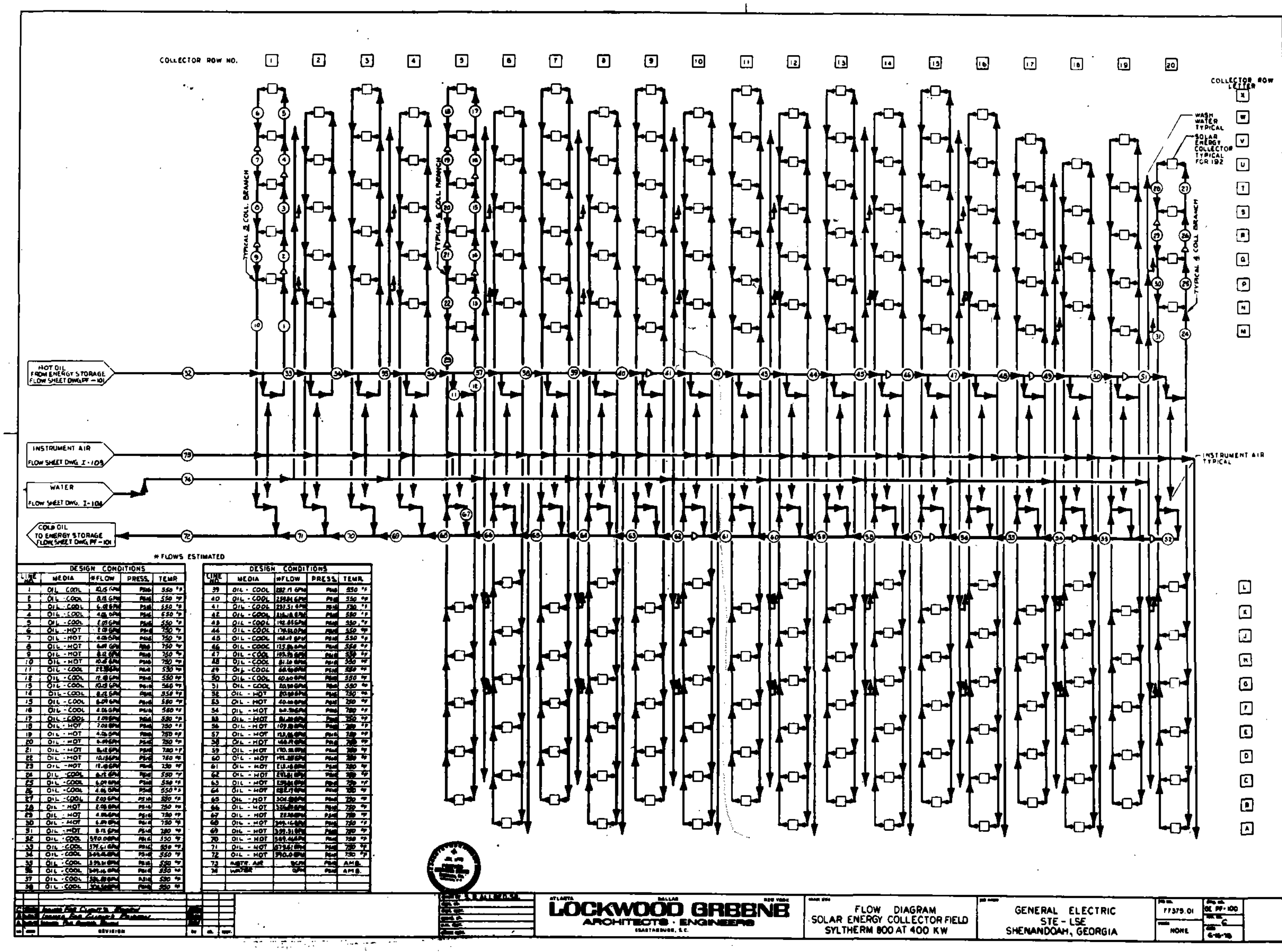


Figure 4.3.2-2. Typical Properties of Dow Corning Syltherm 800



DESIGN CONDITIONS

LINE NO.	MEDIA	*FLOW	PRESS.	TEMP.
1	OIL COOL	[illegible]	PSIG	550 °F
2	OIL - COOL	8.12 GPM	PSIG	550 °F
3	OIL - COOL	6.09 GPM	PSIG	550 °F
4	OIL - COOL	4.06 GPM	PSIG	550 °F
5	OIL - COOL	[illegible]	PSIG	550 °F
6	OIL - HOT	[illegible]	PSIG	750 °F
7	OIL - HOT	4.06 GPM	PSIG	750 °F
8	OIL - HOT	6.09 GPM	PSIG	750 °F
9	OIL - HOT	8.12 GPM	PSIG	750 °F
10	OIL - HOT	10.15 GPM	PSIG	750 °F
11	OIL - COOL	[illegible]	PSIG	550 °F
12	OIL - COOL	12.18 GPM	PSIG	550 °F
13	OIL - COOL	10.15 GPM	PSIG	550 °F
14	OIL - COOL	8.12 GPM	PSIG	550 °F
15	OIL - COOL	6.09 GPM	PSIG	550 °F
16	OIL - COOL	4.06 GPM	PSIG	550 °F
17	OIL - COOL	2.03 GPM	PSIG	550 °F
18	OIL - HOT	2.03 GPM	PSIG	750 °F
19	OIL - HOT	4.06 GPM	PSIG	750 °F
20	OIL - HOT	6.09 GPM	PSIG	750 °F
21	OIL - HOT	8.12 GPM	PSIG	750 °F
22	OIL - HOT	10.15 GPM	PSIG	750 °F
23	OIL - HOT	12.18 GPM	PSIG	750 °F
24	OIL - COOL	8.12 GPM	PSIG	550 °F
25	OIL - COOL	6.09 GPM	PSIG	550 °F
26	OIL - COOL	4.06 GPM	PSIG	550 °F
27	OIL - COOL	2.03 GPM	PSIG	550 °F
28	OIL - HOT	2.03 GPM	PSIG	750 °F
29	OIL - HOT	4.06 GPM	PSIG	750 °F
30	OIL - HOT	6.09 GPM	PSIG	750 °F
31	OIL - HOT	8.12 GPM	PSIG	750 °F
32	OIL - COOL	390.0 GPM	PSIG	550 °F
33	OIL - COOL	379.61 GPM	PSIG	550 °F
34	OIL - COOL	[illegible]	PSIG	550 °F
35	OIL - COOL	[illegible]	PSIG	550 °F
36	OIL - COOL	349.16 GPM	PSIG	550 °F
37	OIL - COOL	[illegible]	PSIG	550 °F
38	OIL - COOL	[illegible]	PSIG	550 °F

DESIGN CONDITIONS

LINE NO.	MEDIA	*FLOW	PRESS.	TEMP.
39	OIL - COOL	282.17 GPM	PSIG	550 °F
40	OIL - COOL	[illegible]	PSIG	550 °F
41	OIL - COOL	237.51 GPM	PSIG	550 °F
42	OIL - COOL	[illegible]	PSIG	550 °F
43	OIL - COOL	192.85 GPM	PSIG	550 °F
44	OIL - COOL	[illegible]	PSIG	550 °F
45	OIL - COOL	[illegible]	PSIG	550 °F
46	OIL - COOL	[illegible]	PSIG	550 °F
47	OIL - COOL	[illegible]	PSIG	550 °F
48	OIL - COOL	[illegible]	PSIG	550 °F
49	OIL - COOL	[illegible]	PSIG	550 °F
50	OIL - COOL	40.60 GPM	PSIG	550 °F
51	OIL - COOL	20.30 GPM	PSIG	550 °F
52	OIL - HOT	20.30 GPM	PSIG	750 °F
53	OIL - HOT	40.60 GPM	PSIG	750 °F
54	OIL - HOT	[illegible]	PSIG	750 °F
55	OIL - HOT	[illegible]	PSIG	750 °F
56	OIL - HOT	[illegible]	PSIG	750 °F
57	OIL - HOT	[illegible]	PSIG	750 °F
58	OIL - HOT	[illegible]	PSIG	750 °F
59	OIL - HOT	[illegible]	PSIG	750 °F
60	OIL - HOT	[illegible]	PSIG	750 °F
61	OIL - HOT	[illegible]	PSIG	750 °F
62	OIL - HOT	[illegible]	PSIG	750 °F
63	OIL - HOT	[illegible]	PSIG	750 °F
64	OIL - HOT	[illegible]	PSIG	750 °F
65	OIL - HOT	[illegible]	PSIG	750 °F
66	OIL - HOT	[illegible]	PSIG	750 °F
67	OIL - HOT	[illegible]	PSIG	750 °F
68	OIL - HOT	349.16 GPM	PSIG	750 °F
69	OIL - HOT	359.31 GPM	PSIG	750 °F
70	OIL - HOT	369.44 GPM	PSIG	750 °F
71	OIL - HOT	379.61 GPM	PSIG	750 °F
72	OIL - HOT	390.0 GPM	PSIG	750 °F
73	INSTR. AIR	SCFM	PSIG	AMB.
74	WATER	GPM	PSIG	AMB.

Figure 4.3.2-3. Flow Diagram Solar Energy Collector Field Syltherm 800 at 400 kW.

GENERAL ELECTRIC

SYSTEM DESIGN PERFORMANCE

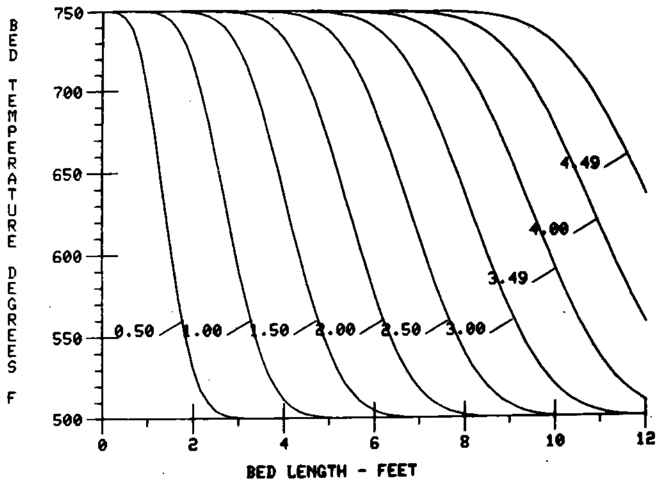
STE-LSE SHENANDOAH

ONE HOUR TANK

TANK CAPACITY = 9 x 10^6 BTU

CHARGE MODE

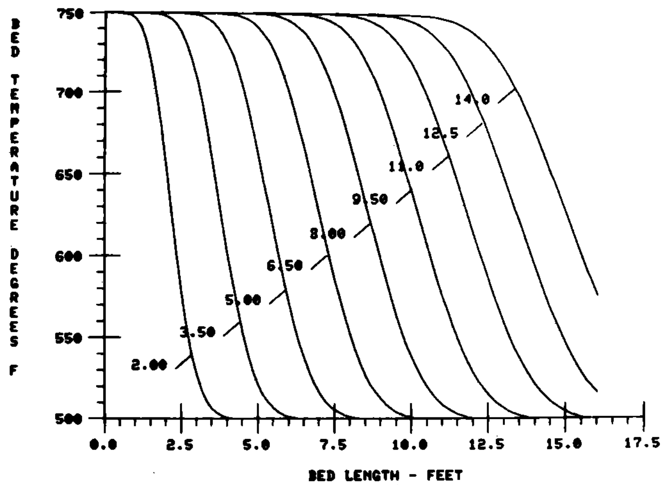
50 GPM



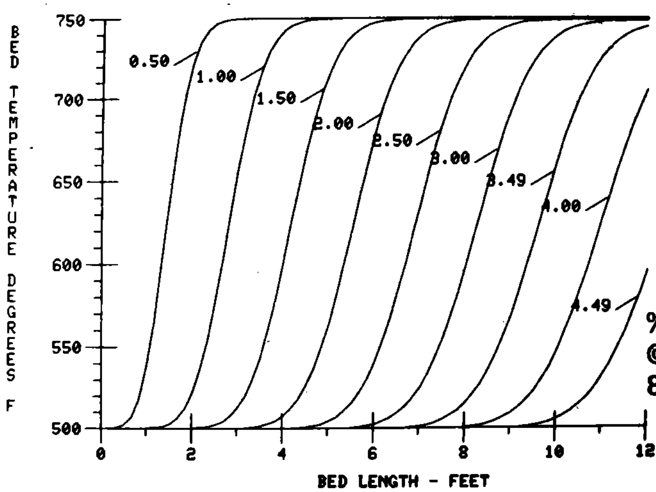
LARGE TANK

TANK CAPACITY = 30.3 x 10^6 BTU

CHARGE MODE

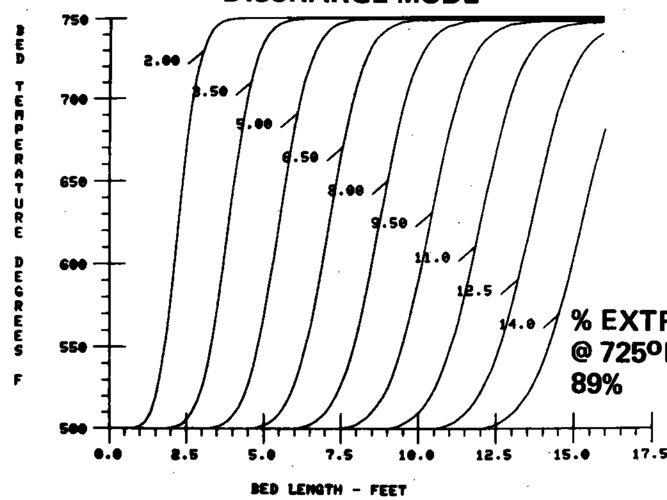


DISCHARGE MODE



% EXTRACTED @ 725°F 87.2%

DISCHARGE MODE



% EXTRACTED @ 725°F 89%

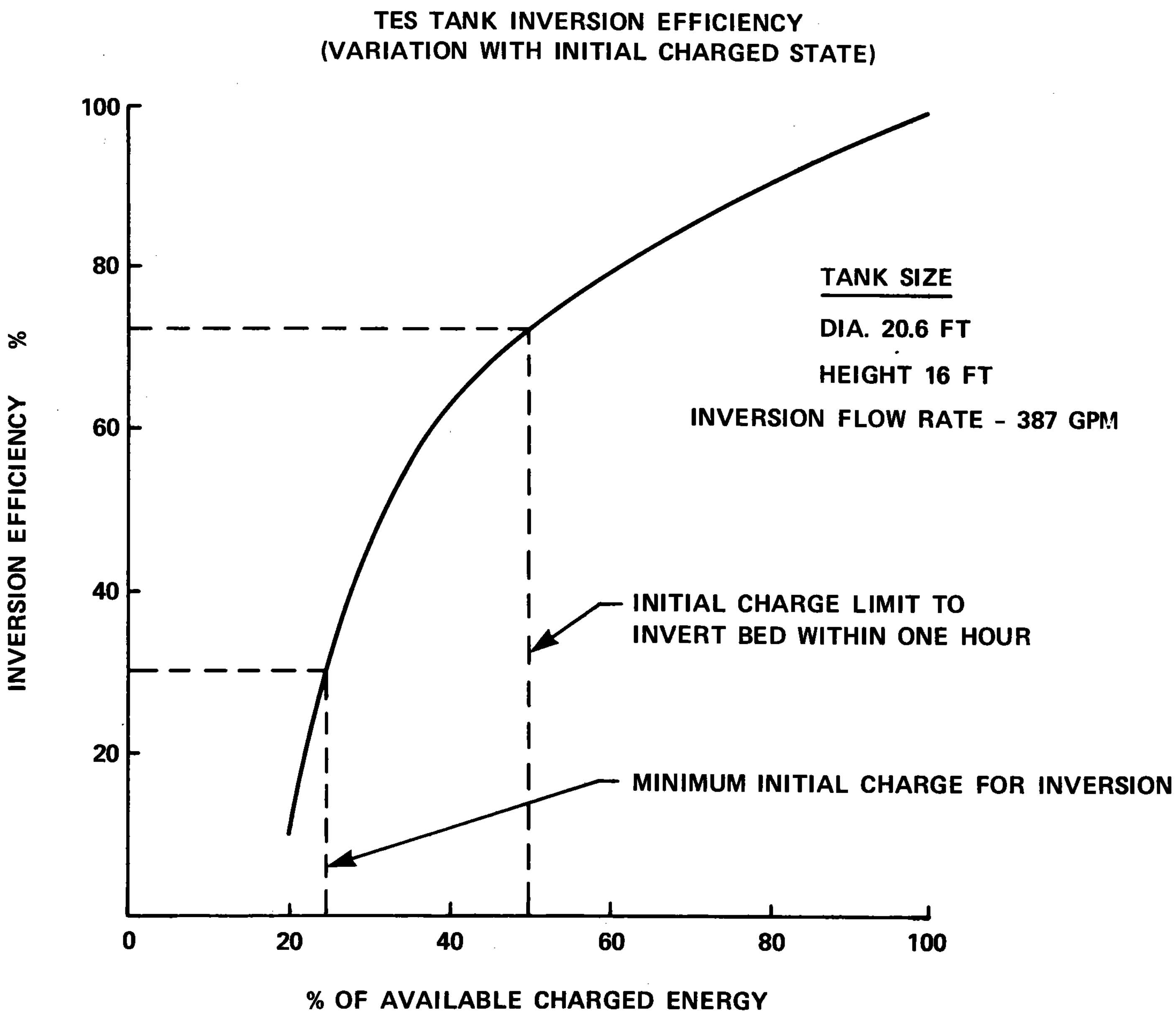


Figure 4.3.2-5. Test Tank Inversion Efficiency

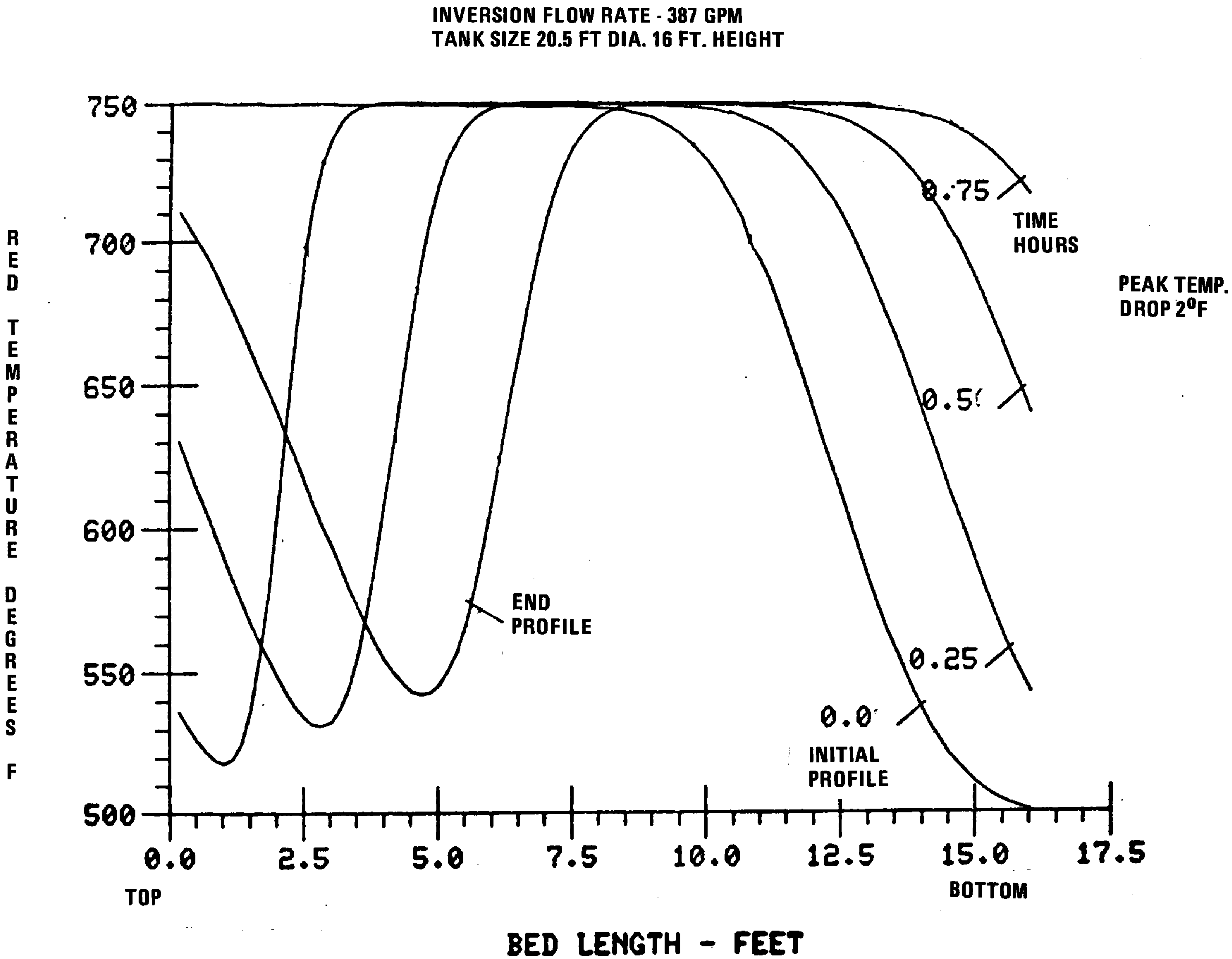
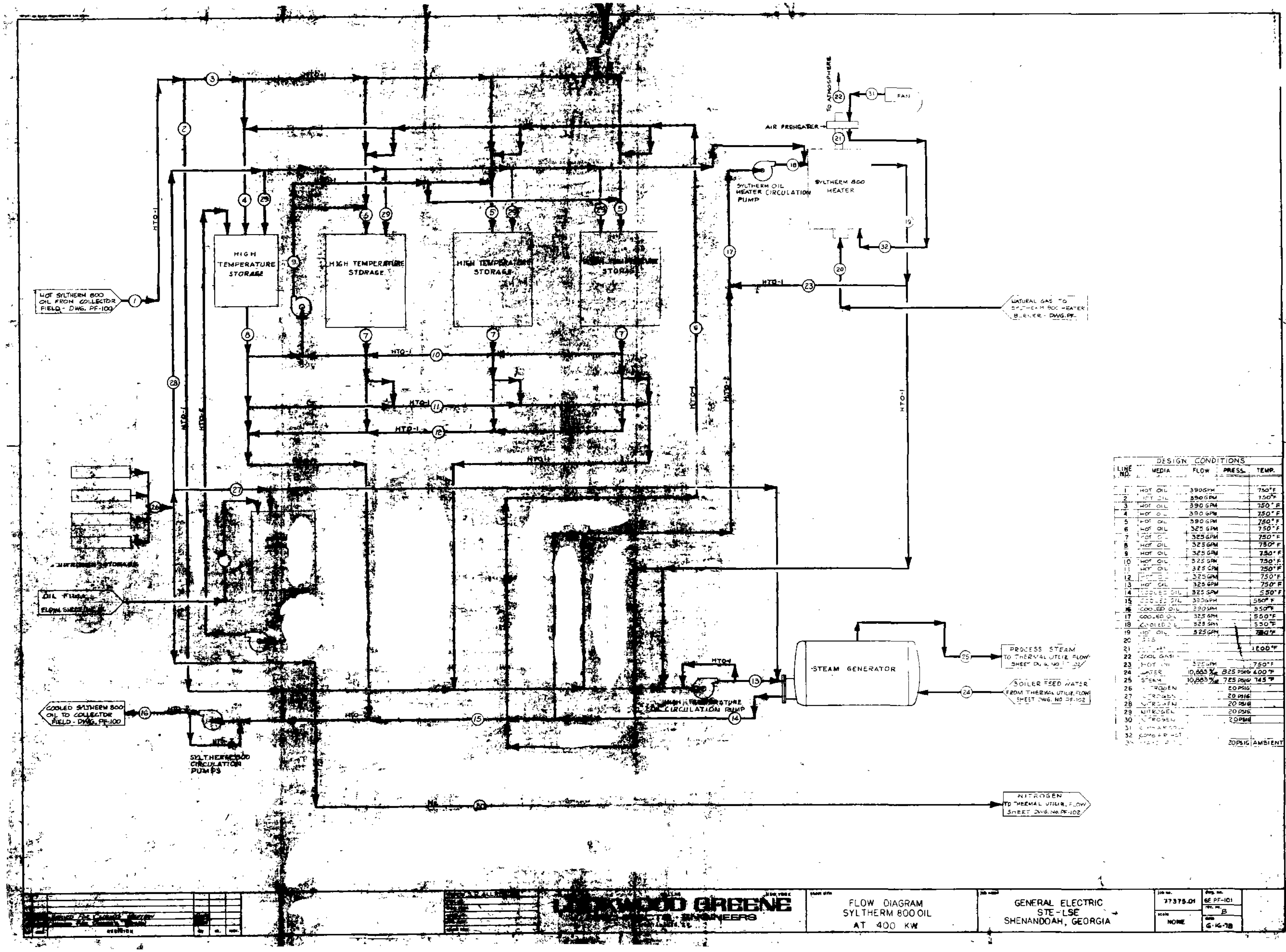


Figure 4.3.2-6. Inversion Profile for the Large Tank



DESIGN CONDITIONS

LINE NO.	MEDIA	FLOW	PRESS.	TEMP.
1	HOT OIL	390GPM		750°F
2	HOT OIL	390GPM		750°F
3	HOT OIL	390 GPM		750°F
4	HOT OIL	390 GPM		750°F
5	HOT OIL	390 GPM		750°F
6	HOT OIL	325 GPM		750°F
7	HOT OIL	325 GPM		750°F
8	HOT OIL	325 GPM		750°F
9	HOT OIL	325 GPM		750°F
10	HOT OIL	325 GPM		750°F
11	HOT OIL	325 GPM		750°F
12	HOT OIL	325 GPM		750°F
13	HOT OIL	325 GPM		750°F
14	COOLED OIL	325 GPM		550°F
15	COOLED OIL	390GPM		550°F
16	COOLED OIL	390GPM		550°F
17	COOLED OIL	325 GPM		550°F
18	COOLED OIL	325 GPM		550°F
19	HOT OIL	325GPM		[illegible]°F
20	GAS			
21	HOT GAS			1200°F
22	COOL GASES			
23	HOT OIL	325GPM		750°F
24	WATER	10,883 #/HR	825 PSIG	400°F
25	STEAM	10,883 #/HR	725 PSIG	745°F
26	NITROGEN		20 PSIG	
27	NITROGEN		20 PSIG	
28	NITROGEN		20 PSIG	
29	NITROGEN		20 PSIG	
30	NITROGEN		20 PSIG	
31	COMB AIR COLD			
32	COMB AIR HOT			
33	[illegible]		20PSIG	AMBIENT

Figure 4.3.2-7. Flow Diagram Syltherm 800

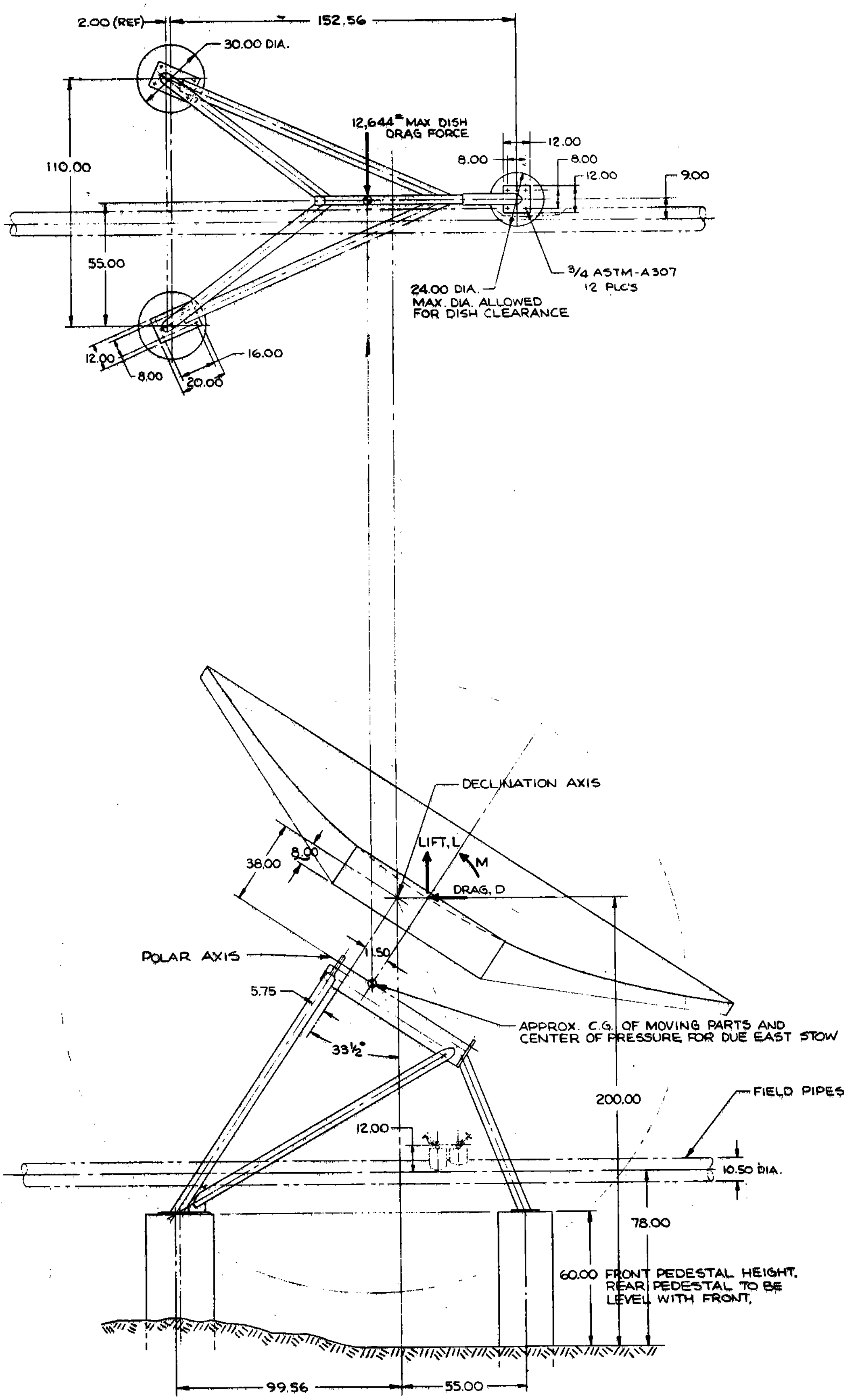


Figure 4.3.3-1. Collector Geometry.

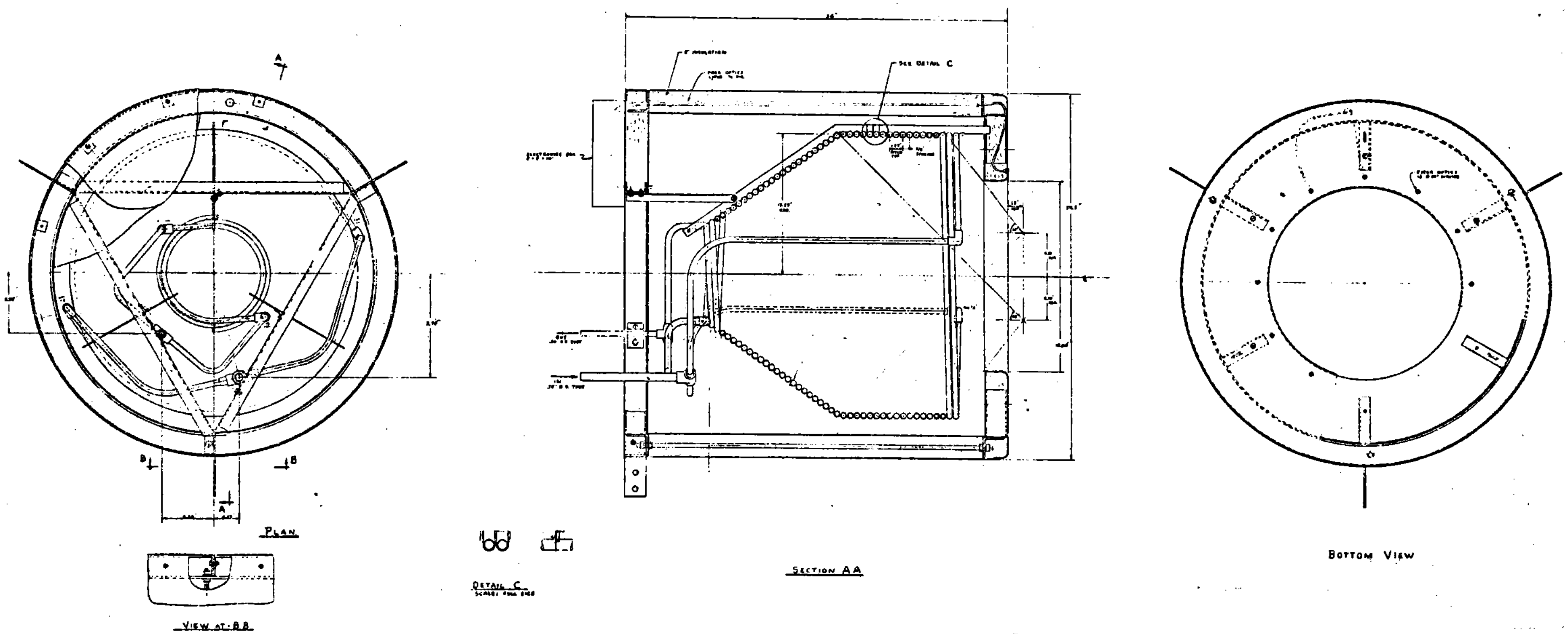


Figure 4.3.3-2. Receiver Configuration

ACTUATOR SPEED SELECTION

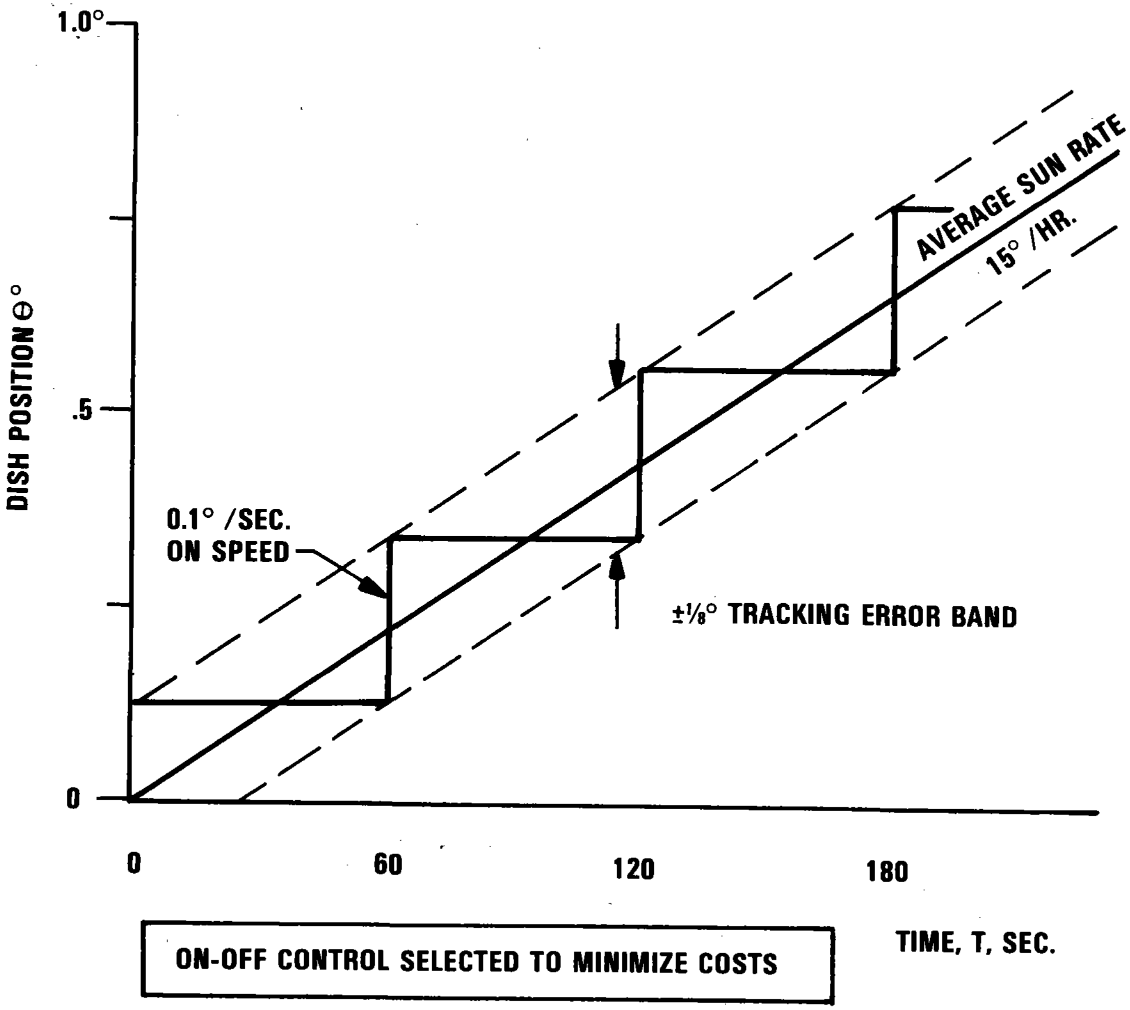


Figure 4.3.3-3. Actuator Speed Selection

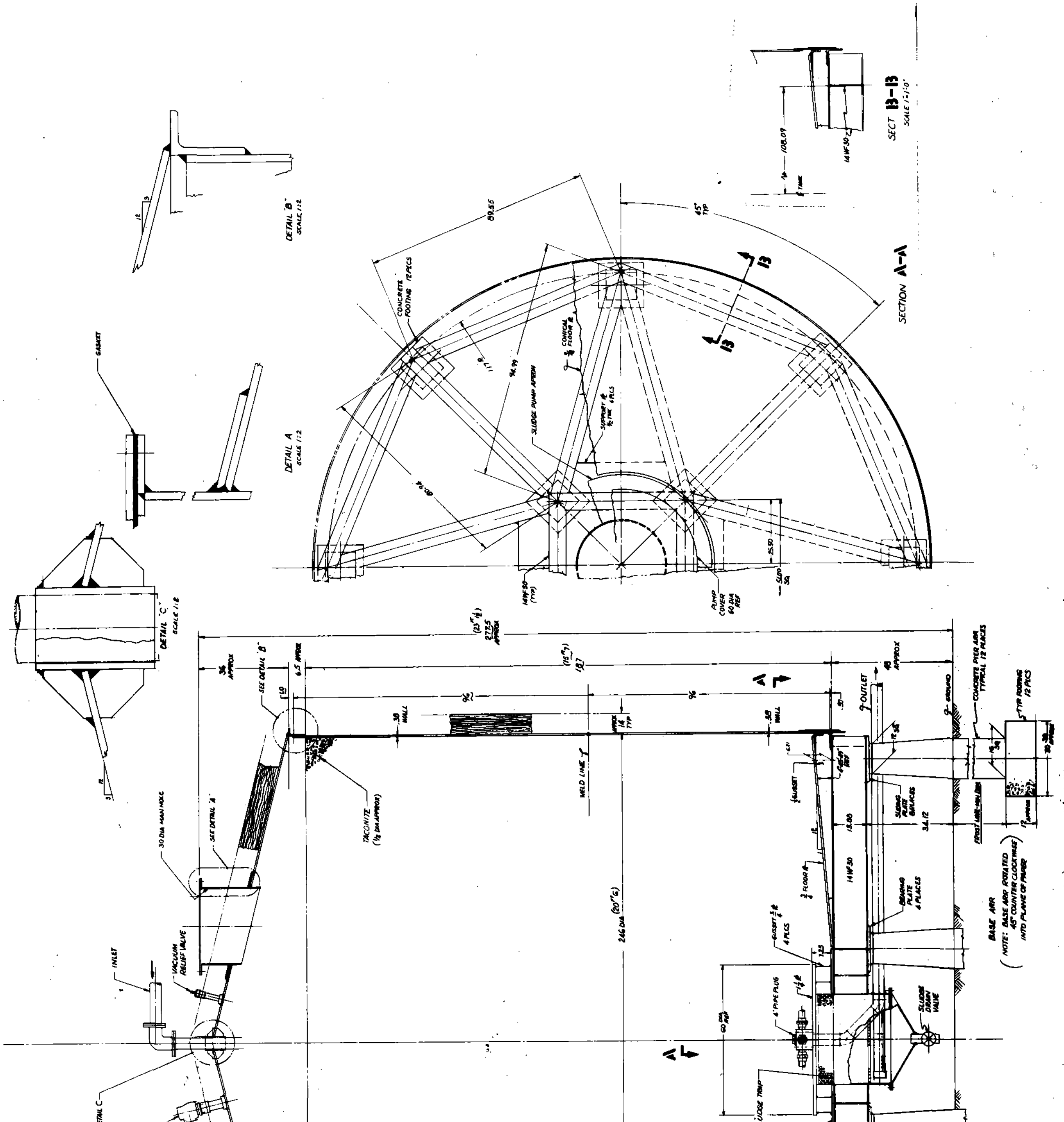
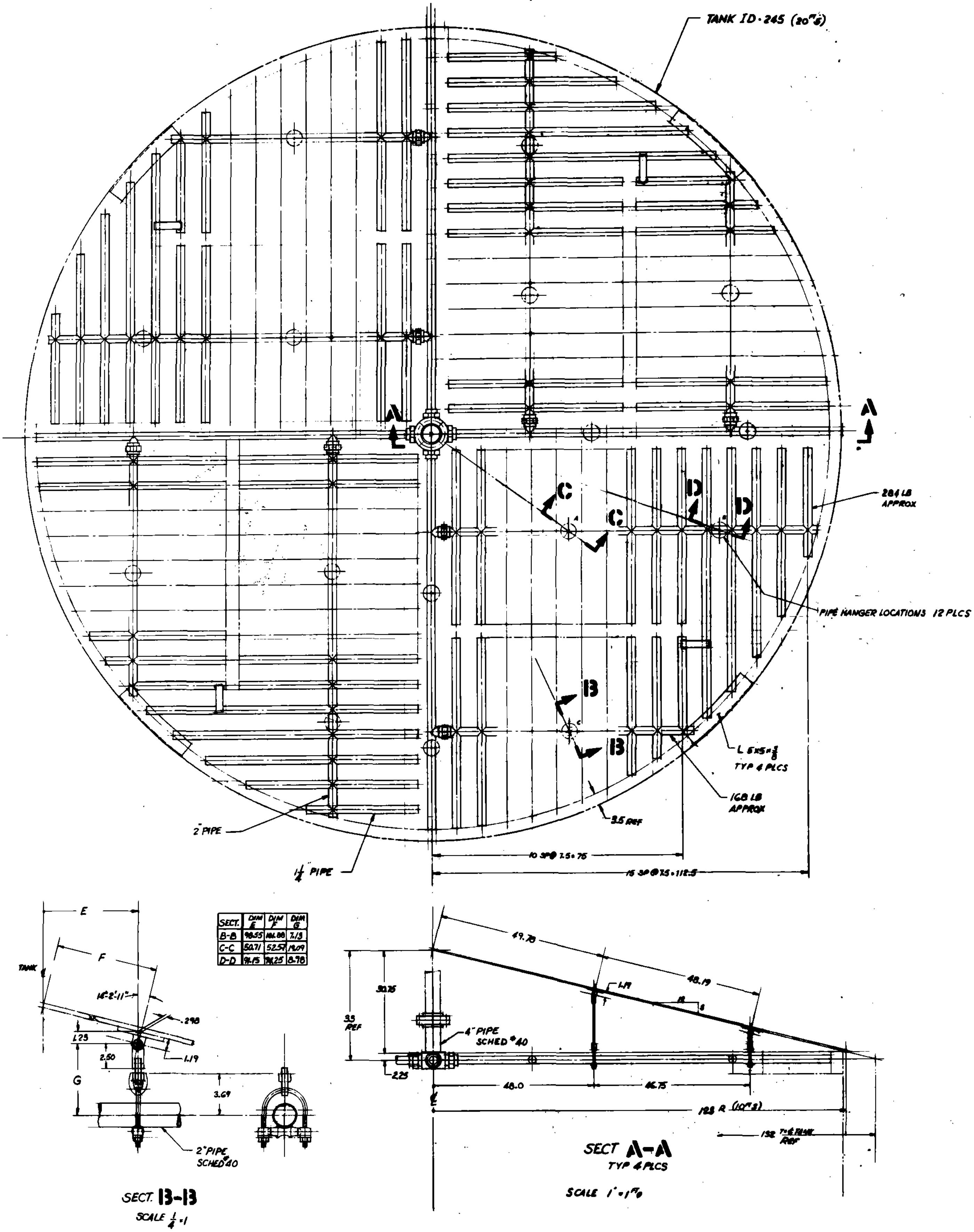


Figure 4.3.3-4. Layout Oil/Storage Medium Tank



SECT.	DIM E	DIM F	DIM G
B-B	98.55	[illegible]	7.13
C-C	50.71	52.57	19.09
D-D	91.15	96.25	8.78

Figure 4.3.3-5. Tank Inlet Piping Arrangement.

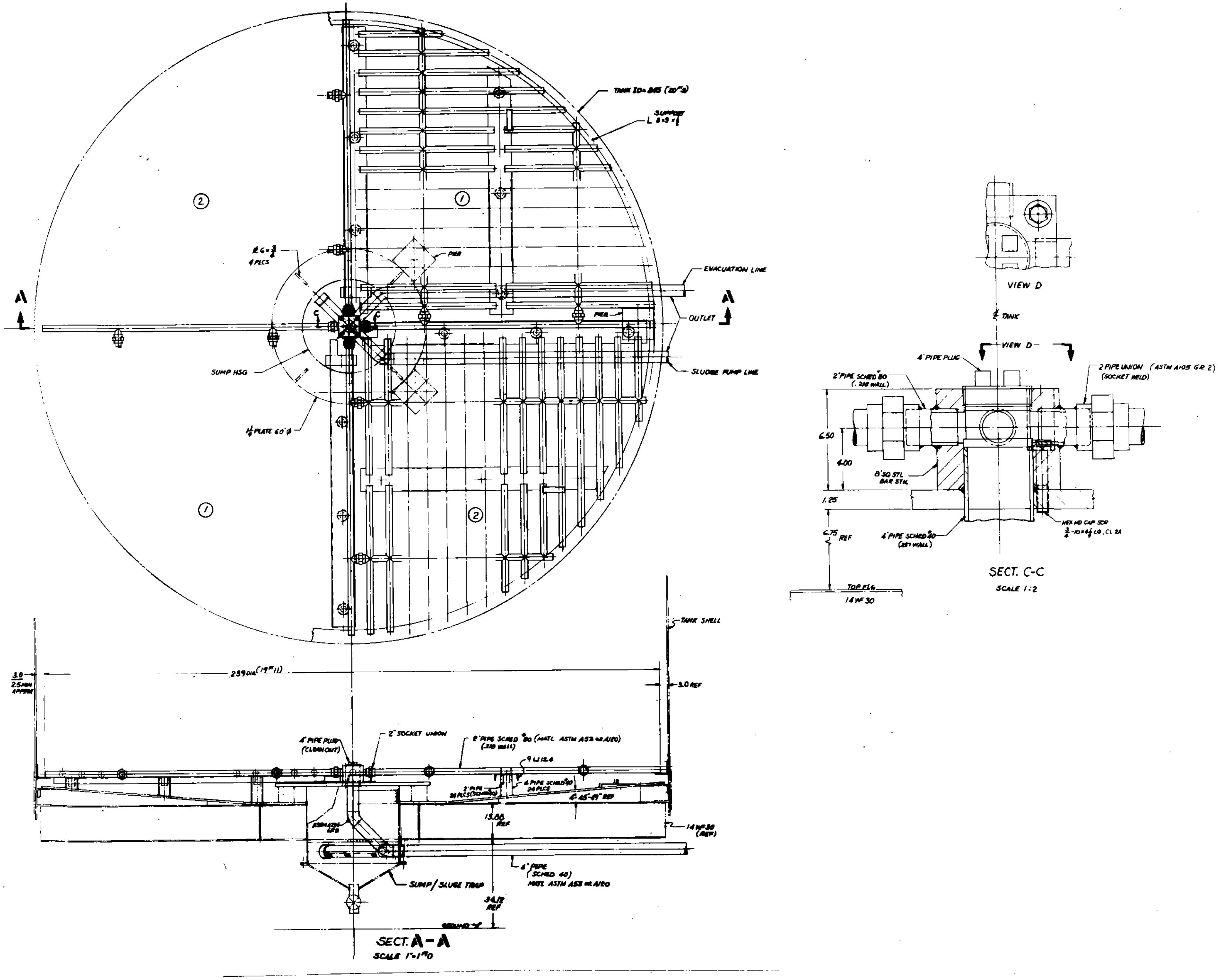
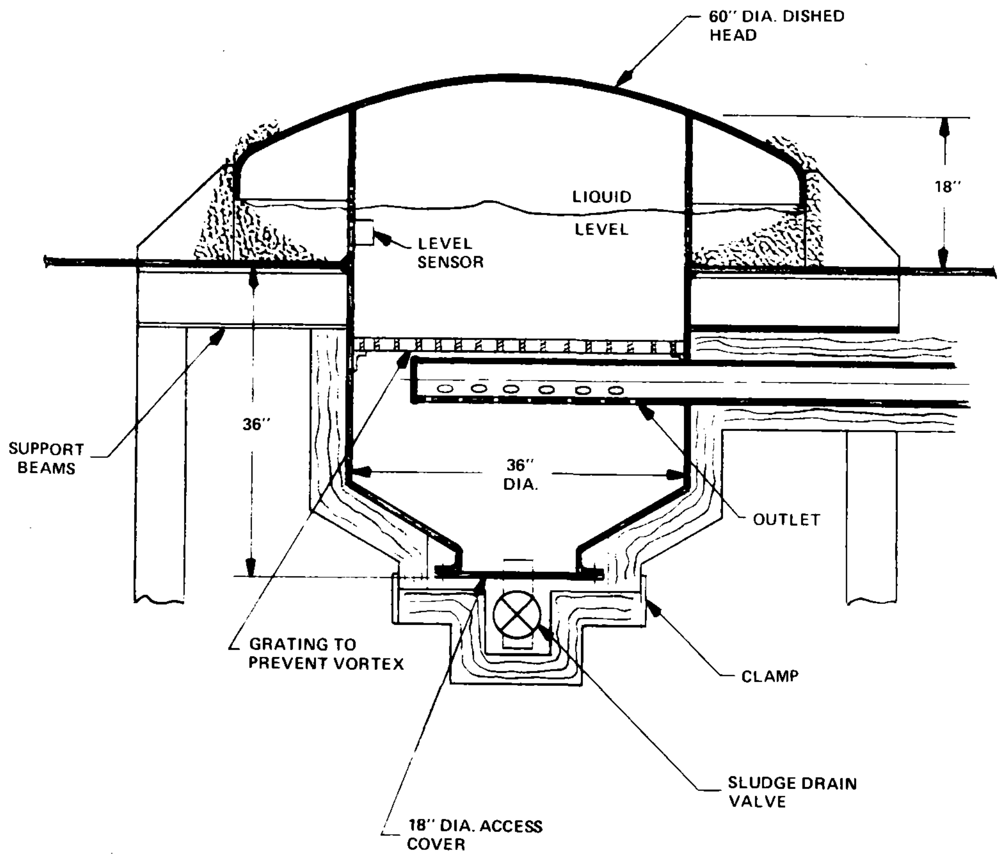


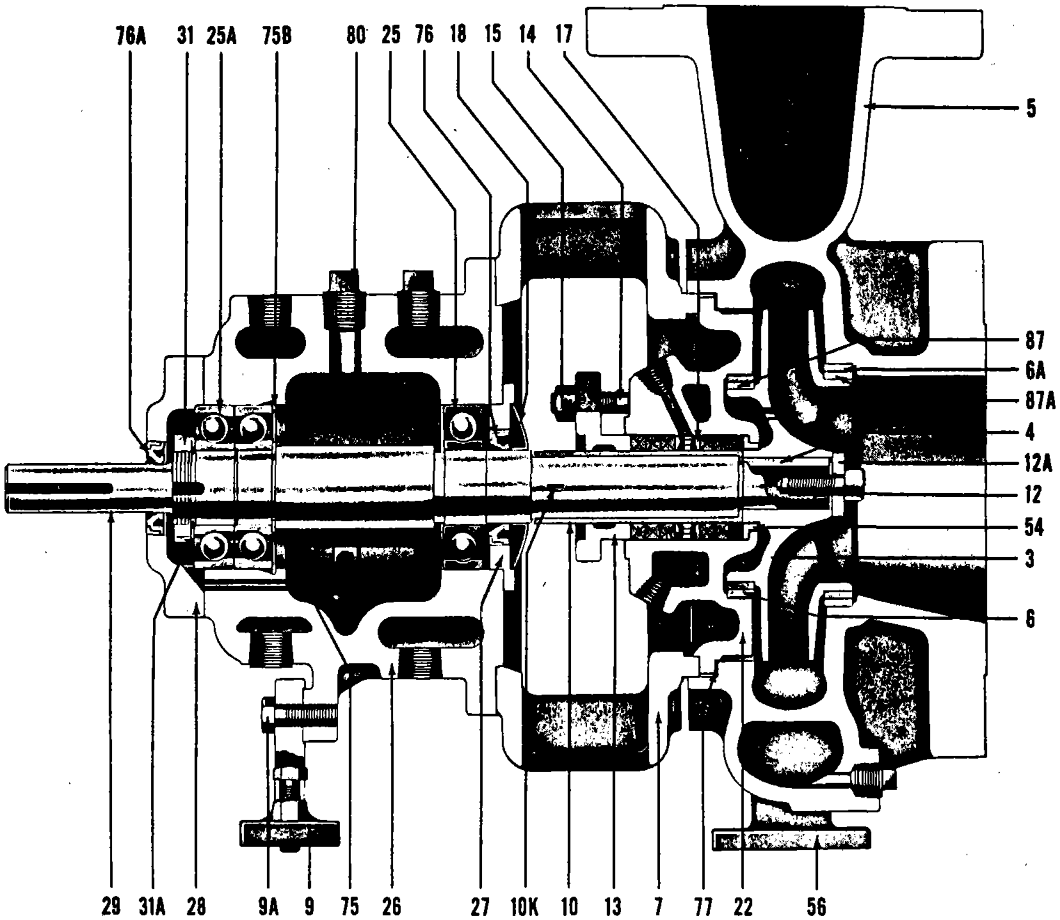
Figure 4.3.3-6. Tank Outlet Piping Arrangement



DESIGN CHARACTERISTICS

- SUMP LOCATED IN CENTER OF TANK WITH SLOPED BASE
- COARSE MEDIA LAYER ON BOTTOM
- SUMP VOLUME ~ 160 GALLONS
- VORTEX PREVENTION DESIGN
- GUSSET SUPPORT TO DISTRIBUTE LOAD TO BASE LEGS

Figure 4.3.3-7. Sump Design



STANDARD MATERIALS OF CONSTRUCTION—LISTED BY MATERIAL CLASS							
PART #	PART NAME	CLASS 40	CLASS 50	PART #	PART NAME	CLASS 40	CLASS 50
3	Impeller	C.I. (1)	316 (3)	25	Shaft Bearing—Radial	Stl.	Stl.
4	Impeller Key	Stl. (2)	316 (8)	25A	Shaft Bearing—Thrust	Stl.	Stl.
5	Casing	Stl. (6)	316 (3)	26*	Bearing Housing	C.I. (1)	C.I. (1)
6*	Backhead Ring	Iron (7)	316 (3)	27*	Seal Ring	C.I. (1)	C.I. (1)
6A	Casing Ring	Iron (7)	316 (3)	28	Bearing End Cover	C.I. (1)	C.I. (1)
7	Cradle Spacer	C.I. (1)	C.I. (1)	29*	Pump Shaft	Stl. (10)	316 (8)
9	Bearing Housing Foot	C.I. (1)	C.I. (1)	31	Bearing Lock Nut	Stl.	Stl.
9A*	Brg. Hsg. Ft. Capscrew	Stl. (2)	Stl. (2)	31A	Bearing Lock Nut Washer	Stl.	Stl.
9F*	Brg. Hsg. Ft. Jack Bolt	Stl. (2)	Stl. (2)	54*	Throat Bushing	C.I. (1)	316 (8)
9G*	Brg. Hsg. Ft. Jack Bolt Nut	Stl. (2)	Stl. (2)	56	Casing Foot	C.I. (1)	C.I. (1)
10*	Shaft Sleeve	316 (8)	316 (8)	75	Snap Ring—Inner Shaft	Stl.	Stl.
10K*	Shaft Sleeve Key	304 (9)	304 (9)	75B	Snap Ring—Inner Housing	Stl.	Stl.
12*	Impeller Bolt	Stl. (2)	316 (8)	76	Oil Seal	Buna	Buna
12A*	Impeller Washer	Stl. (2)	316 (8)	76A	Oil Seal	Buna	Buna
13*	Stuffing Box Gland	Stl. (6)	316 (3)	77	Casing Gasket	Asbestos (11)	Asbestos (11)
14*	Stuffing Box Gland Stud	Stl. (4)	304 (9)	77B*	Bearing End Cover Gasket	Paper (12)	Paper (12)
15*	Stuffing Box Gland Stud Nut	Stl. (5)	304 (9)	80	Oil Vent Plug	C.I.	C.I.
17*	Lantern Gland	C.I. (1)	316 (3)	87*	Impeller Ring—Back (Optional)	C.I. (1)	316 (3)
18*	Splash Collar	Stl. (13)	Stl. (13)	87A	Impeller Ring—Front (Optional)	C.I. (1)	316 (3)
22	Backhead	Stl. (6)	316 (3)	*Denotes parts interchangeable in all pump sizes of same type.			

Figure 4.3.3-8. Pump Cross Section and Materials

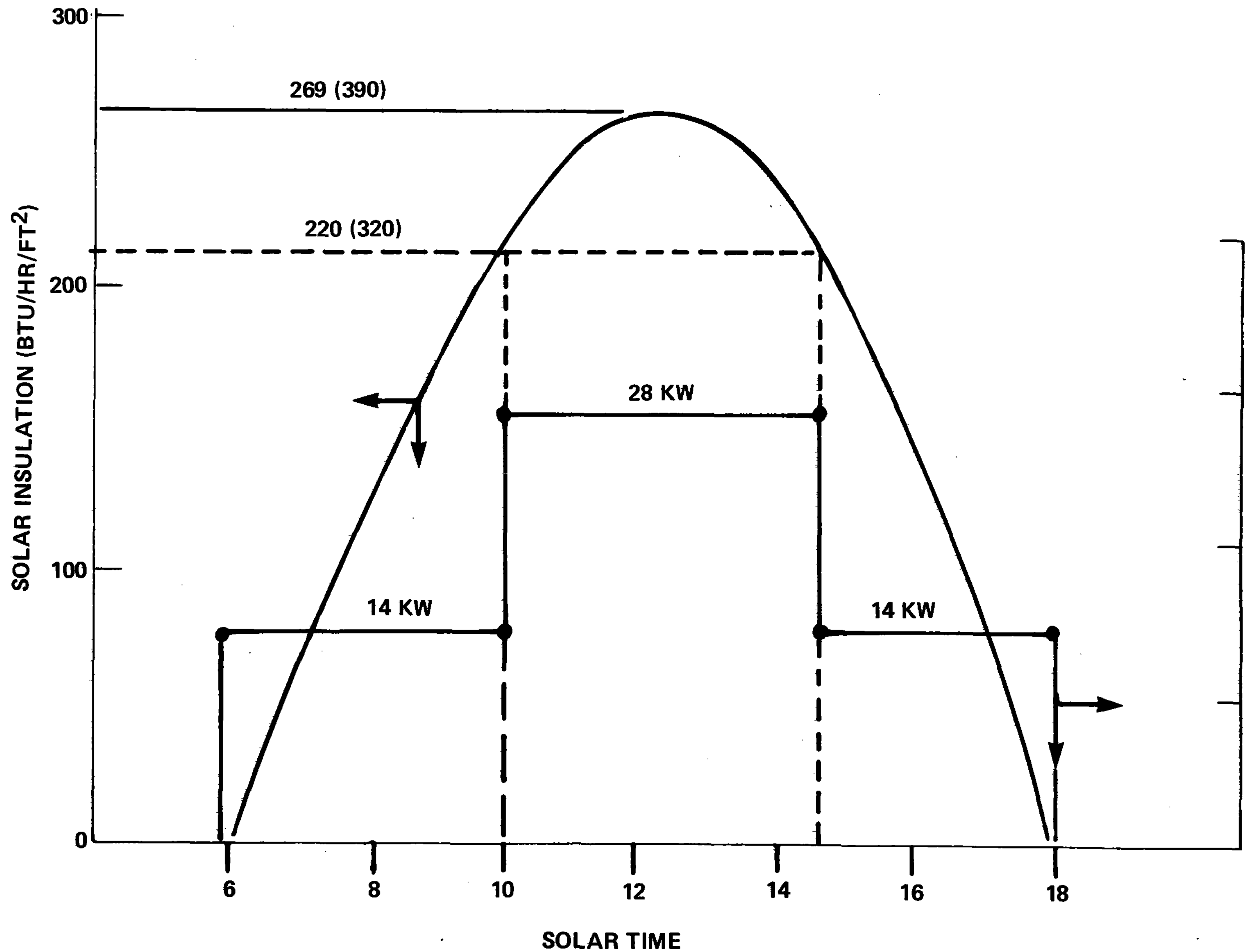


Figure 4.3.3-9. Solar Insolation and Pump Power vs. Solar Time

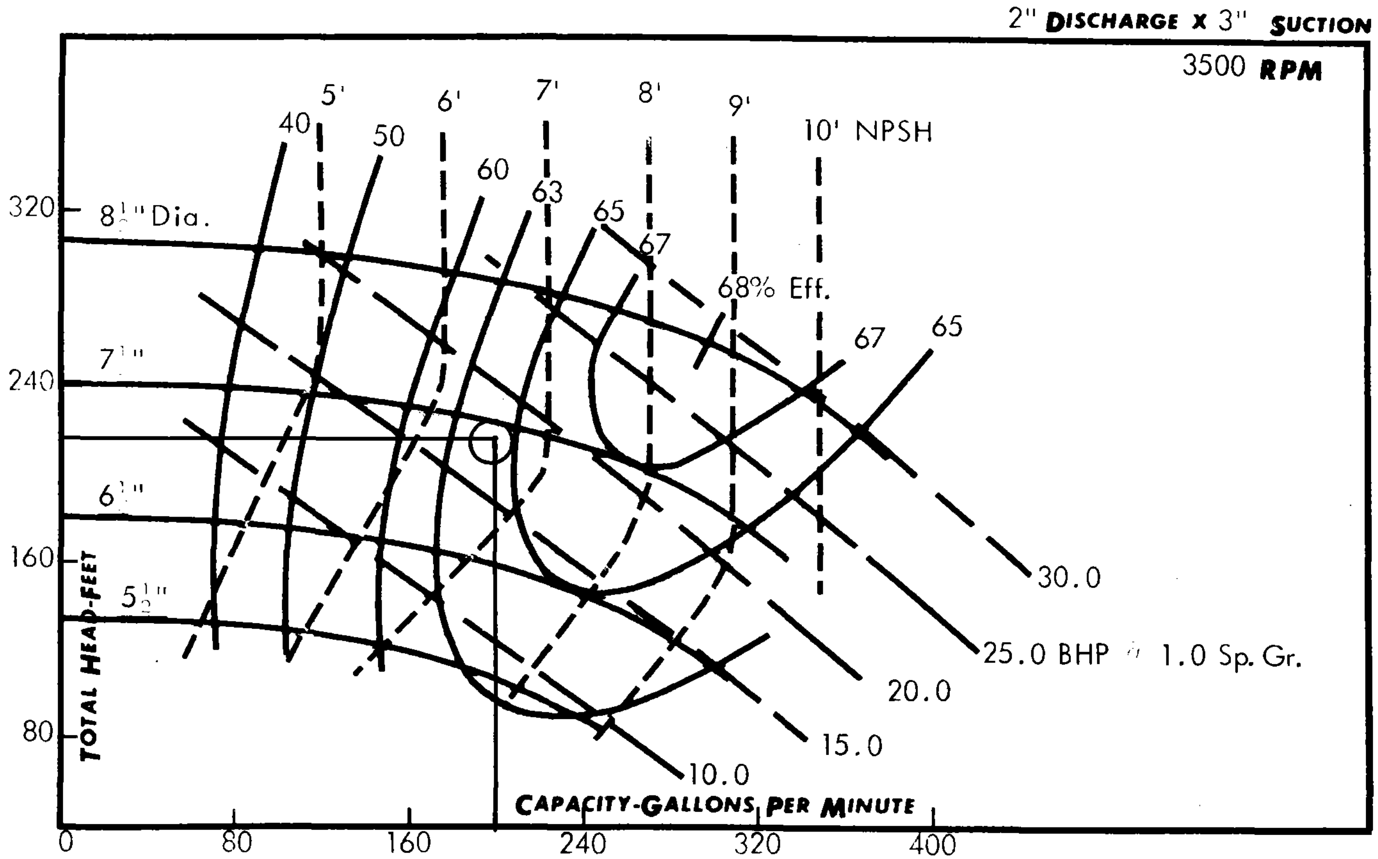


Figure 4.3.3-10. CFS Pump Characteristic Curve

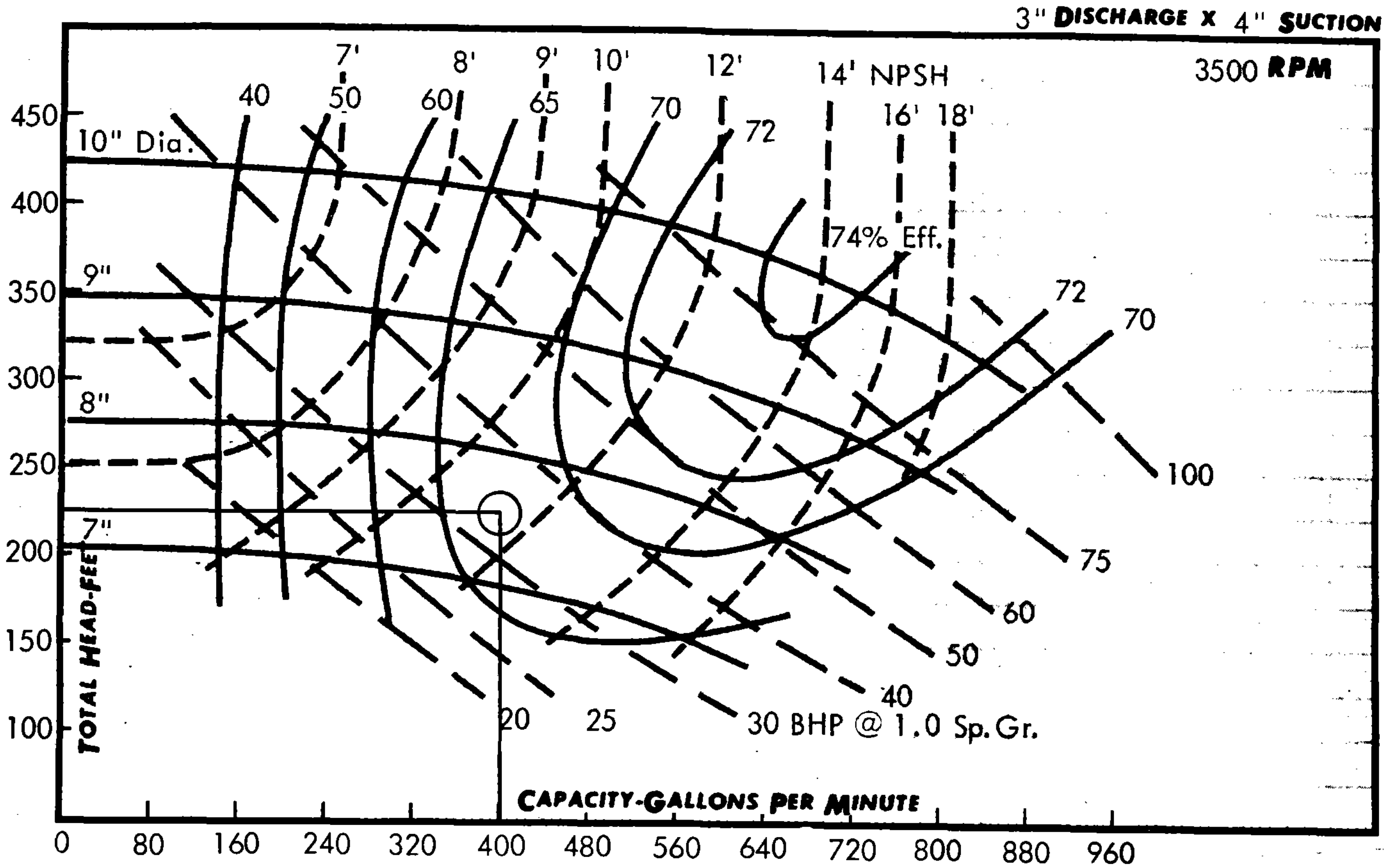


Figure 4.3.3-11. HTS and SGS Pump Characteristic Curves

SECTION 5

SECTION 5

POWER CONVERSION SUBSYSTEM (PCS)

5.1 SCOPE

5.1.1 FUNCTION

The Power Conversion Subsystem uses the steam generated in the solar steam generator to drive the turbine generator set. A portion of this steam is extracted at a mid-point in the turbine expansion to provide steam for process use in the Bleyle Plant. At the turbine discharge, steam flows to the condenser which provides the source of heat for the Thermal Utilization Subsystem. The turbine driven generator provides the electrical power required for the operation of the STES and the Bleyle Plant.

5.1.2 SUBSYSTEM CONFIGURATION

The Power Conversion Subsystem piping and instrumentation diagram is shown in Figure 5.1.2-1. As can be seen from this diagram, the PCS has direct interface connections with various other subsystems. The steam generator serves as the boundary between the PCS and the Solar Collection Subsystem. The condenser forms the boundary between the PCS and the Thermal Utilization Subsystem. The turbine generator set links the PCS with the Electrical Subsystem, and the process steam lines of the PCS connect with the Bleyle Plant steam distribution system. The various input/output devices used throughout the PCS serve as the interface and communcations link with the Control and Instrumentation Subsystem.

5.2 DESIGN CRITERIA

5.2.1 PERFORMANCE CRITERIA

5.2.1.1 PCS Steady State Performance Requirements

a) Electric Power Output:	
Range	200-400 kW
Voltage	480V ± 5%
Frequency	60 Hz ± 1/2%
b) Process Steam	
Flow Range	0-0. 174kg/s (0-1380 lbs/hr)
Pressure	7. 24 x 10^5N/m^2 (105 psig) minimum at header to Bleyle Plant
c) Steam Condition at Turbine Inlet:	
Pressure	4. 83 x 10^6N/m^2 ± 1. 73 x 10^5N/m^2 (700 psig ± 25 psi)
Temperature	655°K ± 14°K (720° F ± 25° F)

d) Maximum Thermal Input to Steam Generator:

@ 400 kW & 0.174kg/s (1380 lbs/hr)*	2638 kW†
@ 300 kW & 0.174kg/s (1380 lbs/hr)*	2171 kW†
@ 200 kW & 0.174kg/s (1380 lbs/hr)*	1591 kW†

e) Heat Transfer Fluid Temperature in Steam Generator:

Inlet Temperature	644-672°K (700-750°F)
Minimum Temperature Change	366°K (200°F)

f) Condenser:

Condensing Pressure	143,000N/m^2 ± 6895N/m^2 (20.78 psia ± 1 psi)
Coolant Inlet Temp	355-364°K (180-195°F)
Coolant Outlet Temp	372°K (210°F) minimum

g) Minimum Heat Delivered to Condenser Coolant:

@ 400 kW & 0.174kg/s (1380 lbs/hr)*	1733 kW†
@ 300 kW & 0.174kg/s (1380 lbs/hr)*	1363 kW†
@ 200 kW & 0.174kg/s (1380 lbs/hr)*	893 kW†

h)	Maximum PCS Parasitic Power	18 kW
i)	Maximum PCS Heat Loss Chargeable to Input:	15 kW
j)	Maximum PCS Heat Loss Chargeable to Output to TUS:	8 kW
	*Process steam flow rate	† 616°K(650°F) & 4.83 x 10^{6}N/m^2 (700 psig)

5.2.1.2 PCS Transient Performance Requirements

a)	Maximum Step Increase in Alternator Load:	25 kW
b)	Maximum Rate of Ramp Increase in Alternator Load:	1.67 kW/sec (100 kW/min.)
c)	Maximum Step Increase in Process Steam Demand	0.126kg/sec (1000 lbs/hr)

5.2.2 SUBSYSTEM OPERATIONAL MODES

5.2.2.1 Interconnected Load Following

The PCS will provide electric power in the 200-400 kW range and extracted, desuperheated, process steam in the 0-0.174kg/sec(0-1380 lb/hr) flow range while operating in parallel with the utility and will be controlled to follow the plant load with a constant 100 kW ± 1 kW input to the plant from the utility.

5.2.2.2 Stand Alone Operation

The PCS will have a capability for supplying electric power in the 200-400 kW range and extracted, desuperheated, process steam in the 0-0.174kg/s (0-1380 lb/hr) flow range while operating unconnected from the utility once the STES has been started up. However, there is no provision for startup of the STES independent of the utility.

5.2.2.3 Bypass Supply of Process Steam and Heat to TUS

The PCS will incorporate a provision for supply of process steam directly from the steam generator discharge to the inlet of the process steam pressure control valve. The PCS will also provide for supply of throttled, desuperheated steam to the condenser directly from the steam generator discharge. Capacity capability for this operational mode will be in the range of 0-100% of the 400 kW/0.174kg/s values specified in 5.2.1.1.

5.2.2.4 Daily Start-up/Shutdown

The PCS will have a capability of start-up from a cold condition to full operational status (per 5.2.2.1.1 or 5.2.2.1.2) within a period not to exceed 30 minutes following availability of heating fluid from the Solar Collection Subsystem. Heating fluid must be available at rated temperature at the end of the start-up period. Daily shutdown time for the PCS will not exceed 15 minutes.

5.2.2.5 Emergency Shutdown

The PCS will carry out an automatically controlled shutdown following contingency events including:

a) Loss of electrical load (steam supply is bypassed to Bleyle Plant process lines and/or condenser)

b) Component malfunctions detected by monitors (specific malfunctions and related monitors described below for specific components)

5.2.2.6 Backup Features for Minimization of Failure Effects

The PCS will incorporate backup components where necessary to assure reliability/availability goals. These will include:

a) Independent shaft driver and motor driven turbine generator lube pumps

b) Independent main governor and overspeed emergency governor

c) Redundant condensate water quality monitoring instrumentation

d) A stand-by condensate pump

e) Redundant monitoring of control set points and controlled variables

5.2.3 INTERFACE REQUIREMENTS

5.2.3.1 Interfacing Subsystem Constraints

5.2.3.1.1 Solar Collection Subsystem

The SCS supplies a flow of heating fluid to the PCS upon demand from the steam temperature control of the PCS. This flow, after being cooled by passage through the steam generator, is returned to the SCS. Instant availability of this flow, subject only to the time delay of the flow control, at a supply temperature within the limits of 5.2.1.1, is required.

5.2.3.1.2 Thermal Utilization Subsystem

The PCS is supplied with a flow of condenser cooling water from the TUS. The flow rate is controlled by the PCS condenser pressure level control and is scheduled as a function of turbine discharge flow and circulatory water inlet temperature. For maintenance of condenser pressure at the desired level of $34,500 N/m^2$ (5 psig), the temperature of the circulatory water delivered to the PCS must be maintained in the range of 355 to $364^{o}K$ ($180^{o}F-195^{o}F$).

5.2.3.1.3 Process Steam Supply Interface

Process steam at a controlled condition will be delivered to the plant at a rate governed by steam press demands from the discharge of the desuperheating pressure reduction station. A steam accumulator to facilitate control of process steam conditions and to even out turbine extraction flow may be incorporated if required by the press load cycle. Any portion of the process steam condensate to be returned to the PCS will be cooled to a maximum temperature of 300°K (80°F) and will be pumped into the makeup demineralizer inlet.

5.2.3.1.4 Plant Service Requirements

The PCS will require the following services for its operation:

a) Electric power 480v, 60 Hz for PCS auxiliaries from the utility

b) Clean raw water from the plant water supply for cycle make-up, demineralizer regeneration, and lubricating oil cooling

c) Filtered, oil free, compressed air for operation of pneumatic controls and for demineralizer regeneration

d) Dry nitrogen for post shutdown purging of the turbine

e) Sewer source for discharge of waste water and neutralized demineralized discharges

5.2.3.1.5 Plant Control Interface - Load Control

Output from a power transducer signalling base load power transferred from the utility to the plant will be required for the interconnected mode PCS load control.

5.2.4 MAINTENANCE AND RELIABILITY REQUIREMENTS

5.2.4.1 Subsystem Availability

The PCS will be designed to meet the following standards of availability:

a)	Forced outage rate	1% (of operating period)
b)	Forced outage hours/year (for maintenance)	45
c)	Planned outage hours/year weekday insolation period	0
	night/weekend	80

5.2.4.2 Routine Maintenance Operations

Routine maintenance operations for the PCS will include the following:

a) Check levels and fill in the chemical injection tanks, the make up demineralizer caustic and acid supply tanks, and the T-G and boiler feed pump lubricant reservoirs (req'd frequency TBD)

b) Conduct weekly analysis of water samples taken from condenser hot well, deaerator storage tank, and condensate storage tank

c) Adjust/replace boiler feed pump packing (interval TBD)

d) Adjust/replace boiler feed pumps V belts (interval TBD)

e) Replace/clean PCS air supply filter (interval TDB)

5.2.4.3 Maintenance Accessibility

Adequate space will be provided for each component to facilitate independent installation/removal and for such disassembly operations as may be required for planned and contingency maintenance and repair.

5.2.5 TESTING AND INSPECTION REQUIREMENTS

5.2.5.1 Preoperational Testing

PCS/components preoperational testing will include:

a) Hydrostatic test of condensate/feedwater flow circuit with turbine valved off; check out of installed valves for leak tight integrity/actuation capability.

b) Hydrostatic test of condenser circulating water circuit

c) Turbine valve leakage/actuation check out

d) Feedwater and condensate control valve check out

e) Water sample analysis following cold flow condensate recirculation

5.2.5.2 Acceptance Testing

PCS/component acceptance tests will include the following:

a) Start up and operate PCS over load range in interconnected mode. Verify proper mechanical operation of all components. Measure thermal inputs and outputs at selected load points.

b) Repeat (a) for stand alone operation. Measure frequency control accuracy.

c) Subject PCS to step function and ramp function load changes and measure response rate and stability characteristics for both interconnected and stand alone operation.

d) Check out bypass steam supply operation of PCS.

e) Simulate contingencies (TBD) and check out emergency shut down operation.

5.2.5.3 Periodic Performance Testing

Repeat (a), (b), (e) above at six month intervals.

5.2.5.4 Routine Inspections

The following inspections will be conducted on the PCS on a routine basis:

a) Conduct periodic (TBD) inspections of major components per detailed procedures to be listed for individual components.

b) Periodically (frequency TBD) check pressure drop of steam generator circuitry as check against deposit formation.

c) Periodically (frequency TBD) check out control electrical/pneumatic sensing elements.

d) Periodically (frequency TBD) check out malfunction monitors.

e) Periodically (frequency TBD) check PCS piping connections for evidence of leaks.

5.3 DESIGN DESCRIPTION

5.3.1 DETAILED SUBSYSTEM DESCRIPTION

The flow circuitry of the Power Conversion Subsystem is illustrated by Figure 5.3.1-1. Detailed circuitry of the make-up demineralizer unit is indicated in Figure 5.3.1-2.

Heat energy input to the PCS is supplied through a flow of liquid Syltherm 800 at a temperature of 672°K (750°F) from the Solar Collection Subsystem. This flow passes through the tube sides of the steam generator heat exchanger units in which superheated steam at 4.83×10^6 N/m^2 (700psig), 655°K (720°F) is produced. The steam pressure is controlled by variation of the Syltherm 800 flow rate. A small variation of superheat temperature ($\pm$ 10°F) occurs over the full range of discharge steam flow. During normal operation, steam is admitted to the turbine through the control valves. Combined function stop valve/throttle valves are located upstream of the control valves for start-up/shutdown and emergency shutdown. The 708 rev/s (4240 rpm) turbine drives a 30 rev/s (1800 rpm) synchronous generator through a reduction gear. At a mid point in the turbine expansion, steam is extracted for process use and also for feedwater deaeration/heating. The extraction port pressure is maintained at or above the required process steam delivery pressure throughout the kW_e/process steam load range. The extracted steam, which has a substantial superheat, is conditioned to the process requirement of 7.24×10^5 N/m^2 (105 psig), saturated, through controlled throttling and desuperheating by spray injection of condensate out of the condenser hot well. At the turbine, discharge steam flows to the condenser through a gate valve and a short make up water preheating passage into which the make up water from the condensate storage tank is sprayed. The major portion of the condenser thermal load is delivered to the Thermal Utilization Subsystem through a flow of circulating water. This flow is controlled so as to maintain a constant condenser pressure. The design provides for minimum hot well condensate subcooling in order to minimize heat input requirement. Hot well level is controlled by a float actuated valve in the make-up injection line. There is also an on-off valve through which condensate can be delivered to the condensate storage tank from the condensate pump discharge. The hot well storage capacity is sufficient for four minutes operation at full load. Make-up water needed to replace the process steam flow is admitted to the make-up demineralizer from the plant water supply at a rate controlled by the condensate storage tank level control.

From the condenser hot well, condensate is pumped by the condensate pump to the deaerator. The deaerator has a storage capacity sufficient for six minutes of operation at full load. The deaerator incorporates a storage level control which regulates condensate in-flow. In the deaerator, entering condensate is mixed with extraction steam from the turbine, and the heated condensate leaves in a saturated condition at deaerator pressure. From the deaerator the heated condensate passes to the boiler feed pump. Near the suction of this pump, hydrazine and ammonia are injected into the feed water by means of metering pumps from which flow is controlled in response to inputs from sensors of dissolved O_2 (hydrazine control) and pH (ammonia control). The boiler feedwater pump discharge pressure is controlled by a recirculation valve which maintains a constant pressure at the steam generator control valve inlet.

In order to implement the requirement for turbine bypass delivery of process steam and of steam to the condenser for use by the Thermal Utilization Subsystem, piping is provided from the steam generator discharge to the process steam pressure control valve and to the condenser. For bypass mode operation, the steam pressure set point is reduced to the process steam pressure level, and saturated steam is taken directly from the boiler. The turbine inlet and discharge valves are both closed.

The make-up demineralizer is a two tank unit preceded by a carbon filter. Acid is required for regeneration of the cation bed; caustic is required for the anion bed regeneration. Following regeneration, the tanks are rinsed with water, and the acid/caustic solutions are flushed through the neutralizing tank. Additional acid is added to lower the pH of the effluent to an acceptable level for discharge to the sewer.

Serious contamination from condenser circulating water leakage is prevented through the use of demineralized circulating water. Water purity is continuously monitored downstream of the feedwater pump (conductivity, dissolved O_2, and pH) and at the make up demineralizer discharge (conductivity and pH).

5.3.2 SUBSYSTEM PERFORMANCE CHARACTERISTICS

In Table 5.3.2-1, performance parameters of the Power Conversion Subsystem are tabulated for ranges of gross electric power output and turbine inlet temperature. Pressures, temperatures, and flow rates for the PCS are shown in Figure 5.3.2-1 which also includes those for the TUS. These flows are at 400 kW.

5.3.3 MAJOR COMPONENTS

The major components of the power conversion subsystems include the following:

a) Steam Generator (or Boiler)

b) Turbine Generator

c) Condenser

d) Makeup Demineralizer

e) Condensate Pump

f) Deaerating Heater

g) Boiler Feed Pump

5.3.3.1 Steam Generator

5.3.3.1.1 Design Criteria

a) Sizing Criteria

The steam generator is sized to deliver the maximum load steam flow rate indicated in Table 5.3.2-1 above at 655°K (720°F), 4.83×10^6 N/m^2 (700 psig) steam outlet conditions. Feedwater inlet enthalpy is 8.55×10^5 J/kg (368 Btu/lb) at full load. The Syltherm 800 inlet temperature is 672°K (750°F), and the flow rate is 12.3kg/s (97,200 lb/Hr). The skid mounted steam generator unit incorporates three heat exchangers: a counterflow preheater, a drum type pool boiler, and a counterflow superheater. These are enclosed in separate shells.

b) Material Compatibility

Material for the Syltherm 800 containment tubing and for the heat exchanger pressure vessels is carbon steel. This material is compatible with Syltherm 800 and is also well proven in steam generator service at the required pressure/temperature conditions.

c) Maintenance and Testing Requirements

The steam generator will be designed for 20 years life without maintenance subject to the requirement that feedwater and Syltherm 800 purity requirements are met. The component will be subjected to a hydrostatic test of the tube side and shell side leak tight integrity-prior to installation and at intervals of approximately 1 year. In all of the steam generator heat exchangers, the tubes can be removed for external (water side) cleaning if this should become necessary.

d) Operational Limitations

The principal operational limitation of the steam generator is that the blowdown water flow rate must be sufficient to meet maximum dissolved solid limits for the boiler water. In particular, the boiler water silica concentration must be limited to 20 ppm.

5.3.3.1.2 Design Description

The steam generator is a skid mounted assemblage of three heat exchangers: a counterflow preheater, a drum type pool boiler with immersed heater tubes, and a counterflow superheater. The Syltherm 800 flow is on the tube side in all heat exchangers. Feedwater is admitted to the preheater through a control valve which operates to maintain the boiler drum level. The preheater discharges water into the boiler drum. Immersed in this drum are Syltherm 800 tubes which enter and leave at one end. Saturated steam leaves the drum and passes to the superheater from which it flows to the turbine. Approximate dimensions of the heat exchanger shells are: preheater, 0.30m. dia x 3.66 m. long (1 ft. dia. x 12 ft. long); boiler, 0.61 m. dia x 4.57 m. long (2 ft. dia. x 15 ft. long); superheater, 0.30 m. dia. x 3.05 m. long (1 ft. dia x 10 ft. long).

Water is continually bled from the boiler drum through a blowdown valve from which it is passed to a flash tank operating at deaerator pressure. Steam formed in the flash tank is passed to the deaerator, and the water is passed through a trap to a second (atmospheric pressure) flash tank in which both water and steam are cooled and condensed to a maximum temperature of 300°K (80°F) by a controlled flow of cooling water for discharge to the sewer.

5.3.3.2 Turbine Generator

(This section currently provides a description of the GE Marine turbine generator which was initially incorporated into the PCS design. This description will be revised to reflect the current design using the MTI turbine generator when this information becomes available.) However the maximum value requirements are still based on the GE turbine generator.

5.3.3.2.1 Design Criteria

a) The steam turbine generator flow/head capacity is selected to meet the maximum throttle flow and inlet/exit steam pressure/temperature conditions indicated in Table 5.3.2-1. Because of the importance of power conversion efficiency to the TES, a high speed 183 rev/sec (11,000 rpm) multistage geared turbine generator unit is employed. The turbine will incorporate 3 or 4 single row impulse stages. The machine will have a rotor inertia such that the acceleration under unbalanced rated torque will not exceed 3 per cent of rated speed per second. This will result in minimal speed transients under load changes during stand alone operation, minimal utility load transients during interconnected operation, and an adequate time tolerance for emergency actions following loss of electrical load.

b) Material Compatibility

The turbine flow path components are made of 12 chrome alloy steel which is compatible with low metallic oxide contamination of the condensate flow circuit. Dry nitrogen purge of the casing following shutdown will be employed as a further precaution against corrosion.

c) Electrical Requirements

Three phase, 480 V, 60 Hz power is required for auxiliary lube pump and for controls.

d) Maintenance and Testing Requirements

The turbine-generator has a high reliability and will not normally require, at intervals of less than 10 years, any major maintenance involving removal/replacement of rotor, buckets, diaphragms, bearings, seals, valve, or governing mechanisms. Such major maintenance if needed should be performed under the supervision of a manufacturer's representative. Minor routine maintenance operations include the following:

1) Receive/inspect steam strainer after first day of operation and annually thereafter.
2) Lubricate external pivots of governor system. Replenish grease in lever systems bearings (once per month).
3) Check oil level in hydraulic system (once per month).
4) Check out overspeed trip (once per month). Once per week lubricate outside moving parts of trip throttle valve and control valves.
5) Test oil neutralization number, flash point, viscosity etc. (every six months).
6) Maintain oil levels.

7) Check temperature drop through oil cooler. Clean cooler when necessary.

8) Maintain supply of nitrogen for post shutdown purge. Steam rate of the turbine-generator will be measured at operating points over the power/process steam load range at initial plant checkout and at one year intervals to detect any wear/deposition effects.

5.3.3.2.2 Design Description

The tubine-generator unit consists of two high speed axial flow turbines coupled through reduction gearing to a 30 rev/s (1800 rpm) synchronous alternator. The unit is being supplied to the program GFE and is manufactured by Mechanical Technology Incorporated (MTI). An extraction port is provided at an interstage point in the turbine for removal of steam for process use and for supply to a deaerating feedwater heater. The pressure level at this port is above the required process steam pressure level of $7.24 \times 10^5 N/m^2$ (105 psig) throughout the operating range of 200-400 kW electrical load.

Construction features of the turbine include the following:

a) Rotor machined from a single forging.

b) Bayonet type steam inlet providing thermal isolation of the inlet passage and nozzle segments from the casing. Highest pressure to which the casing is exposed is that of the first stage shell.

c) Three independent control valves with three admission arcs.

d) An upstream stop/throttle valve.

e) The turbine is provided with an electrohydraulic governor which accommodates both load control under interconnected operation and speed control with reset (isochronous) under stand alone operation. An automatic synchronization control is also provided. The turbine generator unit is mounted on a skid and is equipped with self contained steam seal and bearing lubrication systems. Two lube pumps are provided: a shaft driven pump and an electric motor driver pump which provide redundant lubricant circulation. A water cooled oil cooler is also incorporated.

5.3.3.3 Condenser

5.3.3.3.1 Design Criteria

a) Sizing Criteria

The condenser is sized to transfer the maximum thermal load to the TUS which is indicated in Table 5.3.2-1. This thermal duty is carried out by the condenser heat exchanger tubes. For this duty the minimum condenser coolant inlet temperature is 360^oK (188^oF), and the minimum coolant discharge temperature is 372^oK (210^oF). The maximum condensing pressure is $41,300 N/m^2$ (6 psig). In addition to the heat transferred to the TUS, heat is also absorbed by a make-up heating spray injected into the neck section of the condenser immediately downstream of the turbine outlet valve. The flow rate of this spray is nominally equal to the maximum process steam flow which is returned as make up from the condensate storage tank. The hot well of the condenser is sized to provide a condensate storage volume for four minutes operation at full power/process steam load.

b) Material Compatibility

The condenser tubes and water boxes will be fabricated from 304 stainless steel. The shell and tube sheets are carbon steel.

c) Electrical Requirements

Single phase, 480 V, 60 Hz power is required for controls

d) Maintenance and Testing Requirements

The condenser will be designed for 20 years life. The unit will be subjected to a hydrostatic test of the shell and of the tubes prior to installation, and the tube leak tight integrity will be checked at intervals of not less than six months. Tube leaks will be repaired as required. Controls for main coolant flow will be calibrated over the power/process steam load range. Hot well level controls will also be calibrated. These calibrations will be performed during initial checkout running of the unit and periodically at intervals of not less than six months. At the same times, the unit thermal performance will be checked against minimum requirements.

5.3.3.3.2 Design Description

The condenser unit comprises a two pass heat exchanger contained in a 0.61 meter (two foot) diameter cylindrical shell. Water coolant tubes extend 4.88 meters (16 feet) between tube sheets, supported by two intermediate support plates. Tubes are expanded into the tube sheets and are slightly bowed upward for drainage and accommodation of differential expansion between the shell and the tubes. Dished heads enclose water boxes at both ends of the shell. The condenser is joined to the turbine discharge valve flange through a make up inlet spray passage discharging into the shell at an upper location. A bellows joint is employed at the turbine discharge valve connection. The shell is suspended from the turbine skid. Opposite the desuperheating passage at the bottom of the shell is the hot well. At each side of the shell near the bottom, a small group of tubes is shrouded from the main stream flow in order to subcool uncondensed vapor containing concentrated air which is vented from the shell. Air vents guarded by thermostatic valves are located at each side of the shell.

The hot well level is controlled during normal operation by variation of the rate of make-up water injection. For reduction of PCS water inventory during startup and establishment of normal steam generator operation, condensate is pumped back to the condensate tank.

5.3.3.4 <u>Make Up Demineralizer</u>

5.3.3.4.1 Design Criteria

a) Sizing Criteria

The make-up demineralizer is sized to meet the water inlet/discharge quality/flow rate requirements shown in Table 5.3.3-1 with a minimum operating time at the indicated flow rate of 80 hours. Maximum temperature of the raw water supplied to the unit is 300°K (80°F).

b) Material Compatibility

Demineralizer tanks will be coated with .00152-.00203 meter (60-80 mil) sprayed and baked PVC. All piping, fittings, and valves are PVC. Demineralized water output piping is stainless steel.

c) Electrical Requirements

Three phase, 480 V, 60 Hz AC power is required for electrical pumps and controls.

d) Maintenance and Testing Requirements

The make up demineralizer is designed for automatically sequenced resin regeneration initiated by a manual signal. Water discharge quality is continuously monitored. At intervals of two days during night shutdown, this will be required. Caustic and acid tanks must be kept full. Resin replacement will be required approximately once per year. Acceptance testing of the make-up demineralizer will be carried out during plant check out operation.

5.3.3.4.2 Design Description

The make-up demineralizer is a skid mounted unit including cation and anion resin tanks, caustic and acid regeneration tanks with pumps, and a neutralizing tank. An activated carbon inlet filter is also included to insure uniform discharge water quality under non constant flow. A recirculation pump is provided.

5.3.3.5 Condensate Pump

5.3.3.5.1 Design Criteria

a) Sizing Criteria

The condensate pump is sized to handle the maximum flow rate requirements indicated in Table 5.3.2-1 consisting of the sum of the condenser flow, 0.927 kg/s (7334 lbs/hr.), and the make up flow, 0.174 kg/s (1380 lbs/hr.) The pressure rise of the pumps is controlled at a level of 1.72×10^6 N/m^2 (250 psi) by a discharge pressure control valve which regulates the recirculation flow into the hot well. The NPSH requirement is 3.05 m. (10 ft) minimum.

b) Material Compatibility

The pump rotor and stator parts are constructed of stainless steel which is compatible with either an oxygenated or deoxygenated flow of condensate. Chloride stress corrosion is not a hazard because of the use of demineralized condenser circulating water.

c) Electrical Requirements

Three phase, 480 V, 60 Hz AC power is required for operation of the 4 kW pump drive motor.

d) Maintenance and Testing Requirements

The pump is designed for long term continuous service. Bearings are grease packed and require only an annual lubricant replenishment. Seal replacement will not be required at less than five year intervals.

At initial plant check out, the pump will be tested for flow/head/power characteristics. A semiannual check will be made for seal packing leakage.

5.3.3.5.2 Design Description

The condensate pump is a regenerative (turbine) type pump. This pump receives flow from the condenser hot well and discharges to the deaerator and to the process steam desuperheater. There is also a discharge connection to the condensate storage tank. Discharge pressure is controlled by a pressure control valve through which water recirculates to the hot well. The pump is directly driven by a 29.2 rev/sec (1750 rpm) induction motor.

5.3.3.5 Deaerating Heater

5.3.3.5.1 Design Criteria

a) Sizing Criteria

The deaerating heater is sized for a maximum condensate flow rate of 1.29kg/s (10,200 #/hr). The full load pressure level is 1.65×10^6 (240 psig) with a heating steam flow of 0.158kg/s (1250#/hr) at an enthalpy of 3.01×10^6 J/kg (1297 Btu/#). The feedwater storage capacity is 0.32 m^3 (85 gallons) which will supply the steam generator for four minutes at full load.

b) Material Compatibility

The deaerating heater with shell and internal parts, including trays, will be stainless steel. The outer shell is carbon steel.

c) Maintenance and Testing Requirements

The deaerator will be hydrostatically tested prior to initial system start-up for leak tight integrity of the shell, steam and condensate piping, and vent condenser circuit. This test will be repeated during normal shutdown periods at six month intervals. Free actuation of the level control valve and operating mechanism will be periodically checked.

5.3.3.5.2 Design Description

The deaerator is an open feedwater heater in which condensate is spread in thin sheets over successive layers of air separating trays where it is raised to saturation temperature through contact with injected steam. In this process the steam is desuperheated and condensed, adding to the quantity of saturated deareated water which is delivered to the storage volume in the lower part of the shell. Residual steam and entrained air are passed from the shell to the vent condenser which is cooled by the incoming condensate before being vented to the atmosphere.

5.3.3.6 Boiler Feed Pump

5.3.3.6.1 Design Criteria

a) Sizing Criteria

The boiler feed pump is a triplex pump with a flow/head capacity of .00158m/s and 7.24×10^6 N/m^2 (25 gpm/1050 psig) at 3.34 rev/sec (200 rpm). It is the smallest, commercially available, continuous duty triplex pump with more than 4.13×10^6 N/m^2 (600 psi) pressure capability. NPSH requirement is 4.57 m. (15 ft.) minimum.

b) Material Compatibility

Operating plungers, cylinder block, and valves will be fabricated from stainless steel.

c) Electrical Requirements

The boiler feed pump is belt driven by an induction motor requiring 3 phase, 60 Hz AC power at 480 volts.

d) Maintenance and Testing Requirements

The pump is designed for long term continuous service. Lubricant is sealed in and requires only a level check at six month intervals. At yearly intervals the plunger packing will require a sealing check and possible adjustment. Packing should be replaced annually.

At initial plant check out, the pump will be tested for flow/head/power performance over the required flow range. A check will be made for packing leakage.

5.3.3.6.2 Design Description

The boiler feed pump is a three cylinder, horizontal plunger pump driven from a crankshaft through a connecting rod-cross head mechanism. Main bearings at the ends of the crankshaft are tapered roller type. Valves are mounted in replaceable bushings. The plungers are externally sealed with packing. The pump is driven at 6.67 rev/s (400 rpm) through a V belt drive from an 29.2 rev/s (1750 rpm) induction motor.

5.3.4 CONTROL AND INSTRUMENTATION

5.3.4.1 Design Criteria

a) Control functions required by the Power Conversion Subsystem include the following:

1) Boiler - turbine control - this is an automatic, multi-loop, centralized control

2) Condenser pressure level control - this is a local automatic control

3) Process steam pressure/temperature control - this is a local automatic control

4) Level controls for hot well condensate storage tank, deaerator storage volume

5) Chemical injection control - this is a local automatic control

6) Sequencing of special operations: by pass supply of process steam/heat, subsystem start up, subsystem shutdown, and demineralizer regeneration. These are manual controls or manually initiated automatic sequencing controls

b) The following parameters will be continuously monitored:

Steam throttle temperature
Steam throttle pressure
Alternator output power
Alternator voltage and frequency
Turbine shell pressure downstream of extraction port
S800 temp at steam generator inlet
Condenser pressure
Water quality
boiler feed pump discharge
conductivity
O_2
Ph
Condensate pump discharge
Conductivity

Make up demineralizer discharge
Conductivity
Turbine rotor vibration level
Turbine bearing temperature
Reduction gear lubricant temperature
Alternator bearing temperature

5.3.4.2 Control Description

5.3.4.2.1 Boiler Turbine Control

A block diagram of the boiler-turbine control is shown in Figure 5.3.4-1. The turbine speed/load control is indicated in further detail in Figure 5.3.4-2. As indicated by these diagrams, the turbine load is controlled by regulation of the utility load to a constant value for interconnected operation, and for independent operation, the speed is regulated to a constant value as load varies. Steam pressure is controlled by variation of feedwater flow as the turbine valve position is varied, and steam temperature is controlled by variation of Syltherm 800 flow rate. The temperature control loop utilizes a feed forward signal from turbine throttle flow as indicated by first stage shell pressure as well as a feedback signal from throttle temperature. In addition to the operational controls described by the block diagrams, the turbine is subject to trip-out controls initiated by contingency events:

a) loss of electrical load

b) equipment malfunction as indicated by out of limit signals from monitored parameters:

   bearing temperatures
   rotor vibrations
   water quality
   frequency
   voltage

5.3.4.2.2 Control Actuators:

Provision for control equipment test and check out.

5.3.4.3 Devices

Instrumentation required for the Power Conversion Subsystem is summarized in Table 5.3.4-1.

5.3.4.4 Alarms

Alarms are to occur whenever parameters in Table 5.3.4-1 are out of limits by amounts TBD for the individual parameters.

5.4 SUBSYSTEM OPERATION

5.4.1 NORMAL OPERATION

Normal operation of the STES includes both the interconnected and independent operating modes. During manual operation, Syltherm 800 and feedwater from the boiler feed pump are supplied to the steam generator from which superheated steam flows to the turbine at 4.83×10^6 N/m^2 and 655°K (700 psig/720°F). Steam is extracted from the turbine at an interstage port. A portion of the extraction steam flows to the deaerating heater, and another portion flows to the desuperheating pressure reduction station from which process steam is supplied to the plant at a 7.24×10^5 N/m^2 (105 psig) saturation condition. Desuperheating water is supplied from the condensate pump discharge. The turbine exhausts to the condenser which operates at a pressure of 1.43×10^5 N/m^2 (20.8 psia). Demineralized make-up water at 300°K (80°F) is sprayed into the neck section of the condenser at a rate controlled by the hot well liquid level. Condenser pressure is controlled by the circulating water flow rate. The make-up demineralizer receives raw water from the plant water supply and delivers demineralized water to the condensate storage tank at a rate controlled by the level in this tank. From the condenser hot well, condensate is pumped to the deaerator. The deaerator incorporates a condensate storage tank and a level control which governs the rate of flow into the unit. Air removal from the condensate is expelled from the deaerator vent condenser.

From the deaerator, condensate is pumped to the steam generator by the boiler feed pump. Hydrazine and ammonia are injected by a proportioning pump into the boiler feed pump suction flow. Hydrazine injection is controlled in response to a dissolved oxygen analyzer and ammonia injection regulated in response to a pH meter.

5.4.2 OFF-NORMAL OPERATION

Off normal operation of the PCS includes turbine bypass operation, start-up, and shutdown.

5.4.2.1 Turbine Bypass Operation

The STES may be operated in the turbine bypass mode. The turbine stop valve and the turbine discharge gate valve are closed. The steam generator is operated at a reduced pressure setting, and saturated steam is taken directly from the boiler without superheat.

In this mode steam is passed through the turbine bypass line to the process steam pressure reduction desuperheating station and/or to the condenser. For the turbine bypass operating mode, steam is supplied to the deaerator directly from the steam generator outlet.

5.4.2.2 Start-up Operation

Start-up of the Power Conversion Subsystem involves the sequential operations described below (valves from N_2 bottles which pressurize the deaerator, steam piping and steam generator are closed). With the turbine stop valve and discharge gate valve closed, the boiler drum, deaerator storage, and hot well storage are brought to full levels. The boiler pressure set point is 7.24×10^5 N/m^2 (105 psig). A flow of Syltherm 800 is initiated through the steam generator. When the set point pressure is reached, the turbine discharge valve is opened. N_2 pressurization of the turbine is turned off. The auxiliary lube pump is turned on and cooling water flow through the oil cooler is started. The stop/throttle valve is partially opened and the turbine is rolled. Over a period of 15 minutes, the turbine is accelerated to full speed.

The automatic synchronizer closes the generator contactor. The turbine governor is set for start-up load. Gas passed to the condenser is expelled through the condenser vent. The steam bypass valve to the deaerator is closed. The steam generator pressure controls are set for 4.83×10^6 N/m^2 (700 psig). Pressure and temperature are ramped to operating levels. The turbine governor is set for normal operation. The process steam valve is opened. The auxiliary lube pump is turned off.

5.4.2.3 Shutdown

Shutdown operations include the following. The turbine stop valve is closed. The line contactor is opened. The process steam valve is closed. The Syltherm 800 valve is closed and the boiler feed pump is turned off. The condensate pump is turned off. The chemical injection unit is turned off. The turbine discharge valve is closed, and the turbine casing drains are opened. The turbine is purged with N_2 for 15 minutes, following which the drains are closed leaving the casing pressured with N_2 at 3.45×10^4 N/m^2 (5 psig). N_2 pressurizing bottle valves are opened to permit pressurization of the deaerator, condenser, and steam piping if and when the pressure in these vessels falls below 1.38×10^4 N/m^2 (2 psig).

TABLE 5.3.2-1. POWER CONVERSION SUBSYSTEM PERFORMANCE TABULATION

	(MTI turbine generator)								
Thermal Input kW	2628	2110	1544	2629	2143	1569	2638	2171	1591
Electric Output kW	400	300	200	397	300	200	391	300	200
Process Steam Flow #/hr	1380	1380	1380	1380	1380	1380	1380	1380	1380
Heat Delivered to Condenser Coolant kW	1713	1302	846	1718	1336	871	1733	1363	893
Throttle Pressure psig	700	700	700	700	700	700	700	700	700
Throttle Temp °F	720	720	720	680	680	680	650	650	650
P extr. psig	110	110	110	110	110	110	110	110	110
H in Btu/#	1356	1356	1356	1333	1333	1333	1313	1313	1313
H extr Btu/#	1244	1248	1253	1225	1228	1233	1209	1212	1217
UEEP Btu/#	1152	1158	1164	1135	1143	1149	1122	1129	1135
T cond °F	230	230	230	230	230	230	230	230	230
Throttle Flow #/hr	8591	6897	5049	8789	7165	5245	8995	7402	5423
Extr. Flow to Process #/hr	1308	1304	1298	1333	1329	1323	1354	1350	1343
Extr. Flow to D/A #/hr	936	749	546	976	793	578	1014	832	607
Condenser Flow #/hr	6347	4844	3205	6480	5043	3344	6627	5220	3473

TABLE 5.3.3-1

INLET/DISCHARGE WATER QUALITY

SPECIFICATIONS FOR MAKE UP DEMINERALIZER

	Raw Make up Water	Demineralizer Discharge Water
Total Solids	1 ppm	1.5 ppm
Silica ($Si0_2$)	0.3	0.3
Total Hardness ($CaC0_3$)	.03	0.03
Iron (Fe)	0.16	0.5
Chloride (c ℓ)	0.03	0.03
Sodium (Na^+)	0.03	0.03
Copper (Cu)	0.07	0.07
pH	9.5	9.5

TABLE 5.3.4-1. PCS INSTRUMENTATION SET POINTS

Parameter to be Measured	Location	Range	Set Point	Instrument/Readout
Steam Temp	Steam generator Disch.	100-800°F	720°F	TBD
Steam Pressure	Steam generator Disch.	25-750 psi	700 psi	TBD
S-800 Temp	Steam generator Outlet	100-800°F	750°F	TBD
Steam Temp	Process steam delivery header	100-500°F	340°F	TBD
Steam Pressure	Process steam delivery header	50-150 psi	105 psig	TBD
Steam Pressure	Condenser	1-25 psi	5 psig	TBD
Steam Pressure	1st stg. shell	TBD	TBD	TBD
Steam Pressure	3rd stg. shell	TBD	TBD	TBD
Circulating water temp	Condenser inlet	100°F-250°F	190°F	TBD
Circulating water temp	Condenser disch	100°F-250°F	210°F	TBD
Condensate Conductivity	Make up device outlet	.01 to .1 umas/cm	.05	TBD
Condensate conductivity	Unit pump disch	.01 to .1 umas/cm	.05	TBD
Condensate conductivity	BFP disch.	.01 to .1 umas/cm	.05	TBD
Chloride ion Conc.	Cond. pump disch	1-50ppb	2ppb	TBD
Chloride ion Conc.	BFP disch	1-50ppb	2ppb	TBD
Dissolved O_2 Conc.	BFP disch	.001-1ppm	.002ppm	TBD
Si Concentration	BFP disch.	.005-10ppm	.01ppm	TBD
Condensate ph	make	7.0-10	8.5	TBD
Condensate ph	BFP disch	7.0-10	9.5	TBD
Alternate or Frequency		59-61 Hz	60Hz	TBD
Alternate or Voltage		470-490V	480V	TBD

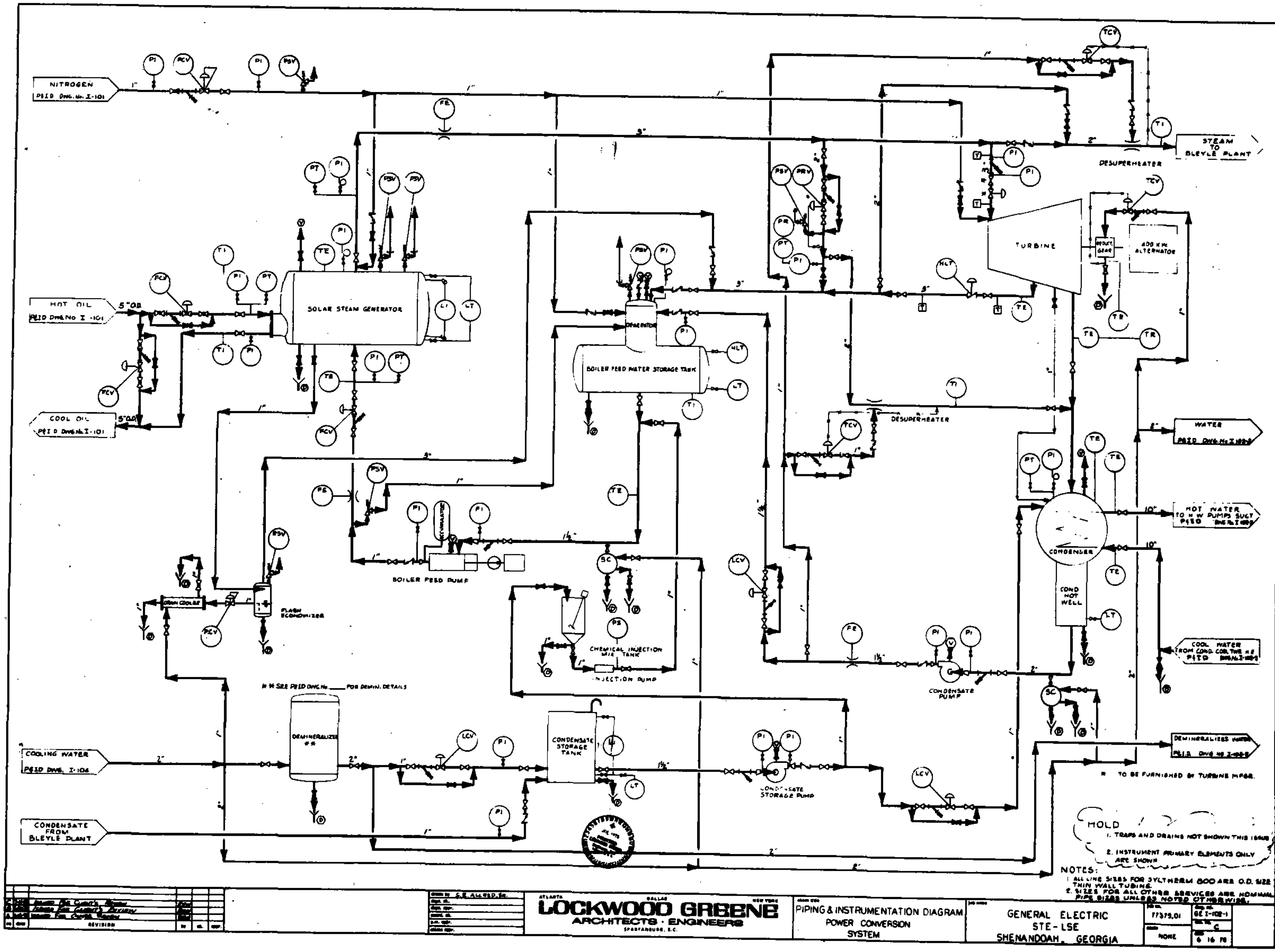
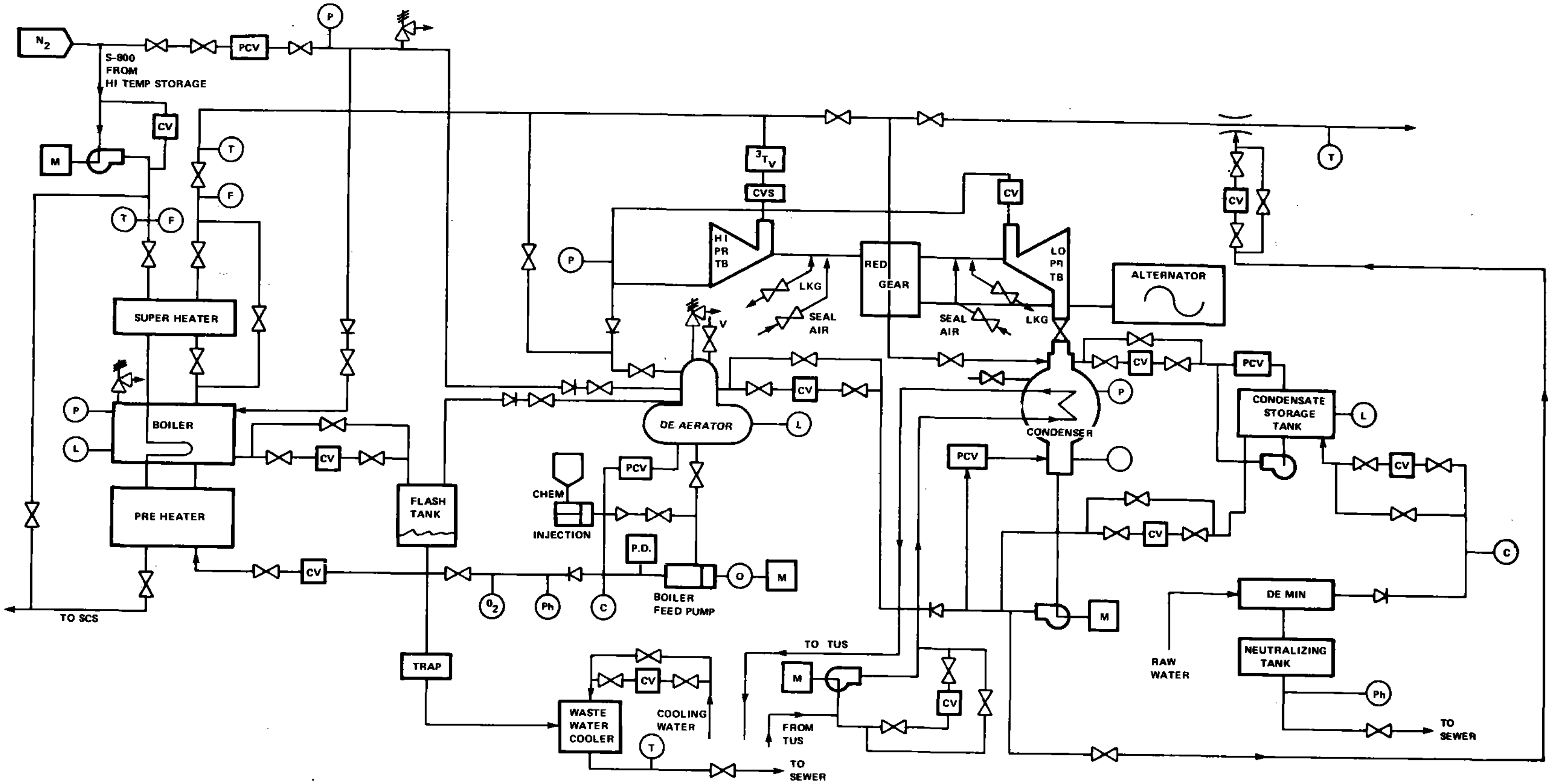


Figure 5.1.2-1. Piping & Instrumentation Diagram Power Conversion Subsystem



Legend:

Gate Valve	STV Stop/Throttle Valve	L Level Indicator	N_2 Nitrogen Supply
Check Valve	PCV Pressure Control Valve	F Flow Sensor	C Conductivity Meter
Relief Valve	T Temperature Sensor	pH pH (acidity) Indicator	PD Pulsation Dampener
CV Control Valve	P Pressure Sensor	O_2 Oxygen Analyzer	M Motor

Figure 5.3.1-1 Power Conversion Subsystem Flow Circuit

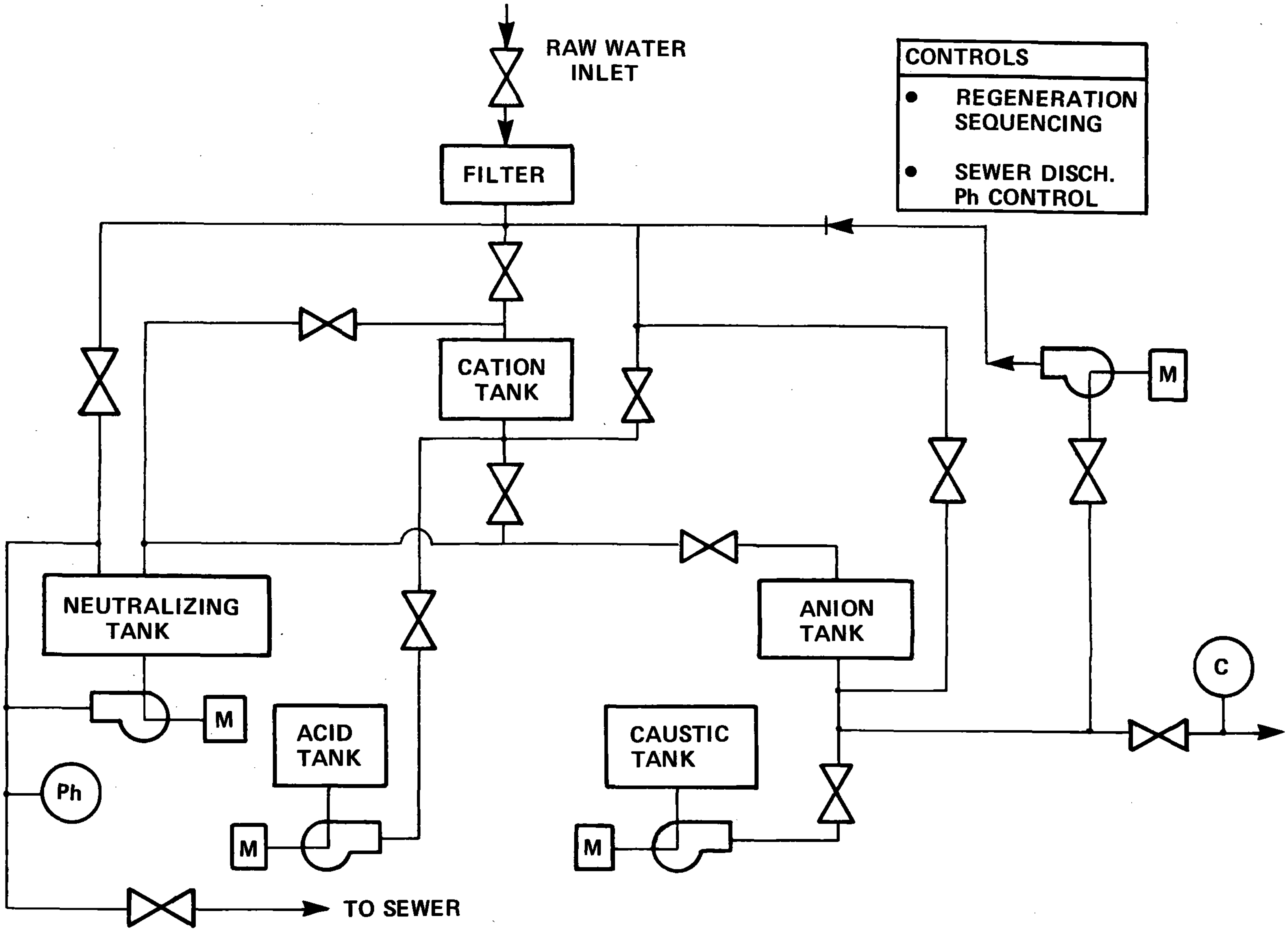
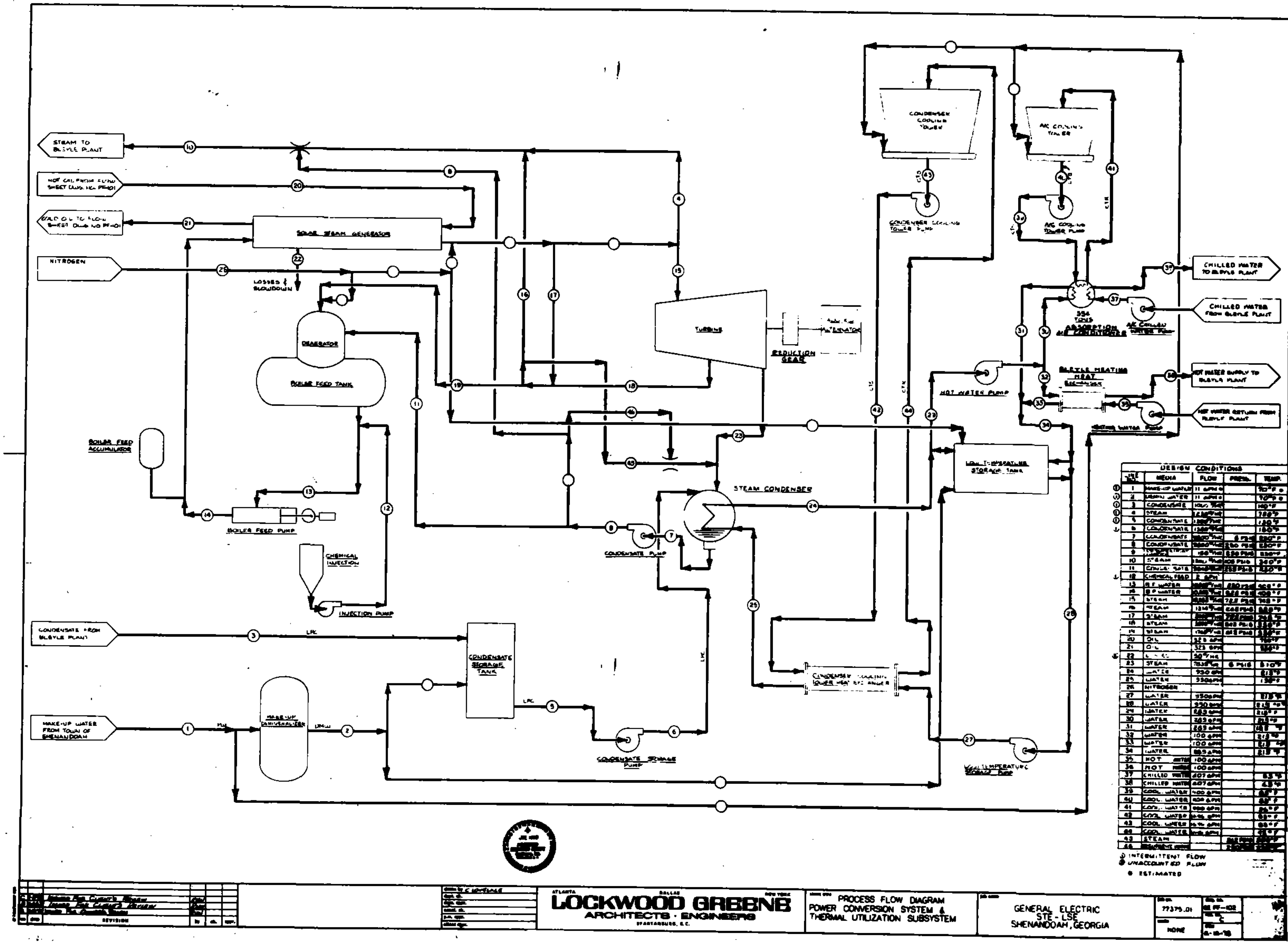


Figure 5.3.1-2. Demineralizer Unit Flow Circuit



LINE NO.	MEDIA	FLOW	PRESS.	TEMP.
DESIGN CONDITIONS				
1	MAKE-UP WATER	11 GPM ●		70°F ●
2	DEMIN WATER	11 GPM ●		70°F ●
3	CONDENSATE	[illegible]		140°F
4	STEAM	[illegible]		180°F
5	CONDENSATE	[illegible]		180°F
6	CONDENSATE	[illegible]		180°F
7	CONDENSATE	[illegible]	6 PSIG	[illegible]
8	CONDENSATE	[illegible]	250 PSIG	250°F
9	[illegible]	160 #/HR	[illegible]	[illegible]
10	STEAM	[illegible]	[illegible]	240°F
11	CONDENSATE	[illegible]	[illegible]	[illegible]
12	CHEMICAL FEED	2 GPH		
13	B.F. WATER	[illegible]	[illegible]	[illegible]
14	B.F. WATER	[illegible]	[illegible]	[illegible]
15	STEAM	[illegible]	725 PSIG	[illegible]
16	STEAM	1314 #/HR	[illegible]	[illegible]
17	STEAM	[illegible]	[illegible]	[illegible]
18	STEAM	[illegible]	[illegible]	[illegible]
19	STEAM	[illegible]	[illegible]	[illegible]
20	OIL	325 GPM		[illegible]
21	OIL	323 GPM		[illegible]
22	[illegible]	50 #/HR		
23	STEAM	[illegible]	6 PSIG	[illegible]
24	WATER	930 GPM		[illegible]
25	WATER	930 GPM		[illegible]
26	NITROGEN			
27	WATER	[illegible]		[illegible]
28	WATER	930 GPM		[illegible]
29	WATER	243 GPM		[illegible]
30	WATER	243 GPM		[illegible]
31	WATER	243 GPM		[illegible]
32	WATER	100 GPM		[illegible]
33	WATER	100 GPM		[illegible]
34	WATER	[illegible]		[illegible]
35	HOT WATER	100 GPM		
36	HOT WATER	100 GPM		
37	CHILLED WATER	407 GPM		55°F
38	CHILLED WATER	407 GPM		45°F
39	COOL. WATER	400 GPM		[illegible]
40	COOL. WATER	[illegible]		[illegible]
41	COOL. WATER	[illegible]		[illegible]
42	COOL. WATER	[illegible]		[illegible]
43	COOL. WATER	[illegible]		[illegible]
44	COOL. WATER	[illegible]		[illegible]
45	STEAM		[illegible]	[illegible]
46	[illegible]		[illegible]	[illegible]

INTERMITTENT FLOW
UNACCOUNTED FLOW
● ESTIMATED

Figure 5.3.2-1. Process Flow Diagram Power Conversion System & Thermal Utilization Subsystem.

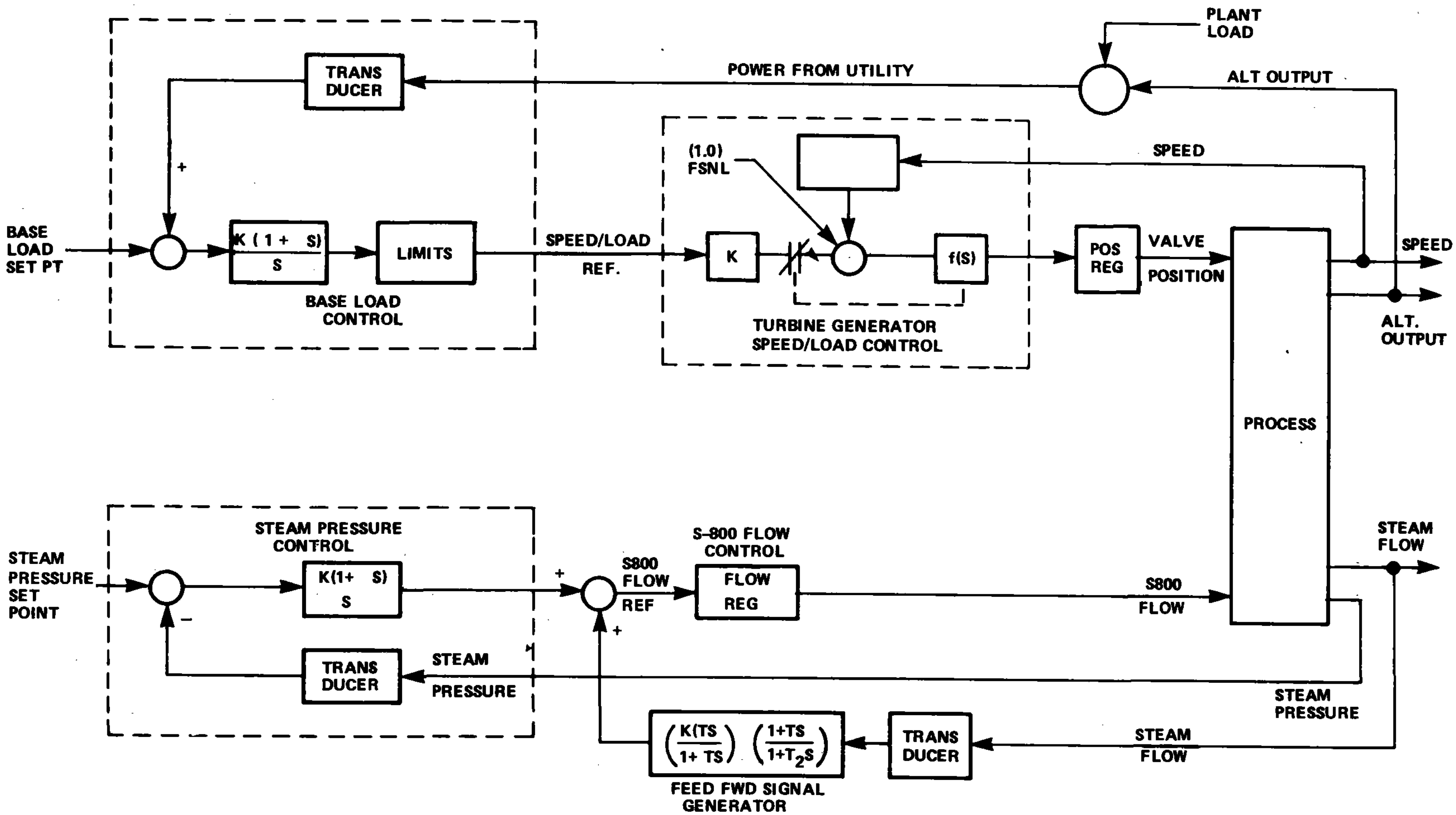


Figure 5.3.4-1. Boiler-Turbine Control

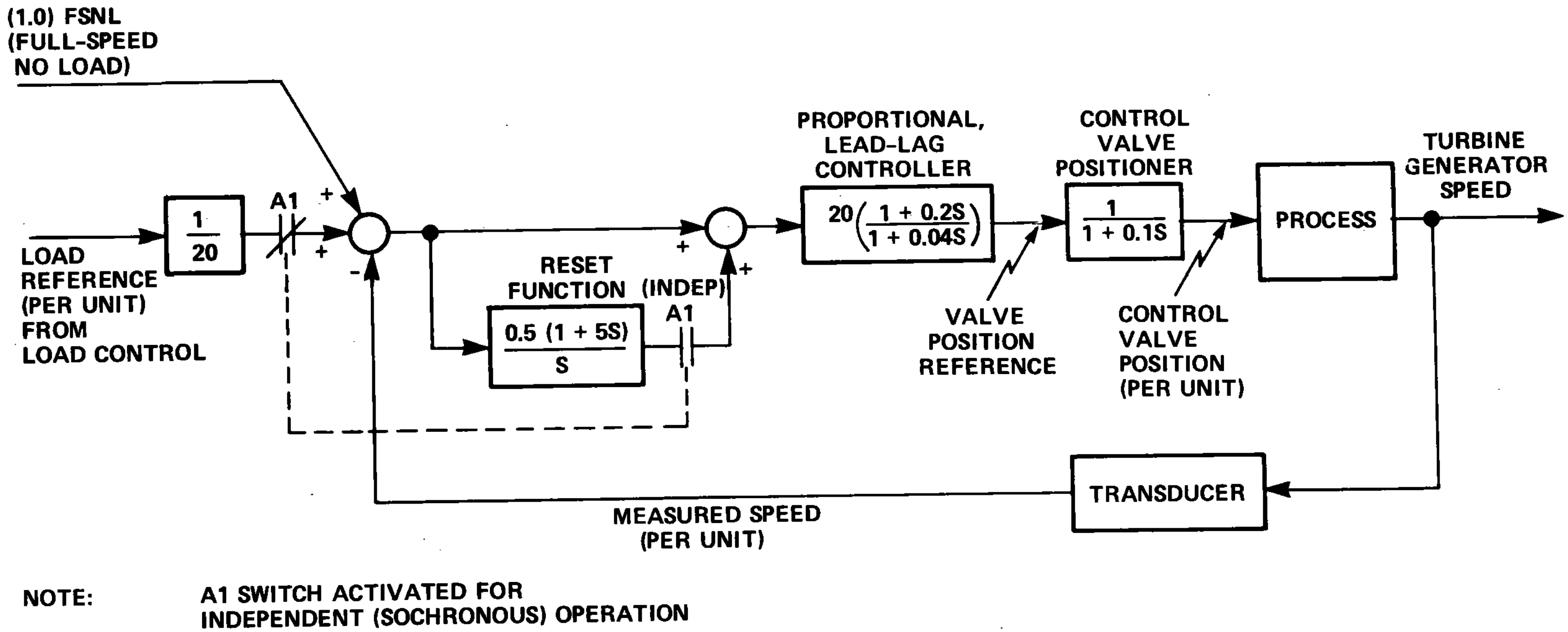


Figure 5.3.4-2. Turbine-Generator Speed/Load Governor Control (For Both Interconnected and Independent Operation)

SECTION 6

SECTION 6

THERMAL UTILIZATION SUBSYSTEM (TUS)

6.1 SCOPE

6.1.1 FUNCTION

The Thermal Utilization Subsystem serves as the condensing medium for the steam condenser and the heat source for the heating and cooling of the Bleyle Plant and the Mechanical Building. The exhaust heat from the steam turbine provides the heat input to the TUS. When the turbine is out of service, steam will be provided directly to the condenser. A large, low temperature storage (LTS) tank is included in the TUS for the storage of thermal energy. Excess energy is dissipated through two cooling towers. Chilled and heated water are pumped to the Bleyle Plant and the Mechanical Building for cooling and heating purposes.

6.1.2 SUBSYSTEM CONFIGURATION

The Thermal Utilization Subsystem Piping and Instrumentation Drawing (P&ID) is shown in Figure 6.1.2-1. The steam condenser acts as the boundary between the TUS and the Power Conversion Subsystem. The chilled and heated water lines of the TUS connect with the HVAC distribution system in the Bleyle Plant.

6.2 DESIGN CRITERIA

6.2.1 PERFORMANCE CRITERIA

a) The absorption air conditioning (AAC) subsystem in the TUS shall have a maximum cooling capacity of 6.09×10^5 J/s (173 tons) when supplied with condenser cooling water at an outlet temperature of 372° (210°F). This capacity is sufficient to handle the maximum combined cooling load of the Bleyle Plant and the STE-LSE Mechanical Building.

b) The hot water coil heating subsystem in the TUS shall be capable of satisfying a maximum heat load of 1.64×10^5 J/s (559×10^3 Btu/hr) when supplied with condenser cooling water at an outlet temperature of 372°K (210°F).

c) The low temperature TES subsystem shall be sized for a maximum storage capacity of 2.1×10^{10} joules (20×10^6 Btu).

d) The condenser cooling tower will be a 2.1×10^6 J/s (600 ton) capacity tower at 299°K (79°F) wet bulb temperature.

e) The AAC cooling tower will be a 7.0×10^5 J/s (200 ton) capacity tower at 299°K (79°F) wet bulb temperature.

6.2.2 SYSTEM OPERATIONAL REQUIREMENTS

Both the heating and air conditioning subsystems of the TUS shall have multiple zone distribution systems.

6.2.3 INTERFACE REQUIREMENTS

The Bleyle Plant has been designed to accept the STES heating and cooling water subsystems.

6.2.4 MAINTENANCE AND RELIABILITY REQUIREMENTS

Maintenance on pumps or cooling towers will require shutdown of that particulr piece of equipment. Single pumps and cooling towers are installed. Spare pumps will be purchased and maintained in storage for quick replacement. Chemical feed systems are provided for the cooling towers and the closed water systems to reduce corrosion on piping and wetted equipment.

6.2.5 TESTING AND INSPECTION REQUIREMENT

No special provisions are provided for testing and inspection. Room has been provided for pulling tubes on all heat exchangers.

6.3 DESIGN DESCRIPTION

6.3.1 DETAILED SUBSYSTEM DESCRIPTION

The Thermal Utilization Subsystem is shown on the piping and instrument drawing, Figure 6.1.2-1. The flows shown are at 400 kW(e). Using this figure as a guide, water is circulated through the condenser by using the discharge of the low temperature storage pump. The heated water from the condenser may then be placed in the low temperature storage tank. The hot water will enter in the top of the low temperature storage tank and relatively cold water will be removed from the bottom of the tank to the suction of the low temperature storage pump. In the event of excess thermal energy (low temperature storage tank too hot), the condenser cooling tower may be used to cool the condenser circulating water discharging from the low temperature storage tank. Water is routed from the cooling tower by the condenser cooling tower pumps to the heat exchanger and then back to the cooling tower.

A hot water pump is provided. It takes suction from the hot water line leaving the steam condenser. The pump discharges either to the heat exchanger supplying Bleyle heating or to the absorption air conditioner. The heat exchanger is used to extract the heat from the hot water pump discharge and to transfer this to the water supply for heating the Bleyle plant.

The hot water from the discharge of the hot water pumps is routed through the absorption air conditioner. The heat from the water is used as the heating source in the absorption air conditioner. The expanded gas is used to cool the cooling water supply to the Bleyle Plant. The water pumped by the hot water pump leaves the absorption air conditioner and then may go to the middle of the low temperature storage tank, if heat is still available in the water, or may flow to the suction of the low temperature storage pump.

6.3.2 SUBSYSTEM PERFORMANCE CHARACTERISTICS

Pressures, temperatures, and flows for the Thermal Utilization Subsystem are shown on Figure 5.3.2-1. These flows are at 400 kW(e).

6.3.3 MAJOR COMPONENTS

6.3.3.1 Low Temperature Storage Tank

A 458 cubic meter (121,000 galion) storage tank is provided for stratified storage of thermal energy. The storage tank is used to store heated water in the top and cool water in the bottom. There are three water connections on the tank.

A. Top connection - Hot water can enter the tank from the condenser or can be drawn from the tank with the hot water pump.

B. Middle connection - Cooled water can enter the middle connection from the Bleyle heating heat exchanger or from the absorption air conditioner.

C. Bottom connection - Provides suction (cool water) to the low temperature storage pump.

The tank is provided with a make-up water supply, relief valve, a vacuum breaker, and a nitrogen supply. The tank is sized to accommodate thermal expansion for the system. Drains and overflow controls are provided. The tank is located south of the Mechanical Building. It will be 9.1 meters (30 feet) in diameter and 7 meters (23 feet) high and insulated.

6.3.3.2 Absorption Air Conditioning Unit

A 1.25×10^6 J/s (354 ton) absorption air conditioner (AAC) is provided inside the Mechanical Building. The packaged absorption air conditioner will consist of a 5.6 kW (7 1/2 hp)/sealed pump, a 190 watt (1/4 hp) purge pump, an absorber, evaporator, concentrator, condenser, and a heat exchanger. Thermal energy is provided to the AAC by 0.018 m^3/s (285 gpm) water at a nominal temperature of 372°K (210°F).

Cooling tower water is provided to the AAC at 302°K (85°F) and 0.057 m^3/s (900 gpm). The water leaves the AAC at 309°K (96°F). Chilled water at 280°K (45°F) will be supplied to Bleyle at a flow rate of 0.026 m^3/s (407 gpm). The water will be returned from Bleyle at 286°K (55°F).

The AAC utilizes the proven lithium bromide-water, absorption refrigeration cycle. This cycle takes place in a sealed hermetic shell from which essentially all air has been removed. Consequently, the pressures within the shell are the vapor pressures of the liquids used in the cycle at their respective temperatures. In operation, the pressure in the absorber and the evaporator section is about 1000 N/m^3 (1/100th of an atmosphere). Pressure in the concentrator and condenser sections is about 1×10^4 N/m^2 (1/10th of an atmosphere). In the operating cycle, distilled water is used as the refrigerant and lithium bromide as the absorbent.

6.3.3.3 Cooling Towers

Two cooling towers are being provided. The AAC cooling tower is a nominal 7.0×10^5 J/s (200 ton) double flow unit. It will be provided with a 7.5 kW (10 hp) fan driven thru a gear reducer. The tower is capable of operating thru a range of 0.012 to 0.071 m^3/s (190 to 1125 gpm) of cooling tower water flow. It will be provided with an overflow, make-up system and chemical treatment system. Construction of baffles for water droplet dispersion will be PVC. Casing and louvers will be corrugated asbestos. An access ladder will be provided to the fan.

The condenser cooling tower is a 2.1×10^6 J/s (600 nominal ton) double flow unit. It will be provided with a 30 kW (40 hp) fan driven through a gear reducer. The tower is capable of operating through a range of 0.038 to 0.0151 m^3/s (600 to 2400 gpm) cooling water flow. Construction materials will be similar to the AAC cooling tower.

6.3.3.4 Condenser Cooling Tower Heat Exchanger

The condenser cooling tower heat exchanger shall be capable of cooling 0.060 m^3/s (950 gpm) of water at 375°K to 364°K (215°F to 195°F). It will give up its heat to the condenser cooling tower water that will flow at 0.011 m^3/s (696 gpm) at 302°K (85°F) and return at 308°K (95°F). The hot water will flow through the shell. The cool water will be on the tube side.

6.3.3.5 Pumps

The following pumps will be used in the Thermal Utilization Subsystem. All pumps will be driven by 480V, 3 phase motors with local and remote start-stop controls:

- The low temperature storage pump will be capable of pumping .057 m^3/s (900 gpm) @ 34 meter (110 ft.) head.
- The condenser cooling tower pump will be capable of pumping 0.107 m^3/s (1700 gpm) @ 12 meter (40 ft.) head.
- The air conditioning cooling tower pump will be capable of pumping 0.057 m^3/s (900 gpm) @ 15 meter (50 ft.) head.

- The hot water pump will be capable of pumping .016 m^3/s (250 gpm) @ 12 meter (40 ft.) head.
- The chilled water pump will be capable of pumping 0.026 m^3/s (407 gpm) at 12 meter (40 ft.) head.
- The heating water supply pump will be capable of pumping .0063 m^3/s (100 gpm) @ 12 meter (40 ft.) head.

6.3.3.6 Piping Valves and Insulation

The piping and valve material specifications for the Thermal Utilization Subsystem are shown on Figure 6.3.3-1. ASTM A-53 Grade A Schedule 40 welded or seamless pipe will be used. Pipe connections will be welded except for valves and pumps that may be flanged. Standard 57 kg (125 lb.) valves will be used. Insulation will be installed on the tanks and piping to minimize heat loss and to prevent sweating where necessary.

6.3.4 CONTROLS AND INSTRUMENTATION

6.3.4.1 Design Criteria

Control functions required by the Thermal Utilization Subsystem include the following:

1. Low temperature storage tank level control - This control will admit make-up water and operate the overflow valve. A vacuum breaker is provided and a relief valve for over pressure protection.

2. Cooling towers - Level controls are provided for control of make-up. Fan controls will be operated remotely by hand.

3. Heating and cooling controls - Hot water may be routed to the AAC or the Bleyle heating heat exchanger. Pneumatic valves are provided for this.

4. Chemical injection - This will be controlled manually.

6.3.4.2 Alarms

Overload protection is provided for all pump motors. Low suction pressure trip is provided for the hot water pump since it takes suction from the top of the low temperature storage tank.

6.4 SUBSYSTEM OPERATION

Operation of the TUS will occur when either the PCS is operating or there is a heating or cooling demand from the Bleyle Plant.

6.4.1 NORMAL OPERATION

6.4.1.1 Operation With PCS Operating

When the PCS is operating, the TUS cooling loop takes heat from the PCS condenser and delivers energy by way of the low temperature storage pump to the low temperature storage tank or, if there is a heating or cooling load as indicated by the Bleyle Plant thermostats, directly to the heat exchanger (for space heating) or to the absorption air conditioner generator. The absorption air conditioner will control internal flows to match the load and maintain the required chilled water temperature and condenser/absorber temperatures. Excess thermal energy above that required for heating or cooling is stored in the LTS. When the LTS is fully charged, additional excess heat is dissipated through activation of the condenser cooling tower loop.

6.4.1.2 Operation Without PCS Operating

In this mode of operation, the LTS stored energy is used to supply either the absorption air conditioner generator or heating heat exchanger directly to satisfy Bleyle Plant cooling or heating loads, respectively. This mode continues until either the loads are supplied or PCS operation begins and typically will occur during the third shift or on weekends.

6.4.2 OFF NORMAL OPERATION

Off normal operation will occur when there is no heating or cooling required for prolonged periods or the absorption air conditioner is not operating. In this mode, the PCS will continue to operate at design backpressure, and the heat to the TUS will be dissipated through the condenser cooling tower. If cooling is required by the plant, it will be supplied by the vapor compression air conditioning units currently installed.

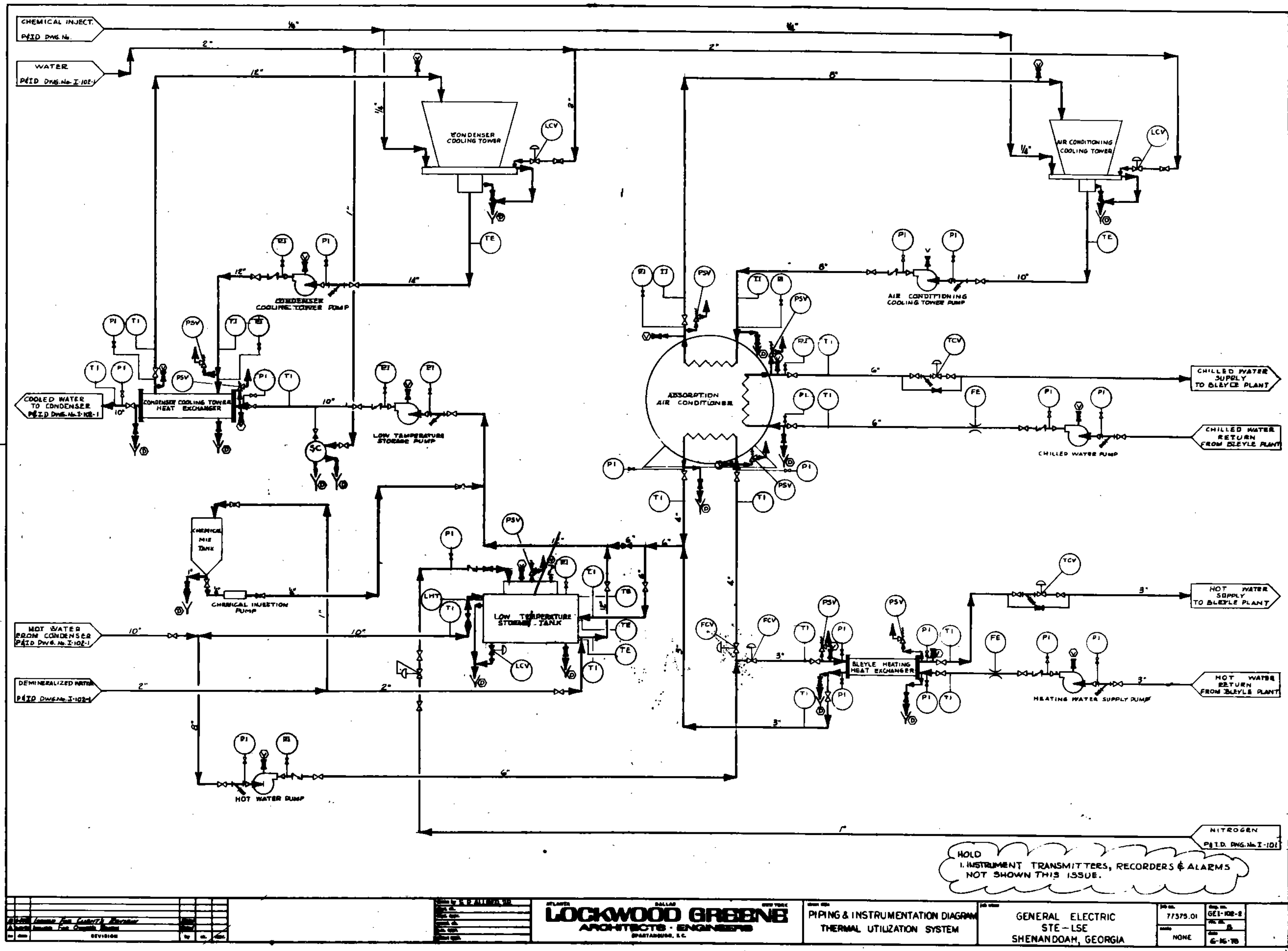


Figure 6.1.2-1 Piping & Instrumentation Diagram Thermal Utilization Subsystem

DESIGNATION	SERVICE	DESIGN PRESSURE PSIG	DESIGN TEMP °F	PIPE MATERIAL SPEC. 2 INCH AND SMALLER	PIPE MATERIAL SPEC. 2½ INCH AND LARGER	FITTINGS 2 INCH AND SMALLER	FITTINGS 2½ INCH AND LARGER	UNIONS	FLANGES SEE NOTE 2	GASKETS	BOLTING	VALVES GATE	VALVES GLOBE	VALVES CHECK	VALVES BALL	VALVES SPECIALS	INSTRUMENT AND SAMPLE VALVES	INSULATION SEE NOTE 3	HYDROSTATIC TEST PRESSURE PSIG	EXCEPTIONS	REMARKS
HTO-1	HIGH TEMPERATURE OIL-1 (HEATED)		750	ASTM A179 OR A192 SEAMLESS THIN WALL TUBING	ASTM A179 OR A192 SEAMLESS THIN WALL TUBING	ASTM A105 3000 lb. FORGED STEEL, SOCKET WELD. ('SWAGLOK'-CARBON STEEL NUTS, FERRULES)	ASTM A234 GRADE WPB, BUTT WELD. ('SWAGLOK'-CARBON STEEL NUTS, FERRULES)	3000 lb. FORGED STEEL, SOCKET WELD ASTM A105. ('SWAGLOK'-CARBON STEEL NUTS, FERRULES)		'GRAFOIL											
HTO-2	HIGH TEMPERATURE OIL-2 (COOLED)		500	↓	↓	↓	↓	↓		↓											
HPS	HIGH PRESSURE STEAM	750	700	ASTM A-106 GR. B., SCH. 80 SEAMLESS, PLAIN END	ASTM A-106 GR. B., SCH. 40, SEAMLESS. BEVEL END.	ASTM A-105, 3000 LB., SOCKET WELD. FORGED STEEL.	ASTM A-234 GR. WPB, STANDARD WT, WELD END.	ASTM A-105 3000 LB., SOCKET WELD FORGED STEEL	ASTM A-181 GR. II, CLASS 600, R.F.S.O.	1/16" THICK SPIRAL RING, COMPRESSED ASBESTOS	ASTM A-307 GR. B., STUDS WITH ASTM A-307, HEAVY HEX NUTS.										
MPC	MEDIUM PRESSURE CONDENSATE	300		↓	↓	↓	ASTM A-234 GR. WPB, EXTRA STRONG, WELD END.	↓	ASTM A-181 GR. II, CLASS 150, FLAT FACE	↓	↓										
LPC	LOW PRESSURE CONDENSATE	50		↓	↓	↓	↓	↓	↓	↓	↓										
MPS	MEDIUM PRESSURE STEAM	150		ASTM A-106, GR. B. SCH. 40 SEAMLESS, PLAIN END	ASTM A-106 GR. B. STANDARD WT., SEAMLESS BEVELED END	↓	ASTM A-234 GR. WPB, STANDARD WT., WELD END	↓	ASTM A-181 GR. II, CLASS 300, R.F.S.O.	↓	↓										
BFW	BOILER FEED WATER	850	400																		
DMW	DEMINERALIZED WATER																				
SW	SERVICE WATER	100	125	ASTM A-106 GR. B, SCH. 40 SEAMLESS PLAIN END	ASTM A-106 GR. B., STANDARD WT., SEAMLESS, BEVELED END	ASTM A-105 3000 LB., SOCKET WELD, FORGED STEEL	ASTM A-234 GR WPB. STANDARD WT., WELD END	ASTM A-105 3000 LB., SOCKET WELD FORGED STEEL	ASTM A-181 GR. II, CLASS 150, FLAT FACE	FULL FACED 1/8" THICK RED RUBBER	ASTM A-307 GR. B. STUDS WITH ASTM A-307, HEAVY HEX NUTS										
SA	SERVICE AIR			↓	↓	↓	↓	↓	↓	↓	↓										
IA	INSTRUMENT AIR	100	125	↓	ASTM A-106 GR. B, SCH. 40, SEAMLESS. BEVELED END	↓	↓	↓	↓	↓	↓										
CTS	COOLING TOWER SUPPLY			ASTM A-53 GR. A, SCH. 40 WELDED OR SEAMLESS, PLAIN END	ASTM A-53 GR. A, SCH. 40 WELDED OR SEAMLESS, BEVELED END.	ASTM A-105, 3000 LB., SOCKET WELD FORGED STEEL.	ASTM A-234 GR. WPB STANDARD WT, WELD END.	ASTM A-105 3000 LB., SOCKET WELD FORGED STEEL	ASTM A-181 GR. II, CLASS 150 FLAT FACE	FULL FACE 1/8" THICK RED RUBBER	ASTM A-307 GR. B. STUDS WITH ASTM A-307, HEAVY HEX NUTS										
CTR	COOLING TOWER RETURN																				
CWS	COOLING WATER SUPPLY			↓	↓	↓	↓	↓	↓	↓	↓										
CWR	COOLING WATER RETURN																				
CTCF	COOLING TOWER CHEMICAL FEED																				
BCF	BOILER CHEMICAL FEED																				
OWD	OILY WATER DRAIN																				
SD	STORM DRAIN																				
SS	SANITARY SEWER																				
FP	FIRE PROTECTION																				
PW	POTABLE WATER	100	200	A-120 SCH. 40, GALV. STEEL	A-120 STANDARD WT., GALV. STEEL	150 LB. GALV. MALL IRON ASTM A-197 SCREW	125 LB. GALV. MALL. IRON STANDARD WT., FLANGED	3000 LB. FORGED STEEL GALV. GROUND JT. SCREWED	125 LB. F.F. ASTM A-126 GR. II. GALV.												

NOTES
1. FOR COMPLETE PIPING MATERIAL SPECIFICATIONS SEE SECTION 15, CONSTRUCTION SPECIFICATIONS.
2. WELD NECK FLANGES MAY BE SUBSTITUTED FOR SLIP-ON FLANGES WHERE REQUIRED BY FITTING OR DIMENSIONAL CLEARANCE.
3. FOR INSULATION THICKNESS, SEE PIPING DRAWINGS.

no	date	REVISION	by	ck.	appr.
B	6-20-78	ISSUED FOR CLIENT'S REVIEW	RHW		
A	6-4-78	ISSUED FOR OWNER'S REVIEW	RHW		

drawn by / dept. ch.: ROBERT H. WEE

ATLANTA · DALLAS · NEW YORK
LOCKWOOD GREENE
ARCHITECTS · ENGINEERS
SPARTANBURG, S.C.

sheet title: PIPING MATERIAL SPECIFICATION

job name: GENERAL ELECTRIC STE-LSE SHENANDOAH, GEORGIA

job no. 77375.01 — dwg. no. GEM-104 — rev. no. B

Figure 6.3.3-1. Piping Material Specification

SECTION 7

SECTION 7

CONTROL AND INSTRUMENTATION SUBSYSTEM (CIS)

7.1 SCOPE

7.1.1 FUNCTION

The Control and Instrumentation Subsystem (CIS) provides the controls, monitors, and interfaces for all the other subsystems of intervention, the selection of the system operational mode, provisions for controlling all factors of the various subsystems, provisions for monitoring all critical parameters of the various subsystems, protection of the subsystem components, and integration of operation of the system as a whole.

7.1.2 SUBSYSTEM CONFIGURATION

The control and instrumentation functions are provided via the central control console, the central mini-computer and peripheral equipment, and seven remote microprocessor control units. Individual remote control units interact directly with the individual STES subsystems. These units contain conditioning circuitry to convert the digital computer outputs to signals usable by the control actuators and to transform sensor outputs to digital format for scrutiny and recording by the micro- and as necessary mini-computers. Control units will act autonomously where possible and will interact with the central processor in a distributed control approach as necessary. The control console and computer terminal will provide input-output control and monitor capability to the operator.

7.2 DESIGN CRITERIA

7.2.1 PERFORMANCE REQUIREMENTS

a) The design of the CIS shall make use of standard control devices and functions and existing computer hardware and software. The design should not be dependent upon the development of new control devices.

b) The design of the CIS shall incorporate sufficient controls and monitoring devices to detect and identify system faults and malfunctions, provide appropriate warnings and alarms, and automatically initiate appropriate actions to prevent further damage to system components.

c) The design of the CIS shall include data archiving for monitoring and recording system performance parameters during experimental and normal operating modes.

7.2.2 SYSTEM OPERATIONAL REQUIREMENTS

a) The computer architecture of the CIS shall have sufficient flexibility to be adaptable to experimental modes of operation as well as anticipated commercial operational modes.

b) The design of the CIS shall incorporate provisions for manually overriding control set points and automatic operational modes.

c) The CIS shall be capable of automatic start-up and shutdown operations.

7.2.2.1 Solar Collection Subsystem

The collector field control units must provide tracking control as outlined in Section 4.3.4.1 and field temperature control as outlined in Section 4.3.4.2. These requirements necessitate interactive processing capabilities between collector field control units and the central control console in addition to the input of data from sensors that are located in the Thermal Energy Storage Subsystem to execute the various operating modes of the field.

7.2.2.2 Thermal Energy Storage Subsystem

Requirements for the Thermal Energy Storage Subsystem control unit are summarized in Section 4.3.4.3. In order to manage the referenced tasking effectively, this equipment monitors a number of temperature, flow, and pressure variables within its own environment and additionally defines basic operating modes based on data interactively acquired from outside its system boundaries. The various major modes and submodes of operation are executed via appropriate binary or proportional controls within the local system.

7.2.2.3 Power Conversion Subsystem

The Power Conversion Subsystem control unit is required to provide the applicable functions defined in Section 5.3.4.1. While the internal management functions are as defined in the referenced sections, these tasks are dynamically reconfigured and optimized in direct response not only to the steady state operating protocol but also to changes in load requirements present at the utility and plant interfaces in a closed loop feedback to provide the required system response speed and stability.

7.2.2.4 Thermal Utilization Subsystem

Management of low grade energy assigned to the Thermal Utilization Subsystem control unit is functionally described in Section 6.3.4.1. Operating modes may be reduced to sequential control algorithms providing modal stability as a function of action/response criteria set for various temperature, pressure, and/or flow transducer outputs within the system. Major modes of operation are defined and modified in response to inputs from various linear transducers within the output environment as modified by the state of operating conditions within the TUS.

7.2.3 INTERFACE REQUIREMENTS

The Control and Instrumentation Subsystem interfaces may be broadly divided into three main categories:

1) Power requirements - the central complex and each of the subsystem remotes are designed to operate from 120V AC, 60 Hz as the primary power source. Certain elements of the system may require capability to operate for the period of time necessary to effect orderly shut-down in the event of loss of main power.

2) Subsystem inputs - each of the remote micro-processor control units shall be capable of interfacing with a variety of ranges of analog and digital signals via signal conditioning circuitry. Typical sources are temperature, pressure, and flow transducers; binary status indicators; voltage, power (both real and reactive), and frequency; and various digitally formatted input parameters.

3) Subsystem outputs - the remote micro-processors shall incorporate signal conditioning to output digital and/or analog signals of the appropriate format, scale, and precision to drive the various controls (both binary and analog) resident within that micro-processor's environment.

7.2.3.1 Solar Collection Subsystem

7.2.3.1.1 Collector Field Subsystem (CFS)

The Control and Instrumentation Subsystem will interface with the CFS by means of sensors providing the Syltherm 800 temperature at each collector and the collector pointing position to within $\pm 0.125^{\circ}$. The CIS will provide the collectors with signals to permit tracking of the sun to within $\pm 0.5^{\circ}$ and to adjust the Syltherm 800 flow to maximize the field temperature to a maximum of $672^{\circ}K$ ($750^{\circ}F$). Signals will also be provided to permit emergency defocusing of collectors as well as start-up-shutdown sequences.

7.2.3.1.2 Thermal Energy Storage Subsystem

The Control and Instrumentation Subsystem will be provided with inputs monitoring the state of charge or discharge of the storage tanks and the interconnecting valve positions. Outputs to the TES will set the valves for maximum charging during charge cycle and control the discharge during discharge cycle. Outputs to control the fossil fuel heater will also be provided.

7.2.3.2 Power Conversion Subsystem

The Control and Instrumentation Subsystem will send signals to control the PCS steam generator to maintain the steam temperature and pressure required by the PCS turbine generator and process steam demands. Automatic startup and shutdown sequences will also be executed under the direction of the CIS .

7.2.3.3 Thermal Utilization Subsystem

The Control and Instrumentation Subsystem will provide signals to maintain the proper flow rate and temperature of coolant into the steam condenser. The CIS will also control the charge/discharge of the low temperature storage tank and select between and control the absorption air conditioner or space heating. The Control and Instrumentation Subsystem will also interface with the existing Doric Digitrend 220 Data Logger to provide recording of factory instrumentation data and with the meteorological station to receive its data signals.

7.2.4 ON-SITE MAINTENANCE

7.2.4.1 General STES Considerations

Design of the Control and Instrumentation Subsystem requires that major STES operating criteria be routinely interrogated not only to generate the appropriate control signals for the various subsystems but also to ascertain that the prerequisite response has occurred either in that subsystem or between hydraulically interconnected subsystems. As such these action/response algorithms are in themselves a general system maintenance tool. Responses which do not occur in the predicted manner cause detected instabilities within any particular operating protocol and are brought to the attention of the operator during archiving so that appropriate fault isolation and servicing may be initiated.

7.2.4.2 Subsystem Maintenance

Due to the complexity of the Control and Instrumentation Subsystem, it is most advantageous to provide a series of testing protocols to help isolate suspected device failures. The various testing protocols shall be incorporated into the subsystem diagnostics routine, a software library resident in the mini-computer environment and available to the operator via keyboard command. These diagnostics shall be performed as part of a regular maintenance program as well as for use as a tool in the troubleshooting of suspected Control and Instrumentation Subsystem faults.

7.2.5 TESTING AND INSPECTION REQUIREMENTS

a) Testing of computer hardware will be accomplished by means of standard, vendor supplied, diagnostic programs.

b) Testing of individual software modules will be performed during the fabrication phase. Each module, as it is developed, will be tested by test programs which will exercise all features within the software module.

c) The Control and Instrumentation Subsystem will be tested as a whole by demonstrating proper control of the STES. Startup/shutdown sequences and normal operation will be demonstrated. Proper response to abnormal situations will be demonstrated by simulating STES component failures.

7.2.6 SUBSYSTEM SPECIAL FEATURES

Due to the experimental nature of this project, the Control and Instrumentation Subsystem has been designed to permit system flexibility as an inherent feature. The subsystem may be considered to be a software-driven rather than a hardware-oriented tool. The subsystem may be reconfigured by changes in programs at the computer console rather than by change-out or by time consuming calibration of hardware modules at remote locations. Remote micro-processors may be operationally reconfigured by down loading software via the mini-computer and its associated serial stream data links. Mode changes, operating set-points, archiving requirements, fail-safing may be changed through software techniques with a minimum need to effect remote hardware changes. During routine operation of the Control and Instrumentation Subsystem, the keyboard can be used to interrogate the computer system so that the operator can communicate directly with the mini-computer.

7.3 DESIGN DESCRIPTION

7.3.1 DETAILED SUBSYSTEM DESCRIPTION

Implementation of the various control functions of the STES has been partitioned into distinct areas of device responsibility. Architecturally, the mini-computer is the master system controlling element. Reporting to the mini-computer (Digital Equipment Corp. PDP 11/34) are the various input/output devices (used for archiving, program storage, operator displays, and operator input devices) generally termed peripherals. The mini-computer has minimal control over the operating characteristics of the peripherals.

The flexibility of the total control subsystem resides in the relationship that exists between the mini-computer master controller and the seven slaved micro-computer-driven control units which are physically resident in the collector field (four micro-computers for time-effective collector and branch flow management), the Thermal Energy Subsystem, the Power Conversion Subsystem, and the Thermal Utilization Subsystem. Whereas the mini-computer has minimal influence over the operating characteristics of the peripherals, it has highly flexible control via software reconfiguration of the techniques that the individual micro-processors use to interpret data and execute control over the various transducers and control devices that are resident in their individual domain.

The basic concept is depicted in Figure 7.3.1-1 and is generically called a distributed star configuration. The mini-computer, as the hub of the star, is in a position to analyze inputs from each unit reporting to it for inconsistencies that may indicate improper operation and to initiate appropriate reactions (alert operator, make ready to initiate fail-safe sequencing, etc.) depending on the failure detected.

The slave/master relationship permits (via various data communications protocols and status words in comparison with transducer signals) the slave processor to quantify the basic apparent operating capability of the master controller.

Much of the task load of the entire control subsystem is the acquisition of data from the various subsystems under its control to execute the appropriate control algorithms and to create a data base to serve as an archive for optimization and experimentation. At the analog input interfaces of the micro-computers, the various raw transducer outputs are conditioned and presented to analog multiplexers for conversion by analog-to-digital converters into formatted digital data for linearization and incorporation into control routines and also for archiving.

Control routines may also incorporate binary status indicators to effect control and ascertain feedback stability. To execute control the micro-computer generates two types of signals:

1) Binary (on/off) for control of valves, motors, etc.
2) Analog, by means of digital-to-analog converters, for control of proportional control elements

In addition to archive control, the mini-computer supervises and checks data flow from the individual micro-computers, down loads software to effect mode changes in either a pre-programmed or an on-demand manner, serves via the keyboard or control console as the input mode for human interface, accepts software revision/update, and performs general system housekeeping tasks.

7.3.2 SUBSYSTEM PERFORMANCE CHARACTERISTICS
(TBD)

7.3.3 MAJOR COMPONENTS

The major components of the control system are the central control console, the central mini-computer, and the satellite micro-computers. A hardware selection analysis resulted in selection of Digital Equipment Corp. (DEC) computers. Specifically, the PDP-11/34 is selected for the central mini-computer, and the LSI-11 for the satellite micro-computers.

A distinguishing characteristic of the DEC family is its common physical architecture arising primarily from the patented DEC Unibus, a single high-speed, asynchronous, bidirectional communications path to which all system components (central processing unit - CPU, memories, and input/output I/O controllers) are connected. This common bus structure enables all functional elements to communicate with one another independently of the CPU. This ability reduces the time spent by the CPU in supervising I/O operations and allows it to devote more time to actual data processing.

A second salient feature of the DEC family is that all models, from the smallest LSI-11 to the largest 11/70, use the same basic instruction set, thus allowing great flexibility in software development and transferability. Additional descriptions of the selected models are given below.

7.3.3.1 Central Minicomputer

The PDP-11/34 is a systems level computer that includes increased memory expansion to 124K words, memory relocation and protection, faster processing speeds, and hardware multiply and divide instructions. The computer system is mounted in a 0.133 meter (5 1/4 inch) by 0.267 meter (10 1/2 inch) chassis that mounts in a standard 0.483 meter (19 inch) cabinet. The PDP-11/34 processor is prewired to accept additional memory (parity core or MOS) and standard peripheral device controllers including communications interfaces, mass storage controllers, etc. Additional mounting space is provided within the 0.267 meter (10 1/2 inch) computer chassis for more complex controllers. The computer power supply within the chassis is capable of powering the optional internal devices.

The PDP-11/34 computer, as a member of the PDP-11 family, has the following features:

Single & double operand instructions - powerful and convenient set of programming instructions

Hardware implemented multiply and divide instructions

16-bit word (two 8-bit bytes) -
direct addressing of 32K words or 64K bytes
(K=1024)

Parity detection on each 8-bit byte

Hardware address expansion and protection allowing memory addressing to 124K words

Work or byte processing -
very efficient handling of 8-bit data without the need to rotate, swap, or mask

Asynchronous operation -
system components run at their highest possible speed,
replacement with faster subsystems means faster operation without other hardware or software changes

Modular component design -
extreme ease and flexibility in configuring systems

Stack processing -
hardware sequential memory manipulation makes it easy to handle structured data, subroutines, and interrupts

Direct memory access (DMA) -
inherent in the architecture is direct memory access for multiple devices

8 internal general-purpose registers -
used interchangeably for accumulators or address generation

Automatic priority interrupt -
four-line, multi-level system permits grouping of interrupt lines according to response requirements

Vectored interrupts -
fast interrupt response without device polling

Power fail & automatic restart -
hardware detection and software protection for fluctuations in the AC power

The minimum PDP-11/34 includes:

Parity MOS or core memory

Memory management -
program protection and relocation for memory expansion to 124K 16-bit words

Automatic bootstrap loader -
automatic starts from a variety of peripheral devices

Self-test feature -
ROM hardware automatically performs diagnostics on the CPU and memory

Operator's front panel -
allows complete control of the computer via any ASCII terminal. All front panel functions are key entries on the terminal, thereby eliminating the need and cost of a programmer's lights and switches console

The following optional equipment is available:

Battery backup for MOS memory

Programmer's console

Serial communications line interface and line frequency clock

Large variety of standard PDP-11 peripherals

7.3.3.2 Microcomputers

The LSI-11 is a 16-bit micro-computer with the speed and instruction set of a mini-computer.

The LSI-11 has the following features:

400 Plus Instruction Set

More than 400 instructions make up the LSI-11's extensive instruction set. This instruction set (also used by the PDP-11/34) permits the user to take advantage of standard PDP-11 software. The only departure from the standard software is the addition of two new instructions used to access the processor status word (PSW) explicitly. Development programs (as in the PDP-11 family) include assemblers, linkers, editors, loaders, utility packages, operating systems, and higher level languages.

Extensive Compute Power and Small Processor Size

The processor module is built around a set of four N-channel metal oxide semiconductor (MOS) chips, which include control and data elements as well as two microcoded read-only memories (microms). The latter are programmed to emulate the powerful PDP-11/35,40 instruction set, along with routines for on-line debugging techniques (ODT), operator interfacing, and boot-strap loader capability. The processor also contains a 16-bit buffered parallel input/output (I/O) bus, a 4096-word MOS random-acess memory (RAM), a real-time clock input, priority interrupt control logic, power-fail, auto restart, and other features to provide stand-alone operation. The entire processor plus all of the above mentioned features are contained on one 0.216 by 0.254 meter (8.5 by 10 inch) printed circuit board.

Modularity

The process, memory, device interfaces, backplane, and interconnecting hardware are all modular in design. Modular selection, such as the type and size of memory and device interfaces, enables custom tailoring to meet specific application requirements.

Serial and Parallel I/O Modules

Serial and parallel I/O modules are available for interfacing the processor bus with external devices. These modules simplify connection to peripherals when and if required and also facilitate assembly of prototype systems without penalizing later development of customized interfaces.

Choice of Memory

Memory modules are offered for applications requiring more storage than is available with the 4096-word MOS random-access memory on the processor board. Included are a non-volatile 4096-word core memory, a 1024-word static RAM, a 4096-word dynamic RAM which can be automatically refreshed by central processor microcode, and read-only memory (PROM/ROM) with capacity to a maximum of 4096 words in 512-word increments (2048 words in 256-word increments).

16-Bit Word (Two 8-Bit Bytes)

Direct addressing of 32K 16-bit words

Word or Byte Processing

Very efficient handling of 8-bit characters without the need to rotate, swap, or mask

Asynchronous Operation

System components run at their highest possible speed; replacement with faster devices means faster operations without other hardware or software changes

Stack Processing

Hardware sequential memory manipulation makes it easy to handle structured data, subroutines, and interrupts

Direct Memory Access (DMA)

Inherent in the architecture is direct memory access for multiple devices

8 General-Purpose Registers

For accumulators or address generation

Priority-Structured I/O System

Daisy-chained grant signals provide a priority-structured I/O system

Vectored Interrupts

Fast interrupt response without device polling

Single and Double Operand Instructions

Powerful and convenient set of programming instructions

Power Fail/Auto Restart

Whenever DC power sequencing signals indicate an impending AC power loss, microcoded power fail sequence is initiated. When power is restored, the processor can automatically return to the run state. Four options are available for power-up sequencing.

7.4 SUBSYSTEM OPERATION

The subparagraphs of this section describe in a general manner the various modes of operation of the four subsystems that comprise the STES. All control functions are incorporated into a software operating hierarchy that permits a multi-moded operation as the STES cycles through start-up/run/shut-down with the constant need to assess and modify as needed subsystem modes in response to the presence of a typical operating conditions.

7.4.1 CFS CONTROL

The CFS micros perform two types of control simultaneously and interactively: solar tracking and temperature control. Preliminary logic flow diagrams for these functions are shown in Figures 7.4.1-1 and 7.4.1-2.

The tracking control is based on time of day and inputs from the autotracker. Coarse tracking control, typically ±2°, is derived from time of day. When outputs from the solar autotracker are available, these are used to refine tracking commands to ±0.125. Therefore, the collectors track the sun to within $\pm 1/8^{\circ}$ when the sun is shining, but during temporary obscurations due to cloud passage, the collector tracking will continue under computer control. The system will automatically provide for collector stowage at the end of the day or in the case of rain and will reset each morning. Manual intervention will permit stowage for maintenance or in the case of excessive winds.

Syltherm 800 temperature in the collector field is controlled on a branch line basis with appropriate logic to maximize the temperature from each branch while also protecting each collector from overtemperature. This is performed by controlling the field circulation pump for approximate temperature control based on isolation conditions with finer adjustment provided by proportional branch control valves. The temperature control interacts with the tracking control by allowing rapid emergency defocus of the collectors in the event of overtemperature.

7.4.2 TES CONTROL

The TES control logic, depicted in Figure 7.4.2-1 consists of first identifying the state of charge or discharge of each of the four storage tanks. Discrete valves in the supply and return lines of each tank can be set to permit each tank to discharge if it is identified to be in a charged state or to be charged if it is identified to be in a discharged state. Thus, each tank is prepared to accept energy from the field should it be available and to deliver energy to the steam generator on demand.

Note that since the trickle tank concept being employed is rather innovative, considerable monitoring must be performed to verify proper operation. This is accomplished by a large number of thermocouples imbedded in the tanks.

7.4.3 PCS CONTROL

As shown in the turbine-generator operation logic, Figure 7.4.3-1, the control of the electrical output of the turbine-generator, i.e., speed (frequency) and voltage control, is obtained from analog devices which are an integral part of the turbine-generator set. These computer systems requirements therefore reduce to executing the typical startup/shutdown sequences shown in Figure 7.4.3-1 and the PCS steam generator control.

This control consists of monitoring the steam demand from the turbine and process steam system. Flow of Syltherm 800 into the steam generator is regulated to maintain output steam temperature, and flow of water into the boiler is regulated to control output steam pressure. The Syltherm 800 input temperature is monitored and the fossil fuel heater is controlled to supply supplementary energy when required. If loss of electrical load occurs during parallel operation with GPC, the control subsystem will effect automatic bypass of the steam supply to the turbine generator with the steam going to the process lines in the Bleyle Plant and/or to the condenser to supply the TUS.

7.4.4 TUS CONTROL

The primary function of the TUS control, Figure 7.4.4-1, is to maintain water flow and temperature to the steam condenser for proper condenser pressure. The control system then sets the valve configuration for the AAC, space heater, cooling tower, and storage tank to meet factory demands for air conditioning or heating and to store excess energy while maintaining a suitable condenser input water temperature. The micro assigned to control the TUS will also interface with the existing Doric Digitrend 220 Data Logger as a tool to quantify plant energy profiles for archiving.

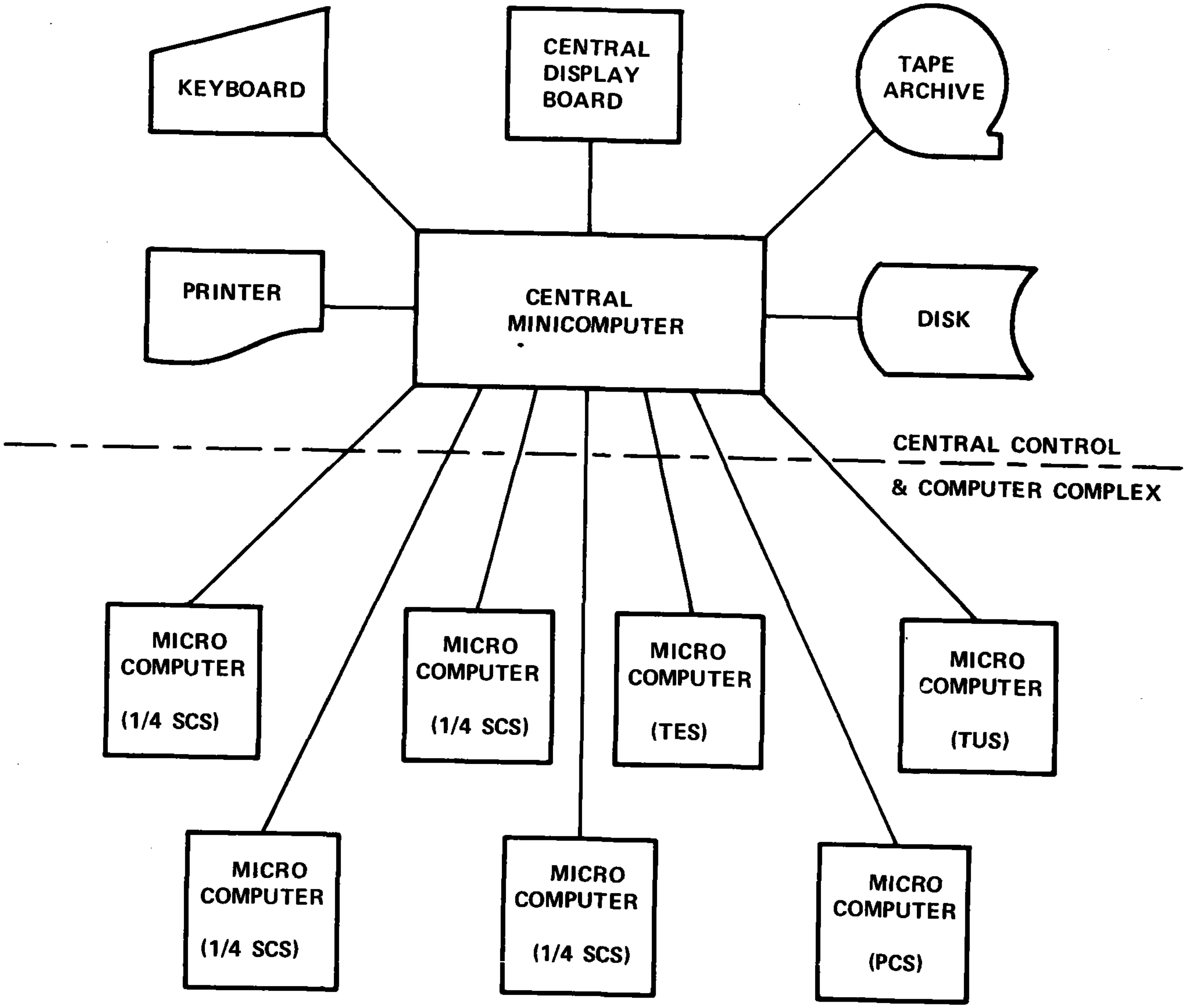


Figure 7.3.1-1. Computer Architecture

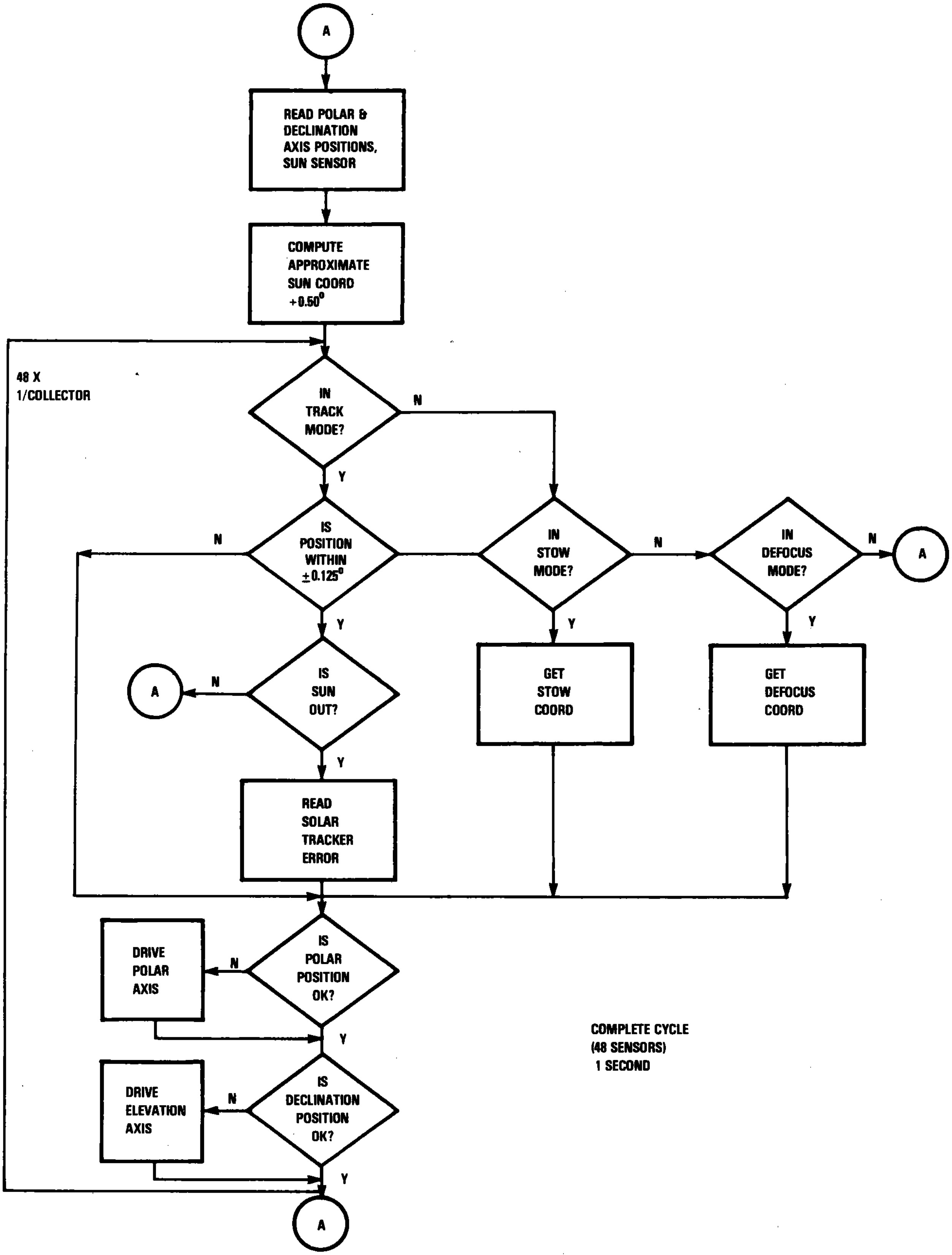


Figure 7.4.1-1. Tracking Logic Normal Operation

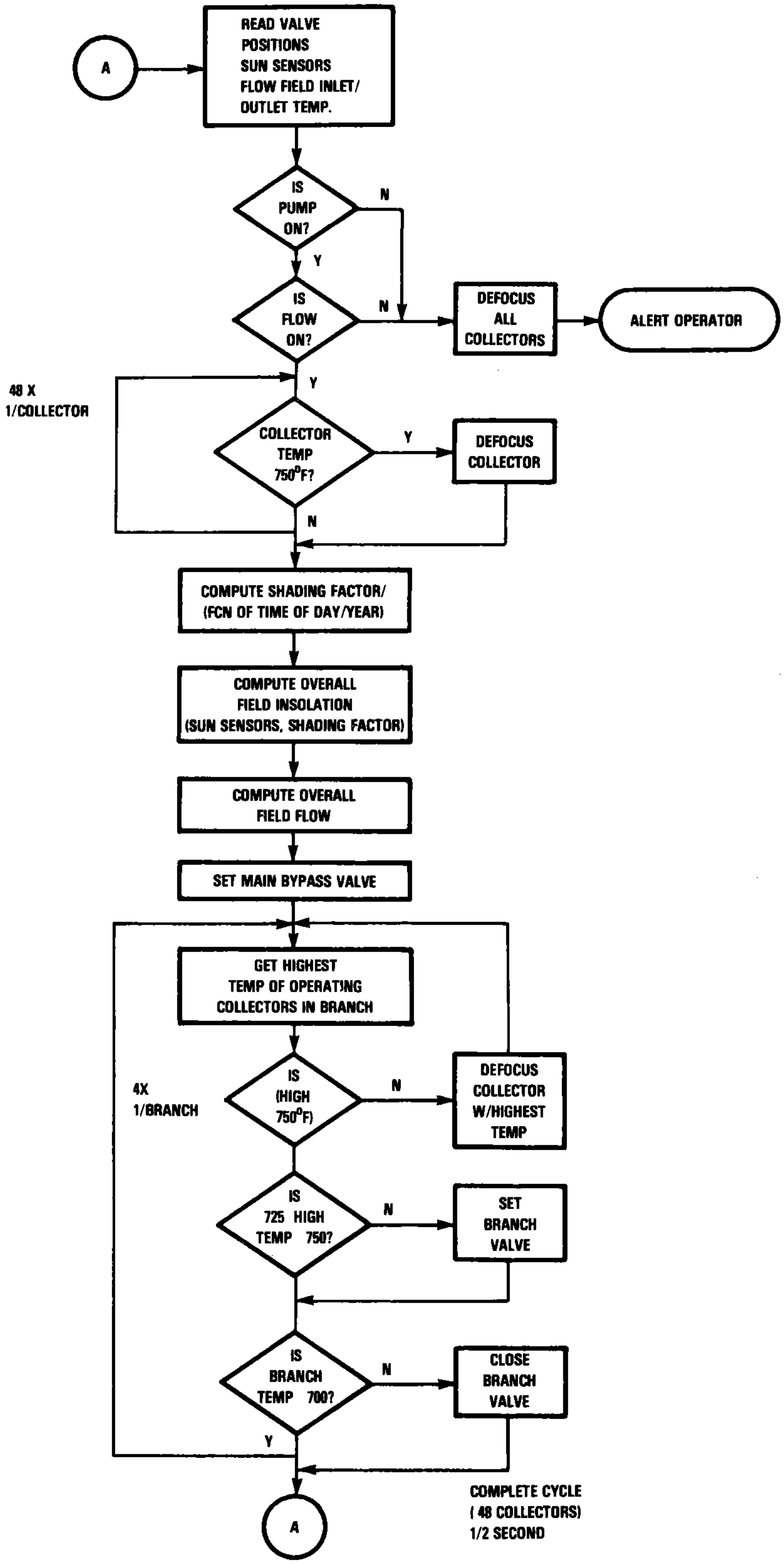


Figure 7.4.1-2. Collector Field Flow Control Logic
Normal Operation

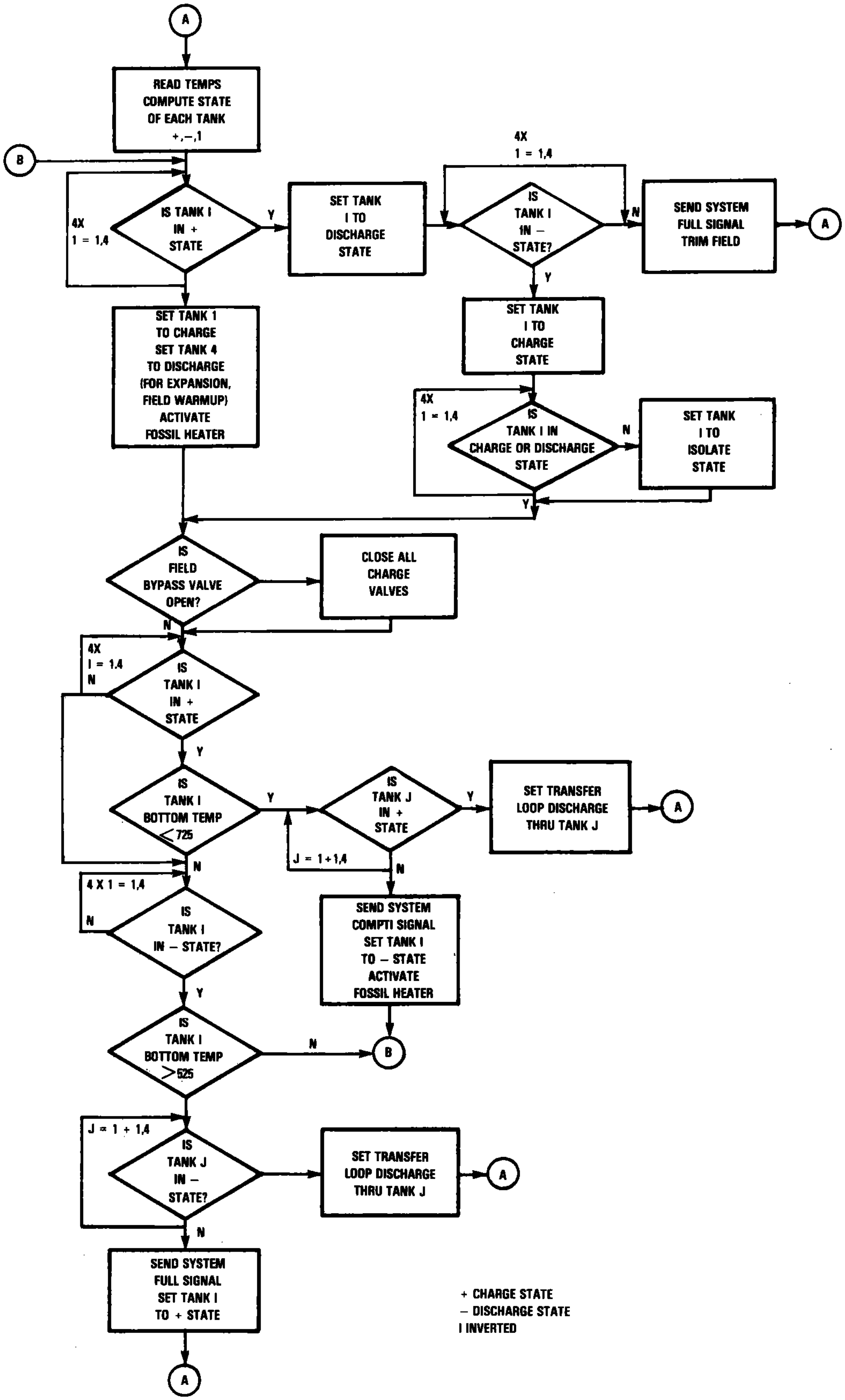


Figure 7.4.2-1. Thermal Energy Storage Subsystem Normal Operation

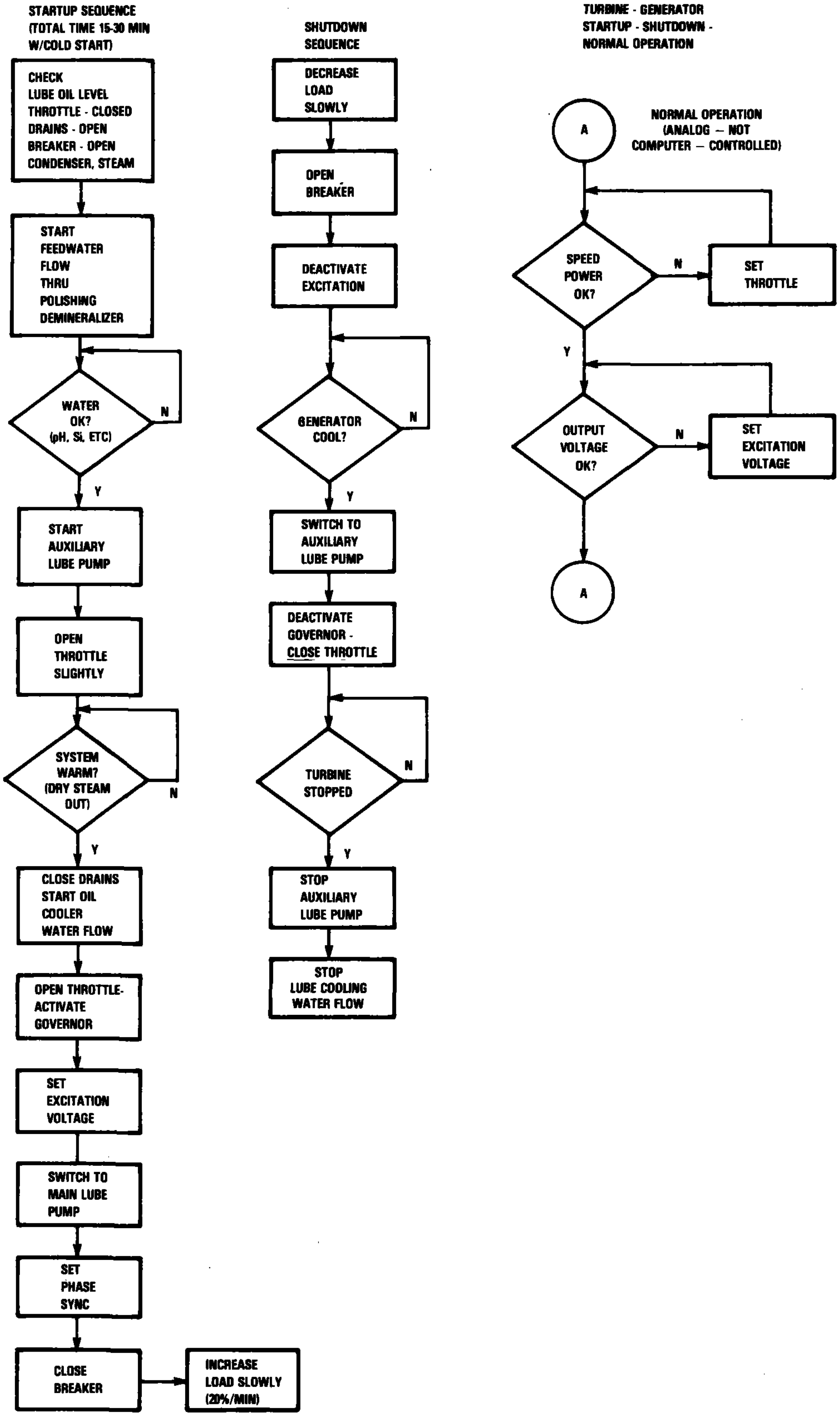


Figure 7.4.3-1. Turbine-Generator Startup-Shutdown-Normal Operation

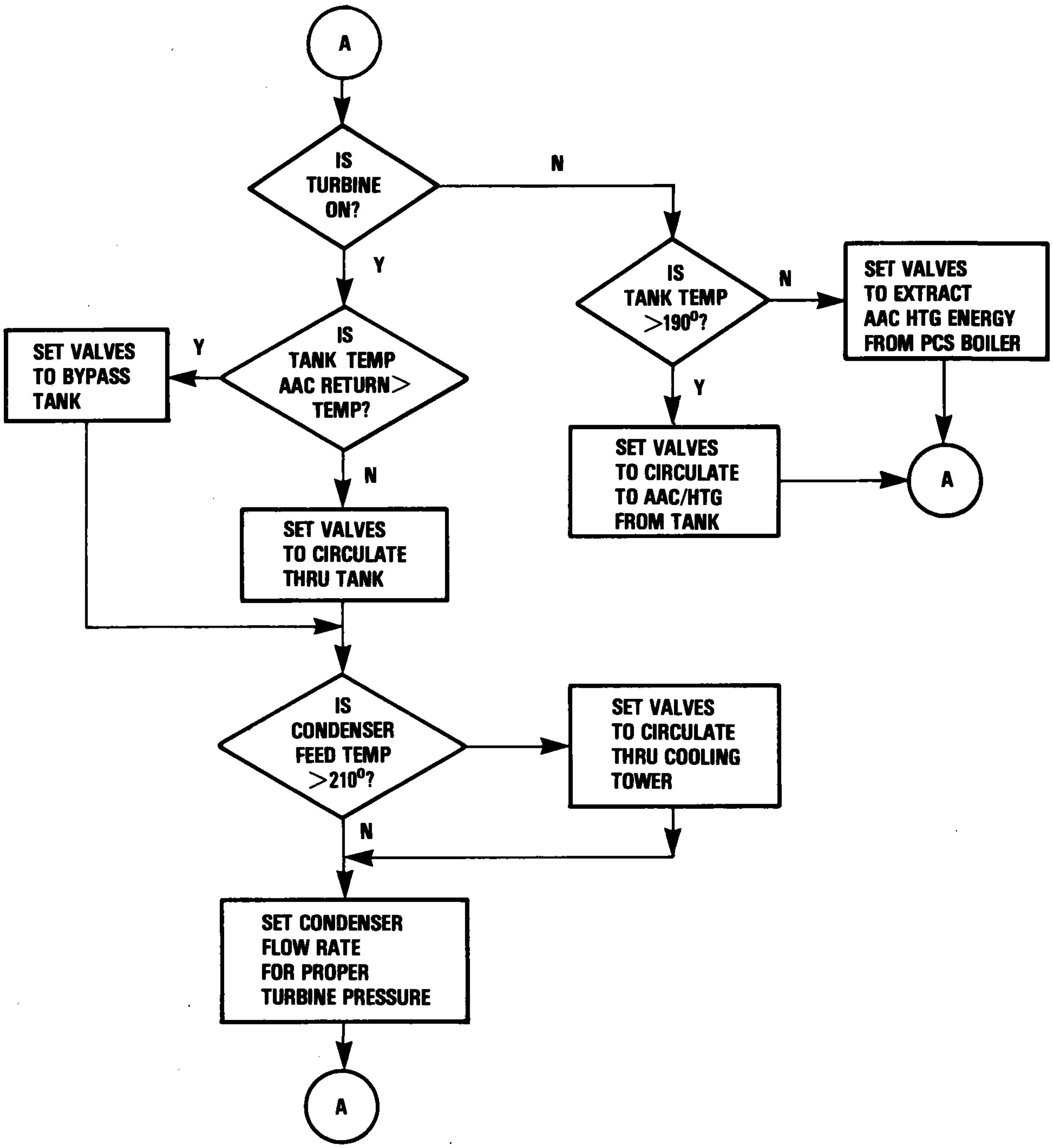


Figure 7.4.4-1. Thermal Utilization System Logic

SECTION 8

SECTION 8

ELECTRICAL SUBSYSTEM (ES)

8.1 SCOPE

8.1.1 FUNCTION

The Electrical Subsystem provides for the distribution of the electrical power from the PCS generator to the components of the STES and to the parallel electrical connection with the Georgia Power Company and the Bleyle Plant. The ES also provides the backup power supply for collector defocus in the event of loss of normal electrical power. In addition, the ES contains a grounding system to prevent damage to the collector field in the event of lightning strikes.

8.1.2 SUBSYSTEM CONFIGURATION

The Electrical Subsystem is shown in Figure 8.1.2-1. The ES interfaces with all subsystems in the STES since it supplies electrical power to all electrical components and control devices. The primary ES boundary connection with the Georgia Power Company occurs at the air circuit breaker which connects the two systems in parallel. The turbine driven generator serves as the link between the ES and the PCS.

8.2 DESIGN CRITERIA

8.2.1 UTILITY REQUIREMENTS

The Georgia Power Company requires that the STES electrical system, which connects to both their system and to the Bleyle plant, not interfere with the operation of either GPC or the Bleyle Plant nor cause degradation or interruption of service. Specifically,

a) The existence and/or operation of the STES shall not cause an interruption in the GPC system

b) The existence and/or operation of the STES shall not cause any degradation of electrical service to the Bleyle Plant

c) The STES electrical output will operate in parallel with the GPC 480 Y277 volt bus supplying Bleyle in order to enhance voltage and frequency regulation

d) For STES operation alone to serve the Bleyle plant, power quality requirements are:

   1) Voltage regulation
      480 volts ±5%, normal operation
      480 volts ±7%, with ±10% load transient

2) Frequency regulation (any conditions)
   60 hertz ± 0.5%
   (±0.3 hertz)

3) Voltage Waveform Distortion
   5% maximum

4) Net output at Bleyle Bus
   300 kilowatts, 0.8 power factor

8.2.2 STES SYSTEM REQUIREMENTS

a) Supply STES parasitic electrical loads of approximately 100 kilowatts, 0.8pf

b) Provide supervisory control capability of electrical system

c) Provide transducers for monitoring and recording of electrical parameters

d) Provide a backup power source for critical systems and controls to allow for safe shutdown in the event of primary power failure.

e) Interconnect power and instrumentation devices

f) Provide safety and lightning grounding means

g) Design for a lightning strike of
   1) 100,000 amperes peak
   2) 1.0 microsecond rise time
   3) 100 coulomb charge transfer in 0.3 seconds

8.2.3 INTERFACE REQUIREMENTS

a) The STES 480Y277 volt system will connect to the GPC-Bleyle substation by underground cable. A disconnect device will be provided by GPC.

b) An emergency 480Y277 volt connection will be provided by GPC for STES startup and temporary operation if the GPC-Bleyle bus is not energized.

c) Control and instrumentation circuits between GPC and the STES system shall consist of:

   1) Instrument transformer secondary circuits from 3 current and 3 potential transformers

   2) Trip and close circuit contacts for circuit breakers transfer trip and control

   3) GPC power transducer circuit for load following control of turbine

d) Control and instrumentation circuits to the PCS and GFE turbine generator are as follows:

   1) Power transducer interface to set turbine electrical power demand

   2) Mode select for parallel or stand alone operation

   3) Start-up and shutdown sequencing including emergencies

   4) Instrumentation list for control, evaluation, and monitoring

e) Control and instrumentation circuits to the SCS shall be as listed in Section 4.

f) Auxiliary power circuits shall be circuit breaker or fusible disconnect protected and switchable.

g) Circuits subject to lightning interference or contact between instrumentation and power circuits shall be provided with surge arrestors.

h) STES service power at 480/277/208/120 volts, 60 hertz will be provided from the STES auxiliary power distribution system which is paralleled to the GPC-Bleyle bus with an emergency connection available as described in b) above.

8.2.4 MAINTENANCE AND RELIABILITY

8.2.4.1 Availability

a) Auxiliary power is subject to the GPC system availability with an estimated forced outage rate of (TBD) hours per year.

b) STES electrical output availability is determined by the PCS subsystem discussed in Section 5.2.4

c) Standard electrical equipment will be utilized to maximize STES power distribution system availability

8.2.4.2 Routine Maintenance

a) Inspect and clean external ventilation openings on enclosed switchgear and electrical apparatus.

b) Tap meter faces and observe indicating meter readings.

8.2.4.3 Periodic Maintenance and Inspection

a) Check calibration of protective relaying utilizing external test circuit devices at (TBD) intervals.

b) Check operation and lubricate operating mechanism of circuit breakers every 500 operations or 12 months per manufacturers instructions.

c) Check and tighten terminal board connections and megger test (high voltage insulation resistance test) wire insulation after 12 months.

d) Every 5000 operations, perform manufacturers recommended major maintenance on circuit breakers.

8.2.4.4 Accessibility

Adequate space for door opening and circuit breaker drawout and transport shall be provided. All accessible electrical equipment shall be suitably interlocked with the power circuits to prevent contact with energized parts during maintenance operations.

8.2.5 TESTING

8.2.5.1 Preoperational Tests

a) Megger all circuits at 500 volts for insulation resistance greater than 100 megohms. Disconnect or isolate sensitive electronics before meggering.

b) Megger generator and transformer insulation per the manufacturers recommendations.

c) Operate circuit breakers in test position to check functional control circuit and mechanism performance.

d) Check phase sequence of main, auxiliary, and emergency circuits.

e) Check emergency power system batteries for full charge state and for correct operation of charging circuit.

8.2.5.2 Acceptance Testing

No special tests are planned for electrical subsystem acceptance. Exercise of the CIS, TUS, PCS, and SCS subsystems will demonstrate acceptable Electrical Subsystem operation.

8.3 DESIGN DESCRIPTION

8.3.1 DETAILED SUBSYSTEM DESCRIPTION

The Electrical Subsystem (ES) shown in Figure 8.1.2-1 consists of the electrical portions of the STES from the PCS generator through the protective relaying, transformer, and circuit breaker switchgear assemblies to the parallel electrical connection with the GPC-Bleyle 480/277 volt bus. Within the Mechanical Building, the ES also includes the auxiliary power distribution to the CIS and portions of the SCS, such as motor starter circuits.

Collector field SCS power distribution consists of 208/120 volt service through panelboard circuit breakers located in the two field control enclosures which house the CIS micro-computers utilized for SCS control. Each half branch of five to six collectors has a circuit breaker, and each collector has an individually fused power circuit for maximum SCS availability. The collector field will have a ground grid installation consisting of driven rods and bonded cable.

The backup DC power supply for collector defocus consists of low maintenance batteries at each collector kept under float charge and controlled to drive an SCS motor at high rate. The system is shown in Figure 8.3.1-1.

Sensor and control cable to each collector and the field control valves will consist of multi-conductor shielded cable terminating at the field control boxes as shown in Figure 8.3.1-2.

8.3.2 SUBSYSTEM PERFORMANCE CHARACTERISTICS

Performance characteristics of the ES are tabulated in the major components sections beginning at 8.3.3.

8.3.3 MAJOR COMPONENTS

8.3.3.1 Generator and Exciter

A turbine driven generator with shaft mounted, brushless exciter is provided to generate the electrical portion of the total energy output of the STES. The generator has the following characteristics for specification purposes.

Rating	500	KVA
Power Factor	0.8	
Speed	1800	RPM
Connection	WYE	4 Leads Out
Distortion	5	Percent, Maximum
Voltage	480	Volts, Line to Line, 3 Phase
Overspeed	25	Percent, Standard
Frame	OPEN	Dripproof
Exciter	2.5	Per Unit, Forcing Capability
Shaft	Keyed	Standard extension

Additionally, an oversized connection box will be supplied to house lightning arrestors, surge capacitors, and current transformers. The windings and bearings will have RTD detectors for operational and experimental temperature measurement.

8.3.3.2 Transformer

An isolation transformer will be connected in DELTA-WYE at the generator output to prevent harmonics from reaching the Bleyle Plant or Georgia Power systems. The transformer KVA rating will be the same or slightly more than that of the generator. An air insulated unit enclosed in the same metal-clad enclosure as the circuit breakers will be utilized to avoid any fire risk which could arise from the use of an oil insulated construction. The WYE connected Bleyle side will have a solidly grounded neutral with a current transformer on the neutral to detect ground fault currents.

8.3.3.3 Paralleling Circuit Breaker

An air circuit breaker will be used to connect the STES electrical system in parallel with the Georgia Power system to supply the Bleyle Plant load. The circuit breaker ratings will be:

Voltage	480	Volts, L-L, 3 Phase
Current	600	Amperes, continuous
Short Circuit	(TBD)	MVA, symmetrical
Operations	5000	Minimum, before major maintenance
Control	125	Volts DC, close and trip circuits
Construction	Drawout	NEMA 12 enclosure

Closing control of the paralleling circuit breaker will be by manual or automatic synchronizing. Tripping control will be manual, automatic, or normal shutdown and through generator or bus lockout relays in cases of protective relay operation. A cable connection serves Bleyle by paralleling with GPC at their substation through this circuit breaker.

8.3.3.4 Auxiliary Circuit Breaker

An air circuit breaker will be used to connect and provide short circuit protection to the STES station service loads. This auxiliary circuit breaker will have the same ratings as the paralleling circuit breaker and be mounted in the same enclosure structure with it and the transformer.

8.3.3.5 Protective Relaying

The STES output electrical system is protected from faults and some forms of equipment malfunction by a group of utility type relays. These devices operate from voltage and current signals through instrument transformers on the main 480 volt circuit. The instrument transformers will be installed in the enclosure housing the isolation transformer and circuit breakers, and the relays will be mounted in a separate, but similar and adjacent, NEMA 12 switchboard.

The relaying utilized operates as follows. Interface drawing E-3, Figure 8.3.3-1, has the connection points and model number of the devices

ANSI Number	Function
27/59	Detect whether paralleling bus voltage is excessively low or high as indicative of a voltage regulator malfunction and open paralleling breaker.
32	Detect power flow towards generator or motoring as indicative of a problem with the turbine control and open breakers plus shutdown turbine.
46	Detect phase unbalance as indicative of excessive unbalanced load or loss of a phase and open breakers plus shutdown turbine.
51V	Detect phase overcurrent as indicative of a line to line fault with greater sensitivity to close voltage reducing faults and open breakers plus shutdown turbine.
86G/86B1	Lockout relays to require manual intervention after protective relay operation.
81	Detect low bus frequency as indicative of islanded system or loss of turbine control and initiate system shutdown.
87	Detect differential current across generator, transformer, and main breaker indicative of ground or phase fault and initiate system shutdown.
151G	Backup ground fault detection in case of main breaker failure. Retrips main breaker and GPC tie breaker.
159	Detect generator terminal overvoltage indicative of voltage regulator malfunction prior to synchronization plus backup on 59. Causes system shutdown on operation.
250/250G	Detect generator ground fault by level of neutral to ground current and cause system shutdown.

ANSI Number	Function
351G	Detect bus ground fault on Bleyle side of isolation transformer by level of neutral current and cause system shutdown. Backup 451G.
451	Detect phase overcurrent on the STES 480 volt system and cause system shutdown.
451G	Detect ground faults on bus or badly unbalanced load and cause system shutdown.

In addition to these relays, the GPC electrical system has a suitable complement of protective devices that are not part of the STES.

8.3.3.6 Auxiliary Power Distribution

A motor control center consisting of a factory assembled NEMA 12 enclosure with plug-in type combination motor starters and feeder circuit breakers will be utilized to distribute and control 480 volt auxiliary loads. Motors of greater than 746 watts (1.0 horsepower) rating will be run at 3 phase 480 volts, and motors of 746 watts (1.0 horsepower) or less or equivalent loads will be powered at 120 volts, single phase through a step down transducer to 208/120 volts.

At least two stepdown transformers will be required: one for Mechanical Building loads and a second, 75 KVA size for collector field supply to control boxes, convenience outlets, and collector drives. Air insulated units in stand alone enclosures or core and coil units mounted inside a throat connected compartment next to the motor control center will be used.

In the collector field, the three phase circuit will connect to panelboards at the two field control boxes. Heating and cooling requirements of the electronics in these boxes and the electronics themselves will be fed 120V, 60 hertz power through separate small circuit breakers on the panelboard. Each half branch of collectors will also be single phase circuit breaker protected in order to trip only a small section of the field for electrical shorts anywhere in the system.

From the panelboards, single phase 120 volt circuits will be laid in below-grade wireway and elevated conduit to the collectors. Convenience outlets will be provided at the collector control boxes for the use of maintenance personnel. Separate fused protection for the collector control and for the outlets is provided. Collector field area lighting will be supplied by a circuit separate from the main field circuit but running in the same wireways.

8.3.3.7 Backup Power Source

The preliminary requirement for the backup power source is safe shutdown of the STES system. Rapid defocus of individual collectors, or possibly the entire field in the event of an AC power outage, requires a short time, instant response capability of about 300 KVA with 1119 watts (1.5 horsepower equal to approximately 1.5 KVA) per collector ignoring inrush requirements. Remote reset of the defocus circuit is required, thereby eliminating a hydraulic dump, manually set system as utilized on the Engineering Prototype Collector.

A central, second AC or DC source was eliminated from consideration due to cost potential for single point failure, response time, and wiring sizes required to handle the simultaneous defocus of the entire field. Individual collector 12 volt batteries are provided to power the automotive type DC defocus motor drive of the collectors.

The batteries of low maintenance, lead-calcium plate, automotive construction will be float charged and power the motor through a deadman switch arrangement that requires both AC power and control circuit energization to remain open. Commanded defocus at four degrees per second of collector motion operates by control circuit de-energization. Loss of AC power has the same effect as commanded defocus but occurs automatically. After approximately five seconds or ten degrees of collector motion, the battery-motor circuit will be opened to prevent thermal damage to the motor or excessive battery discharge in the event of a sustained AC outage. Battery charging will be performed by individual collector circuits with current limited to one ampere. Battery and defocus system condition will be checked by periodic (off-operation) exercise of the defocus system manually with battery voltage drop observed with load. This check will provide the least complicated, best check of battery condition in addition to providing a beneficial low duty discharge cycle.

It might seem attractive to utilize the rapid drive capabilities of the defocus system for rapid acquisition during startup; however, consideration of DC motor produced electromagnetic interference (EMI) and increased parasitic power demand make this potential option undesirable. The basic defocus-only mode permits the local collector control circuits to blockout during defocus and to have an inexpensive low EMI tolerant configuration. Additional cost of shielding and enclosure penetration filtering may be required if the DC motor is used for active control.

As the battery powered DC motor is relatively inefficient, the AC system parasitic energy required to recharge the battery is over four times that needed for direct AC motor operation over the same distance at the same torque level. A five second operation of all DC motors will require about 5 KVA for three hours to restore battery charge which is beyond the budgeted parasitic power for that time interval.

8.3.3.8 Field Control and Signal Wiring

Each collector will be connected to its field control box by a multi-conductor, shielded pair cable and thermocouple leads. The branch flow control valves will have a similar cable connection with fewer pairs. Industrial plug connectors will be used on both ends of each control cable. Cable routing is in the same wireway as, but separated from, the power cables.

The high speed serial data interface connection between the field control boxes and the main control minicomputer will utilize triaxial cable. All electronic connections will require transient protection from induced surges due to nearby lightning ground strokes.

8.3.3.9 Grounding and Lightning Protection

Grounding rods and interconnection to establish a field earth-to-ground resistance of less than five ohms will be provided to conduct any field lightning strikes to earth in a controlled manner. Braid jumpers across bearings will be provided for static discharge and antiweld protection.

One-kV surge arrestors will be applied on the 480 volt power circuits to limit conducted surges due to nearby power line lightning strikes to levels within the base insulation level (BIL) rating of the equipment. Power supply inputs for control circuits will have series shunt protection.

Based on a risk and cost comparison, a shield system for the collector field is not utilized. Collector damage due to a direct strike is accepted or repairable for less cost than a shield. If experience at Shenandoah proves otherwise, a static wire and pole shield can be added and connected to the ground grid.

On an experimental-only basis, a dissipator lightning protective system could be tested. The cost of purported protection is less than a static wire system, but review of performance on field installations is mixed between whether or not the dissipators work as claimed. No shielding is still the basic field design.

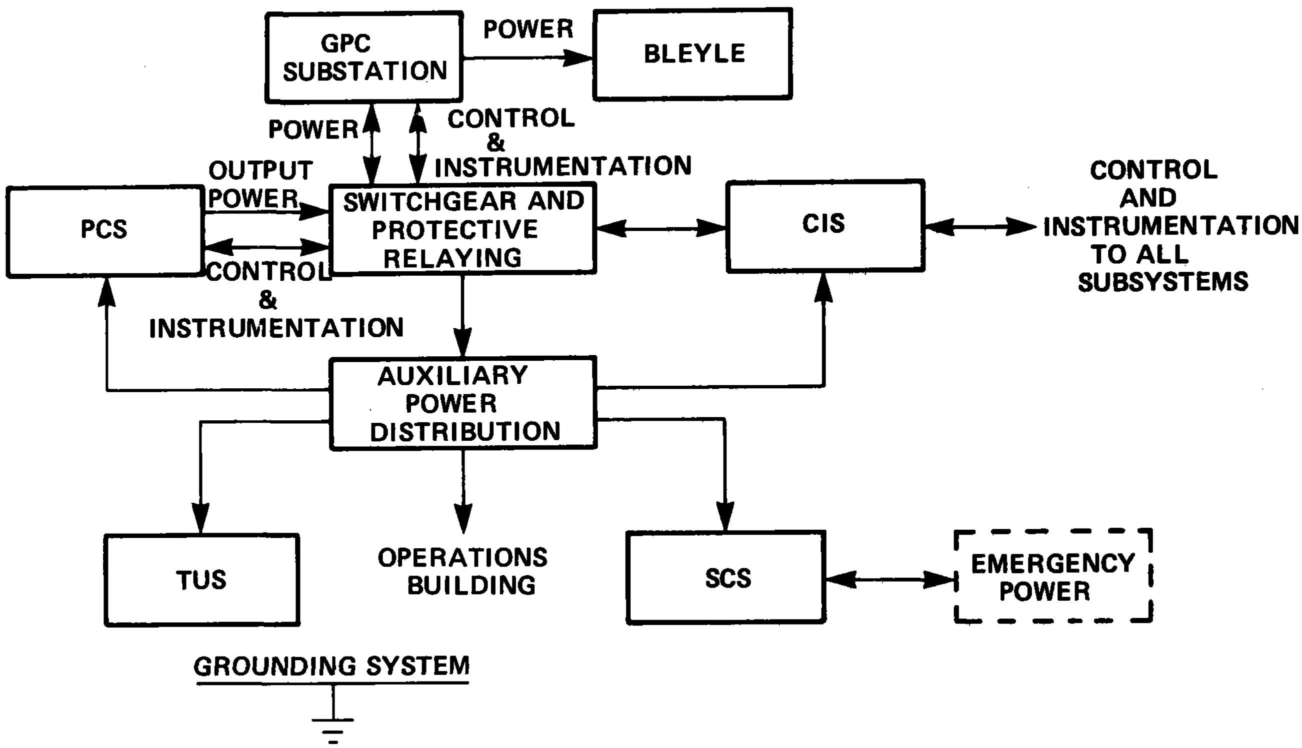


Figure 8.1.2-1. Electrical Subsystem

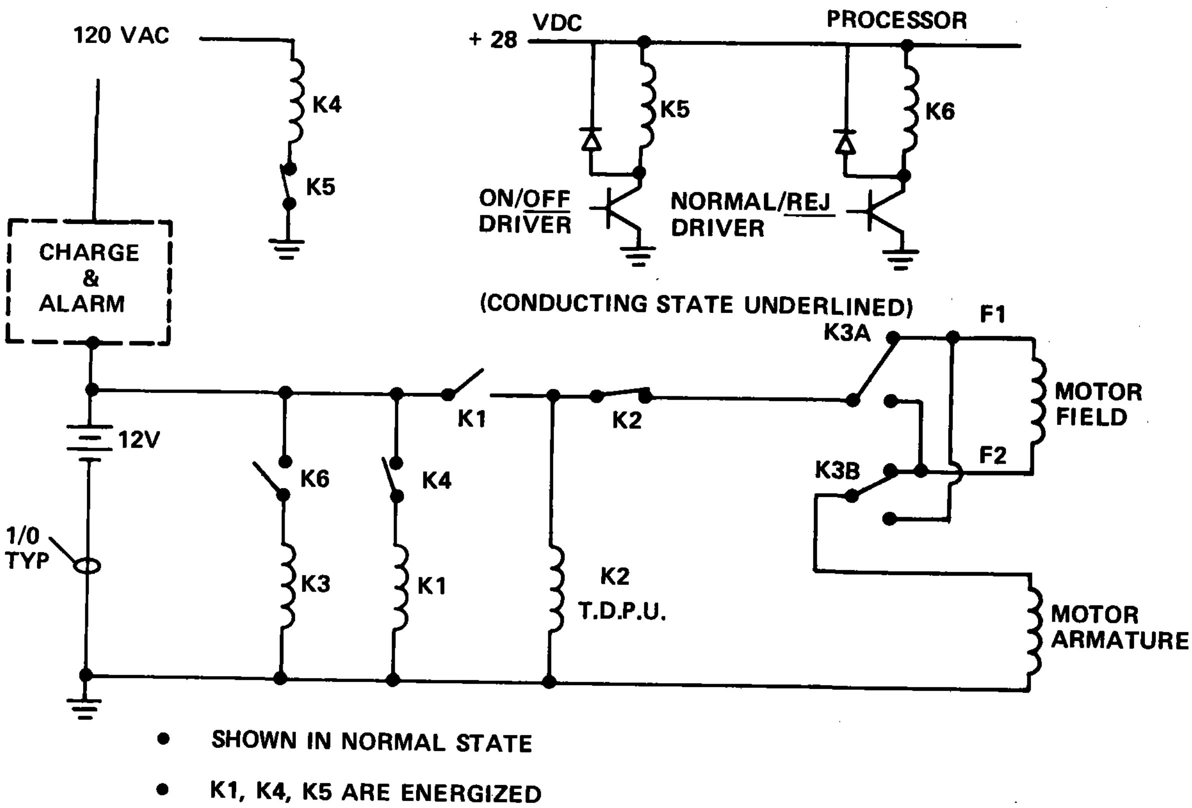


Figure 8.3.1-1. Defocus Circuit

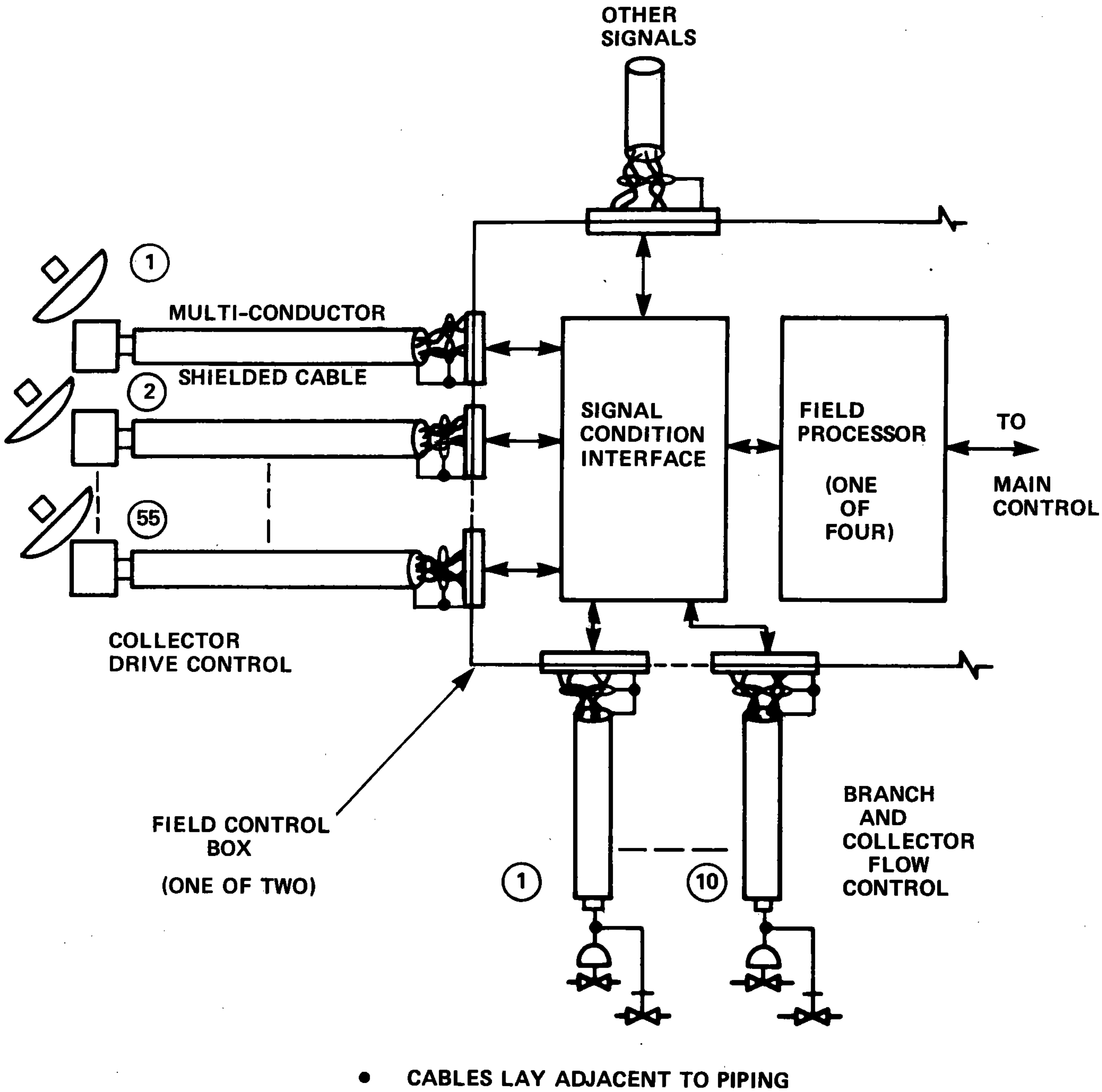
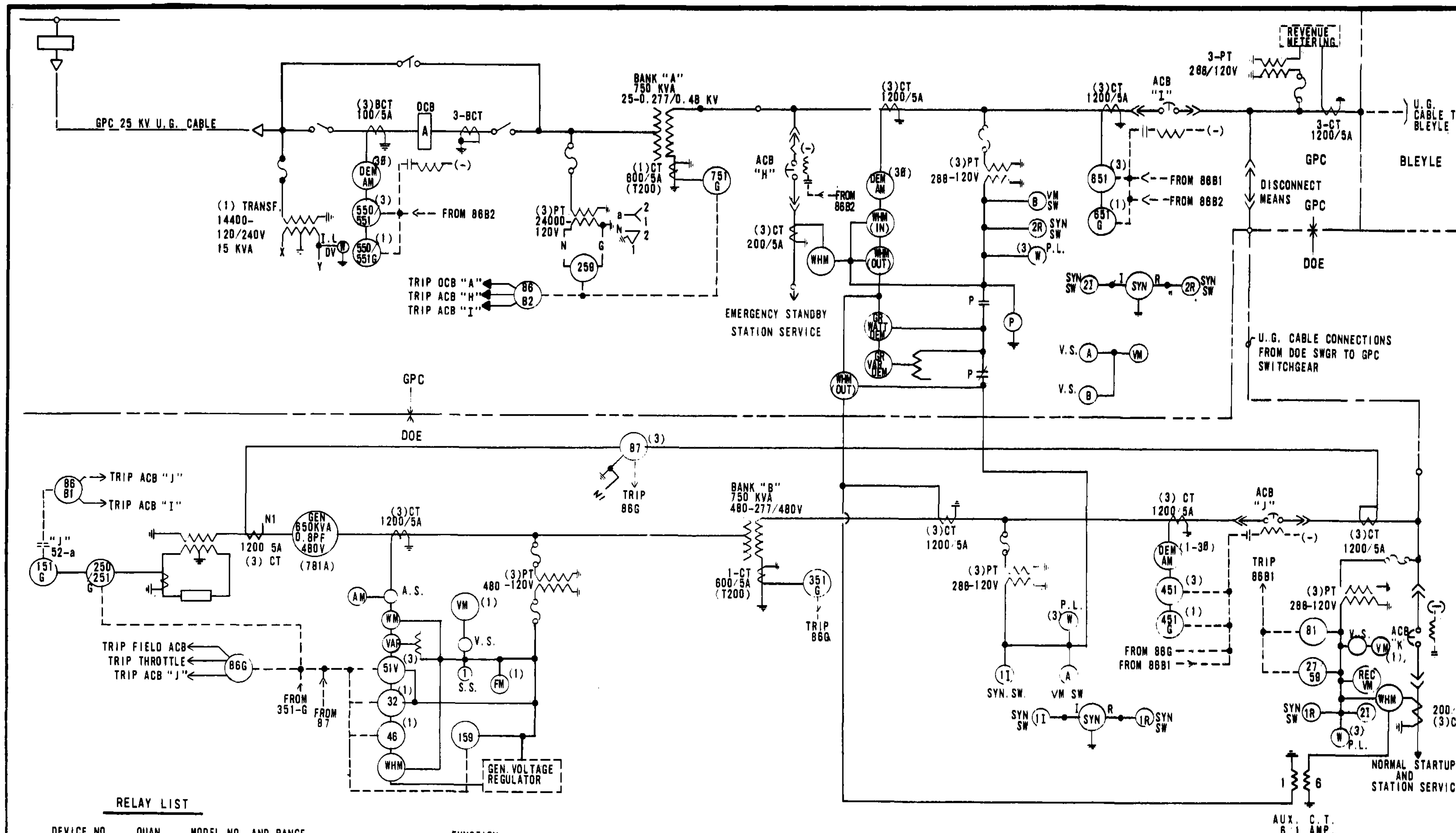


Figure 8.3.1-2. Field Sensor and Control Cable



RELAY LIST

DEVICE NO.	QUAN.	MODEL NO. AND RANGE	FUNCTION
550/551	3	WHSE CAT #CO-9H1111N(1-12T)(6-144I)	H.S. BUOC BANK A
550/551-G	1	WHSE CAT #CO-9H1111N(1-12T)(6-144I)	H.S. BU GND BANK A
259	1	GE MOD #12IAV51D1A(16-64V)	H.S. OV RELAY
751-G	1	WHSE CAT #CO-9H1101N(1-12T)	L.S. BU GND BANK A
651	3	WHSE CAT #CO-9H1101N(1-12T)	PHASE O.C. -ACB "I"
651-G	1	WHSE CAT #CO-9H1101N(1-12T)	GND O.C. -ACB "I"
86B2	1	GE MOD #12HEA61B236(6-NO.4-NC)	AUX. LOCKOUT RELAY
27/59	1	GE MOD #12IAV69A1A(55-140V)	UNDER- & OVER-VOLTAGE
32	1	GE MOD #12GGP53B1A(0.025-3A)(1.5-30 SEC)	ANTI-MOTORING RELAY
46	1	GE MOD #12INC77B3A(WITH ALARM UNIT)	NEG. SEQUENCE RELAY
51V	3	GE MOD #12IJCV51A18A(2-8T)	VOLT RESTR PHASE O.C.
86B1	1	GE MOD #12HEA61B236(6-NO,4-NC)	AUX. LOCKOUT RELAY
86G	1	GE MOD #12HEA61B236(6-NO.4-NC)	AUX. LOCKOUT RELAY
87	3	WHSE STY #HU- #290B346A21(HU-2 REST.)	UNIT DIFFERENTIAL
81	1	GE MOD #12SFF21A1A(4-80 CY)	UNDERFREQUENCY
151-G	1	WHSE CAT #CO-9L1101N(0.5-2.5T)	GEN GND -B.F. "J"
159	1	GE MOD #12IAV51A1A(55-140V)	GEN OVERVOLTAGE
250/251-G	1	WHSE CAT #CO-9L1111N(0.5-2.5T)(2-48)	GEN. GROUND
351-G	1	WHSE CAT #CO-9H1101N(1-12T)	L.S. B.U. GND-BANK B
451	3	WHSE CAT #CO-9H1101N(1-12T)	PHASE O.C.-ACB "J"
451-G	1	WHSE CAT #CO-9H1101N(1-12T)	GND O.C.-ACB "J"

SINGLE LINE ELECTRICAL LOAD INTERCONNECTION

NOTES:

1) ALL CURRENT TRANSFORMERS USED FOR RELAYING SHALL BE RATED "C" OR T200 OR BETTER.

2) STES GENERATOR AND TRANSFORMER SIZES MAY BE CHANGED SUBJECT TO GPC REQUIREMENTS. DETAILED ON DRAWING E-4.

BLEYLE MANUFACTURING PLANT, SHENANDOAH, GEORGIA

STES INTERFACE DEFINITION AND CONTROL DRAWINGS

SINGLE LINE ELECTRICAL LOAD INTERCONNECTION

10/20/77 | 1/25/78 | 2/8/78 | 4/7/78 | 5/1/78

HEERY & HEERY

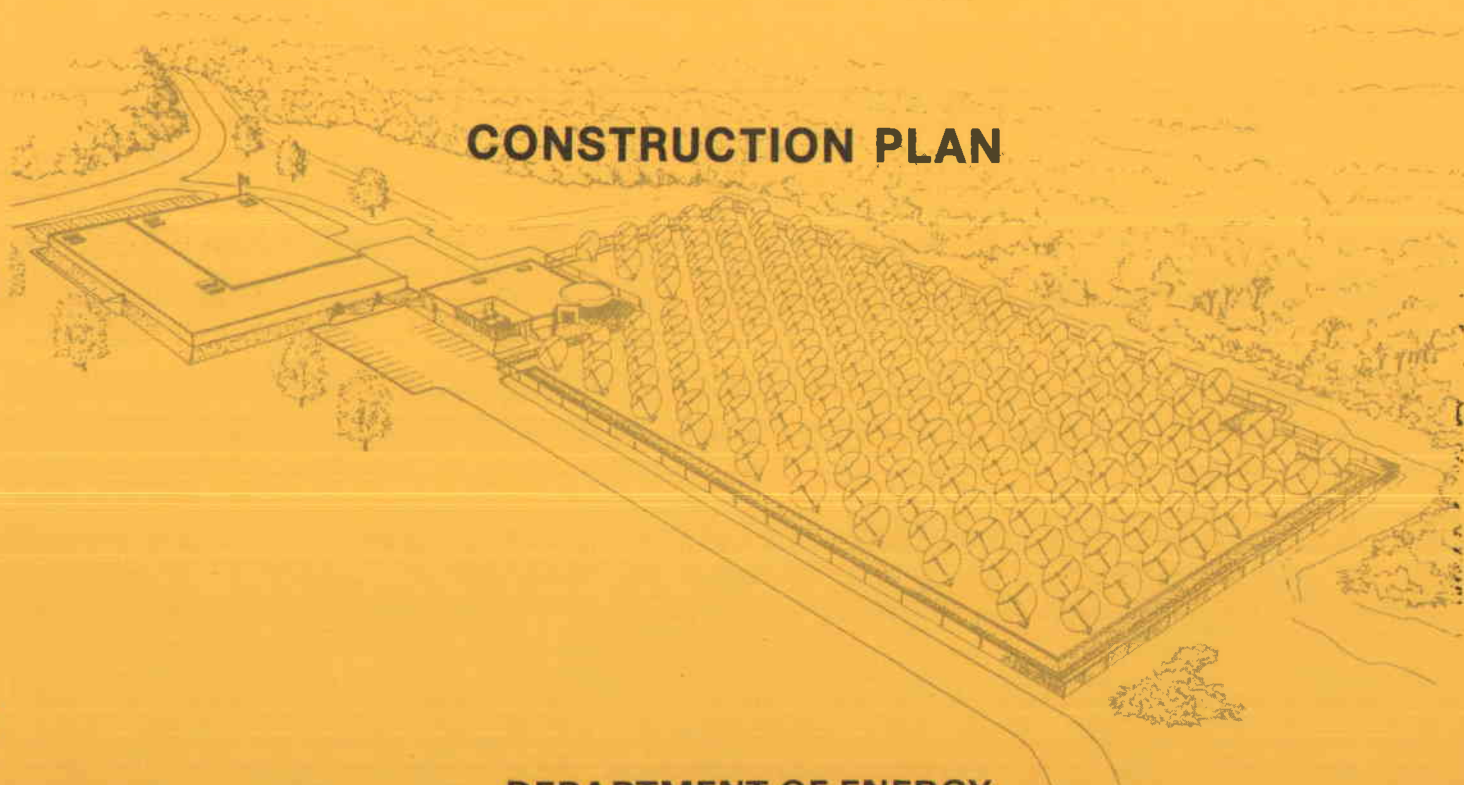
E-3

Figure 8.3.3-1 Single Line Electrical Load Interconnection

DOCUMENT NO. 78SDS4262
DATE: DECEMBER 15, 1978
PRELIMINARY ISSUE

SOLAR TOTAL ENERGY - LARGE SCALE EXPERIMENT AT SHENANDOAH, GEORGIA

CONSTRUCTION PLAN



DEPARTMENT OF ENERGY
CONTRACT NUMBER EG77-C-04-3985

GENERAL ELECTRIC
SPACE DIVISION

GENERAL ELECTRIC

SPACE DIVISION

SPACE SYSTEMS OPERATIONS

GENERAL ELECTRIC COMPANY . . . . VALLEY FORGE SPACE CENTER
KING OF PRUSSIA PARK, P.O. BOX 8661, PHILADELPHIA, PENNA. 19101. . .TEL (215) 962-2000

In Reply Please Refer To
Reference No. 78-STE-0194

December 15, 1978

Mr. R. W. Hunke
Dispersed Power Applications
Division 5722
Sandia Laboratories
Albuquerque, New Mexico 87115

Dear Bob,

Enclosed are three (3) copies, Preliminary Issue of the "Construction Plan", for the STE-LSE at Shenandoah, Georgia, GE Document No. 78SDS4262, dated December 15, 1978. These documents totally replace the draft copies sent to you earlier.

As mutually agreed, the "Construction Plan" will be a working document, which will be continually updated throughout the Construction Phase of the Contract.

If you have any questions concerning any part of this document, please call me.

Sincerely yours,

A. J. Poche, Program Manager
Solar Total Energy-Large Scale Experiment
at Shenandoah, Georgia
Room 7246, Bldg. 7
(215) 962-4934

trm

Bob Hunke

GENERAL ELECTRIC

VALLEY FORGE SPACE CENTER
P.O. BOX 8661
PHILADELPHIA, PA. 19101

SPACE SYSTEMS OPERATIONS

COPIES:

S. Kahn
S. Caltabiano
D. Hemler
C. Romig
M. Bongiovanni

SUBJECT COST USED IN CONSTRUCTION PLAN

TO: A. J. Poche

FROM: T. Duff

December 29, 1978

The costs for material and labor used in the construction plan were the actual dollars as specified in the estimating books, that are defined below:

- Building Cost file, 1978 Eastern Edition (BCF)
- Building Construction Cost data, 1978, 36th Annual Ed. (BCC)
- Current Construction Cost, 1978, 15th Annual Edition (CCC)

The costs as defined in each Manual are based on slightly different base lines and therefore are not directly related to each other, but are very close. The BCF costs are based on Philadelphia wages and materials that were projected as of May 31, 1978. The Manual then gives a geographical ajustment index for various cities in the country, attached is an adjustment index table for Atlanta, Ga. The BCF costs are based on labor and material cost averaged from 30 major U. S. cities that were in effect on January 1, 1978. The Manual then gives a city cost index (Attachment #2) for Atlanta, Ga. The CCC cost data is based on an average of major population areas with prevailing union rates used at the start of 1978, no exact date was given.

The Construction plan did not use any of the adjustment indexes to convert the cost to the Shenandoah area.

Attachments:

(1) 122 City Geographical Adjustment Index
(2) City Cost Index

GE DIAL COMM
8*242-

ATTACHMENT # 1

122-CITY GEOGRAPHICAL ADJUSTMENT INDEX

	ABILENE, TX	ALBANY, NY	ALBUQUERQUE, NM	AMARILLO, TX	ANCHORAGE, AK	ATLANTA, GA	BALTIMORE, MD	BANGOR, ME	BASE, 20-CITIES	BATON ROUGE, LA
COMPOSITE	82.2	96.7	93.2	85.5	132.0	87.0	92.2	90.4	97.1	83.7
SITE WORK/EXCAVATION	74.1	100.7	87.9	79.6	130.8	81.6	94.8	95.1	96.7	83.5
ASPHALT PAVING	82.1	96.8	87.4	85.8	121.0	83.8	95.5	104.7	96.5	81.6
LANDSCAPING	79.6	107.4	91.5	83.5	133.2	77.1	90.6	91.4	99.4	78.6
CONSTRUCTION EQUIPMENT	75.8	99.0	90.6	81.3	124.2	83.7	93.7	101.3	96.4	84.2
CONCRETE PLACEMENT	84.2	108.7	96.2	86.3	136.3	82.7	107.8	107.9	102.6	89.8
FORMWORK	70.2	96.9	86.6	76.6	131.8	76.2	88.2	81.4	94.8	70.7
REBARS	72.5	103.4	91.7	74.8	143.9	83.2	83.7	90.7	94.7	77.7
STRUCTURAL STEEL	85.2	95.8	90.8	88.1	131.3	86.0	90.3	84.1	96.0	78.0
MASONRY	80.1	91.6	85.3	84.5	148.5	79.0	86.3	90.3	96.1	80.2
CARPENTRY	84.7	98.4	95.4	88.1	118.0	79.4	96.1	96.0	96.9	73.2
PRE CAST CONCRETE	90.4	115.6	103.4	93.3	146.3	89.5	97.6	114.0	103.0	83.1
MISC. METAL WORK	93.8	101.1	123.7	94.3	151.9	94.4	98.5	105.5	101.8	92.9
WINDOWS/CURTAIN WALLS	86.8	97.7	135.4	88.4	168.2	92.0	96.2	104.0	101.2	89.8
GLASS AND GLAZING	84.9	107.3	93.1	74.8	150.3	92.3	107.1	72.9	97.6	66.4
ROOFING	55.0	83.2	62.2	50.9	99.0	67.4	73.1	74.4	85.1	68.4
INSULATION	88.2	88.4	95.5	91.5	139.6	82.0	77.3	101.3	99.5	87.1
PLASTER WORK	75.7	98.2	84.5	83.5	142.7	87.8	88.8	86.3	98.8	85.1
DRY WALL WORK	66.0	90.5	87.5	71.8	129.6	82.9	87.9	80.3	92.3	76.1
RESILIENT FLOORING	64.6	91.0	86.7	72.0	127.9	78.8	85.2	74.5	91.9	72.2
CERAMIC/QUARRY TILE	74.7	92.4	76.8	85.4	145.7	87.1	86.6	91.8	99.1	78.6
HOLLOW METAL WORK	85.9	98.0	94.3	89.1	125.7	87.9	94.2	90.9	97.2	85.6
ACOUSTICAL TREATMENT	84.3	94.2	95.8	89.0	139.8	86.0	90.0	90.4	99.7	87.7
PAINTING AND FINISHES	61.9	86.2	69.8	71.5	150.3	87.5	89.8	55.7	95.1	78.6
EQUIPMENT	100.2	101.8	107.4	101.4	132.5	91.6	97.1	105.8	101.9	84.7
CONVEYING SYSTEMS	93.0	99.5	94.5	95.9	124.3	94.4	96.6	100.7	99.0	94.4
PIPING	87.6	96.9	97.5	89.6	136.7	92.3	96.2	93.0	100.0	90.7
PLUMBING FIXTURES	81.7	93.4	93.7	86.0	127.6	91.9	91.8	84.9	98.1	88.4
HVAC EQUIPMENT	97.2	99.0	99.1	97.9	121.1	98.8	98.9	97.7	99.7	98.3
AIR DISTRIBUTION	66.9	83.6	82.4	75.0	120.1	75.0	74.9	69.9	87.9	70.6
WIRING	82.2	95.9	90.1	86.9	129.4	92.9	92.6	83.4	97.4	89.4
ELECTRICAL EQUIPMENT	99.1	99.8	99.5	99.4	120.4	99.6	99.6	99.2	99.9	99.5
LIGHTING	92.1	98.2	95.6	94.2	124.2	96.8	96.7	92.6	98.8	95.3

XXX

ATTACHMENT #2.

① CITY COST INDEXES cont'd.

DIVISION	CALIFORNIA									COLORADO						CONNECTICUT		
	SANTA BARBARA			STOCKTON			VALLEJO			COLORADO SPRINGS			DENVER			BRIDGEPORT		
	MAT.	INST.	TOTAL	MAT.	INST.	TOTAL	MAT.	INST.	TOTAL	MAT.	INST.	TOTAL	MAT.	INST.	TOTAL	MAT.	INST.	TOTAL
SITE WORK	118.7	108.1	114.2	122.4	105.9	115.4	106.2	108.3	107.1	84.4	100.9	91.5	92.0	107.8	98.8	123.7	96.9	112.2
FORMWORK	110.7	117.2	115.6	95.4	121.1	114.9	101.6	121.3	116.6	96.3	89.5	91.2	103.3	96.2	99.1	116.6	94.4	99.7
REINFORCING	100.4	117.6	106.7	84.4	121.7	98.0	100.4	121.8	108.2	97.2	95.1	96.4	97.7	95.1	96.7	100.0	94.3	97.9
CAST IN PLACE CONCRETE	115.5	153.6	138.9	128.0	106.1	114.5	129.4	105.9	114.9	110.5	96.6	101.9	109.3	98.3	102.5	113.4	98.0	103.9
CONCRETE	110.6	135.8	126.3	109.8	113.5	112.1	116.1	113.5	114.5	104.1	93.6	97.5	100.1	97.1	100.5	110.6	96.2	101.6
MASONRY	119.4	110.2	112.1	100.1	121.6	117.1	103.1	122.6	118.5	104.0	94.9	96.8	102.3	97.0	98.1	112.1	84.7	90.5
METALS	99.9	130.2	111.0	98.6	115.8	104.9	101.0	116.2	106.5	99.7	94.7	97.9	101.9	94.9	99.4	100.8	95.7	98.9
WOOD & PLASTICS	112.9	116.9	114.9	90.0	120.8	105.8	99.6	120.9	110.5	100.7	90.6	95.5	100.6	98.8	99.6	111.7	94.5	102.9
MOISTURE PROTECTION	105.3	117.5	110.0	84.9	116.7	97.0	100.9	115.9	106.6	100.1	89.2	96.0	109.8	97.3	105.1	104.6	94.7	100.8
DOORS, WINDOWS, GLASS	105.8	116.8	111.7	97.5	121.6	110.5	103.6	121.7	113.3	100.0	91.2	95.2	101.1	96.4	98.5	131.4	94.2	111.4
LATH & PLASTER	119.1	117.1	117.5	105.1	111.0	109.9	103.8	121.2	117.9	94.3	89.8	90.7	107.4	94.9	97.3	115.7	89.3	94.4
DRY WALL	107.4	117.6	112.4	100.0	110.3	105.0	104.6	121.8	113.0	93.2	89.3	91.3	96.4	96.5	96.4	108.5	91.9	100.4
ACOUSTICAL WORK	100.0	117.5	110.8	100.0	121.6	113.3	108.0	121.7	116.5	100.0	90.2	94.0	96.0	98.7	97.7	122.1	94.2	105.0
FLOORING	100.0	117.5	105.2	88.3	106.8	93.8	82.3	132.2	97.0	103.9	92.0	100.4	104.7	102.2	103.9	86.5	91.0	87.8
PAINTING	118.8	117.5	117.8	100.0	121.6	117.4	136.9	121.7	124.7	113.4	83.4	93.3	93.9	104.2	103.1	90.4	94.2	93.5
FINISHES	106.8	117.5	112.8	97.6	115.0	107.4	103.6	122.4	114.2	98.2	89.3	93.2	99.7	98.6	99.2	102.9	92.7	97.1
TOTAL DIV. 10-14	100.0	117.6	105.0	100.0	123.7	106.8	100.0	123.7	106.8	100.0	94.4	98.3	100.0	96.2	98.9	100.0	96.3	98.9
MECHANICAL	99.1	116.7	108.1	98.4	121.5	110.2	97.0	121.8	109.6	100.5	90.9	95.6	100.8	96.7	98.7	103.9	94.7	99.2
ELECTRICAL	106.3	117.6	114.1	100.0	121.7	115.0	100.0	121.8	115.1	100.0	90.6	93.4	101.8	96.4	98.1	89.0	81.8	84.0
TOTAL	105.6	120.4	113.7	101.1	118.3	110.5	103.1	119.3	112.0	99.8	92.6	95.8	101.5	97.5	99.3	106.6	91.9	98.5

DIVISION	CONNECTICUT												DELAWARE			D.C.		
	HARTFORD			NEW HAVEN			STAMFORD			WATERBURY			WILMINGTON			WASHINGTON		
	MAT.	INST.	TOTAL	MAT.	INST.	TOTAL	MAT.	INST.	TOTAL	MAT.	INST.	TOTAL	MAT.	INST.	TOTAL	MAT.	INST.	TOTAL
SITE WORK	85.5	103.6	93.2	102.9	97.7	100.7	127.3	95.8	114.2	130.8	97.4	116.5	100.7	101.7	101.1	104.9	94.4	100.4
FORMWORK	103.9	86.0	90.3	101.8	96.6	97.9	100.0	91.2	93.3	100.0	95.8	96.8	100.0	100.6	100.4	109.1	97.9	100.6
REINFORCING	100.0	96.4	98.6	100.0	96.6	98.7	100.0	92.6	97.2	100.0	95.8	98.4	100.0	108.1	102.9	118.6	94.8	109.9
CAST IN PLACE CONCRETE	101.8	98.9	100.0	109.6	99.0	103.1	116.4	97.9	105.1	113.5	98.2	104.1	99.0	114.3	108.4	98.2	100.1	99.4
CONCRETE	101.7	93.5	96.6	105.4	97.8	100.7	108.7	94.8	100.0	107.2	97.0	100.8	99.4	108.2	104.9	105.8	98.7	101.4
MASONRY	93.1	86.7	88.1	110.6	96.5	99.5	111.4	92.4	96.4	110.3	86.8	91.7	103.0	100.2	100.8	97.7	104.0	102.7
METALS	94.3	97.3	95.4	100.0	97.4	99.0	100.0	94.4	97.9	100.0	96.8	98.8	100.0	110.6	103.8	103.4	97.0	101.1
WOOD & PLASTICS	102.6	83.7	92.9	117.2	96.7	106.7	101.6	91.0	96.2	100.0	95.9	97.9	95.6	100.2	98.0	123.4	97.5	110.1
MOISTURE PROTECTION	97.3	93.2	95.8	102.6	93.0	99.0	99.6	94.5	97.6	101.1	94.5	98.6	92.7	100.2	95.5	99.0	95.2	97.6
DOORS, WINDOWS, GLASS	82.3	90.3	86.6	96.1	96.5	96.4	81.8	92.3	87.4	82.8	95.7	89.8	95.9	104.9	100.8	105.1	97.9	101.2
LATH & PLASTER	98.7	91.3	92.7	108.4	93.4	96.3	102.5	89.2	91.8	104.4	87.7	90.9	100.0	97.9	98.3	101.8	97.0	97.9
DRY WALL	93.1	85.4	89.3	106.6	92.9	99.9	100.0	87.5	93.9	100.0	92.2	96.2	100.0	97.7	98.8	106.7	96.8	101.8
ACOUSTICAL WORK	112.2	83.0	94.3	122.4	96.5	106.5	122.4	90.7	102.9	122.4	95.7	106.0	100.0	100.2	100.1	131.0	97.4	110.3
FLOORING	70.4	91.2	76.6	83.4	96.5	87.3	101.2	92.2	98.5	101.2	93.1	98.8	75.0	100.2	82.5	98.4	99.0	98.6
PAINTING	118.2	99.0	102.7	103.6	95.5	97.9	100.0	92.5	94.0	108.9	95.7	98.3	100.0	100.2	100.2	95.6	99.9	99.1
FINISHES	92.4	90.7	91.4	102.4	94.8	98.1	101.8	90.0	95.1	102.8	93.5	97.6	94.6	99.0	97.1	105.2	98.1	101.2
TOTAL DIV. 10-14	100.0	97.1	99.1	100.0	97.1	99.1	100.0	95.7	98.7	100.0	96.9	99.1	100.0	100.3	100.0	100.0	98.4	99.5
MECHANICAL	100.7	95.9	98.3	100.8	91.7	96.2	100.8	92.7	96.6	102.3	95.4	98.8	99.4	100.3	99.8	101.9	93.7	97.7
ELECTRICAL	96.1	88.1	90.5	89.0	89.3	89.2	89.0	91.1	90.5	89.0	80.1	82.8	101.9	100.3	100.7	97.3	96.2	96.5
TOTAL	96.5	92.3	94.2	101.5	94.9	97.9	102.2	93.0	97.2	102.7	92.6	97.1	98.6	102.6	100.9	102.9	97.8	100.1

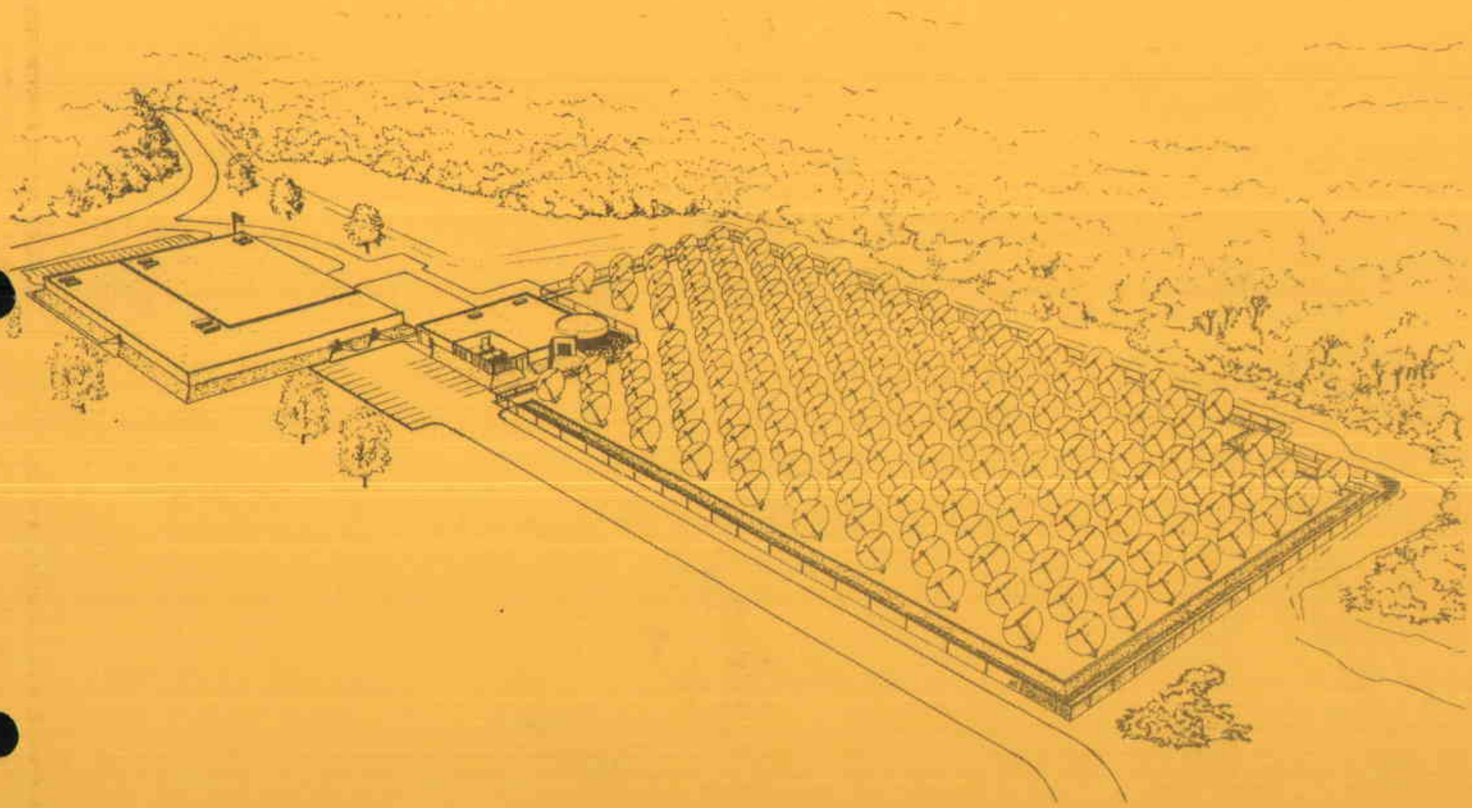
DIVISION	FLORIDA															GEORGIA		
	FT. LAUDERDALE			JACKSONVILLE			MIAMI			ORLANDO			TAMPA			ATLANTA		
	MAT.	INST.	TOTAL	MAT.	INST.	TOTAL	MAT.	INST.	TOTAL	MAT.	INST.	TOTAL	MAT.	INST.	TOTAL	MAT.	INST.	TOTAL
SITE WORK	95.6	82.6	90.0	100.5	86.6	94.5	87.9	94.7	90.8	87.6	88.8	88.2	102.3	95.2	99.2	89.1	94.2	91.3
FORMWORK	95.6	84.2	86.9	95.7	78.6	82.7	91.9	84.2	86.1	93.1	78.8	82.3	93.1	88.9	89.9	95.9	83.6	86.6
REINFORCING	100.0	82.1	93.4	84.4	78.6	82.3	100.0	90.8	96.6	100.0	80.3	92.8	100.0	88.7	95.8	107.7	80.1	97.6
CAST IN PLACE CONCRETE	74.5	95.4	87.3	95.0	90.8	92.5	87.6	96.8	93.3	93.2	94.5	94.0	99.9	114.2	108.7	92.0	91.4	91.6
CONCRETE	85.5	89.7	88.1	92.4	84.8	87.7	91.7	91.2	91.4	94.9	86.9	89.9	96.5	101.8	100.5	96.9	87.3	90.9
MASONRY	94.9	74.9	79.1	83.9	79.2	80.2	81.7	87.0	85.9	88.6	80.1	81.9	93.4	88.7	89.7	84.3	80.9	81.7
METALS	87.8	86.7	87.4	102.4	83.4	95.5	92.6	91.8	92.3	92.6	84.5	89.6	73.9	97.6	82.5	98.2	84.1	93.1
WOOD & PLASTICS	99.0	84.4	91.5	96.5	82.7	89.4	102.5	84.1	93.1	96.4	78.9	87.4	96.0	89.1	92.5	92.6	85.9	89.1
MOISTURE PROTECTION	100.1	82.1	93.3	100.2	76.9	91.4	82.6	89.7	85.3	99.9	80.1	92.4	102.6	88.7	97.3	102.4	72.9	91.2
DOORS, WINDOWS, GLASS	95.0	76.8	85.2	106.5	77.2	90.8	97.5	85.1	90.8	90.1	79.2	84.3	111.1	88.6	99.0	95.3	88.3	91.5
LATH & PLASTER	100.6	70.0	76.0	102.0	74.9	80.1	108.7	92.1	95.4	105.7	75.1	81.0	104.4	84.3	88.2	102.8	90.7	93.1
DRY WALL	100.0	71.8	86.2	101.8	77.0	89.6	98.2	86.4	92.4	100.0	72.3	86.4	94.3	88.7	91.5	97.4	87.2	92.4
ACOUSTICAL WORK	100.0	83.7	90.0	100.0	82.0	88.9	115.3	83.5	95.8	100.0	78.0	86.5	100.0	88.6	93.0	82.9	85.5	84.5
FLOORING	100.0	63.9	89.3	100.0	71.5	91.6	89.8	91.6	90.3	85.8	79.8	84.0	92.9	88.6	91.7	99.1	88.6	96.0
PAINTING	107.7	82.0	87.1	87.1	74.6	77.1	120.9	90.7	96.6	85.4	73.9	76.1	104.0	88.6	91.7	108.3	92.4	95.5
FINISHES	100.8	75.7	86.7	99.7	76.1	86.4	100.2	88.4	93.5	95.4	74.0	83.3	95.6	88.4	91.5	98.1	89.2	93.1
TOTAL DIV. 10-14	100.0	84.3	95.4	100.0	79.4	94.0	100.0	90.8	97.3	100.0	72.7	92.1	100.0	81.1	94.5	100.0	82.5	94.9
MECHANICAL	100.4	82.1	91.1	101.1	75.3	88.0	98.3	90.8	94.5	98.3	80.6	89.2	97.7	88.7	93.1	102.1	83.6	92.7
ELECTRICAL	96.3	82.1	86.4	99.2	77.6	84.2	99.6	90.8	93.5	92.3	80.3	83.9	92.3	88.7	89.8	99.1	86.3	90.2
TOTAL	95.6	82.1	88.2	98.7	79.6	88.2	94.8	89.8	92.1	95.2	81.3	87.5	96.5	91.8	91.9	97.8	85.3	90.9

DOCUMENT NO. 78SDS4262
DATE: 2/15/79
ORIGINAL ISSUE

SOLAR TOTAL ENERGY — LARGE SCALE EXPERIMENT

AT SHENANDOAH, GEORGIA

CONSTRUCTION PLAN



DEPARTMENT OF ENERGY
CONTRACT NUMBER AC04-77ET20260

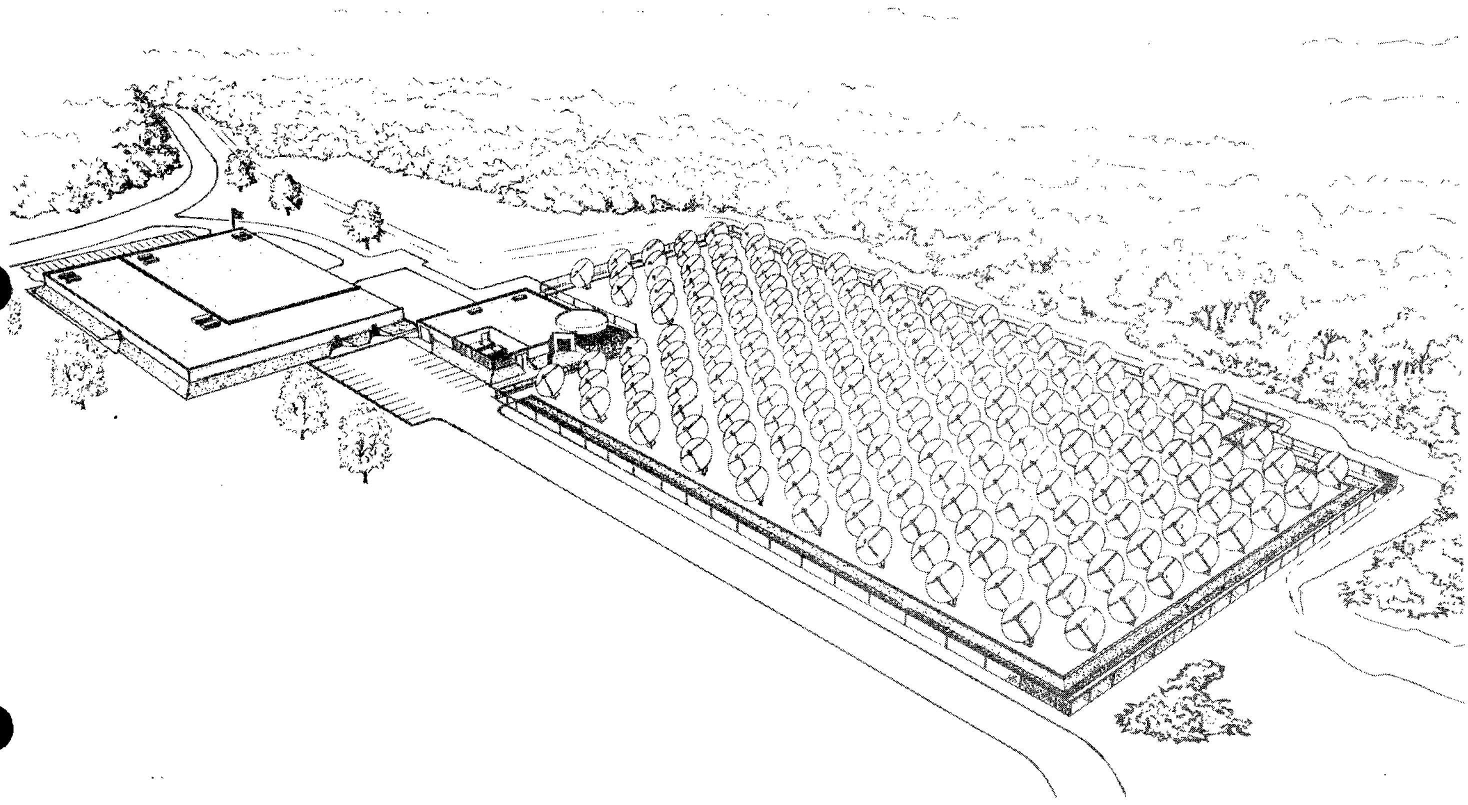
GENERAL ELECTRIC
SPACE DIVISION

DOCUMENT NO. 78SDS4262
DATE: 2/15/79
ORIGINAL ISSUE

SOLAR TOTAL ENERGY – LARGE SCALE EXPERIMENT

AT SHENANDOAH, GEORGIA

CONSTRUCTION PLAN



DEPARTMENT OF ENERGY
CONTRACT NUMBER AC04-77ET20260

GENERAL ELECTRIC
SPACE DIVISION

TABLE OF CONTENTS

LIST OF ILLUSTRATIONS

LIST OF TABLES

INTRODUCTION AND SUMMARY

INTRODUCTION

This document contains the Construction Plan for the Solar Total Energy Large Scale Experiment which will be built at Shenandoah, Georgia to provide electricity, process steam and heating and cooling for the Bleyle knitwear plant. This plan is intended to be primarily a construction handbook that summarizes the project and the system, describes the management of the construction and installation phase of the project and defines in detail the following:

a. The components in each of the subsystems which comprise the STES.

b. The activities involved in site preparation and system installation.

c. The schedules for fabrication of the hardware, construction of the site and installation of the STES.

d. Hardware and construction costs for the STES.

This construction plan will be updated periodically to increase definition as the definitive design of the STES evolves and the project approaches the hardware fabrication and site construction phase.

SUMMARY

The objective of the STE-LSE Project is to design, construct, test, operate and evaluate a solar total energy system to obtain experience with large scale hardware systems, narrow the uncertainties of cost and performance predictions, and establish an industrial engineering capability for subsequent systems. This project has been structured by DOE in several phases as shown in the overall project schedule in Figure 1. The STES will be installed at Shenandoah, Georgia to provide energy to the 3900 square meter (42,000 ft^2) Bleyle knitwear plant. An artists concept of the STES at the Shenandoah site is shown in Figure 2.

The STES will provide both electrical power and thermal energy for process steam, heating and air conditioning requirements. It will supply a major fraction of the yearly energy

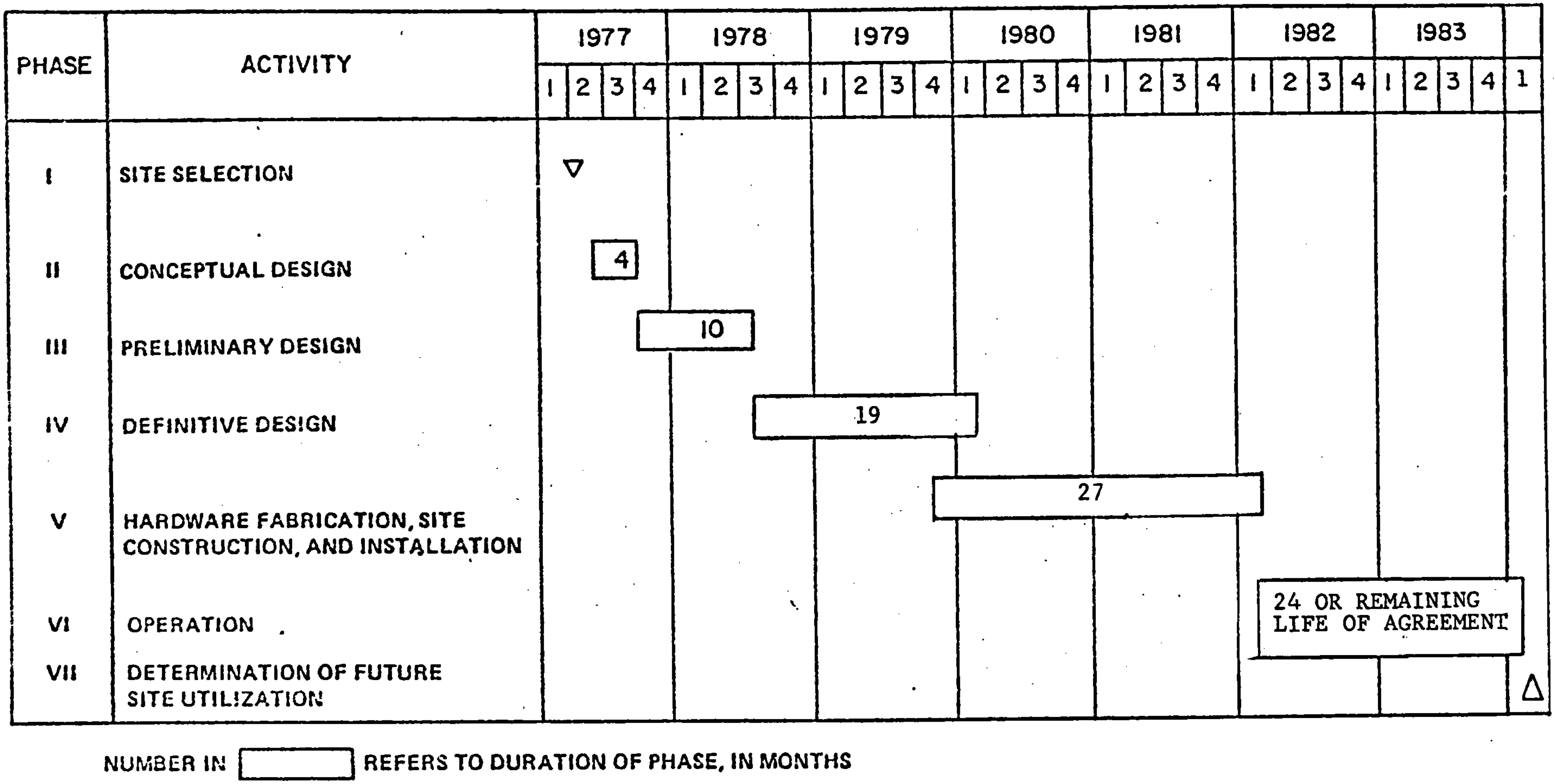


Figure 1. Solar Total Energy – Large Scale Experiment Program Reference Schedule

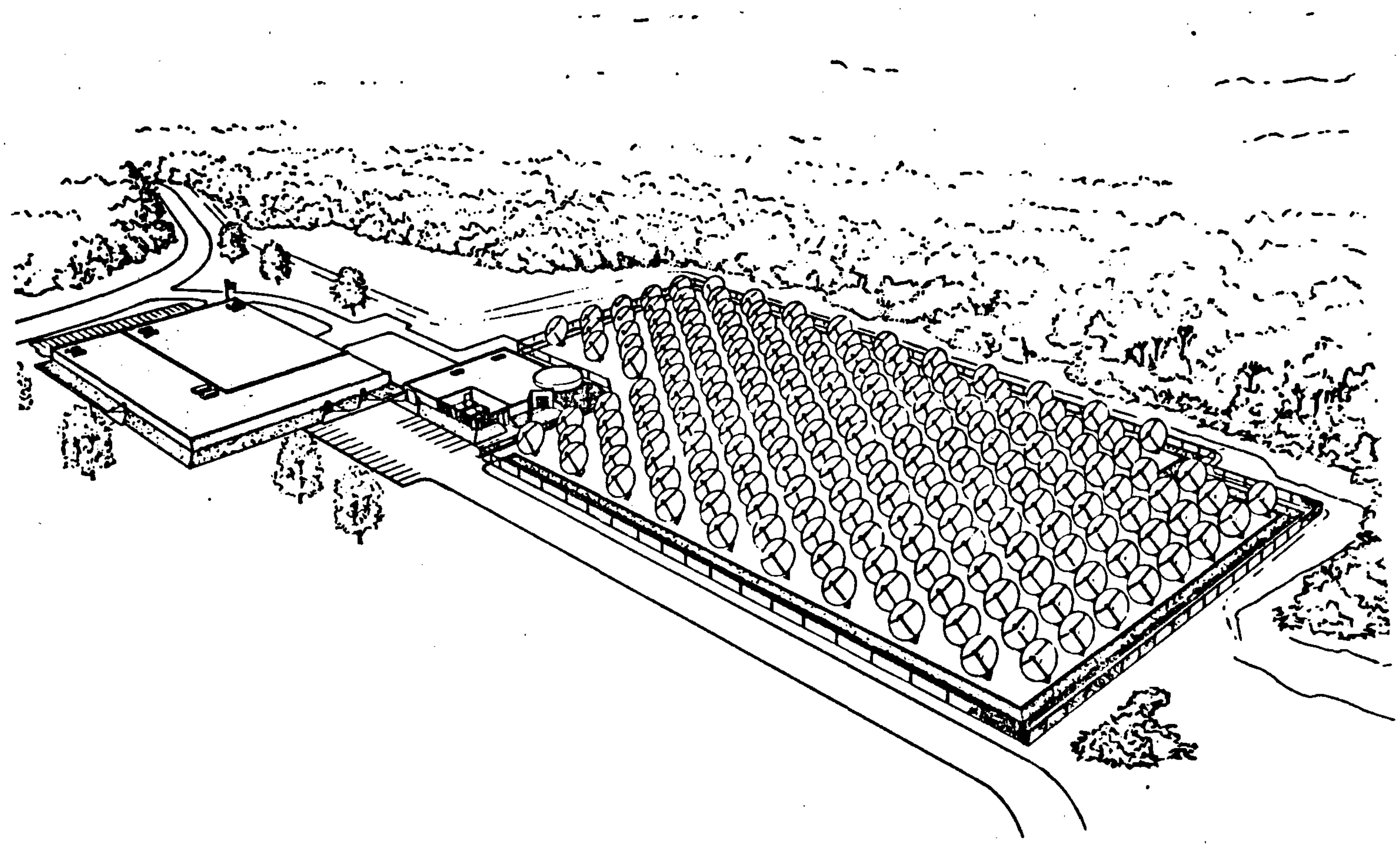


Figure 2. Solar Total Energy-Large Scale Experiment at Shenandoah, Georgia

requirements for the knitwear plant. The system is composed of three hydraulic loops or major subsystems, which transfer the collected solar energy into the appropriate energy forms required by the plant, and a central control system which monitors and controls the overall system operation. The Solar Collection Subsystem (SCS), collects the solar energy using point-focus paraboloidal dish collectors and transports it from the collector field to either the high temperature thermal storage (HTS) or directly to the steam generator in the Power Conversion Subsystem (PCS). In the PCS, electrical power is produced by a generator driven by a dual, tandem steam-turbine. Steam for the process use is extracted from the rear of the first turbine. The heat rejection energy from the PCS is transported to the Thermal Utilization Subsystem (TUS) which channels it to the Low Temperature Thermal Storage (LTS) or directly to the space heating and/or cooling units. The STES nominally operates with a 100 kW(e) base load from the utility and follows the site electric load providing between 200 and 300 kW(e) in operation. The STES is designed to provide the maximum heating and cooling loads of the Bleyle plant and the STES mechanical building. These are 1.64×10^5 joule/sec (5.59×10^5 BTU/hr) and 6.08×10^5 joule/sec (174 tons) respectively.

The STE-LSE at Shenandoah is a research and development project. Some of the key equipment is unique and of highly specialized nature which is intended to advance the economic and technical feasibility of solar total energy systems. Because this is a first of a kind system, this plan proposes to conduct the construction phase with the Program Management Team presently performing the definitive design with the addition of a dedicated construction manager.

Maximum technical and economic benefit to the government is provided by utilizing MATSCO (a wholly owned GE subsidiary) to perform the construction management activities. MATSCO has broad experience managing construction projects, including the soon to be completed Wind Turbine Generator project in Boone, N.C. MATSCO responsibilities include:

- Competitive award and management of construction contractors
- Procurement of process, specialized and long lead time equipment
- Construction management including cost and schedule surveillance and control

Six construction contracts will be awarded after competitive screening and bidding. These include the following:

- Solar Collector Installation
- Site work
- Solar Process Piping
- Mechanical Building
- Electrical
- Insulation

The STE-LSE Program Management Organization for the Construction Phase is shown in Figure 3. This organization evolves from the Definitive Design Organization by the addition of a Construction Manager.

Sections 2 and 3 of this plan contain the detailed component listings and requirements, schedules, costs and cost backup information for the system, the construction and the installation of the system. The special and long lead-time equipment are covered in Section 3. This equipment is arranged by subsystem as follows:

- Solar Collector Subsystem (SC)
- Collector Field Subsystem (CFS)
- High Temperature Energy Storage Subsystem (HTS)
- Power Conversion Subsystem (PCS)
- Thermal Utilization Subsystem (TUS)
- Control and Instrumentation Subsystem (CAIS)
- Electrical Power and Distribution Subsystem (ES)

Section 2 contains the Construction/Installation Plan which includes the site installation packages which are divided into the six major subcontracts.

Preliminary CPM schedules are included for all construction activities. The CPM format presents the logic diagram for all contractor tasks showing task interrelationships and start and complete dates for each task.

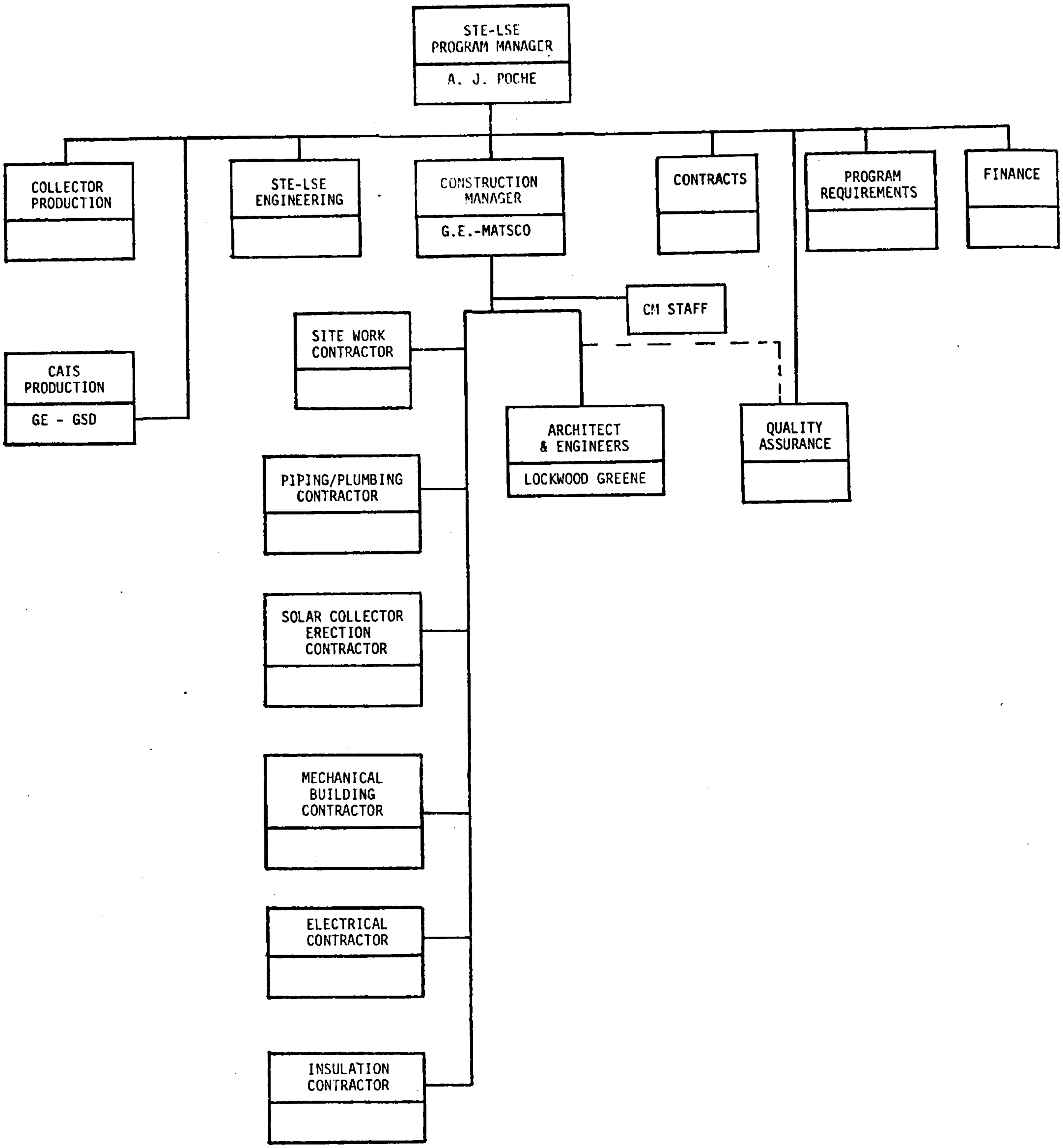


Figure 3. STE-LSE Program Organization

Cost Summary

A summary of construction costs is presented in Table 1. These costs include cost of purchased parts and contractor costs. Details on purchased parts cost and contractor costs are located in Sections 2 and 3 of this plan.

TABLE 1. SUMMARY OF SYSTEM COST INSTALLED
(COSTS IN 1978 DOLLARS THRU G&A)

PURCHASED PARTS:		
SOLAR COLLECTORS 196 Collectors (4 Spares)		$2,616,894
CONTROL & INSTRUMENTATION SUBSYSTEM		594,000
MATSCO PURCHASED PARTS		
SOLAR COLLECTOR FIELD SUBSYSTEM (NOT INCL. COLLECTORS)	$ 104,858	
HIGH TEMPERATURE STORAGE	1,079,038	
POWER CONVERSION SUBSYSTEM	251,859	
THERMAL UTILIZATION SUBSYSTEM	217,675	
CONTROL & INSTRUMENTATION SENSORS	63,339	
ELECTRICAL POWER AND DISTRIBUTION SUBSYSTEM	141,316	
SHIPPING COST	104,610	
SUBTOTAL	1,962,695	
MATSCO G&A	98,135	
SUBTOTAL (NOT INCL. GE-GSD, SOLAR COLLECTORS)		2,060,830
SITE SUBCONTRACTS (Note 1)		
SITE WORK	570,135	
PROCESS PIPING & PLUMBING	499,515	
MECH. BLDG.	122,189	
ELECT.	182,517	
INSULATION	515,181	
COLLECTOR ASSEMBLY	715,764	
SUBTOTAL	2,605,301	
MATSCO G&A	130,265	
SUBTOTAL		2,735,566

TOOLING AND ONE TIME ENGINEERING COST	486,728
INDIRECT COST	
CONSTRUCTION MANAGEMENT	388,207
SPARE PARTS ANALYSIS (5% OF PURCHASED PARTS)	97,548
TEMPORARY FACILITIES	95,505
SUB-TOTAL	9,075,278
TURBINE GENERATOR	500,000
GRAND TOTAL	9,575,278

Note 1:

All Local and Georgia Taxes are excluded from the Site Subcontracts Cost with the assumption that an exclusion from these taxes will be obtained from DOE.

PROJECT DEFINITION

PROJECT DESCRIPTION

1.1 SYSTEM DEFINITION

1.1.1 SCOPE

A Solar Total Energy System (STES) is defined as an energy system which uses collected solar energy to supply high grade (electrical/mechanical) and low grade (thermal) energy needs for selected applications. The basic function of the STES at Shenandoah is to supply the electric power, process steam, and heating and cooling demands of the expanded 3900 square meters (42,000 ft^2) Bleyle Plant.

Figure 1.1-1 presents an artist's concept of the Shenandoah LSE site and system.

The Shenandoah LSE is a total energy system design featuring high temperature paraboloidal dish solar collectors with a 235 concentration ratio, a steam Rankine cycle power conversion system capable of supply 300 - 400 kW(e) output with an intermediate process steam take-off point, and a back pressure condenser to provide hot water for heating and cooling, thus providing a fully cascaded thermal energy utilization system. The design also includes an integrated control system employing the supervisory control concept to allow maximum experimental flexibility. The supervisory control concept provides the capability for the operator to exercise manual control over selected subsystems and components in addition to the automatic control functions.

Functionally, the Solar Total Energy System (STES) consists of three major subsystems; the Solar Collection Subsystem (SCS), the Power Conversion Subsystem (PCS), and the Thermal Utilization Subsystem (TUS).

The SCS itself consists of three subsystems: the Collector Field Subsystem (CFS), the High Temperature Storage Subsystem (HTS), and the Steam Generator Supply Subsystem (SGS). The SCS function is to collect, store, and supply solar and auxiliary energy to the PCS. The PCS converts a portion of the supplied energy to electricity, provides another portion of the

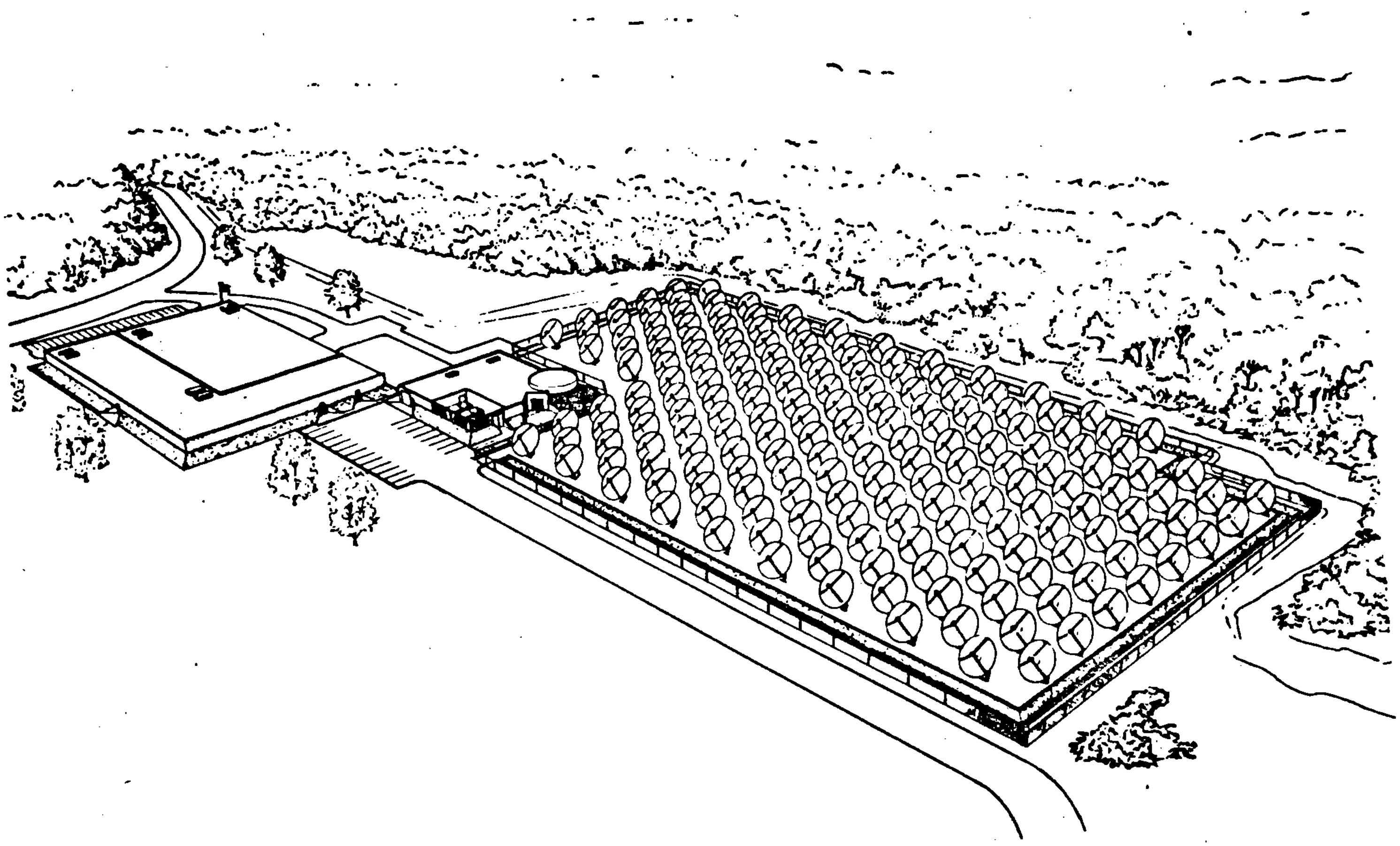


Figure 1.1-1. Solar Total Energy-Large Scale Experiment at Shenandoah, Georgia

energy as process steam, and transfers the remaining energy to the TUS to provide absorption air conditioning and heating. Figure 1.1-2 shows the STES and its subsystems.

1.1.2 SITE LOADS

As a total energy system, the STES has been designed to serve all of the loads on the site and sized to supply at least 60 percent of the expanded 3900 square meter (42,000 square foot) Bleyle Plant yearly load with solar energy consistent with the overall experiment objectives. The system loads include the Bleyle Plant electrical loads and STES operating power and power for the STES Mechanical Building, process steam to the Bleyle Plant used for pressing fabric, and heating and cooling for both the Bleyle Plant and the STES Mechanical Building. In normal operation, the electrical load will not exceed 400 kW. To accommodate load fluctuations and to provide a better match with the site thermal loads, the STES nominally operates with a 100 kW base load from the utility, and electric load follows between 200-300 kW in normal operation.

The plant's process steam demand is currently supplied by a natural gas fired boiler. Process steam at saturated conditions is required during all working hours.

The cooling loads which consist primarily of internal heat generated by the process and building lighting are relatively constant during plant operating hours. However, the plant heating, ventilating, and air conditioning (HVAC) system incorporates an economizer cycle which supplies a major portion of the internally generated cooling load from December to February. To provide a more optimum site thermal-to-electric load ratio for the STES, the cooling loads are served by a chilled water system supplied by an absorption chiller.

1.2 LOCATION AND SITE DESCRIPTION

The proposed Solar Total Energy-Large Scale Experiment will be located in Shenandoah, Georgia. Shenandoah is a new town near Newnan, Georgia, about 40 kilometers (25 miles)

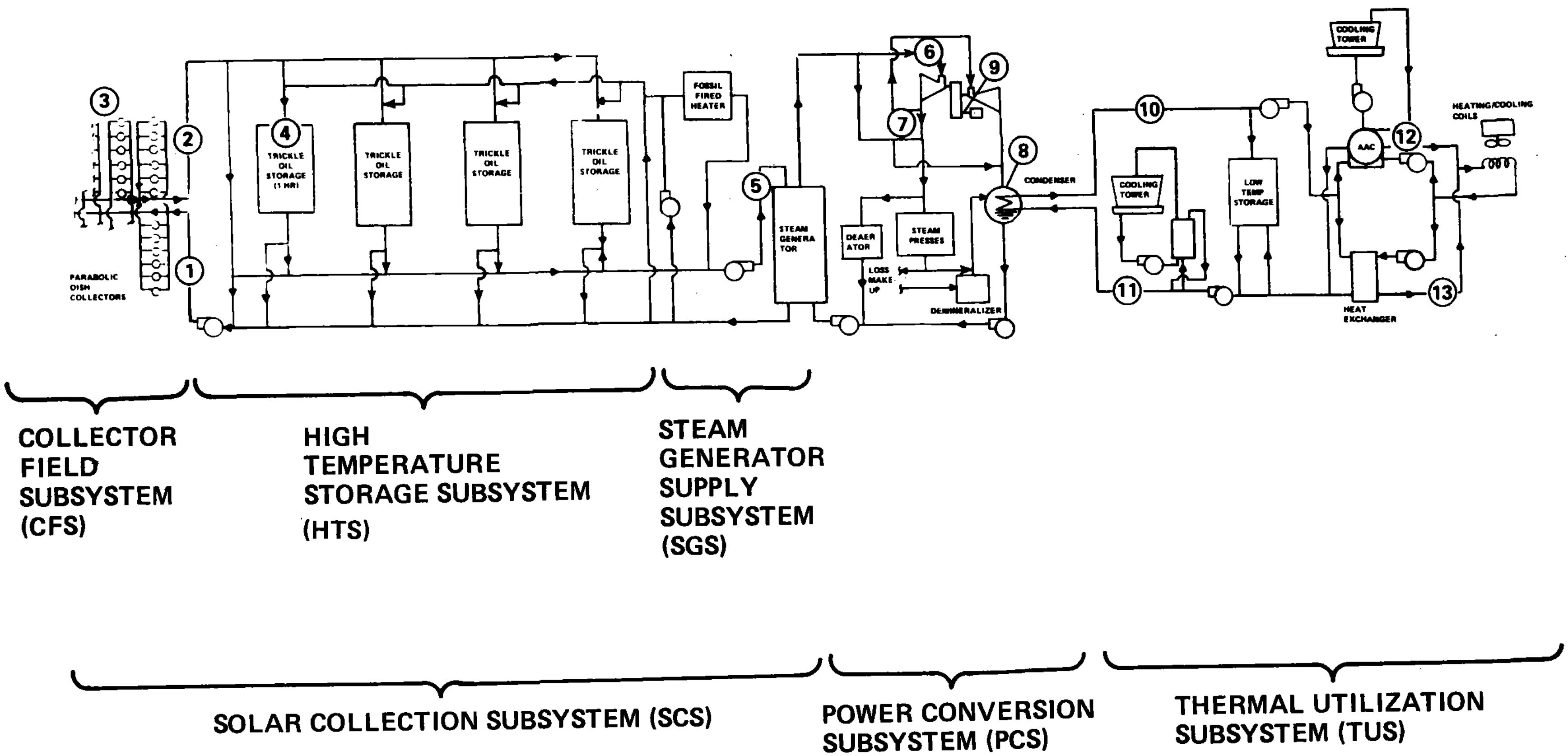


Figure 1.1-2. Shenandoah LSE System

southwest of Atlanta, this new community as shown in Figure 1.2-1 is being developed by Shenandoah Development Incorporated (SDI) which was established in 1969 by Unioamerica-Incorporated. Approximately 30 square kilometers (7,400 acres) are currently being developed by SDI.

The site that was made available by SDI for the proposed solar total energy facility is defined in Figure 1.2-2 (Plat I). It consists of approximately 23,150 square meters (5,72 acres) of gently sloping land. As depicted in Figure 1.2-3, the site is near the intersections of Interstate 85 and Georgia Highway 34. The site is connected to Newnan by Georgia Highway 34 and Atlanta by Interstate 85. The Bleyle knitwear plant is located along the west property line of the development.

Access to the Bleyle facilities will be via Amlajack Boulevard. The property adjacent to the north boundaries of the Bleyle facility/STES site is neither owned nor controlled by SDI. Located near the northeast corner of the collector tract is a parcel of land measuring 15 meters by 44 meters (50 feet x 143 feet). This property is owned by the Housing and Urban Development Administration (HUD) and is designated as a green area. Green areas are intended to be land which will never be developed. However, the HUD property can be modified to control erosion at the STES site, if required.

Positioned directly south of the site on a parcel of land with a peak elevation of 296 meters (970 feet) is a 3785 cubic meter (1,000,000 gallon) water tower. The height of the water tower is approximately 51 meters (166 feet). SDI owns and operates the water facility.

Located on the STES site itself are two man-made structures. The first is a meteorological station on a 6 meter by 6 meter (20 ft. by 20 ft.) concrete pad. This station will eventually be dismantled and repositioned on top of the STE-LSE mechanical building to record data in conjunction with STE-LSE operations. The second structure is a 0.2 meter (8 inch) concrete sanitary sewer line. The concrete pipe is located approximately 2.7 meters (9 feet) below the existing grade elevation. Service to the sewer is via two manholes located on Figure 1.2-2. It should be noted that the sanitary sewer has a three meter (10 feet) easement and that manhole elevations will be adjusted to any changes in surrounding ground elevations.

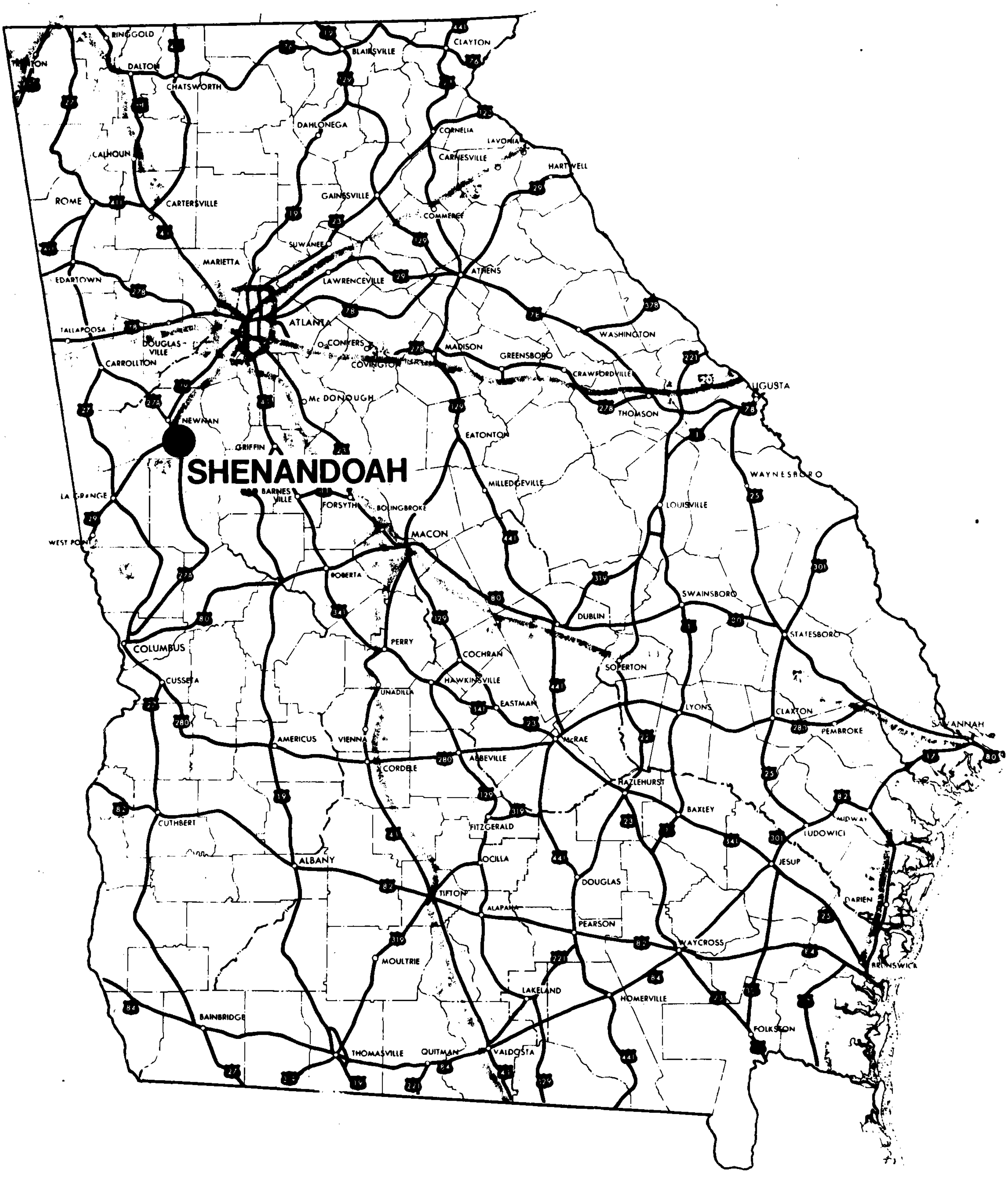


Figure 1.2-1. Location Map

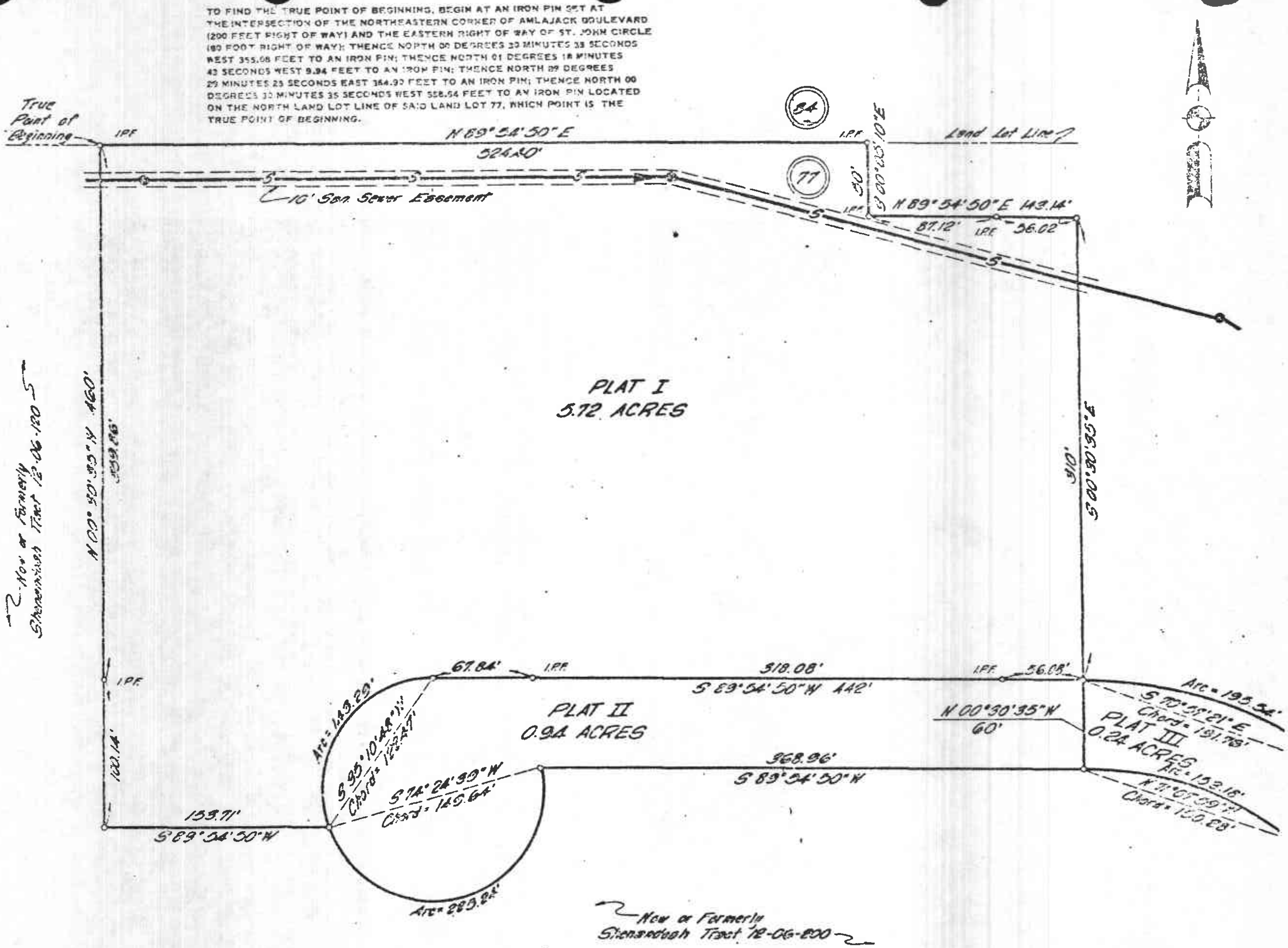


Figure 1.2-2. The Plot Plan (5.72 Acre Plot)

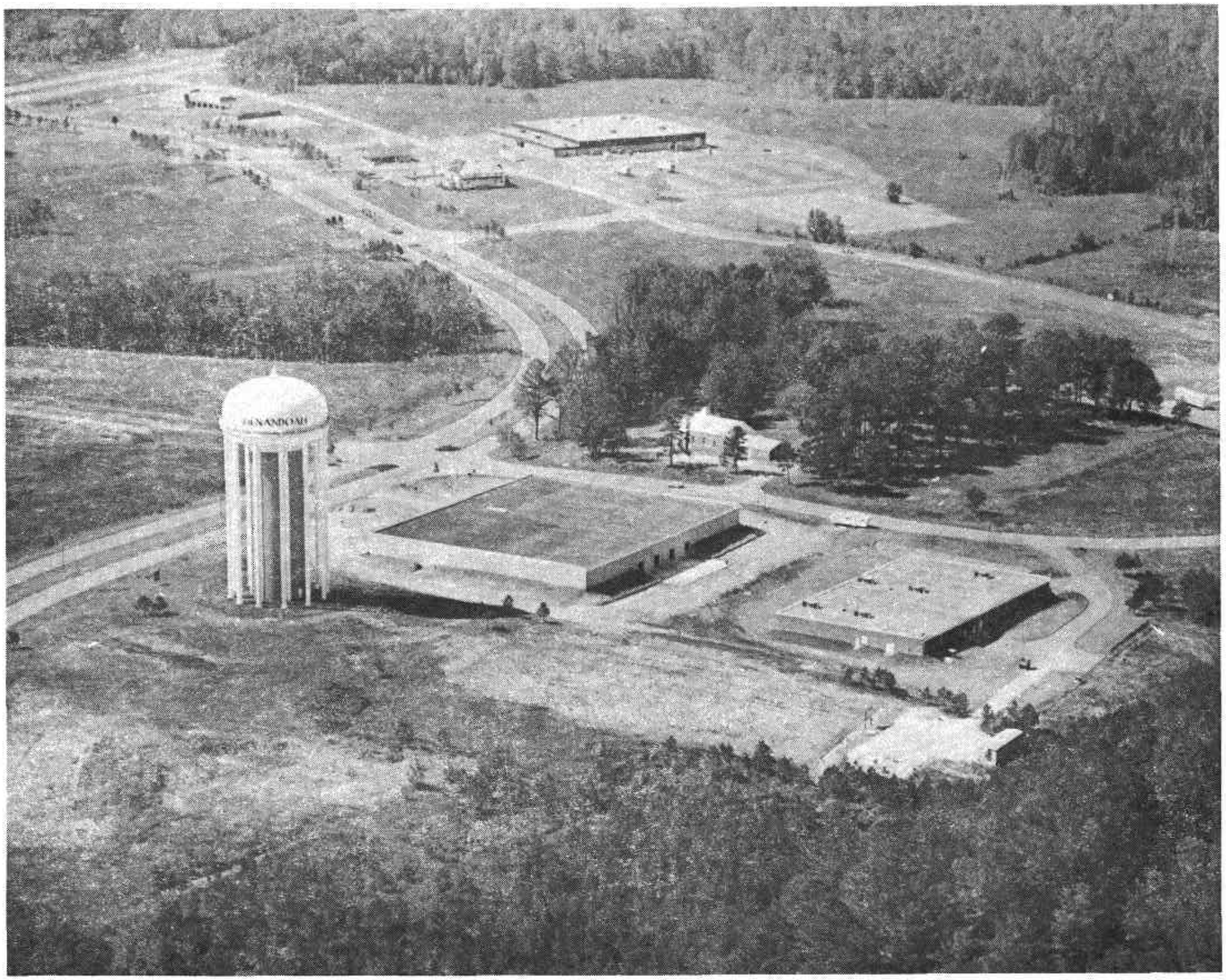


Figure 1.2-3. Aerial Photograph of Site - Looking South

All other lands that adjoin the collector boundary line are owned by SDI. SDI has plans to install a road southeast of the site to provide access to Amlajack Boulevard. The land in this area will be graded in conjunction with STE-LSE site preparation. This will reduce the potential for shadowing the solar collector field and thus enhance system performance.

1.3 OVERALL SYSTEM DESCRIPTION

The system is a fully cascaded total energy system design as shown in the Figure 1.3-1 schematic, featuring high temperature paraboloidal dish solar collectors with a 235 concentration ratio, a steam Rankine cycle power conversion system capable of supplying 200-400 kW(e) output with an intermediate process steam take-off point, and a back pressure condenser providing energy for heating and cooling. The design also includes an integrated control system employing the supervisory control concept to allow maximum experimental flexibility.

1.3.1 Solar Collection Subsystem

The Solar Collection Subsystem, shown schematically on Figure 1.3-2, consists of an array of 192 seven-meter diameter, parabolic dish collectors, which provide a 139°K (250°F) temperature rise to a flow of Syltherm^{TM} 800 fluid through each collector in a parallel arranged, closed, hydraulic circuit. The design collector output temperature is 672°K (750°F). The receiver is a cavity type with the incident concentrated solar flux impinging upon an absorptive surface enclosed within an insulated cylindrical shell. The dish is made up of individual petals which are die-stamped aluminum, and the entire assembly is field assembled. The aluminum is polished, and a weather surface is applied to allow maintenance of total hemispherical reflectance in the range of 0.86. The unit tracks both in polar and declination axes under control of remote and locally mounted electronics.

The field piping network consists of field welded steel tubing covered with high temperature insulation. The parabolic dish collectors are arrayed on the Shenandoah collector field in a repeating diamond pattern. The spacing is optimized to provide maximum annual field energy output from the 20,016 square meter (4.95) acre site for the collector field and Mechanical Equipment Area (MEA).

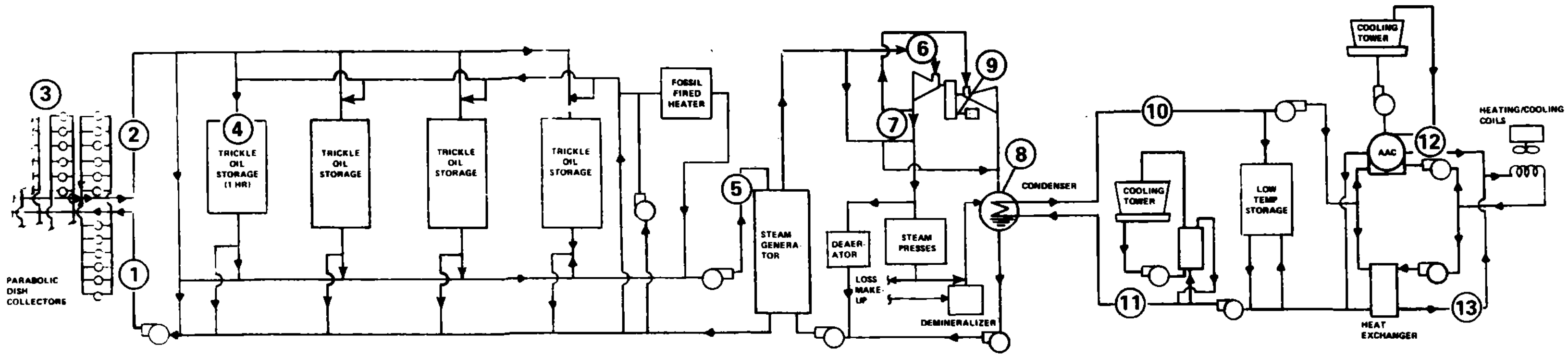


Figure 1.3-1. Shenandoah LSE System Schematic

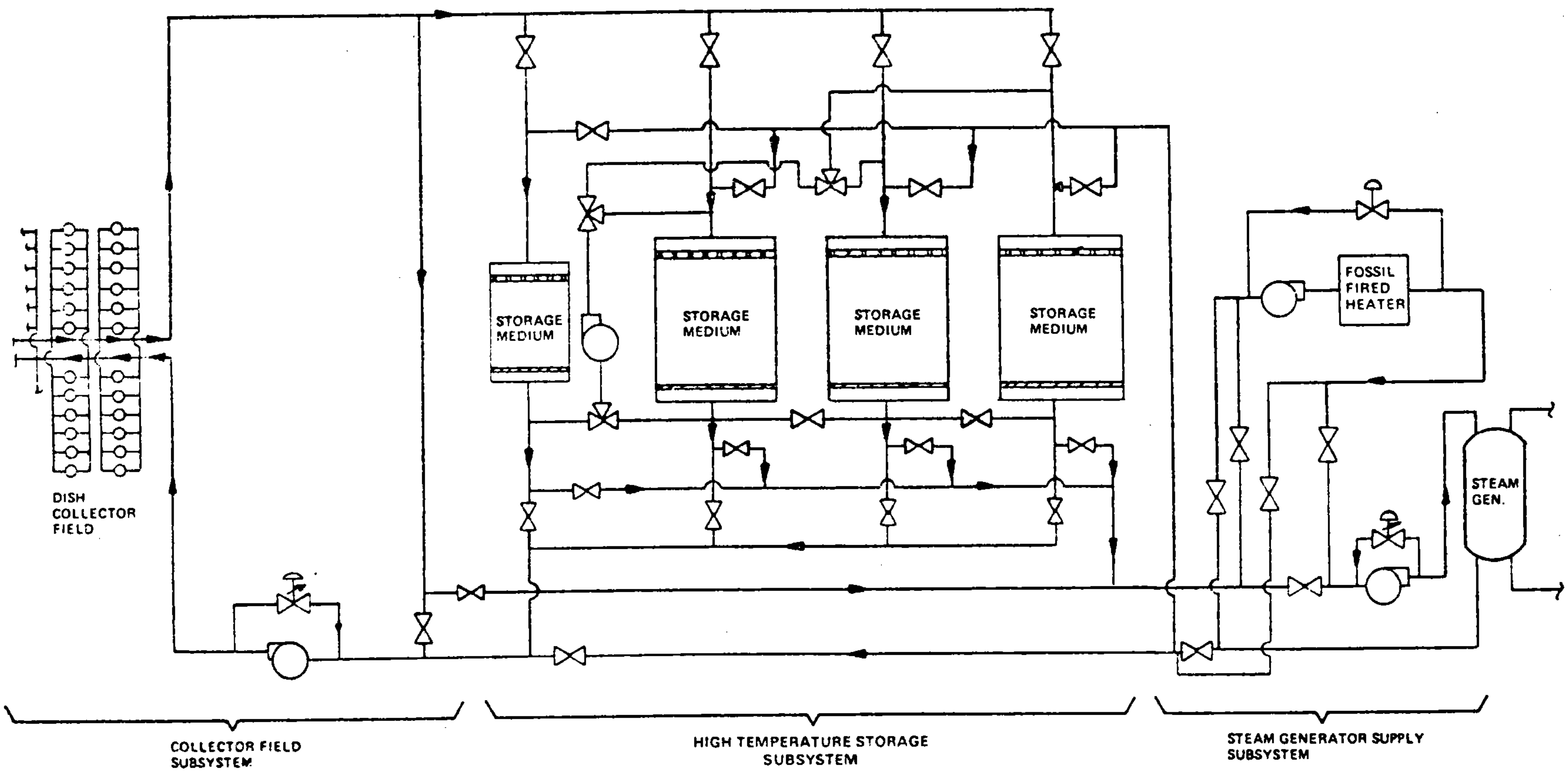


Figure 1.3-2. Solar Collection Subsystem

The trickle oil concept was selected for the High Temperature Storage subsystem (HTS). This concept offers a low-cost solid storage medium for essentially all heat storage, thus reducing to a minimum the inventory of high-cost heat transfer oil.

The storage system on the HTS is either charged or discharged by trickling oil over a cold or hot storage bed, and the heat is transferred by a thin film of oil trickling over an iron ore solid medium. A drain plate is used to collect the oil into a sump area at the bottom of the tank. The design for the STE-LSE at Shenandoah has four thermal storage tanks, one to provide one hour of system operation at full load, 4 meters in diameter and 3.7 meters high (13 feet in diameter, 12 feet high) and the remaining three together to provide a storage capacity adequate for holding the energy collected in the summer over the weekend, 6.3 meters in diameter and 4.9 meters high (20.6 feet in diameter, 16 feet high). During operation of the trickle oil storage system, flow is always into the top of each compartment, whether charging or discharging. A series of flow control valves and thermal sensors direct the flow to the desired tanks under control system supervision.

The Solar Collection Subsystem also includes a fossil fired heater capable of supplying the full PCS heat input requirement when the HTS is depleted.

1.3.2 Power Conversion Subsystem

The Power Conversion Subsystem shown on Figure 1.3-3 consists of a three piece pool-type boiler with preheater, boiler, and superheater, a steam turbine-generator set rated at 400 kW(e) which is being supplied by Mechanical Technology, Inc. as Government Furnished Equipment (GFE), a condenser and condensate storage tank with pump, make-up dimineralizer, chemical injection unit, deaerating heater, and a boiler feed pump. In normal operation, steam is generated in the boiler-superheater, heated by Syltherm™800, and delivered to the turbine inlet. The turbine generator set consists of two high speed (42,450 rpm) turbines coupled to a two-speed gearbox which reduces the speed to the 30 rev/s (1800 rpm), 60 Hz alternator. The back of the first turbine has a take-off for process steam and steam for regenerative feed water heating. The second turbine operates into a condenser at 383°K

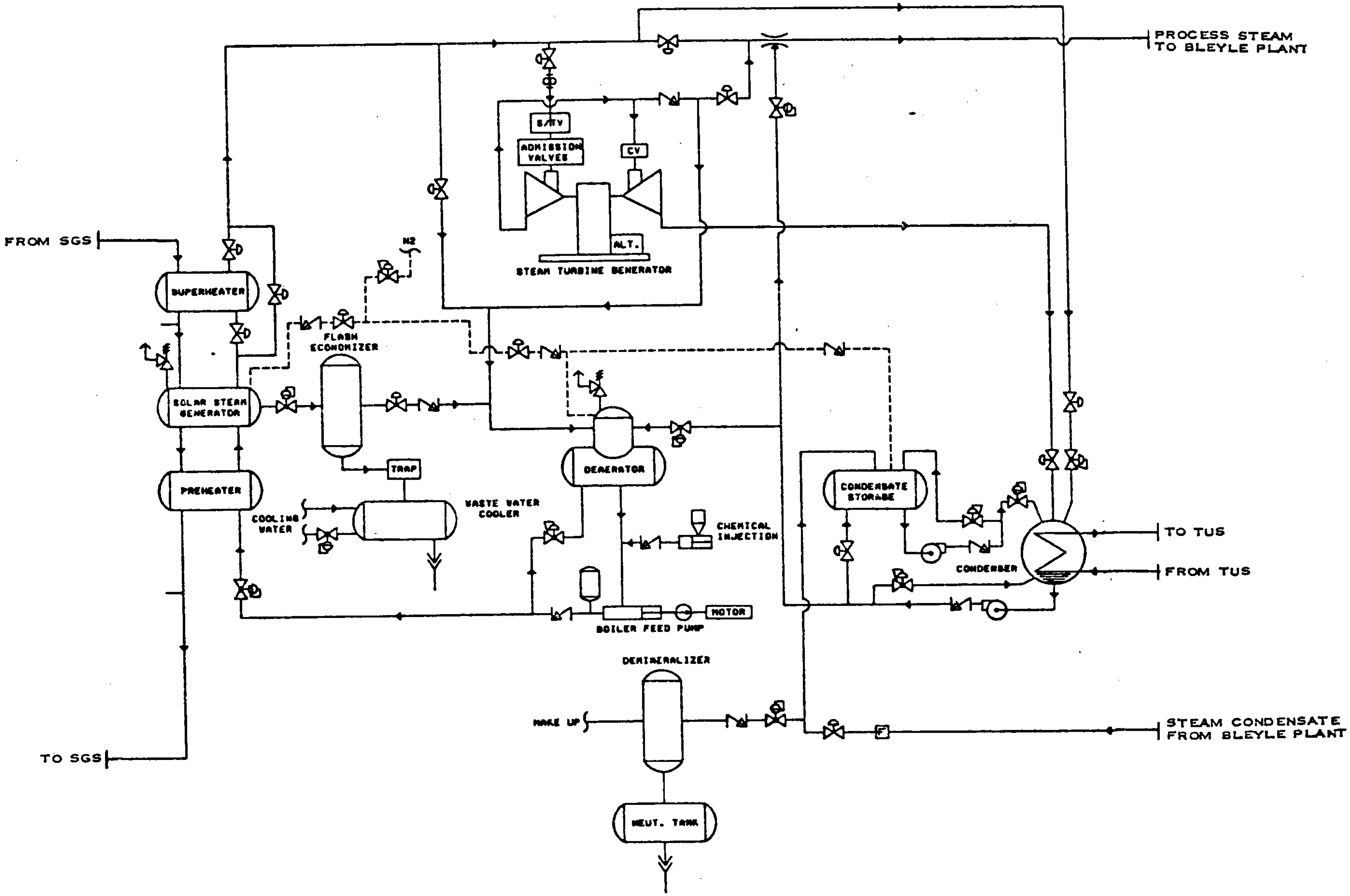


Figure 1.3.3. Power Conversion Subsystem (PCS) Flow Circuit

(230°F) to provide 372°K (210°F) water to the Thermal Utilization Subsystem. Steam make-up is preheated to 383°K (230°F) by being introduced as a spray into the condenser.

1.3.3 Thermal Utilization Subsystem

The Thermal Utilization Subsystem is shown schematically on Figure 1.3-4. The major components include low temperature water storage system, an absorption chiller derated to provide 174 tons with inlet hot water at 372°K (210°F), and two separate cooling towers for heat rejection from both the absorption chiller and the PCS condenser. The storage system is available to supply heating or cooling loads when the PCS is not operating such as at night or on weekends.

The full low temperature storage system capacity, sized for a 11°K (20°F) temperature differential, is contained in a single tank 9.8 meter (32 feet) in diameter by 6.1 meter (20 feet) high. The absorption chiller and cooling towers are standard off-the shelf items which will not require design modifications. The absorption chiller has self contained controls to sense load variations and will supply chilled water directly to the Bleyle Plant piping system. The system will have the capability to supply heating to the office areas and cooling to the plant process areas simultaneously.

1.4 SYSTEM OPERATION & CONTROL

The Control and Instrumentation Subystem (CAIS) design allows maximum operational flexibility of the LSE system. Six modes of operation are defined:

- Normal
- Experimental
- Diagnostic
- Fail Safe
- Degraded
- Maintenance

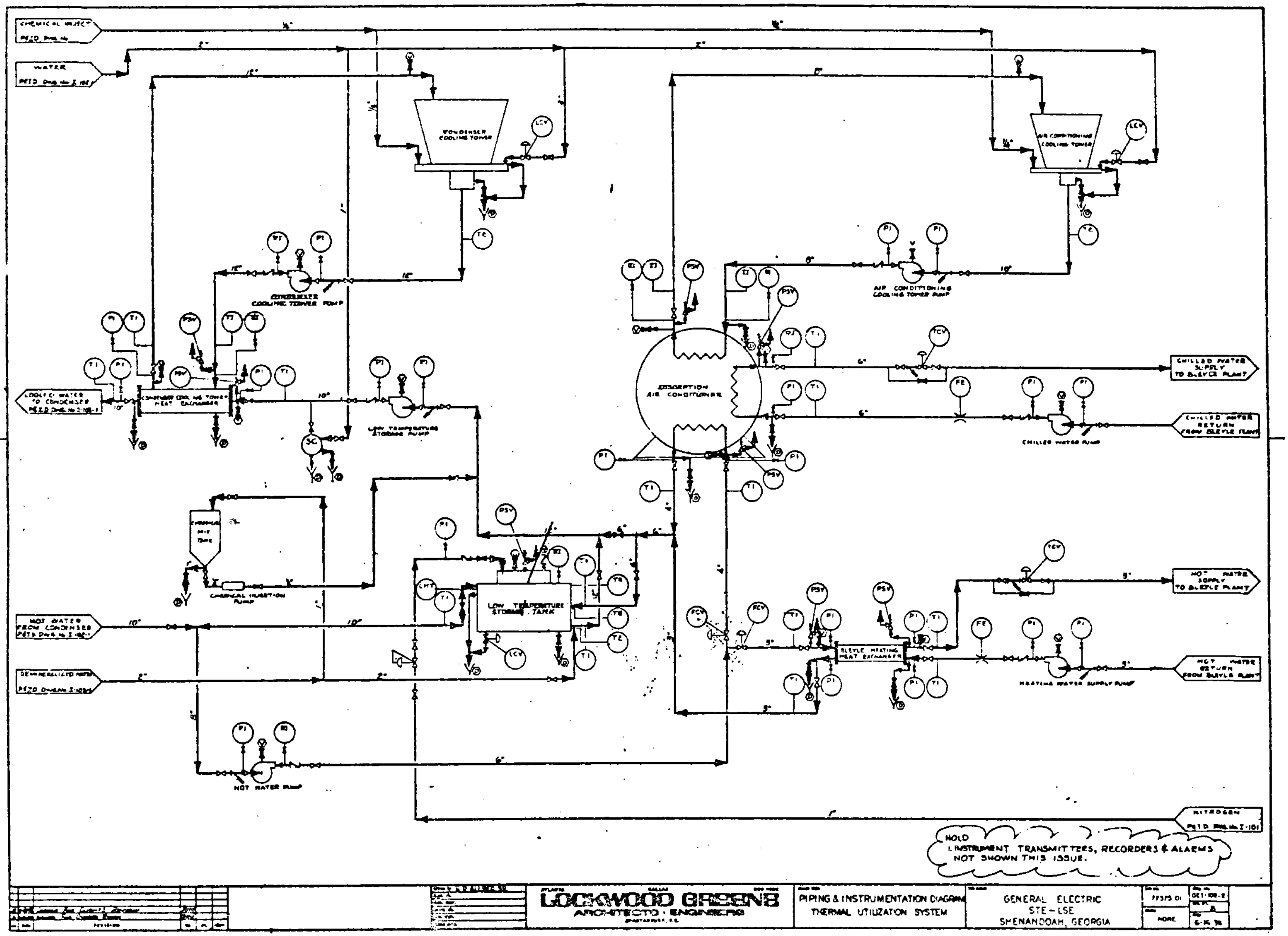


Figure 1.3-4. Piping & Instrumentation Diagram Thermal Utilization Subsystem

In the normal mode of operation, the control system will initiate collector tracking, energy storage, electrical power generation, air conditioning or heating, and record System Performance Evaluation Data. The electrical requirements of the Bleyle Plant will be monitored and sufficient power generated to supplement the base load supplied by Georgia Power Company. On weekends and during periods of lower power demand, thermal energy will be stored for later use.

A switch to alternate modes will allow the operator to initiate solar collection experiments, monitoring, and recording experimental data as needed. The operator may initiate computer stored diagnostic routines in the event of a malfunction. The critical components of the system are fail-safed to prevent damage during power or primary control failures or over temperature conditions. Finally, the system will be operational in a degraded mode when certain components, such as a collector branch, are not available due to routine maintenance or component failures.

Control of the solar collectors will be achieved via four micro-processor control units in the collector field. Coarse solar tracking will be provided by a computer controlled algorithm with fine tracking provided by an optical feedback control loop. The outlet temperature of the fluid at each receiver will be monitored and branch fluid flow rate adjusted to achieve the desired fluid temperature. Automatic defocus will activate should the fluid in any collector receiver exceed a safe temperature. Automatic stowing will actuate if necessary to protect a collector under adverse climatic conditions.

The high temperature thermal energy storage (HTS) subsystem will be carefully monitored with level and temperature sensors to determine charge and discharge readiness. The Syltherm™ 800 fluid will be routed according to the HTS status. Additionally, if the system is fully charged and no additional energy can be handled, collector stowage will automatically occur to prevent fluid over-temperature. A microprocessor control unit will interface with the central control console for the high temperature storage, power conversion, and thermal utilization subsystems.

The Power Conversion Subsystem incorporates the steam generation plant (boiler) and the steam turbine-generator. Semi-automatic start-up/shut-down sequences as well as built-in protection functions are an inherent part of this equipment. The electrical requirements of the knitwear factory will be monitored and generator output modulated according to need and operating mode.

Heat to the Thermal Utilization Subsystem is provided by means of a fluid coolant loop from the PCS condenser. The control system will provide coolant flow and temperature control to maintain the PCS condenser pressure. The absorption air conditioning and hot water heating system will respond to the requirements of the Bleyle Plant as well as the STES Mechanical Building.

The Control and Instrumentation Subsystem is comprised of a central control console, the central mini-computer, and five micro-processor control units and associated peripheral devices. The operator will have the capability to monitor and control basic system functions from the control panel. All other detailed monitored and controlled functions will be via the computer keyboard and CRT (Cathode Ray Tube) interface. Monitored data will be recorded from experiments, alarms, and normal operation on magnetic tape storage and in hard copy form on the computer line printer. Signal conditioning circuitry will be provided as needed in the remote control units. The remove micro-processors will be programmable from the central mini-computer to allow a high degree of system control and monitor flexibility.

1.5 SYSTEM PERFORMANCE

For the system design of 192 seven-meter diameter collectors and 1.05×10^{11} joule (100 MBTU) of high temperature storage capacity, direct solar contribution to the plant loads includes an estimated 33 percent of the annual electrical energy requirements, 62 percent of the process steam required, and 85 percent of the energy required to drive the absorption air conditioning system and 95 percent of the annual heating requirement.
If air conditioning is considered as part of the electric load, then STES provides fifty percent of the plant non-thermal loads while on solar operation. This results in an annual solar

replacement of 65 percent. Remaining low grade 372°K (210°F) thermal energy may be used to supply part of the hot water requirements for other nearby applications. On cloudy days, after solar energy is expended, the total energy system can be operated on the fossil heater. The system thus has the capability to supply the full plant loads on-site.

1.6 PROJECT SCHEDULE

The STE-LSE Project Schedule of Figure 1.6-1 defines the program phase schedules from Definitive Design thru system checkout and acceptance in February, 1982.

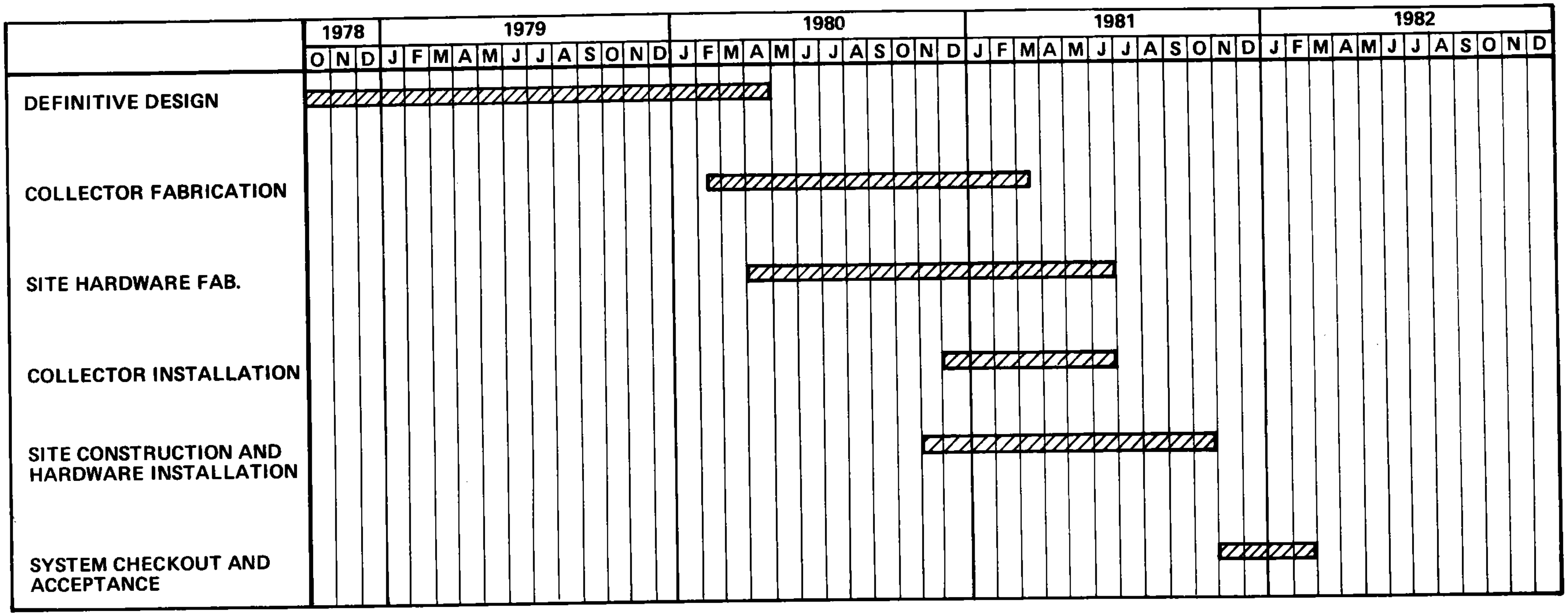


Figure 1.6-1. STE-LSE Program Schedule

CONSTRUCTION
INSTALLATION

2.0 CONSTRUCTION/INSTALLATION

2.1 CONTRACTOR DIVISION OF WORK

The construction of the Solar Total Energy-Large Scale Experiment system to be installed at Shenandoah, Georgia, has been separated into six major construction bid packages, defined by work type, as follows:

- Solar Collector Installation
- Site Work
- Solar Process Piping
- Mechanical Building
- Electrical
- Insulation

The following section provides a brief description of the scope of work, the costs necessary for the contractor to install the purchased parts, and the costs to procure and install the balance of the hardware for each bid package. The purchased parts, which are defined in Section 3, contain the tanks and active components in each of the (7) seven subsystems. A summary of contractor tasks within each of the six construction bid packages, is shown on Figure 2.1-1.

Purchased parts are supplied to the installing contractor at the Shenandoah installation site. The contractor is responsible for the handling of the purchased parts after they are delivered to the site.

2.1.1 COST BASIS

The Labor and Material costs developed were obtained by using standard construction estimating books. The following estimating books were used:

- Building Cost File, 1978 Eastern Edition (BCF)

TASK DESCRIPTION

<u>Solar Collector Installation</u>

- Base Assembly
    - Perform Welding and Bolting
    - Mount Brackets
    - Assemble Solar Axis Bearing Assembly
    - Align and Grout Base Assembly
    - Paint Base Assembly
- Yoke Support Installation
    - Mount Yoke Assembly on Base
    - Attach to Torque Tube
    - Install Jactuator & Couplings
    - Fabricate and Install Counterweight Assembly
- Reflector Assembly and Installation
    - Position Hub Assembly in Center of Assembly Area
    - Attach Ribs (21 Places)
    - Loosely Assemble Petals (21 Places)
    - Tighten Petals to Assembly
    - Install Annulus to Hub Assembly
    - Mount Receiver to Reflector Assembly Struts
    - Install Reflector to Yoke Assembly
    - Attach Reflector to Jachuator
- Place Collector in Stow Position - Manually

TASK DESCRIPTION

<u>Site Work:</u>

- Final Field Grading
- Installation of 192 Collector Foundation Assemblies
    - Excavation
    - Rebar Fabrication
    - Forming
    - Concrete Pouring
    - Form Removal
    - Dry Finish
- Install (2) FCE Foundations
- Drain Field Installation
    - Catch Basin Installation
    - Underground Pipe Installation
    - Oil-Water Separator Installation
- Meteorology Station Removal & Reinstallation on Mech Building Roof
- Fence Installation
- Collector Field Piping/Elec. Trench
    - Excavation
    - Trench Installation
- Collector Field Ground Cover
    - Sub Base Installation
    - Top Cont. Installation
- Collector Field Front Wall
    - Excavation
    - Foundation
    - Block Erection
- Gas Line Installation
    - Excavation
    - Pipe Installation
    - Backfill
- Water Line Installation
    - Excavation
    - Pipe Installation
    - Backfill
- Sewer Line Installation
    - Excavation
    - Pipe Line Installation
    - Backfill

Road and Parking Lot Installation

- Grading
- Curbs & Gutter Installation
    - Excavation
    - Form Erection
    - Concrete Pouring
    - Form Removal
    - Wet Finish
    - Backfill
- Sub-Base Installation
- Base Installation
- Top Coat Installation
- Landscaping
    - Final Contouring
    - Seeding

TASK DESCRIPTION

<u>Solar Process Piping and Plumbing:</u>

- High-Temperature Storage Tank Erection (4)
    - Tank Erection
    - Sparges Assembly/Installation
    - Leak Test
    - Tank Exterior Painting
- Fossil Fuel Heater
    - Del. Unit to Site
    - Erection of Base
    - Assembly of Stack
    - Gas Line Installation
- Low-Temperature Storage Tank Erection
    - Tank Erection
    - Leak Test
    - Pressure Test (ASME)
    - Tank Exterior Painting
- Solar Steam Generator Installation
    - Install S. G. Assembly onto Concrete Base
    - Align and Level Unit
    - Grout Unit
- Condenser Installation
    - Install Condenser onto Concrete Base
    - Align and Level Unit
    - Grout Unit
- Turbine-Generator Installation
    - Install T/G onto Support Base
    - Align and Level Unit
    - Check Shaft Run-out
    - Grout Unit
- Absorption Air Conditioner Installation
    - Install A/C onto Base
    - Align and Level Unit
    - Grout Base
- Excess Heat Cooling Tower Installation
    - Install Unit on Base
    - Align and Level Unit
- Air Conditioning Cooling Tower Installation
    - Install Unit on Base
    - Align and Level Unit
- Deaerator Installation
    - Install Unit on Base
    - Align and Level Unit
- Condensate Storage Tank
    - Install Unit on Concrete Base
    - Align and Level Unit
    - Grout Unit
- Chemical Storage Tank Installation
    - Neutral Storage
    - Acid Storage
    - Caustic Storage
- Air Compressor Installation
    - Install Unit on Concrete Base
    - Align and Level Unit
- Make-up Oil Tank Installation
    - Install Unit on Concrete Base
    - Align and Level Tank
- Nitrogen Storage System Installation
    - Place Unit in Location
    - Align and Secure
- Demineralizer Installation
    - Place Unit in Location
    - Align and Secure
- Chemical Injection System
    - Place Unit at Location
    - Align and Secure
- Pump Installation

    (Note) Install the Follqwing Pumps

    - Collector Field Oil Cir. Pumps (2)
    - High-Temp. Oil Cir. Pump
    - Syltherm Heater Oil Cir. Pump
    - Heat Storage Cir. Pump
    - Oil Fill Pump
    - BFW Pump
    - Chem. Injection Pump
    - Condensate Storage Pump
    - Condensate Pump
    - Hot Water Pump
    - Low-Temperature Storage Pump
    - Excess Heat Cooling Twr. Pump
    - Air Conditioning Cooling Twr. Pump
    - Hot Water System Chem. Ing. Pump
    - Chilled Water Pump
    - Heating Water Pump
    - Caustic Pump
    - Acid Pump
    - Install Pump on Base
    - Align/Level Pump
    - Grout Pump
    - Lubricate Bearing/Seal Housing
    - Install Pressure Gages
    - Install Check Valves
    - Install Suction Strainers
- Install Iron Ore in Storage Tanks
    - Screen to Remove Contaminates
    - Load Tanks
    - Collector Field Piping Installation
        - Route and Install E/W Supply/Return Pipes
            - Install Branch Tee's
            - Install Expansion Compensators
            - Fabricate/Install Pipe Anchors
        - Route and Install Branch Line
            - Install Modulating and On/Off Control Valves
            - Install Expansion Compensators
            - Fabricate/Install Tube Anchors
            - Perform Leak/Proof Tests
        - Route and Install Collector Piping
            - Install Flex Joints
            - Fabricate Tubing Assemblies
            - Install Tubing Assemblies
            - Leak Tests
        - High-Temperature Storage Piping Installation
            - Fabricate/Install HTS Tank Piping Manifolds
            - Install HTS Tank Selection Valves
            - Fabricate/Install HTS Piping to Fossil Fuel Heater
            - Fabricate/Install HTS Piping to Steam Generator
            - Fabricate/Install HTS Piping to Coll. Field Pumps
        - Steam Piping
            - Fabricate/Install Pipe from S.G. to T/G
            - Fabricate/Install Pipe from S.G. to Bleyle Plant
            - Fabricate/Install Pipe from T/G to Condenser
        - Hot Water Piping Installation
            - Fabricate/Install Pipe from Condenser to Cond. Pump
            - Fabricate/Install Pipe from Cond. Pump to Dearator
            - Fabricate/Install Pipe from Dearator to BFW Pump
            - Fabricate/Install Pipe from BFW Pump to S.G.
            - Fabricate/Install Pipe from LTS Tank to Cond.
            - Fabricate/Install Pipe from Cond. to LTS Tank
            - Fabricate/Install Pipe from LTS to Air Cond.
            - Fabricate/Install Pipe from Air Cond. to LTS Tank
            - Fabricate/Install Pipe from LTS to Excess Heat C.T.
            - Fabricate/Install Pipe from Excess Heat C.T. to LTS Tank
        - Chilled Water Piping Installation
            - Fabricate/Install Pipe from Air Cond. to Building A.H.
            - Fabricate/Install Pipe from Building A.H. to Air Cond.
            - Fabricate/Install Pipe from Air Cond to Bleyle Plant
            - Fabricate/Install Pipe from Bleyle to Air Cond.
        - Leak/Proof Test All Piping Assemblies
        - Fill System with 16,000 gallons of Syltherm 800 Fluid

TASK DESCRIPTION

<u>Mechanical Building:</u>

- Site Preparation
    - Grading and Leveling
    - Trenching and Footing Excavation
    - Form Work
    - Concrete Pouring
- Concrete Slab Installation
    - Form Work
    - Rebar Reinforcement
    - Tank Footing Excavation
    - Rebar Reinforcement
    - Equipment Footing Excavation
    - Concrete Pourings (4-5)
    - Oil Containment Curb Installation
    - Form Removal
    - Back Grading
- Building Wall Erection
    - Concrete Block
    - Brick Facing
- Roof Installation
    - Steel Installation
    - Metal Deck Installation
    - Insulation Installation
    - Roof Membrane Installation
- Interior Work
    - Interior Walls and Door
    - Dry Wall Installation
- Building Electrical
- Building Mechanical
    - HVAC
    - Pumping
- Interior Finishing
    - Wall Painting
    - Raised Floor in Control Room
    - Floor Covering
    - Acoustical Ceiling
    - Projection Screen Installation

TASK DESCRIPTION

<u>Insulation Subcontract:</u>

- Tank Insulation
    - High-Temperature Storage Tanks
    - Low-Temperature Storage Tank
    - Condensate Storage Tank
- Component Insulation
    - Absorption Air Conditioner
    - Pipe Specialties
    - Control Valves
    - Bleyle Heating Heat Exchanger
    - Pumps (20)
- Pipe Insulation Installation
    - Collector Field Piping
    - Collector Piping
    - HTS Piping
    - LTS Piping
    - PCS Piping
    - TUS Piping
    - Hot Water Supply/Return Piping
    - Chilled Water Supply/Return Piping

TASK DESCRIPTION

<u>Electrical Subcontract:</u>

- Main Power Installation
    - Install Auxiliary Generator
    - Install Transformer and Breaker Assembly
    - Install Motor Control Center
    - Install Switchboard
    - Wire T/G Panel to Sw. Relay Control
    - Wire Power to Building Facilities Distribution Center
    - Wire Auxiliary Generator to Switching Relay Panel
    - Wire Power Equipment to Switchboard
- Control Center Installation
    - Install Main Control Panel
    - Computer Installation
    - Printer Installation
- Collector Field Elec. Installation
    - Install Collector Grounding System
    - Install Collector Control Unit (CCU)at Each Collector
    - Install Field Control Enclosure (FCE) (2 Ea.)
    - Install Collector to CCU Cables
        - Motor Drives
        - Position Potentiometers
        - Receiver Instrumentation
        - Optical Control
    - Install Wireways/Conduit in Collector Field
    - Wire Control Valves to Field Control Boxes
    - Wire Field Control Boxes to Control Room
- Install Wireways/Conduit in Mechanical Area
- Motor Electrical Installation
    - Install Motor Disconnects
    - Wire Motor Starters to Control Room
    - Wire Motor Starters to Motors/Motor Disconnects
- Wire Control Valves to Control Room
    - HTS Subsystem
    - LTS Subsystem
    - PCS Subsystem
    - Thermal Utilization Subsystem
- Instrumentation Installation
    - Sensor Installation
        - Pressure
        - Temperature
        - Flow
        - Pyronometers
        - Pyroheliometers
    - Wire Sensors to Control Room
- Control Room Wiring
    - Interconnect Control Console to Distribution Panel
    - Interconnect Control Console to Computer Input Terminal
- Wire Fossil Fuel Heater to Control Panel
- Interconnect Turbine/Generator Panel to Control Room

Figure 2.1-1. Summary of Contractor Tasks

- Current Construction Costs, 1978 15th Edition (CCC)
  Lee Saylor, Inc.
- Building Construction Cost Data, 1978 (BCC)
  36 Edition
  R. S. Means Co.

The cost as defined in the site subcontracts were obtained from the above referenced estimating manuals. In each of the manuals cost are based on slightly different base lines and, therefore, are not directly related to each other, but are very close. The BCF are based on Philadelphia wages and materials that were projected as of May 31, 1978. The manual then gives a composite adjustment for the Atlanta, GA area of 87.0%. The BCC costs are based on labor and material cost averaged from 30 major U.S. cities that were in effect on January 1, 1978. The manual then defines a city cost index for major cities. The index for Atlanta, GA is 90.9%. The CCC cost data are based on average of major population areas using prevailing union rates.

The site subcontracts cost are adjusted for the Atlanta, GA area, by adjusting the BCF and BCC cost to 89%. No adjustment is made to the CCC data.

The Building Cost File was used for the majority of the solar process piping installation work. The Building Construction Cost Data was used for the mechanical building installation. The Current Construction Cost data was used in general for the site work.

Several estimating books were required because no single estimating book contained cost estimates for all of the construction tasks. The Building Cost File book is mainly process orientated and lends itself to the solar process piping installation. The Building Construction Cost Data book is mainly a building and facility orientated data source and lends itself to the mechanical building and facility work. The Cost Sheets define the cost source and the Uniform Construction Index (UCI) number. The UCI allows for cross checking of cost data and will allow for updating when additional data is available.

The design that has been costed is that defined in the Phase IV Design Review No. 1 (November, 1978). A level-of-definition factor has been applied to take into account the level to which each subsystem definition has progressed. This level-of-definition allows for the addition of components that may be necessary to support the present design. It does not allow for a major design change to the subsystem/construction bid package. Some material cannot be defined in detail at this time and, therefore, needs to be estimated. The level-of-definition factor will cover items which will be necessary to construction and installation but have not been identified due to the less than finalized nature of the design. As the details of the design proceed through definitive design, this factor will become unity. The level-of-definition factor varies from a high of 2.0 (100%) to a low of 1.05 (5%) for the design as costed.

The estimated cost is presented in 1978 construction dollars with the contractor's estimated overhead and profit included.

SOLAR COLLECTOR
INSTALLATION

2.2 SOLAR COLLECTOR INSTALLATION

The work included in this section consists of Installation of the Solar Collector Assemblies. The installation of foundations are included in the Site Work bid package and are available for base installation.

The installation of a collector will involve the assembly of the base structure, installation of the yoke assembly onto the base, assembly and installation of the dish and receiver onto the yoke assembly, mounting of jackscrew gearmotor assemblies, fabrication and installation of the counterweight.

The collector base assembly will be supplied to the installation contractor in prefabricated weldments. The weldments will be shop painted except for the ends of the weldments that require field welding.

The Yoke Assembly will be supplied to the installation contractor fully fabricated and painted.

The yoke will be mounted to the base assembly by bearing assemblies, supplied to the contractor. The Reflector Assembly will be supplied to the installing contractor completely disassembled. The assembly must be performed in a flat area, next to the collector field. The hub, ribs, and petals are assembled by bolting together. The receiver is mounted to the dish assembly by 3 support legs that attach through the petals and into the ribs. The jackscrew and gearmotor assemblies are provided to the installing contractor for mounting on the Base and Yoke Assemblies. The Dish Assembly is mounted on top of the Yoke Assembly, by using a dish lifting fixture supplied by G.E. The counterweight, which is comprised of a concrete block with "J" bolts installed, is supplied by the installing contractor.

Collector Field Construction
Subsystem/Subcontract

2/16/78
Date

ITEM NO.	TASK DEFINITION	UCI REF.	LABOR INDEX	QUANT.	$/UNIT	INSTAL. COST/ UNIT	TOTAL
1.	Base Assembly	N/A	B. C. F.	192	N/A	1282.45	246,230.00
2.	Reflector Assembly	N/A	B. C. F.	192	N/A	793.47	152,346.00
3.	Reflector Mounting	N/A	B. C. F.	192	N/A	232.99	44,734.00
4.	Piping Mat'l. & Install'n.	N/A	B. C. F.	192	844	575.00	272.448.00
5.	Counter w't. Fabrication	N/A	Est.	192	$80.00	Incl.	15,360.00
						Total	$731,118.00
						Atlantic Area Cost Modifier (.89)	650,695.00
						Level of Definition Factor 1.1	715,764.00

Collector Installation Costs

2/16/79

Labor Information Based on 1978 Building Cost File (Eastern Edition)

Collector Installation Cost Formula:

Crew Hours x 1.23 Productivity Factor x Crew Rate x 1.25 OH&P = Total

Crew Designation - A

1/2 Foreman	16.58/2 −	8.29
2 Ironworkers	15.58x2 −	31.16
1 Laborer	9.94 −	9.94
1 Welder	15.58 −	15.58
1/2 Operating Eng.	14.26/2 −	7.13
1/2 Oiler	11.85/2 −	5.92
1/2 Crane	29.32/2 −	14.66
		$92.68 = Crew Rate

Crew Designation - B

1/2 Foreman	16.58/2 −	8.29
2 Sheet Metal Wrk'rs.	16.17x2 −	32.34
1 Mechanic	13.94 −	13.94
1 Helper	9.94 −	9.94
		$64.51 = Crew Rate

Crew Designation - C

1/2 Forman	16.58/2 −	8.29
1 IronWorker	15.58 −	15.58
2 Mechanics	13.94x2 −	27.88
1/2 Operating Eng.	14.26/2 −	7.13
1/2 Oiler	11.85/2 −	5.92
1/2 Crane	29.32/2 −	14.66
		$79.46 = Crew Rate

CPM Activity No.	Activity	Duration Hrs/ Crew	Crew Design'tn	Rate	Total
250 & 260	Assemble, Mount & Weld Base	3	A	92.68	278.04
268	Level & Grout Base	1	A	92.68	92.68
279	Paint Base	1	A	92.68	92.68
261 & 301	Mount Yoke & Align Brgs.	1	A	92.68	92.68
311	Mount Drive Mech.	2	A	92.68	185.36
318	Mount Cwt.	1	A	92.68	92.68
	Subtotal for Base Assy. 834.12 x 1.23 x 1.25 = $1282.45				
262 & 269	Position Hub & Attach Ribs	1	B	64.51	64.51
275 & 286	Assemble Petals & Bolt to Ribs	4	B	64.51	258.04
293, 320 329	Drill Hub & Bolt Annulus	1	B	64.51	64.51
319, 328 341	Assemble & Attach Receiver & Sling	2	B	64.51	129.02
	Subtotal for Reflector Assy. 516.08 x 1.23 x 1.25 = $793.47				
350	Mount Reflector to Base	2	C –	75.77	151.54
	Subtotal for Reflector Mtg. 151.54 x 1.23 x 1.25 = $232.99				

– Pipe insulator labor rate – 14.02 x 1.23 x 1.25 = $21.55 (Ref. B.C.F. xxiii)

2.2 SOLAR COLLECTOR INSTALLATION

The work included in this section consists of Installation of the Solar Collector Assemblies. The installation of foundations are included in the Site Work bid package and are available for base installation.

The installation of a collector will involve the assembly of the base structure, installation of the yoke assembly onto the base, assembly and installation of the dish and receiver onto the yoke assembly, mounting of jackscrew gearmotor assemblies, fabrication and installation of the counterweight.

The collector base assembly will be supplied to the installation contractor in prefabricated weldments. The weldments will be shop painted except for the ends of the weldments that require field welding.

The Yoke Assembly will be supplied to the installation contractor fully fabricated and painted.

The yoke will be mounted to the base assembly by bearing assemblies, supplied to the contractor. The Reflector Assembly will be supplied to the installing contractor completely disassembled. The assembly must be performed in a flat area, next to the collector field. The hub, ribs, and petals are assembled by bolting together. The receiver is mounted to the dish assembly by 3 support legs that attach through the petals and into the ribs. The jackscrew and gearmotor assemblies are provided to the installing contractor for mounting on the Base and Yoke Assemblies. The Dish Assembly is mounted on top of the Yoke Assembly, by using a dish lifting fixture supplied by G.E. The counterweight, which is comprised of a concrete block with "J" bolts installed, is supplied by the installing contractor.

Collector Field Construction
Subsystem/Subcontract

2/16/78
Date

ITEM NO.	TASK DEFINITION	UCI REF.	LABOR INDEX	QUANT.	$/UNIT	INSTAL. COST/ UNIT	TOTAL
1.	Base Assembly	N/A	B. C. F.	192	N/A	1282.45	246,230.00
2.	Reflector Assembly	N/A	B. C. F.	192	N/A	793.47	152,346.00
3.	Reflector Mounting	N/A	B. C. F.	192	N/A	232.99	44,734.00
4.	Piping Mat'l. & Install'n.	N/A	B. C. F.	192	844	575.00	272.448.00
5.	Counter w't. Fabrication	N/A	Est.	192	$80.00	Incl.	15,360.00
						Total	$731,118.00
						Atlantic Area Cost Modifier (.89)	650,695.00
						Level of Definition Factor 1.1	715,764.00

Collector Installation Costs

2/16/79

Labor Information Based on 1978 Building Cost File (Eastern Edition)

Collector Installation Cost Formula:

Crew Hours x 1.23 Productivity Factor x Crew Rate x 1.25 OH&P = Total

Crew Designation - A

1/2 Foreman	16.58/2 −	8.29
2 Ironworkers	15.58x2 −	31.16
1 Laborer	9.94 −	9.94
1 Welder	15.58 −	15.58
1/2 Operating Eng.	14.26/2 −	7.13
1/2 Oiler	11.85/2 −	5.92
1/2 Crane	29.32/2 −	14.66
		$92.68 = Crew Rate

Crew Designation - B

1/2 Foreman	16.58/2 −	8.29
2 Sheet Metal Wrk'rs.	16.17x2 −	32.34
1 Mechanic	13.94 −	13.94
1 Helper	9.94 −	9.94
		$64.51 = Crew Rate

Crew Designation - C

1/2 Forman	16.58/2 −	8.29
1 IronWorker	15.58 −	15.58
2 Mechanics	13.94x2 −	27.88
1/2 Operating Eng.	14.26/2 −	7.13
1/2 Oiler	11.85/2 −	5.92
1/2 Crane	29.32/2 −	14.66
		$79.46 = Crew Rate

CPM Activity No.	Activity	Duration Hrs/ Crew	Crew Design'tn	Rate	Total
250 & 260	Assemble, Mount & Weld Base	3	A	92. 68	278. 04
268	Level & Grout Base	1	A	92. 68	92. 68
279	Paint Base	1	A	92. 68	92. 68
261 & 301	Mount Yoke & Align Brgs.	1	A	92. 68	92. 68
311	Mount Drive Mech.	2	A	92. 68	185. 36
318	Mount Cwt.	1	A	92. 68	92. 68
	Subtotal for Base Assy. 834. 12 x 1. 23 x 1. 25 = $1282. 45				
262 & 269	Position Hub & Attach Ribs	1	B	64. 51	64. 51
275 & 286	Assemble Petals & Bolt to Ribs	4	B	64. 51	258. 04
293, 320 329	Drill Hub & Bolt Annulus	1	B	64. 51	64. 51
319, 328 341	Assemble & Attach Receiver & Sling	2	B	64. 51	129. 02
	Subtotal for Reflector Assy. 516. 08 x 1. 23 x 1. 25 = $793. 47				
350	Mount Reflector to Base	2	C -	75. 77	151. 54
	Subtotal for Reflector Mtg. 151. 54 x 1. 23 x 1. 25 = $232. 99				

– Pipe insulator labor rate - 14. 02 x 1. 23 x 1. 25 = $21. 55 (Ref. B. C. F. xxiii)

SITE WORK

2.3 SITE WORK

SCOPE:

The work included in this section consists of preparing the collector field for collector and piping installation, performing final grading and installation of a roadway from Amlajack Blvd, installation of underground services to the mechanical building area, removal of the meteorology station, and erection of fence and wall around property line.

The collector field preparation work will include the following tasks:

- Installation of 192 collectors foundation of 20'' dia. imbedded area and 18'' dia. above grade area. The rear cassions (2) will be 14'-3'' imbedded length and the front cassion will be 18' imbedded length. Each cassion foundation will be 5' above grade level. A W6x15 wide flange triangular structure will be placed on top of the cassions and interface with the collector base.
- 620' collector field east-west trenchway through center of field for installation of piping and electrical service from mechanical building to collector branches.
- Installation of collector drainfield containing 20 catch basins and terminating into one catch basin containing an underground oil water separator.
- Installing an asphalt pavement in the collector field, 3'' sub-base with 3'' finished asphalt cover. Area to be covered 150,000 sq. ft.

At the completion of the above tasks the collector field will be ready for collector installation, with piping and electrical installation work to follow the collectors. Those tasks are part of another section and will be covered in the applicable section.

The final grading and installation of a roadway will include the following tasks:

- Installation of 27,000 ft^2 of roadway. Consisting of 10'' sub-base, 8'' base, and 3'' top coat of asphalt.
- Installation of 1500 ft of combination curb and gutter.

The installation of underground services to the mechanical building consists of the following tasks:

- Sewer line installation of 350 ft of 6'' diameter clay pipe, plus 1 man-hole, with tie-in to existing sewer line at North West property line.
- Gas line installation of 1000 ft of 2'' pipe from Amalajack Blvd. to mechanical building area.

- Water line installation of 900 ft of 2" pipe from Amalajack Blvd. to mechanical building area.

The distribution of these services within the mechanical building will be done in the mechanical building task contained in another section.

The perimeter fence and wall erection will consist of the following tasks:

- Installation of 1650 ft of 6' high chain link fence containing 4 personnel access gates and 1 double gate 12 ft wide.
- Erection of a 5 ft high cinder block wall 500 ft long and containing 8 gates 10 ft wide.

2.3.1 COLLECTOR FIELD FOUNDATION LAYOUT

The contractor shall be responsible for the siting and construction of all collector foundations. The foundations shall be constructed in accordance with Lockwood Greene Drawing GE-1.

Foundation layout shall be in accordance with standard surveying practices. Field boundaries shall be in accordance with the Lowe Engineering Survey of March 24, 1978 and shown on interface drawing S-3. Reference markers for determining solar easement setback on adjacent properties shall be placed in accordance with Exhibit D of the Solar Easement Agreement between Georgia Power and Shenandoah Development, Inc. and shown on interface drawing S-5. Rows of collectors will generally run north to south parallel to the boundary. The placement schedule for all collector and the height of each of the footing groups is given on drawing GE-S-1.

Specification of the collector position on this drawing applies to the front foot of each collector as defined on GE drawing 919E105. Angular orientation of each of the footings will be with respect to true north and not with respect to the boundaries. Slight collector structure alignment corrections after installation can be made by rotation about the verticle axis within the limits of the mounting holes and by selective shims under the mounting feet. Such adjustments are not anticipated on initial installation but are available in the event that settlement of the foundation becomes a problem at some future time.

Site Work Subcontract
Subsystem/Subcontract

12/4/78
Date

ITEM NO.	TASK DEFINITION	UCI REF.	LABOR INDEX	QUANT.	$/UNIT	INSTAL. COST/ UNIT	TOTAL
1.	Road Installation	2.6114	C.C.C	27,000 SF	.77	.53	$ 35,100
2.	Curb & Gutter Installation	2.6621	C.C.C.	1,500 LF	2.79	2.11	7,350
3.	Sewer Line Installation	2.5282	C.C.C.	350 LF	2.65	6.90	3,343
4.	Manhole Installation	5.5414	C.C.C.	1 EA.	184.31	122.28	307
5.	Gas Line Installation	2.5416	C.C.C.	1,000 LF	2.17	2.61	4,780
6.	Water Line Installation	2.5416	C.C.C.	900 LF	2.17	2.61	4,302
7.	Storm Sewer Installation						
	Catch Basins	02556.0303	B.C.F.	20 EA.	206.00	115.00	6,420
	3" ABS Drain Pipe	2.5262	C.C.C.	1,500 LF	2.85	2.43	7,920
	6" ABS Drain Pipe	2.5264	C.C.C.	500 LF	6.51	3.36	4,935
8.	Oil/Water Seperator Installation	15320.2250	B.C.F.	1 EA.	2546.00	261.00	2,807
9.	Met. Station Demolition	02113.0200	B.C.F.	264 CF	N/A	3.64	961
10.	Fence Installation						
	6 Ft. Chain Link Fence	02712.0106	B.C.F.	1,650 LF	8.18	5.03	21,796
	Gates	02712.3106	B.C.F.	6 EA.	13.93	8.65	135
11.	Collector Foundations						
	a) Augering	02302.0136	B.C.F.	8,928 LF	N/A	8.22	73,388
	b) Forming						
	18" Diameter	03128.0118	B.C.F.	2,880 LF	1.72	1.62	9,619
	c) Reinforcement						
	#6 Rebar	03216.1103	B.C.F.	88.9 T	425.00	213.00	56,718
	d) Concrete	03311.0200	B.C.F.	896.6 CY	35.29	14.49	44,632
	e) Anchor Bolts	02415.0102	B.C.F.	576 EA	2.20	1.65	2,217
	f) Structure Steel	05121.0700	B.C.F.	61.92 T	982.00	774.81	108,781
	g) Rub Finish			15170 Ft^2	.06	.75	12,288
12.	Collector Field Trenchway	Phone Quote		620 LF	30.00	N/A	18,600 – GP. #82,500
13.	Collector Field Paving	2.6311	C.C.C.	150,000 SF	.95	Incl.	142,500
14.	Front Wall						
	Conc. Block Wall (5'x500')	4.2213	C.C.C.	2,500 SF	1.88	2.01	9,725

yard fire $20,000 | GP
" lighting $32,000

Site Work Subcontract
Subsystem/Subcontract

12/4/78
Date

ITEM NO.	TASK DEFINITION	UCI REF.	LABOR INDEX	QUANT.	$/UNIT	INSTAL. COST/ UNIT	TOTAL
14. cont'd.	Gates	2.7123	C.C.C.	8 EA.	322.31	241.54	4,510
						Total	583,314
						Altanta Area Adjustment (.89) (366,618)	542,986
						Level of Definition Factor 1.05	570,135

PROCESS PIPE

2.4 SOLAR PROCESS PIPING

The work included in this section is comprised of the installation of all process piping components except the high temperature storage tanks, they will be installed by the tank fabricator. The process piping contractor will install the iron ore medium in the tanks after the tanks have been installed, tested and cleaned. All piping, valves, expansion compensators, drains, strainers, filters, pressure gages, line instrumentation, and thermometers will be installed by the piping contractor. The contractor will be responsible for the installation of all pipe, pipe supports, guides and anchor. Foundations and piping support beams will be installed as part of the Site Work Subcontract.

The purchased parts that are supplied to the contractor will be made available to the contractor at a warehouse staging area within a 10 mile radius of the site. It will be the responsibility of the contractor to obtain the equipment from the warehouse and deliver it to the job site. The contractor will be responsible for the care and maintenance of the equipment while it is in his possession.

Solar Process Piping (SCF)
Subsystem/Subcontract

12/5/78
Date

ITEM NO.	TASK DEFINITION	UCI REF.	LABOR INDEX	QUANT.	$/UNIT	INSTAL. COST/ UNIT	TOTAL
1.	Tubing -3/8"	15054.0103	B.C.F.	3055 FT	1.03	2.01	9,287.00
	-3/4"	15054.0106	B.C.F.	6450 FT	1.96	2.58	29,283.00
	-1"	15054.0108	B.C.F.	3055 FT	2.32	2.47	14,633.00
	-1 1/2"	15054.0112	B.C.F.	122 FT	3.74	2.72	788.00
	-2"	15054.2116	B.C.F.	122 FT	5.46	3.40	1,080.00
	-2 1/2"	15068.0120	B.C.F.	182 FT	5.89	3.43	1,696.00
	-3 1/2"	15068.0128	B.C.F.	304 FT	9.55	4.56	4,289.00
	-4 1/2"	15068.0205	B.C.F.	687 FT	27.70	8.56	24,910.00
2.	Air Piping-Stl. -1 1/2"	15053.0112	B.C.F.	600 FT	1.95	3.40	3,210.00
	-1"	15053.0108	B.C.F.	4300 FT	1.26	2.72	17,114.00
3.	Globe Valves -1/4"	15106.	Eng. Est.	404 EA	40.00	4.00	17,776.00
	-1 1/2"	15106.	Eng. Est.	120 EA	150.00	8.10	18,972.00
4.	Strainers -1 1/2"	15081.0112	B.C.F.	40 EA	14.25	24.21	1,538.40
5.	Exp. Compensators -3/4"	15162.0106	B.C.F.	122 EA	25.06	16.10	5,021.50
	-1"	15162.0108	B.C.F.	70 EA	39.36	24.28	4,454.00
	-1 1/2"	15162.0112	B.C.F.	4 EA	80.88	32.21	452.00
	-2"	15162.0116	B.C.F.	2 EA	116.00	48.35	328.00
	-2 1/2"	15162.0120	B.C.F.	4 EA	157.00	65.13	888.52
	-3 1/2"	15162.0204	B.C.F.	4 EA	399.00	152.00	2,204.00
	-4 1/2"	15162.0205	B.C.F.	12 EA	480.00	192.00	8,064.00
						Subtotal	165,987.00

Solar Process Piping Contract
Subsystem/Subcontract

2/15/79
Date

ITEM NO.	TASK DEFINITION	UCI REF.	LABOR INDEX	QUANT.	$/UNIT	INSTAL. COST/ UNIT	TOTAL
SCS 1	Solar Collectors	N/A	N/A	192 ea.	N/A	See Collector Field	- - -
HTS 1	Collector Field Pump	15711. 0415A	B. C. F.	2 ea.	2,500.00	578.00	6,156
HTS 2	Collector Fluid	N/A	N/A	17,000 gal	20.00	N/A	340,000.00
SCS 2	Control Valves (Modulating)	15124. 0204A	B. C. F.	20 ea.	1,300.00	129.00	28,580.00
SCS 3	Control Valves (on/off)	15124. 0204A	B. C. F.	20 ea.	800.00	129.00	18,580.00
SCS 4	Isolation Valves	15106. 0103A	B. C. F.	384 ea.	52.00	4.03	21,515.00
HTS 3	Large HTS Tank	Quote	N/A	3 ea.	86,314.00	Incl.	258,942.00
HTS 4	Small HTS Tank	Quote	N/A	1	48,843.00	Incl.	48,843.00
HTS 5	Oil Vapor Condensing Tank	15. 65. 20	Means	1	155.00	40.00	195.00
HTS 6	Make-up Oil Storage Tank	15. 65. 20	Means	1	780.00	105.00	885.00
HTS 7	Iron Ore Storage Medium	N/A	Est.	1147 T	75.00	25.00	114,700.00
HTS 8	Oil Fill Pump	15712. 1508E	B. C. F.	1	783.00	248.00	1,031.00
HTS 9	HTS Transfer Pump	15711. 0415E	B. C. F.	1	2,500.00	578.00	3,078.00
HTS 10	Steam Generator Supply Pump	15711. 0415E	B. C. F.	1	2,500.00	578.00	3,078.00
HTS 11	Fossil Fired Heater	16533. 0440E	B. C. F.	1	200,000.00	2,000.00	202,000.00
SCS 5	Collector Field Trim Valves	15122. 0106A	B. C. F.	14 ea.	800.00	129.00	13,006.00
HTS 12	Nitrogen Regulation Valve	15122. 0108A	B. C. F.	1	172.00	24.04	196.00
HTS 13	Condensable Back Pressure Valve	15122. 0104A	B. C. F.	1	165.00	16.17	181.00
HTS 14	Nitrogen Storage System	15443. 0110A	B. C. F.	1	1,803.00	199.00	2,002.00
HTS 15	Tank Selection Valve (C. F. Return)	15122. 0205A	B. C. F.	4	1,828.00	195.00	8,092.00
HTS 16	Tank Selection Valve (Stm. Gen. Ret)	15122. 0204A	B. C. F.	4	1,828.00	131.00	7,836.00
HTS 17	Stm. Gen. Ret. Selector Valve	15122. 0205A	B. C. F.	4	1,828.00	195.00	8,092.00
HTS 18	Fossil Fuel Htr. Supply Select Valve	15122. 0205A	B. C. F.	2	1,828.00	195.00	4,046.00
HTS 19	Fossil Fuel Htr. Ret. Select. Valve	15122. 0205A	B. C. F.	3	1,828.00	131.00	7,836.00
HTS 20	Collector Field Pump Select. Valve	15122. 0205A	B. C. F.	2	1,828.00	195.00	4,046.00
HTS 21	Collector Field Pump By-Pass Valve	15122. 0205A	B. C. F.	1	2,346.00	195.00	2,541.00
HTS 22	Tank Select. Valve(Stm. -Gen. Supply)	15122. 0205A	B. C. F.	4	1,828.00	195.00	8,092.00
HTS 23	Tank Selection Valve (Collector Field Supply)	15122. 0205A	B. C. F.	4	1,828.00	195.00	8,092.00

Solar Process Piping Contract
Subsystem/Subcontract

2/15/79
Date

Cont'd.

ITEM NO.	TASK DEFINITION	UCI REF.	LABOR INDEX	QUANT.	$/UNIT	INSTAL. COST/ UNIT	TOTAL
HTS 24	Energy Stg. Cir. Pump Trottle Valve	15122.0204A	B. C. F.	1	2,512.00	131.00	1,959.00
HTS 25	Cir. Pump Discharge Tank Select. Valve	15122.0204A	B. C. F.	4	1,828.00	131.00	7,836.00
HTS 26	Cir. Pump Suction Tank Select. Valve	15122.0205A	B. C. F.	4	1,828.00	195.00	8,092.00
HTS 27	Stg. Tank Flow Control Valves	15122.0116A	B. C. F.	8	4@ 2,000.00	195.00	8,780.00
					4@ 1,000.00	39.85	4,159.00
						Subtotal	
						49,519.00	

Solar Process Piping (HTS)
Subsystem/Subcontract

2/15/79
Date

ITEM NO.	TASK DEFINITION		UCI REF.	LABOR INDEX	QUANT.	$/UNIT	INSTAL. COST/ UNIT	TOTAL
1.	Gate Valves	-1" Threaded	15.1.2100	C.C.C.	11	19.80	12.69	357.00
		-2" Threaded	15103.0116	B.C.F.	3	140.00	11.89	455.00
		-4" Flanged	15104.0204	B.C.F.	5	253.00	129.00	1,910.00
		-4 1/2" Flanged	15104.0205	B.C.F.	4	401.00	191.00	2,368.00
		-5" Flanged	15104.0205	B.C.F.	1	401.00	191.00	592.00
2.	Check Valves	-1" Threaded	15110.0108	B.C.F.	6	20.77	4.92	154.14
		-2" Threaded	15110.0116	B.C.F.	1	87.03	23.82	110.85
		-4" Threaded	15111.0204	B.C.F.	2	188.00	127.00	630.00
		-4 1/2" Threaded	15111.0205	B.C.F.	3	308.00	199.00	1,497.00
		-5" Threaded	15111.0205	B.C.F.	1	308.00	199.00	507.00
3.	Strainers	-1" Threaded	15081.0108	B.C.F.	1	8.87	16.10	25.00
		-2" Threaded	15081.0116	B.C.F.	1	24.08	32.21	56.00
		-4" Threaded	15081.0204	B.C.F.	3	212.00	128.00	1,020.00
		-4 1/2" Flanged	15081.0305	B.C.F.	2	321.00	191.00	1,024.00
		-5" Flanged	15081.0305	B.C.F.	2	321.00	191.00	1,024.00
4.	Pressure Gauges		-	Est.	23	50.00	10.00	1,380.00
5.	Thermometers		-	Est.	10	50.00	10.00	600.00
6.	Pressure Relief Valves		15125.0216	B.C.F.	7	69.73	31.61	709.30
7.	Sch. 40, Stl. Pipe-2" Threaded		15053.0116	B.C.F.	350 FT	1.26	2.72	1,393.00
8.	Carbon Stl. Tubing	-2"	15068.0117	B.C.F.	230 FT	4.45	3.21	1,761.80
		-4"	15068.0204	B.C.F.	440 FT	14.02	6.44	9,002.00
		-4 1/2"	15068.0205	B.C.F.	750 FT	27.70	8.56	27,195.00
							Subtotal	53,770.00

Solar Process Piping
Subsystem/Subcontract

2/15/79
Date

ITEM NO.	TASK DEFINITION	UCI REF.	LABOR INDEX	QUANT.	$/UNIT	INSTAL. COST/ UNIT	TOTAL
PCS 1	Steam Generator	15633.0340	B.C.F.	1	90,000.00	1,906.00	91,906.00
PCS 2	Deaerator	15643.0115E	B.C.F.	1	40,000.00	1,235.00	41,235.00
PCS 3	Turbine/Generator		B.C.F.	1	GFE	10,500.00	
PCS 4	Condenser	15677.0130	B.C.F.	1	10,238.00	1,024.00	11,262.00
PCS 5	Condenser Storage Tank	-	-	1	6,000.00	1,000.00	7,000.00
PCS 6	Boiler Feed Pump	15141.0210	B.C.F.	1	39,722.00	1,016.00	40,738.00
PCS 7	Chemical Injection System	-	-	1	2,000.00	100.00	2,100.00
PCS 8	Demineralizer	-	-	1	25,000.00	500.00	25,500.00
PCS 9	Condensate Storage Pump		B.C.F.	1	809.00	494.00	1,303.00
PCS 10	Condensate Pump	15642.0112E	B.C.F.	1	3,000.00	560.00	3,560.00
PCS 11	Syltherm By-Pass Valve	15122.0205A	B.C.F.	1	880.00	195.00	1,075.00
PCS 12	Desuperheater	-	-	1	6,500.00	100.00	6,600.00
PCS 13	Mode Selection Valve	15122.0116A	B.C.F.	7	403.00	47.60	3,152.00
PCS 14	Nitrogen Regulator	-	-	1	144.00	53.94	197.94
PCS 15	Turbine Extraction Non Return Valve	15122.0124	B.C.F.	1	419.00	63.21	482.21
PCS 16	Inlet Steam Filter	15122.0124A	B.C.F.	1	3,000.00	11.89	3,011.89
PCS 17	Steam Pressure Regulator	-	-	1	144.00	53.94	197.94
PCS 18	Process Return Filter	15110.0116	B.C.F.	1	250.00	11.89	261.59
						Subtotal	
						18,348.00	

Solar Process Piping (PCS)
Subsystem/Subcontract

12/4/78
Date

ITEM NO.	TASK DEFINITION		UCI REF.	LABOR INDEX	QUANT.	$/UNIT	INSTAL. COST/ UNIT	TOTAL
1.	Gate Valves	-1" Threaded	15.1.2100	C.C.C.	55 EA	19.80	12.69	1,786.95
		-1 1/2" Threaded	15103.0112	B.C.F.	7 EA	97.55	9.52	749.49
		-2" Threaded	15103.0116	B.C.F.	11 EA	140.00	11.89	1,670.79
		-3" Flanged	15104.0203	B.C.F.	6 EA	183.00	48.70	1,390.20
		-5" Flanged	15104.205	B.C.F.	7 EA	401.00	191.00	4,144.00
		-8" Flanged	15104.210	B.C.F.	1 EA	1,144.00	352.00	1,496.00
2.	Strainers	-1" Threaded	15081.0108	B.C.F.	7 EA	16.10	8.87	174.79
		-1 1/2" Threaded	15081.0112	B.C.F.	3 EA	14.25	24.21	115.38
		-2" Threaded	15081.0116	B.C.F.	2 EA	24.08	32.21	112.58
		-3" Threaded	15081.0203	B.C.F.	1 EA	72.26	64.14	136.40
		-5" Flanged	15081.0305	B.C.F.	1 EA	321.00	191.00	512.00
3.	Check Valves	-1" Threaded	15110.0108	B.C.F.	7 EA	20.77	4.92	179.83
		-1 1/2" Threaded	15110.0112	B.C.F.	2 EA	32.65	8.00	81.30
4.	Sch. 40, Stl. Pipe	-1" Threaded	15053.0108	B.C.F.	920 FT	2.72	1.26	3,661.60
		-1 1/2" Threaded	15053.0112	B.C.F.	25 FT	1.95	3.40	133.75
		-2" Threaded	15053.0116	B.C.F.	360 FT	2.59	3.89	2,332.80
		-3" Welded	15053.2203	B.C.F.	230 FT	5.36	5.43	2,481.70
		-10" Welded	15053.2310	B.C.F.	20 FT	37.75	14.27	1,040.00
5.	Thermometers		-	Est.	10 EA	50.00	10.00	600.00
6.	Pressure Relief Valves		15125.0216	B.C.F.	7 EA	69.73	31.61	709.38
7.	Pressure Gauges		-	Est.	20 EA	50.00	10.00	1,200.00
							Subtotal	24,709.00

Solar Process Piping
Subsystem/Subcontract

2/15/79
Date

ITEM NO.	TASK DEFINITION	UCI REF.	LABOR INDEX	QUANT.	$/UNIT	INSTAL. COST/ UNIT	TOTAL
TUS 1	Absorption Air Conditioner	15683. 0217E	B. C. F.	1	70,000.00	1,666.00	71,666.00
TUS 2	Condenser Cooling Tower	15671. 0270E	B. C. F.	1	24,000.00	1,895.00	25,895.00
TUS 3	A/C Cooling Tower	15671. 0220E	B. C. F.	1	8,400.00	1,103.00	9,503.00
TUS 4	Condenser Cooling Tower H/x	15732. 1803E	B. C. F.	1	5,673.00	849.00	6,522.00
TUS 5	Low Temp. Storage Pump	15711. 1010E	B. C. F.	1	2,279.00	1,990.00	4,269.00
TUS 6	Low Temp. Storage Tank	131. 100	Means	1	59,500.00	N/C	59,500.00
TUS 7	Bleyle Heating Heat Exchanger	15732. 0603E	B. C. F.	1	495.00	139.00	634.00
TUS 8	Hot Water Pump	15711. 0840E	B. C. F.	1	6,477.00	900.00	7,377.00
TUS 9	Chilled Water Pump	15711. 0840E	B. C. F.	1	6,477.00	900.00	7,377.00
TUS 10	A/C Cooling Tower Pump	15711. 0520E	B. C. F.	1	1,928.00	681.00	2,609.00
TUS 11	Condenser Cooling Tower Pump	15711. 0830E	B. C. F.	1	3,694.00	897.00	4,591.00
TUS 12	Heating Water Supply Pump	15711. 0320E	B. C. F.	1	1,177.00	554.00	1,731.00
TUS 13	Chemical Mix Tank	-	-	1	250.00	50.00	300.00
TUS 14	Hot Water Flow Control Valve	15122. 0204A	B. C. F.	2	419.00	131.00	1,178.00
TUS 15	Chilled Water Tank Temp. Control Valve	15122. 0206A	B. C. F.	1	895.00	260.00	1,155.00
TUS 16	Hot Water Supply Temp. Control Valve	15122. 0204A	B. C. F.	1	419.00	63.21	482.21
						Subtotal 12,209.00	

Solar Process Piping (TUS)
Subsystem/Subcontract

12/4/78
Date

ITEM NO.	TASK DEFINITION		UCI REF.	LABOR INDEX	QUANT.	$/UNIT	INSTAL. COST/ UNIT	TOTAL
1.	Gate Valves	-1" Threaded	15. 1. 2100	C. C. C.	26	19. 80	12. 69	844. 00
		-2" Threaded	15103. 0116	B. C. F.	4	140. 00	11. 89	607. 50
		-3" Flanged	15104. 0203	B. C. F.	9	183. 00	48. 70	2, 085. 30
		-4" Flanged	15104. 0204	B. C. F.	3	253. 00	129. 00	1, 146. 00
		-6" Flanged	15104. 0206	B. C. F.	9	401. 00	255. 00	5, 904. 00
		-8" Flanged	15104. 0208	B. C. F.	5	667. 00	291. 00	4, 790. 00
		-10" Flanged	15104. 0210	B. C. F.	6	1, 144. 00	352. 00	8, 976. 00
		-12" Flanged	15104. 0212	B. C. F.	5	1, 619. 00	389. 00	10, 040. 00
		-14" Flanged	-	Est.	1	2, 000. 00	500. 00	2, 500. 00
2.	Strainers	-3" Threaded	15080. 0116	B. C. F.	2	72. 26	64. 14	272. 80
		-4" Threaded	15080. 0204	B. C. F.	1	212. 00	128. 00	340. 00
		-6" Flanged	15080. 0306	B. C. F.	1	363. 00	258. 00	621. 00
		-8" Flanged	15080. 0308	B. C. F.	1	629. 00	288. 00	917. 00
		-10" Flanged	15080. 0310	B. C. F.	1	1, 284. 00	357. 00	1, 641. 00
		-12" Flanged	15080. 0312	B. C. F.	1	1, 773. 00	379. 00	2, 152. 00
		-14" Flanged	-	Est.	1	2, 000. 00	500. 00	2, 500. 00
3.	Check Valves	-1" Threaded	15010. 0108	B. C. F.	1	20. 77	4. 92	25. 69
		-3" Threaded	15112. 0203	B. C. F.	1	124. 00	48. 17	172. 17
		-6" Threaded	15112. 0206	B. C. F.	2	308. 00	263. 00	1, 142. 00
		-8" Threaded	15112. 0208	B. C. F.	1	650. 00	288. 00	938. 00
		-10" Threaded	15112. 0210	B. C. F.	1	1, 055. 00	356. 00	1, 411. 00
		-12" Threaded	-	Est.	1	1, 150. 00	450. 00	1, 600. 00
4.	Pressure Gauges		-	Est.	30	50. 00	10. 00	1, 800. 00
5.	Thermometers		-	Est.	17	50. 00	10. 00	1, 020. 00
6.	Pressure Relief Valves		15125. 0216	B. C. F.	7	69. 73	31. 61	709. 38

Solar Process Piping (TUS)
Subsystem/Subcontract

12/4/78
Date

Cont'd.

ITEM NO.	TASK DEFINITION		UCI REF.	LABOR INDEX	QUANT.	$/UNIT	INSTAL. COST/ UNIT	TOTAL
7.	Sch. 40, Stl. Pipe	-1" Threaded	15052. 0108	B. C. F.	135 FT	1. 26	2. 72	537. 30
		-3" Welded	15053. 2203	B. C. F.	275 FT	5. 36	5. 43	2,967. 75
		-4" Welded	15053. 2204	B. C. F.	60 FT	6. 47	6. 49	777. 60
		-6" Welded	15053. 2206	B. C. F.	240 FT	16. 23	10. 87	6,504. 00
		-8" Welded	15053. 2308	B. C. F.	145 FT	23. 82	13. 57	5,421. 00
		-10" Welded	15053. 2310	B. C. F.	170 FT	37. 75	14. 27	8,843. 00
							Subtotal	79,206. 00
		-12" Welded	15053. 2312	B. C. F.	55 FT	48. 85	15. 96	3,564. 00
		-14" Welded	15053. 2314	B. C. F.	10 FT	59. 09	18. 09	771. 00
		-2" Threaded	15053. 0116	B. C. F.	20 FT	2. 03	3. 00	100. 00
							Subtotal	4, 436. 00
						Total Solar Process Piping Subcontract		408.184.00
						Atlanta, Ga. (. 89)		363, 284.00
						Level of Definition Factor 1. 10		399, 612.00
						Contractors OH & P 25%		99, 903.00
							TOTAL	499.515.00

MECHANICAL
BULDING

2.5 MECHANICAL BUILDING

SCOPE

The work contained in this section includes the construction of the Mechanical building and equipment area as shown in Figure 2.5-1 as well as the concrete slab and foundation assemblies required for the equipment that will be installed outside the north side of the building.

The building contains 4300 sq. ft. of total enclosed area, of which 1900 will be shop and equipment with 2400 sq. ft. office and visitor area. The building will be a single story flat roof design, with cinder block walls and a red brick exterior facing. The roof is a steel roof supported by open web joists, insulated with 2 1/2 inches of high denisty insulation between the steel roof and the membrane. The building will contain 3 each roll up overhead doors 8 ft. wide. Two of the overhead doors are in the mechanical equipment area, one each located by the absorption air conditioner unit and the steam turbine respectively. The third overhead door will be located in the storage and shop area. A acoustical ceiling located in the control room, visitors area, conference room, and office area will be installed directly below the open web ceiling joists. The overhead lighting system will be intergrated into the acoustical ceiling.

The building consists of a Visitor Center which contains a display area for visual and audio presentations, with provisions for formal presentations as shown in Figure 2.5-2, Plan View of Mechanical Building. The building includes a small reception and conference room, office, men's and women's rest rooms, shop and storage area, and control room. The interior furnishings have not been defined at this time and are excluded from the building costs.

The shop and storage area will be used for storage of spare parts and consumables, namely oils and chemicals, and bench repair of pumps and valves. Storage of spare collector parts will be stored in the storage area.

The Control Room has a raised floor for installation of cabling from process equipment to the operating console and computer. The Control Room will contain the operating console, computer processor, interface rack, switch board, printer, color graphic CRT, and magnetic tape recorder as shown in Figure 2.5-3. An equipment area to perform chemical analysis of water samples has also been provided.

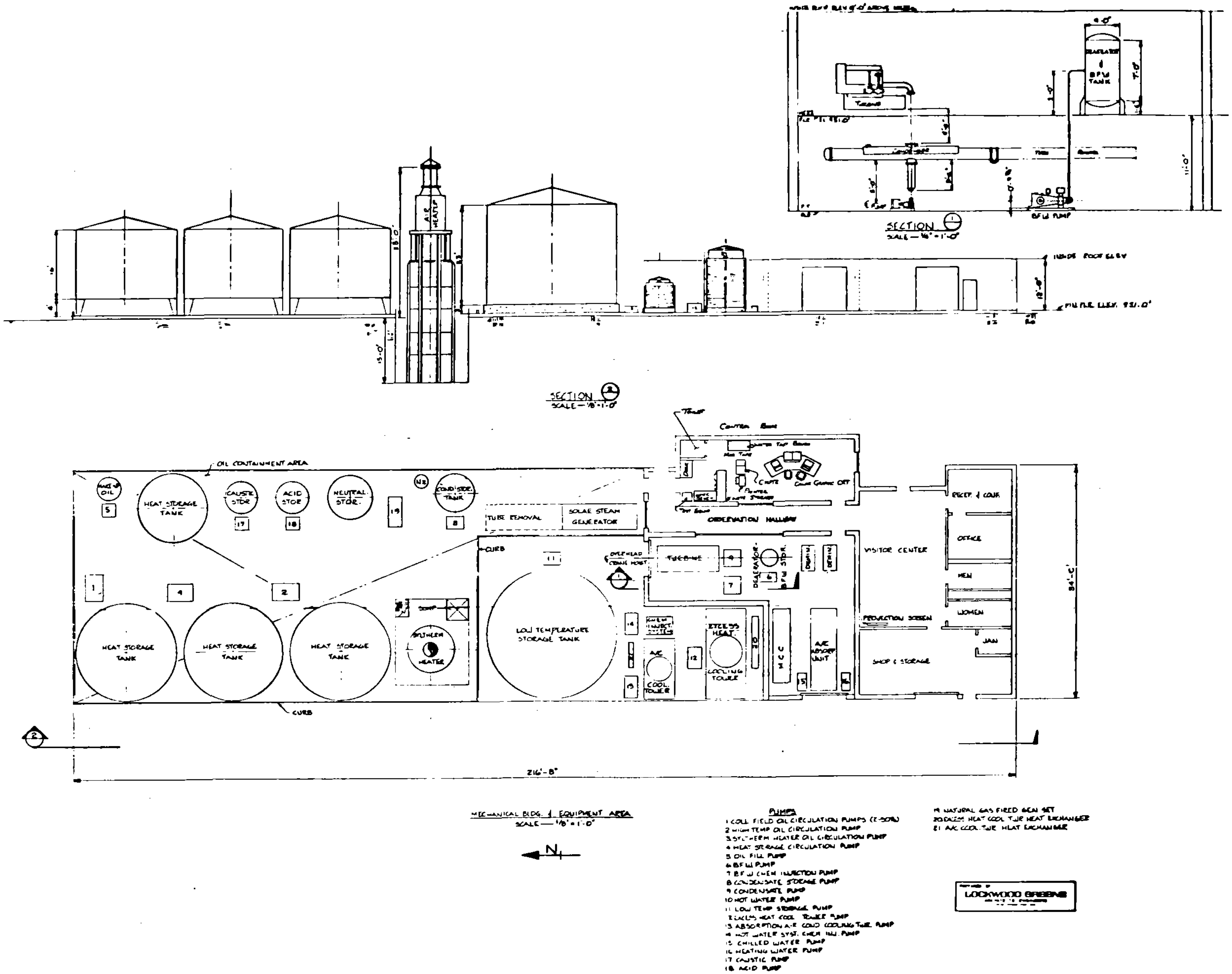


Figure 2. 5-1. Mechanical Building and Equipment Area

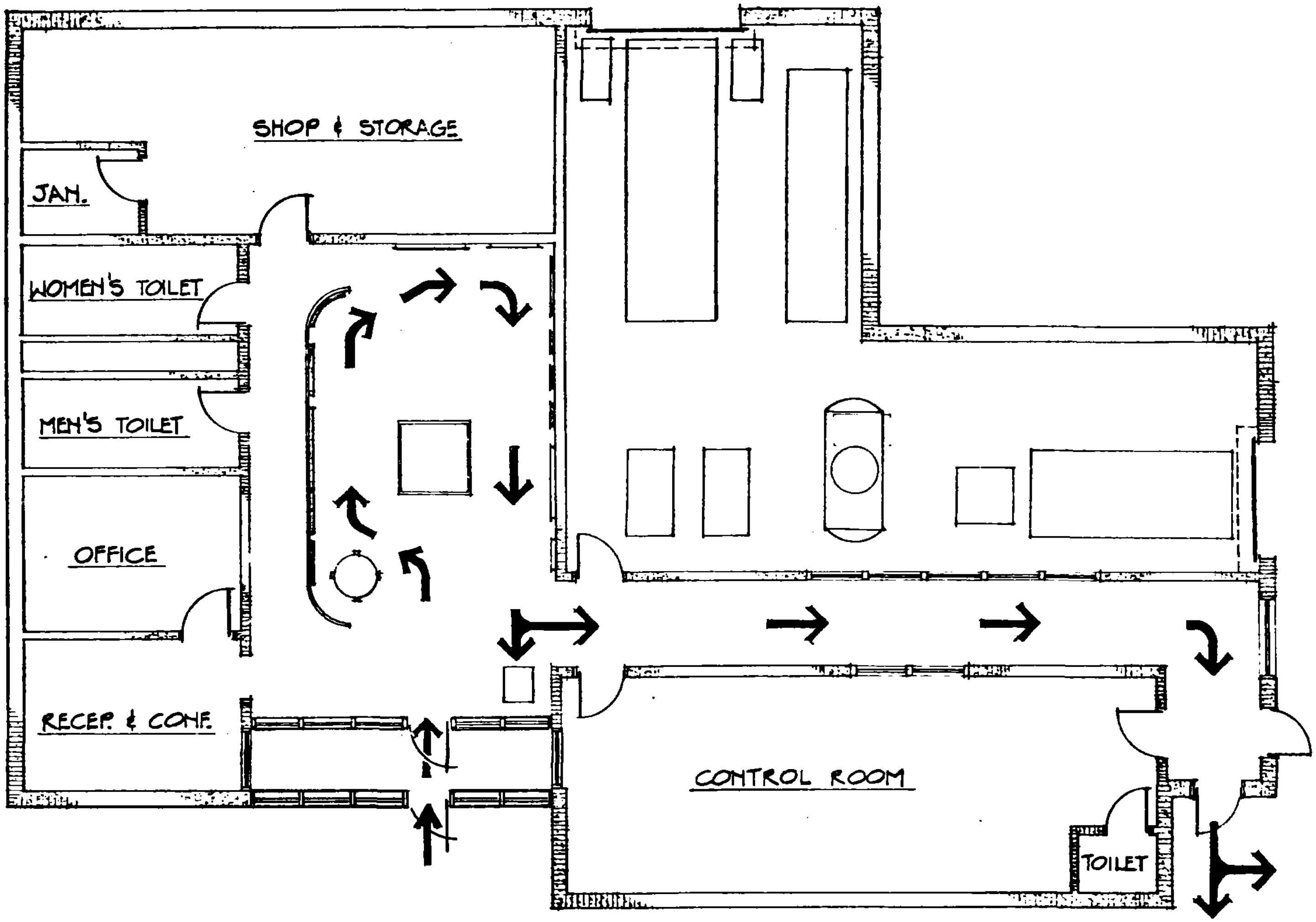


Figure 2.5-2. Visitor Center Plan

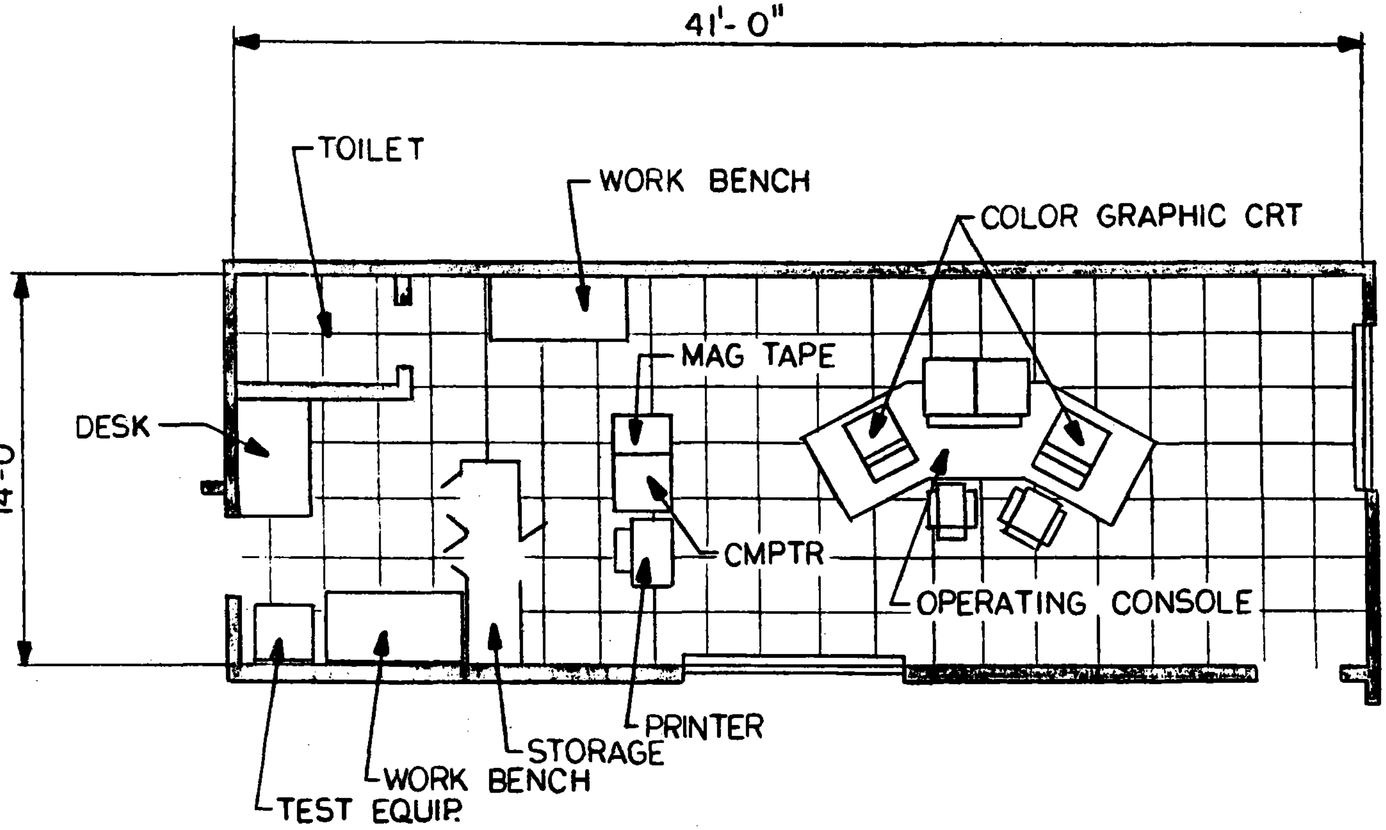


Figure 2.5-3. Control Room Layout

An indoor area will be provided for the following equipment:

- Turbine/Generator Assembly
- Condensor
- Deaerator
- Absorption Air Conditioner
- Motor Control Center
- Demineralizers
- Condensate Pump
- Boiler Feed Water Pump
- Power Equipment

The visitors will have visual access to the equipment area through a interior window located in the hallway.

The turbine/generator assembly will be elevated above the floor, with the condenser sitting directly below in a sump. The condensate pump and the hot well of the condenser will be located in the sump with the condenser. The sump has been designed to allow for tube removal of the condenser.

Located on the roof of the mechanical building will be the meteorology station and a closed circuit television system for observing the operation of the collector field.

The concrete slab for the equipment area will be installed along with the Mechanical Building. The base will contain an oil containment area for controlling any Syltherm^{TM}800 spills or leaks. The Syltherm^{TM}/fossil fired heater will be located in a sump, 15 feet deep. The Syltherm^{TM} heater has been located below grade to prevent its stack from shadowing the collector field.

Mechanical Building Cost Estimate

Visitors Area/Control Room

Sitework

Site Grading & Leveling (02215.0100)

70' x 80' = 5600 ÷ 9 ft^2/yd^2 = 622 yd^2 x \$.23/40^2 = \$143.00

Trenching & Footing Excavation (02221.0203)

300' x 3' x 3' = 2700 Ft^3 ÷ 27 ft^3/yd^3 = 100 yd^3 x \$3.33/40^3 = \$333.00

Formwork - Wall Footings (03100.0101)

300 LF x 2 Sides x 3' High = 1800 SFx \$3.08/SF = \$5544.00

Concrete - Wall Footings (03311.0100)

300 LF x 3' High x 1' Wide = 900 Ft^3 ÷ 27 = 33.3 yd^3 x \$44.93 = \$1497.00

- Slabs (03311.0806)

4300 x .33' Thick = 1419 Ft^3 ÷ 27 Ft^3/yd^3 = 52.55 yd^3 x \$46.80 = \$2459.00

Concrete Reinforcement - (03200.03211)

4300 x 14.10/Sq = \$606.30 \$606

Walls - Concrete Block (04221.0310)

300 LF x 12' High = 3600 x \$2.82/SF = \$10,152.00

- Brick (04211.0100)

3600 x 655 Brick/Sq. = 23.6M x 476/M = \$11,224.08

- Mortar (04100.0200)

7200 x 6 Ft^3/Sq = 432 Ft^3/.27 = 16 yd^3 x 46.85/yd^3 = \$749.60

Metal Furring - Exterior Walls (09112.1213)

300 LF x 10' High = 3000 SF x \$1.12/SF = \$3360.00

Studding Interior Partitions (09111.1232)

280 LF x 10' High = 2800 SF x 1.22 = \$3416.00

Dry Wall (09251.0105)

Interior Walls 2800 SF x 2 Sides = 5600 SF

Exterior Walls 3000 SF

8600 SF x \$.37 = \$3182.00

Finishing (09258.8201)

8600 SF x \$.17 = \$1462.00

Floor Covering (09666.0102)

Mechanical Building Cost Estimate (Cont'd)

4300 x \$.65 = \$2,795.00

Interior Doors (8.2.295 Means)

10 EA @ \$109.00 + 10.00 (Hdwr) = \$1190.00

Painting (09922.0204)

8600 x \$.20/Ft^2 = \$1720

Windows (Interior) (8.5.430 Means)	
2 EA @ \$280 Ea =	\$560.00
Windows (Exterior) (8.5.250)	
2 EA @ \$66.00 EA =	132.00
Exterior Doors (8.2.55 Means)	
2 EA @ \$75.10 EA =	150.20
O.H. Doors (8.3.39110 Means)	
3 EA @ \$390.00 EA =	1170.00
Acoustical Ceiling (9.5.10.100 Means)	
780 SF x \$.89/SF	694.20
Raised Control Room Floor (11.1.52.510) Means	
480 SF x 4.95/SF	2376.00
Plumbing (17.1.62.272 Means)	
4300 x \$1.81/SF	7783.00
Roofing (Means 17.1.69.114)	
4300 x \$.82/SF =	3526.00
HVAC (Means 17.1.62.277)	
4300 x \$4.30 =	18490.00
Electrical (Means 17.1.62.290)	
4300 x \$3.94 =	16942.00
Total	\$99,465.00
4300 SF =	23.13

Using Means Building Construction Cost on a Cost/Sq. ft. Basis.

- 2400 sq. ft. Office @ 28.00 =	67,200
- 1900 sq. ft. Mech Area @ 11.95 =	22,705
	\$89,905

Mechanical Building Cost Estimate (Cont'd)

Mechanical Area 7700

Site Grading & Leveling (02215.0100)

7700 9SF/SY x \$.23 = 197.00

Trenching & Footing Excavation (02221.0203)

330' x 3' x 3' = 2988 Ft^3 27 Ft^3/yd^3 = 110 yd^3 x. 3.33/yd^3 = \$368.00

Formwork - Slab on Grade (03107.0106)

480 LF x 1.16/LF = 557.00

Concrete - Slab (03311.0806)

7000 x .5' = 129.6 yd^3

1000 x .75' = 27.7 yd^3

157.3 yd^3 x \$44.84 = \$7040.00

Sump Pits (2) (03311.1000,1100)

Pit Walls - 616 x .33' 27 Ft^3/yd^3 = 7.5 yd^3 x \$51.52/yd^3 = \$387.00

Pit Slabs - 404 x .5' 27 Ft^3/yd^3 = 7.48 yd^3 x \$48.74 = \$364.64

Pump Supports (03311.1300)

20 EA @ 1.5 Ft^3/Support = 1.11 yd^3 x 47.57 = 52.80

Conc. Reinforcement

7700 x \$14.10/Sq = 1085.70

Mechanical Area Total \$10,052.00

Grand Total "Mechanical Building" \$109.517.00 - Total Cost Includes OH&P

Level-of-Definition 1.2 \$131.420.00

Mechanical Building Construction Subcontract
Subsystem/Subcontract

2/15/79
Date

ITEM NO.	TASK DEFINITION	UCI REF.	LABOR INDEX	QUANT.	$/UNIT	INSTAL. COST/ UNIT	TOTAL
1	Site Grading & Leveling	02216. 0100	B. C. F.	622SY	N/A	. 23	143. 00
2	Footing Excavation	02221. 0203	B. C. F.	100CY	N/A	3. 33	333. 00
3	Footing Forms	03100. 0101	B. C. F.	1800SF	1. 13	1. 35	5, 544. 00
4	Conc. Footing Placement	03311. 0100	B. C. F.	33CY	35. 21	9. 72	1, 497. 00
5	Conc. Slab Placement	03311. 0806	B. C. F.	53CY	35. 14	11. 66	2, 459. 00
6	Conc. Reinforcement	03211. 0899	B. C. F.	43CSF	4. 57	9. 53	606. 00
7	Conc. Block Walls	04221. 0310	B. C. F.	3600SF	. 83	1. 99	10, 152. 00
8	Brick Facing	04211. 0100	B. C. F.	23. 6M	143. 00	333. 00	11, 224. 00
9	Mortar	04101. 0200	B. C. F.	16CY	39. 04	7. 81	749. 00
10	Metal Furring	09112. 1213	B. C. F.	3000SF	. 46	. 66	3, 360. 00
11	Interior Studding	09111. 1232	B. C. F.	2800SF	. 59	. 63	3, 416. 00
12	Drywall Installation	09251. 0105	B. C. F.	8600SF	. 14	. 23	3, 182. 00
13	Drywall Finishing	09258. 8201	B. C. F.	8600SF	. 02	. 15	1, 462. 00
14	Floor Covering	09666. 0102	B. C. F.	4300SF	. 42	. 23	2, 795. 00
15	Hang Interior Doors	8. 2. 295	Means	10EA	55. 00	64. 00	1, 190. 00
16	Painting	09921. 0204	B. C. F.	8600SF	. 03	. 17	1, 720. 00
17	Windows (Interior)	8. 5. 430	Means	10EA	32. 00	24. 00	560. 00
18	Windows (Exterior)	8. 5. 250	Means	2EA	45. 00	22. 00	132. 00
19	Exterior Doors	8. 3. 55	Means	2EA	59. 00	16. 10	150. 20
20	Overhead Doors	8. 3. 39. 110	Means	3EA	280. 00	110. 00	1, 170. 00
21	Acoustical Ceiling	9. 5. 10100	Means	780SF	. 64	. 25	694. 00
22	Control Room Floor	11. 1. 52. 510	Means	480SF	4. 95	Incl.	2, 376. 00
23	Plumbing	17. 1. 62. 272	Means	4300SF	1. 81	Incl.	7, 783. 00
24	Roofing	17. 1. 69. 114	Means	4300SF	. 82	Incl.	3, 526. 00
25	HVAC	17. 1. 62. 277	Means	4300SF	4. 30	Incl.	18, 490. 00
26	Electrical	17. 1. 62. 290	Means	4300SF	3. 94	Incl.	16, 942. 00
27	Site Grading and Leveling	02215. 0100	B. C. F.	856SY	-	. 23	197. 00
28	Slab Footing Excavation	02221. 0203	B. C. F.	110CY	-	3. 33	367. 00

Mechanical Building Construction Subcontract
Subsystem/Subcontract

2/15/79
Date

ITEM NO.	TASK DEFINITION	UCI REF.	LABOR INDEX	QUANT.	$/UNIT	INSTAL. COST/ UNIT	TOTAL
29	Formwork	03107. 0106	B. C. F.	480LF	. 19	. 97	557.00
30	Conc. Slab Pouring	03311. 0806	B. C. F.	157. CY	35. 12	9. 72	7040. 00
31	Conc. Pit Wall Pouring	03311. 1000	B. C. F.	7. 5CY	35. 53	13. 21	366. 00
32	Conc. Pit Slab Pouring	03311. 1100	B. C. F.	7. 5CY	35. 38	16. 14	387. 00
33	Pump Supports	03311. 1300	B. C. F.	1. 1CY	35. 26	12. 31	53. 00
34	Conc. Reinforcement	03211. 2151	B. C. F.	770SQ	4. 57	9. 53	1085. 00
35	Metrology Station Installation		Est.				5000. 00
						Total	114,409.00
						Atlanta Adjustment	101,824.00
						Level-of-Definition Factor 1. 2	122.189.00

2.5 MECHANICAL BUILDING

SCOPE

The work contained in this section includes the construction of the Mechanical building and equipment area as shown in Figure 2.5-1 as well as the concrete slab and foundation assemblies required for the equipment that will be installed outside the north side of the building.

The building contains 4300 sq. ft. of total enclosed area, of which 1900 will be shop and equipment with 2400 sq. ft. office and visitor area. The building will be a single story flat roof design, with cinder block walls and a red brick exterior facing. The roof is a steel roof supported by open web joists, insulated with 2 1/2 inches of high denisty insulation between the steel roof and the membrane. The building will contain 3 each roll up overhead doors 8 ft. wide. Two of the overhead doors are in the mechanical equipment area, one each located by the absorption air conditioner unit and the steam turbine respectively. The third overhead door will be located in the storage and shop area. A acoustical ceiling located in the control room, visitors area, conference room, and office area will be installed directly below the open web ceiling joists. The overhead lighting system will be intergrated into the acoustical ceiling.

The building consists of a Visitor Center which contains a display area for visual and audio presentations, with provisions for formal presentations as shown in Figure 2.5-2, Plan View of Mechanical Building. The building includes a small reception and conference room, office, men's and women's rest rooms, shop and storage area, and control room. The interior furnishings have not been defined at this time and are excluded from the building costs.

The shop and storage area will be used for storage of spare parts and consumables, namely oils and chemicals, and bench repair of pumps and valves. Storage of spare collector parts will be stored in the storage area.

The Control Room has a raised floor for installation of cabling from process equipment to the operating console and computer. The Control Room will contain the operating console, computer processor, interface rack, switch board, printer, color graphic CRT, and magnetic tape recorder as shown in Figure 2.5-3. An equipment area to perform chemical analysis of water samples has also been provided.

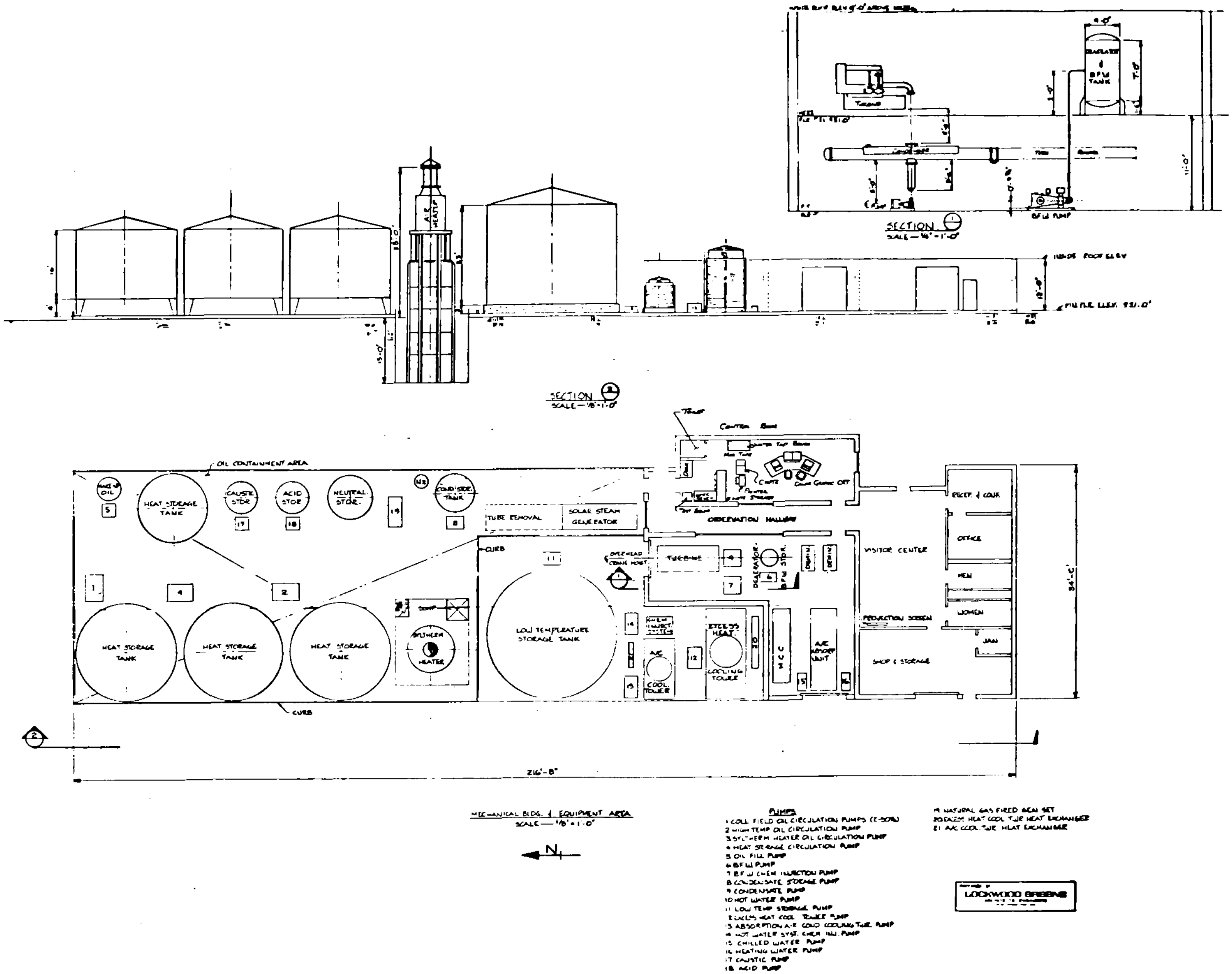


Figure 2.5-1. Mechanical Building and Equipment Area

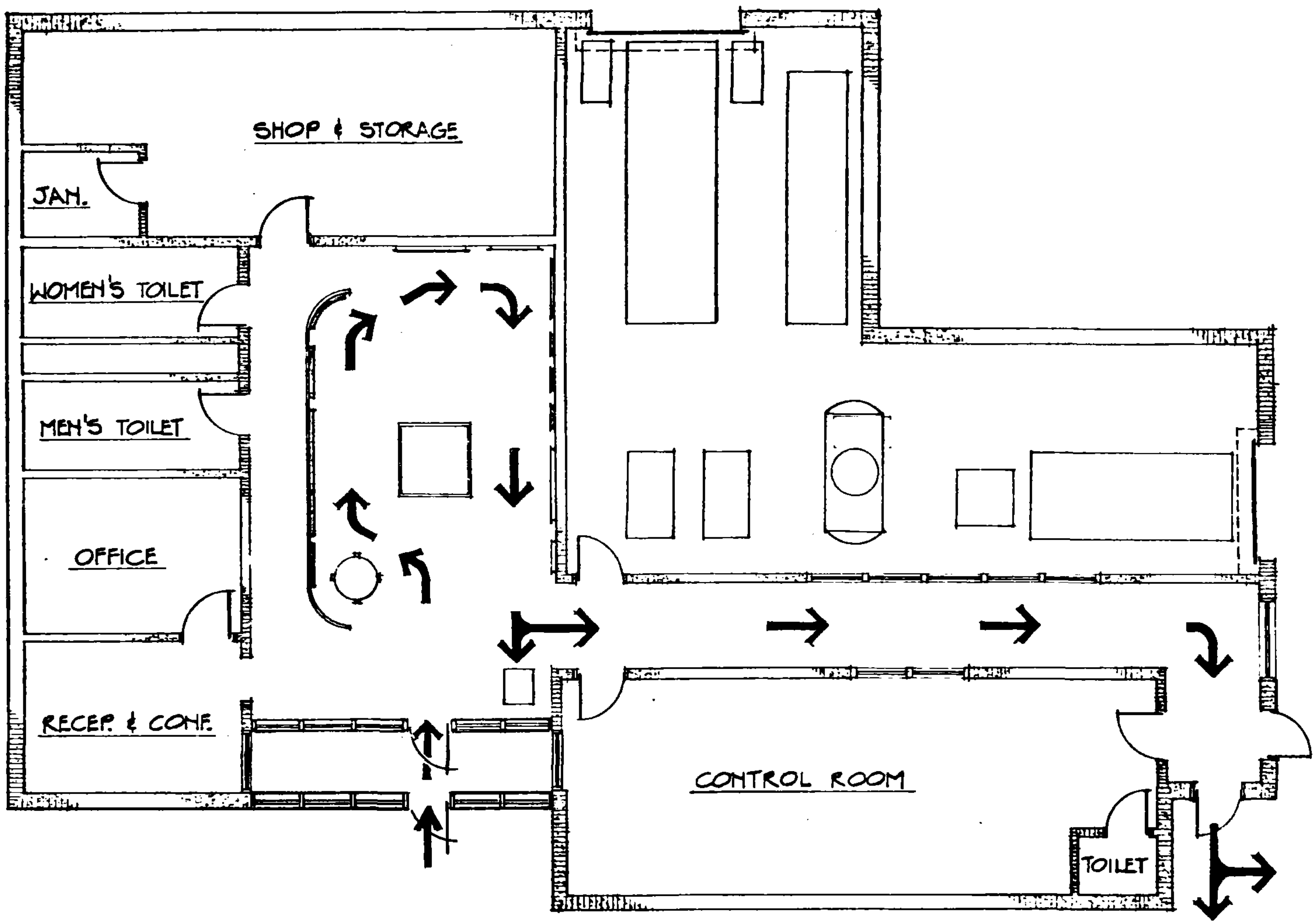


Figure 2.5-2. Visitor Center Plan

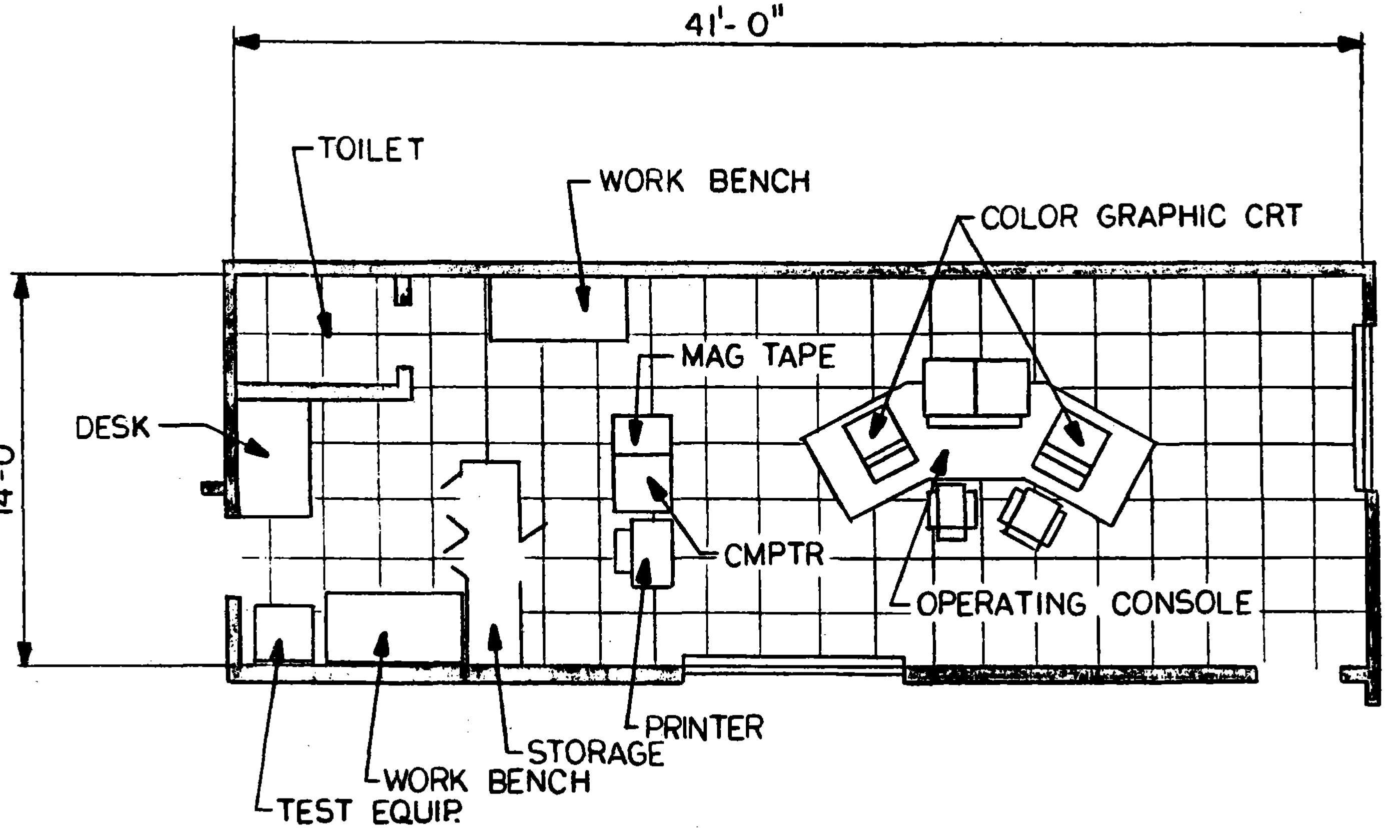


Figure 2.5-3. Control Room Layout

An indoor area will be provided for the following equipment:

- Turbine/Generator Assembly
- Condensor
- Deaerator
- Absorption Air Conditioner
- Motor Control Center
- Demineralizers
- Condensate Pump
- Boiler Feed Water Pump
- Power Equipment

The visitors will have visual access to the equipment area through a interior window located in the hallway.

The turbine/generator assembly will be elevated above the floor, with the condenser sitting directly below in a sump. The condensate pump and the hot well of the condenser will be located in the sump with the condenser. The sump has been designed to allow for tube removal of the condenser.

Located on the roof of the mechanical building will be the meteorology station and a closed circuit television system for observing the operation of the collector field.

The concrete slab for the equipment area will be installed along with the Mechanical Building. The base will contain an oil containment area for controlling any Syltherm™800 spills or leaks. The Syltherm™/fossil fired heater will be located in a sump, 15 feet deep. The Syltherm™ heater has been located below grade to prevent its stack from shadowing the collector field.

Mechanical Building Cost Estimate

Visitors Area/Control Room

Sitework

Site Grading & Leveling (02215.0100)

70' x 80' = 5600 ÷ 9 ft^2/yd^2 = 622 yd^2 x \$.23/40^2 = \$143.00

Trenching & Footing Excavation (02221.0203)

300' x 3' x 3' = 2700 Ft^3 ÷ 27 ft^3/yd^3 = 100 yd^3 x \$3.33/40^3 = \$333.00

Formwork - Wall Footings (03100.0101)

300 LF x 2 Sides x 3' High = 1800 SFx \$3.08/SF = \$5544.00

Concrete - Wall Footings (03311.0100)

300 LF x 3' High x 1' Wide = 900 Ft^3 ÷ 27 = 33.3 yd^3 x \$44.93 = \$1497.00

- Slabs (03311.0806)

4300 x .33' Thick = 1419 Ft^3 ÷ 27 Ft^3/yd^3 = 52.55 yd^3 x \$46.80 = \$2459.00

Concrete Reinforcement - (03200.03211)

4300 x 14.10/Sq = \$606.30 \$606

Walls - Concrete Block (04221.0310)

300 LF x 12' High = 3600 x \$2.82/SF = \$10,152.00

- Brick (04211.0100)

3600 x 655 Brick/Sq. = 23.6M x 476/M = \$11,224.08

- Mortar (04100.0200)

7200 x 6 Ft^3/Sq = 432 Ft^3/.27 = 16 yd^3 x 46.85/yd^3 = \$749.60

Metal Furring - Exterior Walls (09112.1213)

300 LF x 10' High = 3000 SF x \$1.12/SF = \$3360.00

Studding Interior Partitions (09111.1232)

280 LF x 10' High = 2800 SF x 1.22 = \$3416.00

Dry Wall (09251.0105)

Interior Walls 2800 SF x 2 Sides = 5600 SF

Exterior Walls 3000 SF

8600 SF x \$.37 = \$3182.00

Finishing (09258.8201)

8600 SF x \$.17 = \$1462.00

Floor Covering (09666.0102)

Mechanical Building Cost Estimate (Cont'd)

4300 x \$. 65 = \$2,795. 00

Interior Doors (8. 2. 295 Means)

10 EA @ \$109. 00 + 10. 00 (Hdwr) = \$1190. 00

Painting (09922. 0204)

8600 x \$. 20/Ft^2 = \$1720

Windows (Interior) (8. 5. 430 Means)	
2 EA @ \$280 Ea =	\$560. 00
Windows (Exterior) (8. 5. 250)	
2 EA @ \$66. 00 EA =	132. 00
Exterior Doors (8. 2. 55 Means)	
2 EA @ \$75. 10 EA =	150. 20
O.H. Doors (8. 3. 39110 Means)	
3 EA @ \$390. 00 EA =	1170. 00
Acoustical Ceiling (9. 5. 10. 100 Means)	
780 SF x \$. 89/SF	694. 20
Raised Control Room Floor (11. 1. 52. 510) Means	
480 SF x 4. 95/SF	2376. 00
Plumbing (17. 1. 62. 272 Means)	
4300 x \$1. 81/SF	7783. 00
Roofing (Means 17. 1. 69. 114)	
4300 x \$. 82/SF =	3526. 00
HVAC (Means 17. 1. 62. 277)	
4300 x \$4. 30 =	18490. 00
Electrical (Means 17. 1. 62. 290)	
4300 x \$3. 94 =	16942. 00
Total	\$99,465. 00
4300 SF =	23. 13

Using Means Building Construction Cost on a Cost/Sq. ft. Basis.

- 2400 sq. ft. Office @ 28. 00 =	67,200
- 1900 sq. ft. Mech Area @ 11. 95 =	22,705
	\$89,905

Mechanical Building Cost Estimate (Cont'd)

Mechanical Area 7700

Site Grading & Leveling (02215.0100)

7700 9SF/SY x \$.23 = 197.00

Trenching & Footing Excavation (02221.0203)

330' x 3' x 3' = 2988 Ft^3 27 Ft^3/yd^3 = 110 yd^3 x. 3.33/yd^3 = \$368.00

Formwork - Slab on Grade (03107.0106)

480 LF x 1.16/LF = 557.00

Concrete - Slab (03311.0806)

7000 x .5' = 129.6 yd^3

1000 x .75' = 27.7 yd^3

157.3 yd^3 x \$44.84 = \$7040.00

Sump Pits (2) (03311.1000,1100)

Pit Walls - 616 x .33' 27 Ft^3/yd^3 = 7.5 yd^3 x \$51.52/yd^3 = \$387.00

Pit Slabs - 404 x .5' 27 Ft^3/yd^3 = 7.48 yd^3 x \$48.74 = \$364.64

Pump Supports (03311.1300)

20 EA @ 1.5 Ft^3/Support = 1.11 yd^3 x 47.57 = 52.80

Conc. Reinforcement

7700 x \$14.10/Sq = 1085.70

Mechanical Area	Total	\$10,052.00
Grand Total "Mechanical Building"		\$109.517.00 - Total Cost Includes OH&P
Level-of-Definition 1.2		\$131.420.00

Mechanical Building Construction Subcontract
Subsystem/Subcontract

2/15/79
Date

ITEM NO.	TASK DEFINITION	UCI REF.	LABOR INDEX	QUANT.	$/UNIT	INSTAL. COST/ UNIT	TOTAL
1	Site Grading & Leveling	02216. 0100	B. C. F.	622SY	N/A	. 23	143. 00
2	Footing Excavation	02221. 0203	B. C. F.	100CY	N/A	3. 33	333. 00
3	Footing Forms	03100. 0101	B. C. F.	1800SF	1. 13	1. 35	5, 544. 00
4	Conc. Footing Placement	03311. 0100	B. C. F.	33CY	35. 21	9. 72	1, 497. 00
5	Conc. Slab Placement	03311. 0806	B. C. F.	53CY	35. 14	11. 66	2, 459. 00
6	Conc. Reinforcement	03211. 0899	B. C. F.	43CSF	4. 57	9. 53	606. 00
7	Conc. Block Walls	04221. 0310	B. C. F.	3600SF	. 83	1. 99	10, 152. 00
8	Brick Facing	04211. 0100	B. C. F.	23. 6M	143. 00	333. 00	11, 224. 00
9	Mortar	04101. 0200	B. C. F.	16CY	39. 04	7. 81	749. 00
10	Metal Furring	09112. 1213	B. C. F.	3000SF	. 46	. 66	3, 360. 00
11	Interior Studding	09111. 1232	B. C. F.	2800SF	. 59	. 63	3, 416. 00
12	Drywall Installation	09251. 0105	B. C. F.	8600SF	. 14	. 23	3, 182. 00
13	Drywall Finishing	09258. 8201	B. C. F.	8600SF	. 02	. 15	1, 462. 00
14	Floor Covering	09666. 0102	B. C. F.	4300SF	. 42	. 23	2, 795. 00
15	Hang Interior Doors	8. 2. 295	Means	10EA	55. 00	64. 00	1, 190. 00
16	Painting	09921. 0204	B. C. F.	8600SF	. 03	. 17	1, 720. 00
17	Windows (Interior)	8. 5. 430	Means	10EA	32. 00	24. 00	560. 00
18	Windows (Exterior)	8. 5. 250	Means	2EA	45. 00	22. 00	132. 00
19	Exterior Doors	8. 3. 55	Means	2EA	59. 00	16. 10	150. 20
20	Overhead Doors	8. 3. 39. 110	Means	3EA	280. 00	110. 00	1, 170. 00
21	Acoustical Ceiling	9. 5. 10100	Means	780SF	. 64	. 25	694. 00
22	Control Room Floor	11. 1. 52. 510	Means	480SF	4. 95	Incl.	2, 376. 00
23	Plumbing	17. 1. 62. 272	Means	4300SF	1. 81	Incl.	7, 783. 00
24	Roofing	17. 1. 69. 114	Means	4300SF	. 82	Incl.	3, 526. 00
25	HVAC	17. 1. 62. 277	Means	4300SF	4. 30	Incl.	18, 490. 00
26	Electrical	17. 1. 62. 290	Means	4300SF	3. 94	Incl.	16, 942. 00
27	Site Grading and Leveling	02215. 0100	B. C. F.	856SY	-	. 23	197. 00
28	Slab Footing Excavation	02221. 0203	B. C. F.	110CY	-	3. 33	367. 00

Mechanical Building Construction Subcontract
Subsystem/Subcontract

2/15/79
Date

ITEM NO.	TASK DEFINITION	UCI REF.	LABOR INDEX	QUANT.	$/UNIT	INSTAL. COST/ UNIT	TOTAL
29	Formwork	03107. 0106	B. C. F.	480LF	. 19	. 97	557. 00
30	Conc. Slab Pouring	03311. 0806	B. C. F.	157. CY	35. 12	9. 72	7040. 00
31	Conc. Pit Wall Pouring	03311. 1000	B. C. F.	7. 5CY	35. 53	13. 21	366. 00
32	Conc. Pit Slab Pouring	03311. 1100	B. C. F.	7. 5CY	35. 38	16. 14	387. 00
33	Pump Supports	03311. 1300	B. C. F.	1. 1CY	35. 26	12. 31	53. 00
34	Conc. Reinforcement	03211. 2151	B. C. F.	770SQ	4. 57	9. 53	1085. 00
35	Metrology Station Installation		Est.				5000. 00
						Total	114,409.00
						Atlanta Adjustment	101, 824. 00
						Level-of-Definition Factor 1. 2	122. 189. 00

ELECTRICAL

2.6 ELECTRICAL

The work included in this section is comprised of installation of all power, control, and instrumentation components and interconnecting wire.

The installation will require Main Power Component installation with the Georgia Power Co. interface, control center installation, collector field & collector, electrical installation, power wiring, control valve wiring, control room wiring, and instrumentation wiring. The sensor installations that interface directly with the process piping through a mechanical connection will be installed by the solar process piping contractor.

All wire runs will be made by use of wire ways and open support trays where possible. Electrical conduits will be used on the north-south power distributions in the collector field. Power wiring will be kept isolated from the control and data wiring by use of independent conduits.

The collector field will utilize 2 Field Control Enclosure at 2 locations, for collecting output signals of the collectors, and distributing control room signals to the collectors. The Field Control Enclosures will be located above the E-W wireways in the field and wiring will enter and exit through the bottom of the enclosure. Each Field Control Enclosure contains two (2) Energy Collection Processors (ECP), for a total of 4 ECP's in the collector field. The Energy Collection Processors will provide power and control to 48 collectors per ECP and pipe field valves associated with those collectors.

The Collectors Field will be protected from lightning by a electrical grounding system that will be installed below grade and connected to the base of the collectors.

All power wiring will be kept isolated from the control and instrumentation wiring by use of separate or divided wireways. All motors above 1/3 hp will be controlled by use of a circuit breaker combination motor starter located at the motor control center. Each starter will have a local-remote switch for selecting Manual or Computer control and a on/off switch will provide Manual Control for checkout or maintenance at each motor.

Electrical
Subsystem/Subcontract

2/15/79
Date

ITEM NO.	TASK DEFINITION	UCI REF.	LABOR INDEX	QUANT.	$/UNIT	INSTAL. COST/ UNIT	TOTAL
	Power Distribution Collector Field (919E127)						
1	Copper Cable						
	AWG 2	16.1-10-150	Means	3.2CLF	.52	.24	2,432
	AWG 14	16.1-10-100	Means	68.0CEF	2.70	8.45	7,582
2	Conduit-Galvanized 1/2"	16.0-20-175	Means	2300'	.42	1.22	3.772
	1"	16.0-20-180	Means	5000'	.70	1.69	11,950
	2-1/2"	16.0-20-190	Means	40'	2.45	3.13	223
3	Grounding System						
	Trench & Back Fill	02221.2102	BCF	5866CY	2.28		13,388
	Copper Wire Awg 3/0	16.1-80-80	Means	81.2CLF	92.00	33.00	10,150
	Ground Rods . 10' Lg.	16.1-80-10	Means	24 ea.	19.00	25.00	1,056
	Signal Distribution Collector Field (919E131)						
4	Conduit 1"	16.0-20-180	Means	1980'	.70	1.69	4,732
	2"	16.0-20-187	Means	2750'	1.55	2.44	10,835
	2-1/2"	16.0-20-190	Means	4730'	2.45	3.13	26,393
5	Cable						
	9 pr/Shield Awg.	EST		40,500		.44	17,820
	Coax Cable (RG59/u)	EST		4,800		.21	1,008
	Power & Signal Distribution Mech. Area. (919E132)						
6	Power Supply Cable AWG #8	16.1-10-130	Means	84CLF	10.00	13.70	1,991
7	Primary Power Wire 300 MCM	16.1-10-240	Means	36CLF	170.00	58.00	8,208

Electrical Subcontract
Subsystem/Subcontract

2/15/79
Date

ITEM NO.	TASK DEFINITION	UCI REF.	LABOR INDEX	QUANT.	$/UNIT	INSTAL. COST/ UNIT	TOTAL
8	Control Cable Wiring AWG #18	16. 1-30-2	Means	86CLF	8. 00	12. 20	1,737
9	Thero Wire/Extension KX/AWG#20 20 Pr-CS		Means	24CLF		41. 00	984
10	Control Wiring AWG #12 + #14	16. 1-30-2	Means	187CLF		16. 00	2,992
11	Conx Cable RG59/U	Est.		1700'		. 21	357
12	Collector Field Power AWG #2	16. 1-10-150	Means	14SCLF	. 52	. 24	1,102
13	Wireways:						
	8 x 8	16. 0-95-60	Means	240'	10. 00	5. 50	3,720
	4 x 4	16. 0-95-20	Means	220'	3. 50	2. 74	1,373
14	Conduit:						
	4"	16. 0-20-197	Means	385'	4. 60	5. 50	3,889
	3"	16. 0-20-193	Means	352'	3. 05	4. 38	2,615
	2"	16. 0-20-187	Means	1320'	1. 50	2. 44	5,200
	1"	16. 0-20-180	Means	1540'	. 70	1. 69	3,681
					Subtotal		149,190
					Atlanta Area	Adjustment	132,779
					Level-of-Factor	Definition (1. 1)	146,056
					Contractors Profit	OH and (25%)	36,514
					Total		182,571

INSULATION

2.7 INSULATION SUBCONTRACT

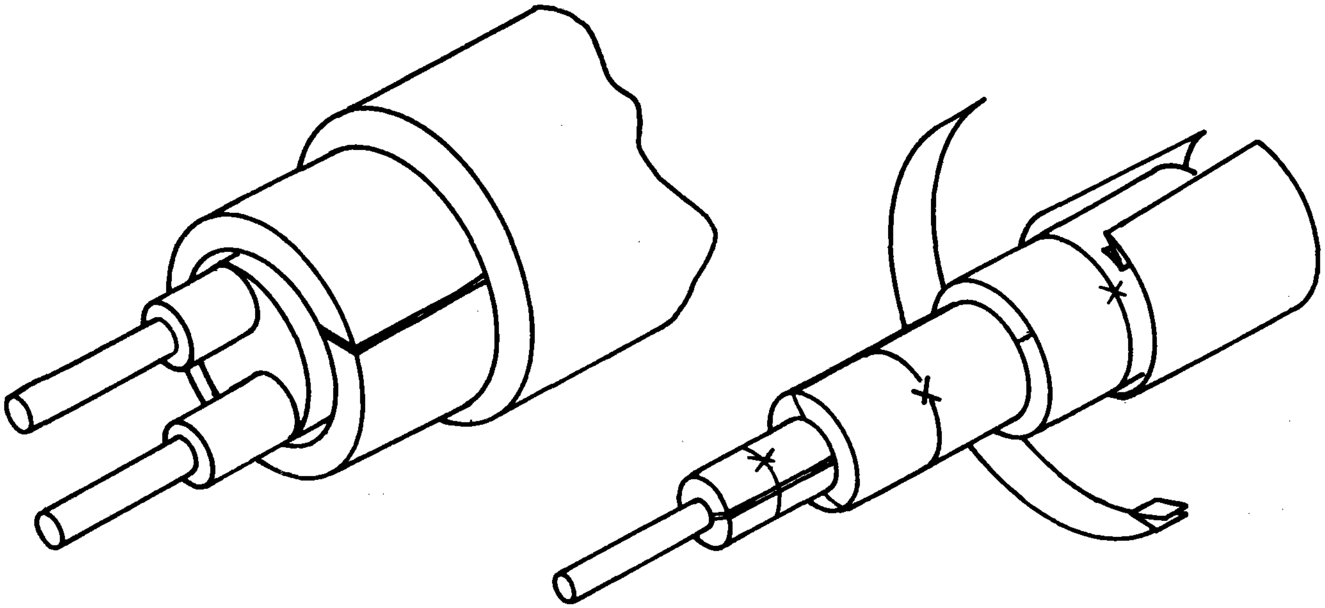
The work covered under this section is the fabrication and installation of insulation for all piping, storage tanks, and components. All insulation exposed to the elements will contain an aluminum jacket for weatherproofing. The piping in the collector loop branch lines and from the branch lines to the collector receiver will be insulated in a nested configuration.

All insulation shall be firmly butted together, with butt joints on double layer of insulation to be staggered. The insulation is to be secured to the pipe with No. 2 gauge corrosion resistant wire on 12" centers. The aluminum jacket shall be 0.016" thick and sealed with a suitable mastic to prevent any moisture from entering the insulation. All valves, fittings and components shall be insulated with the same material as the piping, see Figure 2.7-1 for typical pipe insulation methods. Table 2.7-1 list cost for insulating valves and pipe accessories.

Insulation Subcontract
Subsystem/Subcontract

2/15/79
Date

ITEM NO.	TASK DEFINITION	UCI REF.	LABOR INDEX	QUANT.	$/UNIT	INSTAL. COST/ UNIT	TOTAL
1	Mech. Bldg. Pipe Insulation						
	-1"	Quote	N/A	680 LF	3.21	-	2182.80
	-1-1/2"	Quote	N/A	25 LF	5.17	-	129.25
	-2"	Quote	N/A	610 LF	6.87	-	4190.70
	-3"	Quote	N/A	505 LF	9.25	-	4676.30
	-4"	Quote	N/A	500 LF	11.44	-	5720.00
	-4-1/2"	Est.	N/A	750 LF	15.00	-	11,250.00
	-8"	Quote	N/A	145 LF	19.36	-	2807.20
	-10"	15183.0210	B. C. F	170 LF	5.27	-	895.90
	-12"			15 LF	6.30	-	94.50
2	Collector Field Piping Insulation	Attached				Labor @ 120%	38,336.00
		Quote				Mat'l.	220,864.00
						31,945	
3	Tank Insulation	Phone Quote	J. M.				
	3 Large HTS Tanks			5000 SF	11.00		55,000.00
	1 Small HTS Tank			755 SF	11.00		8,311.00
	1 LTS Tank			3600 SF	8.00		28,800.00
4	Mech. Component Insulation	15.6.4680	Means				
	Condensor			170 SF	4.18	Inc.	710.00
	Steam Generator			350 SF	4.18	Incl.	1463.00
	Absorption A/C			170 SF	4.18	Incl.	710.00
	Deaerator			125 SF	4.18	Incl.	523.00
	Pumps			20 EA	100.00	Incl.	2000.00
5	Insulation of Valves and Fittings						47,740.00
						Total	468,346.00
					Level of Definition Factor 1.1		515,181.00



NESTED SINGLE

Figure 2.7-1. Typical Insulation Arrangement

C. E. THURSTON and SONS, INC.
sales
service
satisfaction
INSTALLERS. DISTRIBUTORS
INSULATION AND REFRACTORY CONTRACTORS
INDUSTRIAL, MARINE AND CONTRACTORS SUPPLIES
523 NORFOLK AVENUE, S.W. • P. O. BOX 1481 • ROANOKE, VIRGINIA 24007
703/342-1841

QUOTATION

No ____________

G. E. Aerospace Division
c/o Jim Polland
57 Providence Forge
Royers Ford, PA 19468

Date May 18, 1978

Your Inquiry No ____________

With reference to the above, we are pleased to submit this proposal.

Quantity	Description			Unit Price	Amount
		H/T composite	H/T Laminate		
15,936	3/8 x 3"	2.89	2.57		
394	1 x 3	3.21	3.00		
8,916	1-1/2 x 4	5.17	5.71		
122	2 x 4-1/2	6.87	6.32		
62	2-1/2 x 5	8.52	8.35		
62	3 x 5	9.26	8.79		
84	4 x 5-1/2	11.44	11.25		
490	6 x 6-1/2	16.19	16.82		
262	8 x 7	19.36	21.52		

Labor cost for above $119,934

Full Freight is allowed on truckload and carload quantities. These prices are firm through August 31, 1978

FOB See Above
Terms 1%
Shipment ____________

Very truly yours,

C.E. THURSTON & SONS, INC.

By: Gary S. Williams
Gary S. Williams

Page 1 of 1
GSW/nwr

Subject to terms and conditions stated on the reverse side.

2-42

J. Voland
18 May 78

Telecon with Gary Williams, C.E. Thurston, Va.

C E Thurston has prepared a quote on material and labor for Foamglass HT Composite and HT Laminate for Shenandoah LSE. The data is as follows.

HT Composite

	Length	$/ft	Cost $
3/8 - 3"	2x6432	2.89	37176.96
1 - 3"	2x197	3.21	1264.76
1½ - 4"	2x4468	5.17	46199.12
2 - 4.5"	2x61.25	6.87	841.58
2½ - 5"	2x30.63	8.52	521.94
3 - 5"	2x30.63	9.26	567.18
4 - 5.5"	2x91.88	7.44	1367.17
6 - 6.5"	2x245	16.19	7933.10
8 - 7.0"	2x130.63	19.36	5057.99
		Total =	100929.80

HT Laminate

3/8 - 3"	2x6432	2.57	33060.00
1 - 3"	2x197	3.00	1182.00
1½ - 4"	2x4468	5.71	51024.56
2 - 4.5"	2x61.25	6.32	774.20
2½ - 5"	2x30.63	8.35	511.44
3 - 5"	2x30.63	8.79	538.39
4 - 5.5"	2x91.88	11.25	2067.30
6 - 6.5"	2x245	16.82	8241.80
8 - 7.0"	2x130.63	21.52	5622.32
		Total	103022.01

Their company estimate to install this material without consideration for insulating valves, fittings etc. is $119,934

	HT Composite	HT Laminate
Material	100929.80	103022.01
Labor	119934.00	119.934.00
	220,863.80	222,956 01

Description

Certain-teed's 850 Snap*On™ Fiber Glass Pipe Insulation now makes it possible to realize the inherent benefits of fiber glass for piping up to 850F. Prior to this technological breakthrough, all fibrous glass, resin-bonded pipe coverings were limited to 500F.

850 Snap*On has the same physical characteristics and appearance as regular Snap*On Pipe Insulation except it is firmer to resist impact damage. It is distinguished by markings on the insulation and packaging.

850 Snap*On is made in precision molded fiber glass cylindrical sections with an integral hinge which spreads open to receive the pipe and snaps closed after it is in place. The fiber glass will not burn, is not affected by moisture, will not corrode metals and is permanent. It will permit expansion and contraction of the pipe without cracking and will not shrink.

Uses

850 Snap*On is recommended for use on all heated piping operating at service temperatures between 500F and 850F. These applications include power, process and heavy industrial plants, indoors or out and concealed or exposed piping in commercial and institutional buildings.

The insulation is normally supplied plain (without jacket) for nesting and subsequent surface finish indoors, or for weather protection outdoors.

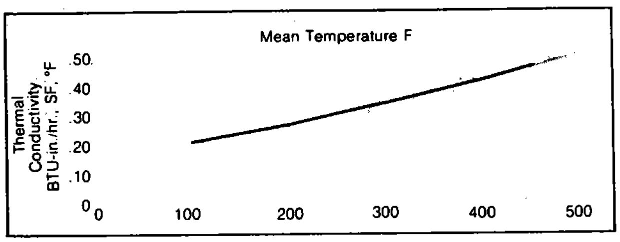
Energy Cost Conservation

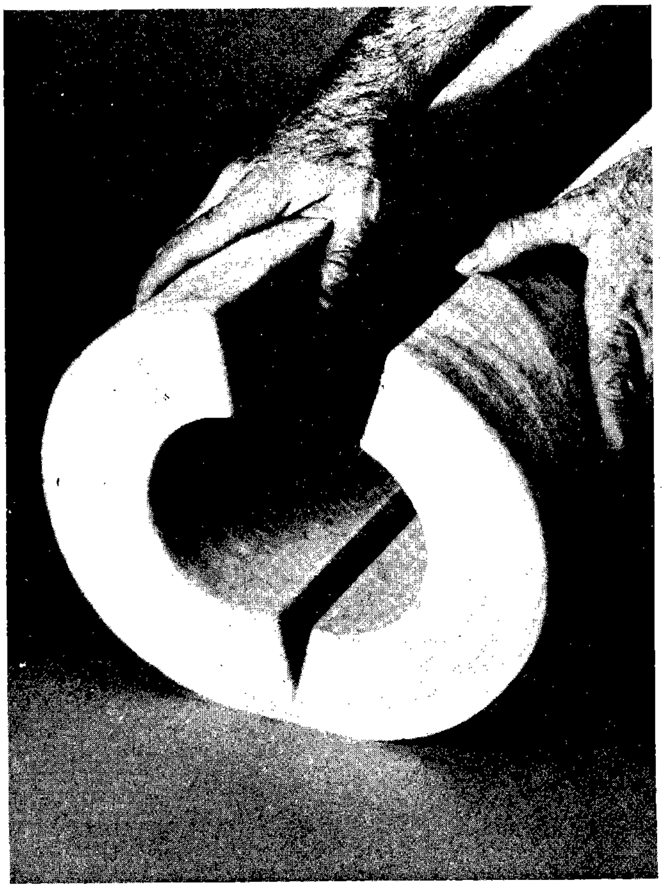
Rising fuel costs and the need to conserve energy makes selection of thickness and type of insulation a critical choice. Efficient insulation, in the best return-on-investment thicknesses, is required to keep energy costs at acceptable levels. Certain-teed's 850 Snap*On is more efficient at temperatures from 500F to 850F than any other insulation used for this service. This means that on a cost/performance basis, Certain-teed 850 Snap*On will save more fuel cost dollars at comparable thicknesses.

Specification Compliance

HH-I-558B Insulation, Blocks, Boards, Blankets, Felts, Sleeving (Pipe and Tube Covering) and Pipe Fitting Covering, Thermal (Mineral Fiber. Industrial Type), Form D, Type III, Class 13 (use up to 850F).

Thermal Efficiency





Benefits

- Lower energy cost—fiber glass is more efficient than any other heat insulation at temperatures up to 850F. No heat loss at joints due to shrinkage. Intermeshing glass fibers and single piece construction means less joints, tighter joints.
- No breakage loss—will not break or crack, in shipping, handling, during or after installation.
- Faster, simpler installation, saves time—complete cylindrical sections snap on the pipe instead of handling two or more sections. No need for double thicknesses in most applications. Single thicknesses up to 2½" available. Cuts with a knife, no saws or special tools required. Light weight saves shipping and handling costs.
- Fire safe—meets the requirements of Underwriters Laboratories fire hazard classification (ASTM E 84) flame spread 25, smoke developed 50, fuel contributed 50.

Recommended Economic Thickness—80F ambient, 8,760 hr./yr.

Thicknesses shown in the tables are economic thicknesses (ECON*) as determined by computer calculation of all cost factors necessary to produce heat and the cost of insulation to conserve heat loss. ECON thickness is the most economical alternative between these two factors. It is the thickness of a given insulation that will save the greatest energy cost while paying for itself within a given period of time. For temperatures below 500F use Certain-teed low and medium temperature Snap*On Pipe Insulation. (See product data sheet 30-31-02).

	PROCESS Operating temperature (F)				UTILITY Operating temperature (F)			
Pipe Size	550	650	750	850	550	650	750	850
1.00	2.5	3.0	3.5	4.0	3.0	3.5	4.0	4.5
1.25	3.0	3.5	4.0	4.5	3.5	4.0	4.5	5.0
1.50	3.0	3.5	4.0	4.5	4.0	4.5	5.0	5.5
2.00	3.5	4.0	4.5	5.0	4.0	4.5	5.5	6.0
2.50	3.5	4.0	5.0	5.5	4.5	5.0	6.0	6.5
3.00	4.0	4.5	5.0	6.0	5.0	5.5	6.0	7.0
3.50	4.0	5.0	5.5	6.0	5.0	6.0	6.5	7.0
4.00	4.5	5.0	5.5	6.5	5.5	6.0	7.0	7.5
4.50	4.5	5.0	6.0	6.5	5.5	6.0	7.0	8.0
5.00	4.5	5.5	6.0	6.5	5.5	6.5	7.5	8.0
6.00	5.0	5.5	6.5	7.0	6.0	7.0	7.5	8.5
7.00	5.0	6.0	6.5	7.5	6.0	7.0	8.0	9.0
8.00	5.5	6.0	7.0	7.5	6.5	7.5	8.0	9.0
9.00	5.5	6.5	7.0	7.5	6.5	7.5	8.5	9.0
10.00	5.5	6.5	7.0	8.0	6.5	7.5	8.5	9.5
12.00	6.0	6.5	7.5	8.0	7.0	8.0	8.5	9.5
14.00	5.5	6.5	7.0	8.0	6.5	7.5	8.5	9.5
16.00	5.5	6.5	7.0	8.0	6.5	7.5	8.5	9.5
18.00	5.5	6.5	7.0	8.0	6.5	7.5	8.5	9.5
20.00	5.5	6.5	7.0	8.0	6.5	7.5	8.5	9.5
24.00	5.5	6.0	7.0	7.5	6.5	7.5	8.0	9.0
30.00	5.0	6.0	6.5	7.0	6.0	7.0	7.5	8.5
36.00	4.5	5.5	6.0	6.5	5.5	6.0	7.0	7.5

*ECON is a term used by the Thermal Insulation Manufacturers Association for thickness recommendations derived from calculating variable cost of heat and cost of insulation to determine the economic thickness.

Qualifications

The maximum use temperature of an insulating material is that temperature above which it no longer provides satisfactory or efficient service as a thermal insulation when applied under conditions of normal usage. A normal condition implies low applied loads, limited vibration, moderate thermal stresses, and a non-destructive atmosphere.

There is no single test for determining the maximum use temperature applicable to all types of insulation or even to one type of insulation under all possible conditions of use. The maximum use temperature of 850F for 850 Snap*On has been estimated from product performances in the following test procedures:

1. ASTM C 356 Linear Shrinkage of Preformed High Temperature Thermal Insulation Subjected to Soaking Heat. 850 Snap*On has negligible linear shrinkage and/or warpage after 96 hours exposure and the loss in weight does not exceed 10% by weight.
2. ASTM C 411 Hot Surface Performance of High Temperature Thermal Insulation. 850 Snap*On does not flame, glow, smolder, crack, warp, or delaminate when applied to the hot surface and exposed for 96 hours. Smoke may be visually detected emanating from the product up to 4 hours following stabilization of the cold faced surface temperature.
3. ASTM C 177 Thermal Conductivity of Materials by Means of the Guarded Hot Plate. The thermal conductivity (k) of 850 Snap*On exposed for 96 hours per ASTM C 411 shows no appreciable deterioration from the thermal conductivity of the specimen measured before the exposure.
4. ASTM E 84 Surface Burning Characteristics of Building Materials. 850 Snap*On has a maximum flame spread classification of 25, and a maximum smoke developed classification of 50.
5. 850 Snap*On does not smolder when a steel rod ¾" x 2" at 1450F is placed between two specimens (12" x 12" x nominal thickness) mounted on a flat surface under a load of 2 pounds for a period of one hour.

The information herein is accurate (subject to normal production and testing variations) and reliable to the best of Certain-teed Products Corporation's knowledge. However, since Certain-teed has no control over installation design, installation workmanship, accessory materials, or conditions of application, no express or implied warranty is made as to the performance or results of an installation containing 850 Snap*On Fiber Glass Pipe Insulation.

Sizes and Thicknesses

Nom. Pipe Size	Pipe O.D.	1½" Wall Wall	1½" Wall Insul. O.D.	2" Wall Wall	2" Wall Insul. O.D.	2½" Wall Wall	2½" Wall Insul. O.D.	3" Wall Wall	3" Wall Insul. O.D.	4" Wall Wall	4" Wall Insul. O.D.
1"	1.32	1.59	4.50	2.12	5.56	2.61	6.63	3.12	7.62	4.12	9.62
1¼"	1.66	1.66	5.00	1.94	5.56	2.47	6.62	2.97	7.62	4.54	10.75
1½"	1.90	1.54	5.00	1.82	5.56	2.60	7.12	2.75	7.62	4.42	10.75
2"	2.38	1.58	5.56	2.11	6.63	2.61	7.63	3.11	8.63	4.17	10.75
2½"	2.88	1.33	5.56	1.86	6.63	2.36	7.63	2.86	8.63	4.42	11.75
3"	3.50	1.55	6.63	2.05	7.63	2.55	8.63	3.05	9.63	4.04	11.75
3½"	4.00	1.29	6.63	1.79	7.63	2.79	9.63	2.79	9.63	4.29	12.75
4"	4.50	1.54	7.63	2.04	8.63	2.54	9.63	3.10	10.65	4.10	12.75
4½"	5.00	1.29	7.63	1.79	8.63	2.85	10.75	2.85	10.75	3.86	12.75
5"	5.56	1.50	8.63	2.00	9.63	2.57	10.75	3.07	11.75	4.19	14.00
6"	6.63	1.47	9.63	2.03	10.75	2.53	11.75	3.05	12.75	4.19	15.00
7"	7.63	1.53	10.75	2.03	11.75	2.53	12.75	3.15	14.00	4.15	16.00

GERTAINTEED 850 INSTALLATION SPECIFICATION

2.2 Outdoor Hot Piping (Up to 850°F)

2.2.1 Material

All piping shall be insulated with CSG Group Heavy Density 850° Snap★On Fiber Glass Pipe Insulation as manufactured by Certain-teed Products Corporation, CSG Group, or approved equal. The insulation shall be one piece molded with a K value of 0.35 at 300°F mean temperature.

2.2.2 Thickness

Thickness of the pipe shall be as listed in CSG Recommended Thickness Tables, or as shown on drawings.

(Double layer with staggered seams and joints is recommended for service temperatures in excess of 600°F.)

2.2.3 Application

Piping:

The insulation shall be firmly butted together and secured to the pipe with No. 20 gauge corrosion resistant wire on 12″ centers. If double layer, all longitudinal and end joints shall be staggered.

Fittings:

Valves and fittings shall be insulated with mitred or nesting sizes of Heavy Density 850° Snap★On Fiber Glass Pipe Insulation securely wired in place with No. 20 gauge corrosion resistant wire. All open joints or voids shall be filled and smoothed with insulating cement.

Weather Protection:

The insulation, valves and fittings shall have a field applied metal jacket 0.016″ thick. A moisture barrier shall be provided between the Heavy Density 850° Snap★On Fiber Glass Pipe Insulation and the aluminum. The insulation and aluminum shall be held in place by a continuous friction type joint, providing a positive weatherproof seal along the entire length of aluminum jacket. Then a preformed strap containing a permanently plastic weatherproof sealant shall be centered and secured over each circumferential joint and secured with ½″ aluminum band and wing seal.

Valves and fittings shall be field covered with prefabricated 0.016″ metal fittings or mitred sections of aluminum metal jackets 0.016″ thick.

Valve Insulation

Valve Size	Thickness	Installed Cost * Labor & Material Inc. OH & Profit
1/2	2.5	$ 11.40
3/4	3.0	13.22
1	3.5	21.26
1 1/2	4.0	28.39
2	4.5	52.90
3	5.0	75.28
4	5.5	164.55
4 1/2	6.0	190.26
5	6.0	190.26
6	6.5	237.56
8	7.0	346.11
10	7.0	381.68
12	7.0	417.25
14	7.0	452.82

* High density foam glass insulation covered with pre-fabricated aluminum jacket (0.16 Thk)

2.7 INSULATION SUBCONTRACT

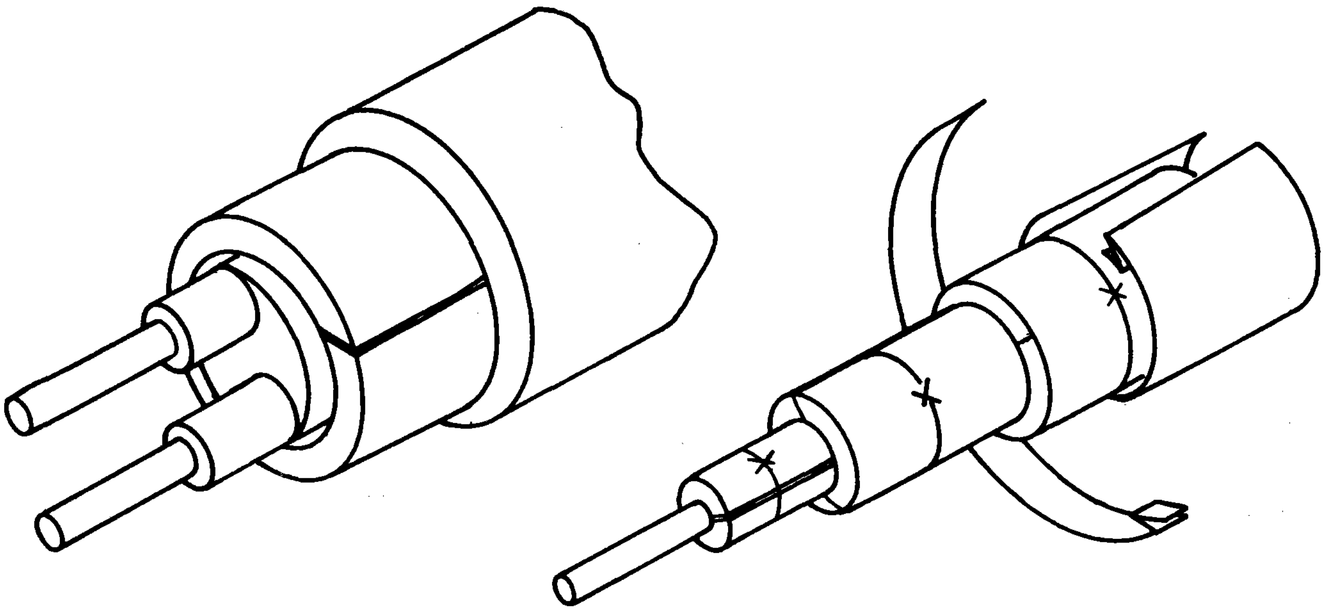
The work covered under this section is the fabrication and installation of insulation for all piping, storage tanks, and components. All insulation exposed to the elements will contain an aluminum jacket for weatherproofing. The piping in the collector loop branch lines and from the branch lines to the collector receiver will be insulated in a nested configuration.

All insulation shall be firmly butted together, with butt joints on double layer of insulation to be staggered. The insulation is to be secured to the pipe with No. 2 gauge corrosion resistant wire on 12" centers. The aluminum jacket shall be 0.016" thick and sealed with a suitable mastic to prevent any moisture from entering the insulation. All valves, fittings and components shall be insulated with the same material as the piping, see Figure 2.7-1 for typical pipe insulation methods. Table 2.7-1 list cost for insulating valves and pipe accessories.

Insulation Subcontract
Subsystem/Subcontract

2/15/79
Date

ITEM NO.	TASK DEFINITION	UCI REF.	LABOR INDEX	QUANT.	$/UNIT	INSTAL. COST/ UNIT	TOTAL
1	Mech. Bldg. Pipe Insulation						
	-1"	Quote	N/A	680 LF	3.21	-	2182.80
	-1-1/2"	Quote	N/A	25 LF	5.17	-	129.25
	-2"	Quote	N/A	610 LF	6.87	-	4190.70
	-3"	Quote	N/A	505 LF	9.25	-	4676.30
	-4"	Quote	N/A	500 LF	11.44	-	5720.00
	-4-1/2"	Est.	N/A	750 LF	15.00	-	11,250.00
	-8"	Quote	N/A	145 LF	19.36	-	2807.20
	-10"	15183.0210	B. C. F	170 LF	5.27	-	895.90
	-12"			15 LF	6.30	-	94.50
2	Collector Field Piping Insulation	Attached Quote				Labor @ 120%	38,336.00
						Mat'l. 31,945	220,864.00
3	Tank Insulation	Phone Quote	J. M.				
	3 Large HTS Tanks			5000 SF	11.00		55,000.00
	1 Small HTS Tank			755 SF	11.00		8,311.00
	1 LTS Tank			3600 SF	8.00		28,800.00
4	Mech. Component Insulation	15.6.4680	Means				
	Condensor			170 SF	4.18	Inc.	710.00
	Steam Generator			350 SF	4.18	Incl.	1463.00
	Absorption A/C			170 SF	4.18	Incl.	710.00
	Deaerator			125 SF	4.18	Incl.	523.00
	Pumps			20 EA	100.00	Incl.	2000.00
5	Insulation of Valves and Fittings						47,740.00
						Total	468,346.00
					Level of Definition Factor 1.1		515,181.00



NESTED SINGLE

Figure 2.7-1. Typical Insulation Arrangement

C. E. THURSTON and SONS, INC.

sales
service
satisfaction

INSTALLERS. DISTRIBUTORS

INSULATION AND REFRACTORY CONTRACTORS
INDUSTRIAL, MARINE AND CONTRACTORS SUPPLIES

523 NORFOLK AVENUE, S.W. • P. O. BOX 1481 • ROANOKE, VIRGINIA 24007
703/342-1841

QUOTATION

No ____________

G. E. Aerospace Division
c/o Jim Polland
57 Providence Forge
Royers Ford, PA 19468

Date May 18, 1978

Your Inquiry No ____________

With reference to the above, we are pleased to submit this proposal.

Quantity	Description			Unit Price	Amount
		H/T composite	H/T Laminate		
15,936	3/8 x 3"	2.89	2.57		
394	1 x 3	3.21	3.00		
8,916	1-1/2 x 4	5.17	5.71		
122	2 x 4-1/2	6.87	6.32		
62	2-1/2 x 5	8.52	8.35		
62	3 x 5	9.26	8.79		
84	4 x 5-1/2	11.44	11.25		
490	6 x 6-1/2	16.19	16.82		
262	8 x 7	19.36	21.52		

Labor cost for above $119,934

Full Freight is allowed on truckload and carload quantities. These prices are firm through August 31, 1978

FOB See Above
Terms 1%
Shipment ____________

Very truly yours,

C.E. THURSTON & SONS, INC.

By: Gary S. Williams
Gary S. Williams

Page 1 of 1
GSW/nwr

Subject to terms and conditions stated on the reverse side.

2-42

J. Voland
18 May 78

Telecon with Gary Williams, C.E. Thurston, Va.

C E Thurston has prepared a quote on material and labor for Foamglass HT Composite and HT Laminate for Shenandoah LSE. The data is as follows.

HT Composite

	Length	$/ft	Cost $
3/8 – 3"	2x 6432	2.89	37176.96
1 – 3"	2x 197	3.21	1264.76
1½ – 4"	2x 4468	5.17	46199.12
2 – 4.5"	2x 61.25	6.87	841.58
2½ – 5"	2x 30.63	8.52	521.94
3 – 5"	2x 30.63	9.26	567.18
4 – 5.5"	2x 91.88	7.44	1367.17
6 – 6.5"	2x 245	16.19	7933.10
8 – 7.0"	2x 130.63	19.36	5057.99
		Total =	100929.80

HT Laminate

3/8 – 3"	2x 6432	2.57	33060.00
1 – 3"	2x 197	3.00	1182.00
1½ – 4"	2x 4468	5.71	51024.56
2 – 4.5"	2x 61.25	6.32	774.20
2½ – 5"	2x 30.63	8.35	511.44
3 – 5"	2x 30.63	8.79	538.39
4 – 5.5"	2x 91.88	11.25	2067.30
6 – 6.5"	2x 245	16.82	8241.80
8 – 7.0"	2x 130.63	21.52	5622.32
		Total	103022.01

Their company estimate to install this material without consideration for insulating valves, fittings etc. is $119,934

	HT Composite	HT Laminate
Material	100929.80	103022.01
Labor	119934.00	119.934.00
	220,863.80	222,956 01

Description

Certain-teed's 850 Snap*On™ Fiber Glass Pipe Insulation now makes it possible to realize the inherent benefits of fiber glass for piping up to 850F. Prior to this technological breakthrough, all fibrous glass, resin-bonded pipe coverings were limited to 500F.

850 Snap*On has the same physical characteristics and appearance as regular Snap*On Pipe Insulation except it is firmer to resist impact damage. It is distinguished by markings on the insulation and packaging.

850 Snap*On is made in precision molded fiber glass cylindrical sections with an integral hinge which spreads open to receive the pipe and snaps closed after it is in place. The fiber glass will not burn, is not affected by moisture, will not corrode metals and is permanent. It will permit expansion and contraction of the pipe without cracking and will not shrink.

Uses

850 Snap*On is recommended for use on all heated piping operating at service temperatures between 500F and 850F. These applications include power, process and heavy industrial plants, indoors or out and concealed or exposed piping in commercial and institutional buildings.

The insulation is normally supplied plain (without jacket) for nesting and subsequent surface finish indoors, or for weather protection outdoors.

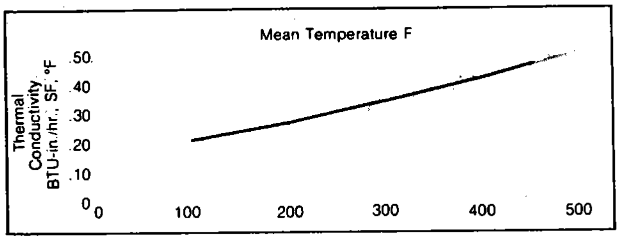
Energy Cost Conservation

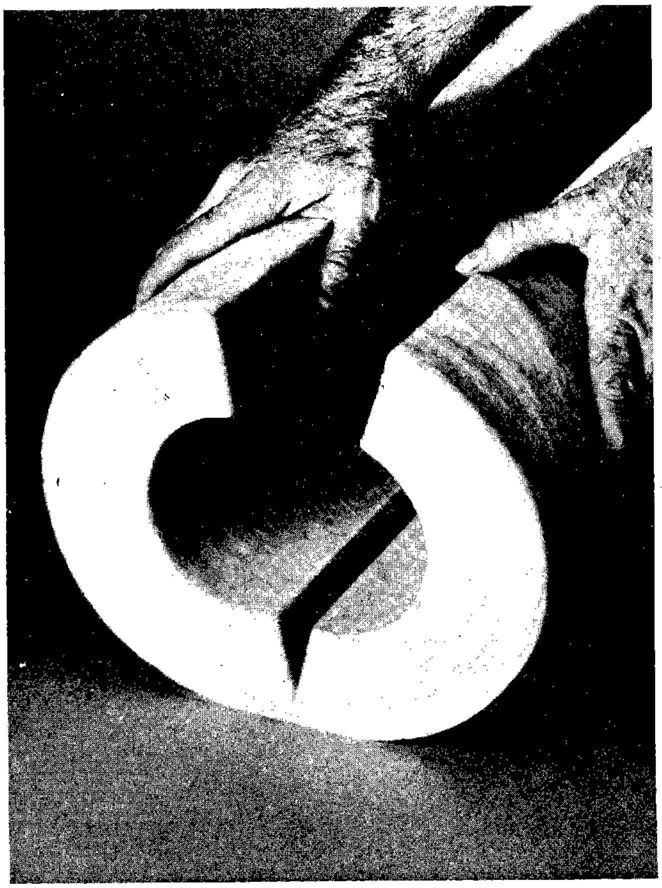
Rising fuel costs and the need to conserve energy makes selection of thickness and type of insulation a critical choice. Efficient insulation, in the best return-on-investment thicknesses, is required to keep energy costs at acceptable levels. Certain-teed's 850 Snap*On is more efficient at temperatures from 500F to 850F than any other insulation used for this service. This means that on a cost/performance basis, Certain-teed 850 Snap*On will save more fuel cost dollars at comparable thicknesses.

Specification Compliance

HH-I-558B Insulation, Blocks, Boards, Blankets, Felts, Sleeving (Pipe and Tube Covering) and Pipe Fitting Covering, Thermal (Mineral Fiber. Industrial Type), Form D, Type III, Class 13 (use up to 850F).

Thermal Efficiency





Benefits

- Lower energy cost—fiber glass is more efficient than any other heat insulation at temperatures up to 850F. No heat loss at joints due to shrinkage. Intermeshing glass fibers and single piece construction means less joints, tighter joints.
- No breakage loss—will not break or crack, in shipping, handling, during or after installation.
- Faster, simpler installation, saves time—complete cylindrical sections snap on the pipe instead of handling two or more sections. No need for double thicknesses in most applications. Single thicknesses up to 2½" available. Cuts with a knife, no saws or special tools required. Light weight saves shipping and handling costs.
- Fire safe—meets the requirements of Underwriters Laboratories fire hazard classification (ASTM E 84) flame spread 25, smoke developed 50, fuel contributed 50.

Recommended Economic Thickness—80F ambient, 8,760 hr./yr.

Thicknesses shown in the tables are economic thicknesses (ECON*) as determined by computer calculation of all cost factors necessary to produce heat and the cost of insulation to conserve heat loss. ECON thickness is the most economical alternative between these two factors. It is the thickness of a given insulation that will save the greatest energy cost while paying for itself within a given period of time. For temperatures below 500F use Certain-teed low and medium temperature Snap*On Pipe Insulation. (See product data sheet 30-31-02).

	PROCESS Operating temperature (F)				UTILITY Operating temperature (F)			
Pipe Size	550	650	750	850	550	650	750	850
1.00	2.5	3.0	3.5	4.0	3.0	3.5	4.0	4.5
1.25	3.0	3.5	4.0	4.5	3.5	4.0	4.5	5.0
1.50	3.0	3.5	4.0	4.5	4.0	4.5	5.0	5.5
2.00	3.5	4.0	4.5	5.0	4.0	4.5	5.5	6.0
2.50	3.5	4.0	5.0	5.5	4.5	5.0	6.0	6.5
3.00	4.0	4.5	5.0	6.0	5.0	5.5	6.0	7.0
3.50	4.0	5.0	5.5	6.0	5.0	6.0	6.5	7.0
4.00	4.5	5.0	5.5	6.5	5.5	6.0	7.0	7.5
4.50	4.5	5.0	6.0	6.5	5.5	6.0	7.0	8.0
5.00	4.5	5.5	6.0	6.5	5.5	6.5	7.5	8.0
6.00	5.0	5.5	6.5	7.0	6.0	7.0	7.5	8.5
7.00	5.0	6.0	6.5	7.5	6.0	7.0	8.0	9.0
8.00	5.5	6.0	7.0	7.5	6.5	7.5	8.0	9.0
9.00	5.5	6.5	7.0	7.5	6.5	7.5	8.5	9.0
10.00	5.5	6.5	7.0	8.0	6.5	7.5	8.5	9.5
12.00	6.0	6.5	7.5	8.0	7.0	8.0	8.5	9.5
14.00	5.5	6.5	7.0	8.0	6.5	7.5	8.5	9.5
16.00	5.5	6.5	7.0	8.0	6.5	7.5	8.5	9.5
18.00	5.5	6.5	7.0	8.0	6.5	7.5	8.5	9.5
20.00	5.5	6.5	7.0	8.0	6.5	7.5	8.5	9.5
24.00	5.5	6.0	7.0	7.5	6.5	7.5	8.0	9.0
30.00	5.0	6.0	6.5	7.0	6.0	7.0	7.5	8.5
36.00	4.5	5.5	6.0	6.5	5.5	6.0	7.0	7.5

*ECON is a term used by the Thermal Insulation Manufacturers Association for thickness recommendations derived from calculating variable cost of heat and cost of insulation to determine the economic thickness.

Qualifications

The maximum use temperature of an insulating material is that temperature above which it no longer provides satisfactory or efficient service as a thermal insulation when applied under conditions of normal usage. A normal condition implies low applied loads, limited vibration, moderate thermal stresses, and a non-destructive atmosphere.

There is no single test for determining the maximum use temperature applicable to all types of insulation or even to one type of insulation under all possible conditions of use. The maximum use temperature of 850F for 850 Snap*On has been estimated from product performances in the following test procedures:

1. ASTM C 356 Linear Shrinkage of Preformed High Temperature Thermal Insulation Subjected to Soaking Heat. 850 Snap*On has negligible linear shrinkage and/or warpage after 96 hours exposure and the loss in weight does not exceed 10% by weight.
2. ASTM C 411 Hot Surface Performance of High Temperature Thermal Insulation. 850 Snap*On does not flame, glow, smolder, crack, warp, or delaminate when applied to the hot surface and exposed for 96 hours. Smoke may be visually detected emanating from the product up to 4 hours following stabilization of the cold faced surface temperature.
3. ASTM C 177 Thermal Conductivity of Materials by Means of the Guarded Hot Plate. The thermal conductivity (k) of 850 Snap*On exposed for 96 hours per ASTM C 411 shows no appreciable deterioration from the thermal conductivity of the specimen measured before the exposure.
4. ASTM E 84 Surface Burning Characteristics of Building Materials. 850 Snap*On has a maximum flame spread classification of 25, and a maximum smoke developed classification of 50.
5. 850 Snap*On does not smolder when a steel rod ¾" x 2" at 1450F is placed between two specimens (12" x 12" x nominal thickness) mounted on a flat surface under a load of 2 pounds for a period of one hour.

The information herein is accurate (subject to normal production and testing variations) and reliable to the best of Certain-teed Products Corporation's knowledge. However, since Certain-teed has no control over installation design, installation workmanship, accessory materials, or conditions of application, no express or implied warranty is made as to the performance or results of an installation containing 850 Snap*On Fiber Glass Pipe Insulation.

Sizes and Thicknesses

Nom. Pipe Size	Pipe O.D.	1½" Wall Wall	1½" Wall Insul. O.D.	2" Wall Wall	2" Wall Insul. O.D.	2½" Wall Wall	2½" Wall Insul. O.D.	3" Wall Wall	3" Wall Insul. O.D.	4" Wall Wall	4" Wall Insul. O.D.
1"	1.32	1.59	4.50	2.12	5.56	2.61	6.63	3.12	7.62	4.12	9.62
1¼"	1.66	1.66	5.00	1.94	5.56	2.47	6.62	2.97	7.62	4.54	10.75
1½"	1.90	1.54	5.00	1.82	5.56	2.60	7.12	2.75	7.62	4.42	10.75
2"	2.38	1.58	5.56	2.11	6.63	2.61	7.63	3.11	8.63	4.17	10.75
2½"	2.88	1.33	5.56	1.86	6.63	2.36	7.63	2.86	8.63	4.42	11.75
3"	3.50	1.55	6.63	2.05	7.63	2.55	8.63	3.05	9.63	4.04	11.75
3½"	4.00	1.29	6.63	1.79	7.63	2.79	9.63	2.79	9.63	4.29	12.75
4"	4.50	1.54	7.63	2.04	8.63	2.54	9.63	3.10	10.65	4.10	12.75
4½"	5.00	1.29	7.63	1.79	8.63	2.85	10.75	2.85	10.75	3.86	12.75
5"	5.56	1.50	8.63	2.00	9.63	2.57	10.75	3.07	11.75	4.19	14.00
6"	6.63	1.47	9.63	2.03	10.75	2.53	11.75	3.05	12.75	4.19	15.00
7"	7.63	1.53	10.75	2.03	11.75	2.53	12.75	3.15	14.00	4.15	16.00

GERTAINTEED 850 INSTALLATION SPECIFICATION

2.2 Outdoor Hot Piping (Up to 850°F)

2.2.1 Material

All piping shall be insulated with CSG Group Heavy Density 850° Snap*On Fiber Glass Pipe Insulation as manufactured by Certain-teed Products Corporation, CSG Group, or approved equal. The insulation shall be one piece molded with a K value of 0.35 at 300°F mean temperature.

2.2.2 Thickness

Thickness of the pipe shall be as listed in CSG Recommended Thickness Tables, or as shown on drawings.

(Double layer with staggered seams and joints is recommended for service temperatures in excess of 600°F.)

2.2.3 Application

Piping:

The insulation shall be firmly butted together and secured to the pipe with No. 20 gauge corrosion resistant wire on 12″ centers. If double layer, all longitudinal and end joints shall be staggered.

Fittings:

Valves and fittings shall be insulated with mitred or nesting sizes of Heavy Density 850° Snap*On Fiber Glass Pipe Insulation securely wired in place with No. 20 gauge corrosion resistant wire. All open joints or voids shall be filled and smoothed with insulating cement.

Weather Protection:

The insulation, valves and fittings shall have a field applied metal jacket 0.016″ thick. A moisture barrier shall be provided between the Heavy Density 850° Snap*On Fiber Glass Pipe Insulation and the aluminum. The insulation and aluminum shall be held in place by a continuous friction type joint, providing a positive weatherproof seal along the entire length of aluminum jacket. Then a preformed strap containing a permanently plastic weatherproof sealant shall be centered and secured over each circumferential joint and secured with ½″ aluminum band and wing seal.

Valves and fittings shall be field covered with prefabricated 0.016″ metal fittings or mitred sections of aluminum metal jackets 0.016″ thick.

Valve Insulation

Valve Size	Thickness	Installed Cost * Labor & Material Inc. OH & Profit
1/2	2.5	$ 11.40
3/4	3.0	13.22
1	3.5	21.26
1 1/2	4.0	28.39
2	4.5	52.90
3	5.0	75.28
4	5.5	164.55
4 1/2	6.0	190.26
5	6.0	190.26
6	6.5	237.56
8	7.0	346.11
10	7.0	381.68
12	7.0	417.25
14	7.0	452.82

* High density foam glass insulation covered with pre-fabricated aluminum jacket (0.16 Thk)

PURCHASED PARTS

3.0 PURCHASED EQUIPMENT ACQUISITION

3.1 PURCHASED EQUIPMENT REQUIREMENTS

The purchased parts identified in this section are separated into the seven (7) subsystems as defined in Table 3.1. All tanks and active components as defined on each subsystem Piping and Instrumentation Diagram Drawing (P&ID) are listed. The purchased parts are defined on a component sheet. The component sheet contains a part number identification which locates the item on the subsystem P&ID drawing. The subsystem component is contained in the Component Nomenclature, the quantity required per subsystem and the general requirements of the component. Also contained on the component sheet are the suggested sources, dates for hardware delivery, the vendor status and cost information.

Following the component sheet are vendor quotes and/or estimates for component cost. Were estimates have been used it is planned to obtain quotations as the component requirements are further defined.

For the components that could be identified in the cost estimating handbooks, as a standard component or similar-to item, that cost estimate was used and the source referenced on the component sheet with the UCI number.

Component delivery time estimates were developed using vendor quotes and part purchase orders on similar equipment. With this data and the hardware need date, the purchase order placement date can be established to meet the hardware installation requirement.

The purchased parts and collector subassemblies will be received by MATSCO at a secured warehouse. The warehouse will be utilized to receive, inspect and accept hardware and to maintain that hardware in an enclosed and secure area. A stock card system will be in place in the warehouse for inventory and stock control.

TABLE 3-1. STE-LSE PURCHASED EQUIPMENT

SOLAR COLLECTOR SUBSYSTEM

- Collector Equipment (196)
- Collector Control Unit (196)

SOLAR COLLECTOR FIELD SUBSYSTEM

- Control Valves (20) - modulating
- Control Valves (20) - on/off
- Isolation Valves (384)

HIGH TEMPERATURE STORAGE SUBSYSTEM

- Collector Field Pumps (2)
- Collector Fluid
- Large HTS Tanks (3)
- Small HTS Tanks (1)
- Oil Vapor Condensing Tank
- Make-up Oil Storage Tank
- Iron Ore Storage Medium
- Oil Fill Pump (1)
- HTS Transfer Pump (1)
- Steam Generator Supply Subsystem (SGS)
- Steam Generator Supply Pump (1)
- Syltherm™ 800 Fossil Fired Heater (1)
- Fossil Heater Booster Pump (1)
- Collector Field Trim Valves (14)
- Nitrogen Regulation Valve (1)
- Condensable Back Pressure Valve (4)
- Nitrogen Storage System
- Fossil Fuel Air Preheater (1)
- Combustion Air Supply Fan (1)
- Tank Selection Valves Collector Field Return (4)
- Tank Selection Valve Steam Gen. Return (4)
- Steam Gen. Return Selection Valves (4)
- Fossil Fuel Htr. Supply Selection Valves (2)
- Fossil Fuel Htr. Return Selection Valves (3)
- Collector Field Pump Selection Valves (2)
- Collector Field Pump By-Pass Valve (1)
- Tank Selection Valves Steam Gen. Supply (4)
- Tank Selection Valves Collector Field Supply (4)
- Energy Storage Cir. Pump By-Pass Valve (1)
- Circulation Pump Discharge Tank Sel. Valve (4)
- Circulation Pump Suction Tank Sel. Valve (4)
- Storage Tank Flow Control Valves (8)
- Steam Gen. Supply Pump By-Pass Valve (1)

POWER CONVERSION SUBSYSTEM

- Steam Generator
- Deaerator
- Turbine/Generator (GFE)
- Condenser
- Condensate Storage Tank
- Boiler Feed Pump
- Chem Injection System
- Demineralizer
- Condensate Storage Pump
- Condensate Pump
- Syltherm™ Control Valve
- Syltherm™ By-Pass Valve
- Condensate Level Control Valve
- Deaerator Level Control Valve
- Desuper Heater (2)
- Turbine Heater Control Valve (2)
- Condenser Level Control Valve
- Steam Generator Supply Valve
- Nitrogen Regulator
- Turbine Extraction Valve

THERMAL UTILIZATION SUBSYSTEM

- Absorption Air Cond.
- Cond. Cooling Tower
- AC Cooling Tower
- Cond. Cooling Tower H/X
- Bleyle Heating H/X
- Hot Water Pump
- Chilled Water Pump
- A/C Cooling Tower Pump
- Condenser Cooling Tower Pump
- Heating Water Supply Pump
- Chemical Mix Tank
- Hot Water Flow Control Valve (2)
- Chilled Water Temp. Control Valve
- Hot Water Supply Temp. Control Valve
- Low Temperature Storage Tank Pump
- Low Temperature Storage Tank

CONTROLS AND INSTRUMENTATION SUBSYSTEM

- Pyrheliometers (4)
- 3" Flowmeters W MAG P/U Transducers
- 5" O.D. Pressure Transducer
- 4 1/2" O.D. Pressure Transducer
- 4" O.D. Pressure Transducer
- RTD (22) (CFS)
- Thermowells (22)
- Pressure Transducers (4)
- RTD (14) (TES)
- Valve Limit Switches (40)
- Level Indicators (4)
- Thermowells (14)
- 3" Flowmeter W P/U
- Gas Transducers
- RTD's (SGS)
- Thermowells
- 1" Flowmeter W P/U
- 2" Flowmeter W P/U
- Pressure Transducers
- Level Switch
- RTD (PCS)
- Thermowells (8)
- Thermowells (6)
- Power Meter (Real) (4)
- Power Meter (Reactive) (4)
- Volt Meters (4)
- 6" Flowmeter W P/U
- 3" Flowmeter W P/U
- 2" Flowmeter W P/U
- Pressure Transducer
- RTD's (TUS) (31)
- Thermowells (31)

ELECTRICAL SUBSYSTEM

- Main Protective Relaying Switchboard
- Instrument Transformers
- Main Breakers
- Main Transformer
- Motor Control Center
- Auxiliary 70KW Generator
- Battery Assembly

The warehouse will be utilized as a staging area for accumulation and release of hardware to the installation site. Use of this method will keep material inventory under control at all times and allow the system installation to proceed in a timely and efficient manner. Material releases to the job site will be coordinated to the system installation schedules to minimize the quantity of hardware at the site. This serves to minimize the risk to hardware damage and loss.

COLLECTORS

3.2 SOLAR COLLECTOR SUBSYSTEM

The on-going collector design-to-cost effort bogies are shown in Table 3.2-1. These costs are for the collectors to be installed at Shenandoah. All costs shown are thru G and A and are in 1978 dollars.

Table 3.2-1 also shows the design-to-cost status, by hardware element, as of Jan. 1979. It is expected that the Quadrant Test will indicate areas for hardware improvement, simplification or elimination which will help in attaining the cost bogies.

It is expected that with a new larger press at DeKalb Tool and Die, Inc., the reflector petals can be made longer (with a die change). If this is successful the annulus can be eliminated. Cables can be simplified to eliminate connectors and potting compounds for the production run, thereby decreasing costs. It may be possible to eliminate the optical tracker by using computer tracking thereby again reducing costs. This last item will be tested and if feasible, proven out during the Quadrant Test.

Field erection of the base assembly can be simplified by eliminating field welding and painting. The base can be completely factory assembled and painted and then bolted together on its foundation.

The above items are to be explored during the product improvement work to follow the Quadrant Test and before releasing the design for high volume fabrication.

Figure 3.2-1 shows the collector as installed on the concrete foundation.

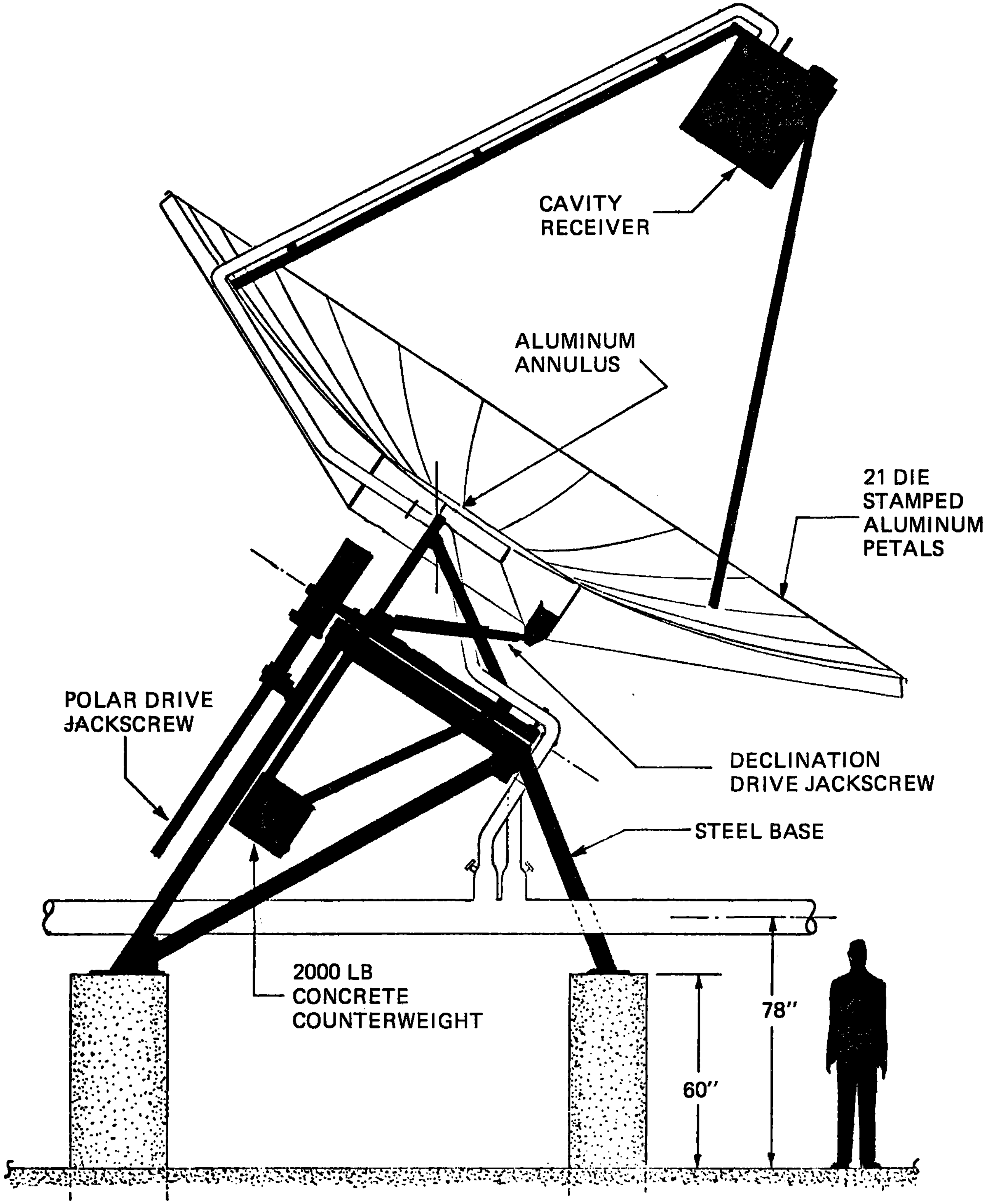


Figure 3.2-1. LSE 7 METER COLLECTOR

PART NO. 1 SHEET NO. ____

COMPONENT SHEET

DATE UPDATED ____

SUBSYSTEM: SCS

COMPONENT NOMENCLATURE: Solar Collectors

QUANTITY REQUIRED: 192 + 4 Spares

REQUIREMENTS:

G. E. - supplied equipment as per GE drawings

SUGGESTED SOURCES:
1. General Electric
2.
3.
4.
5.

DATES:
- RFQ ____
- DEL. TIME WKS. ____
- POI ____
- HARDWARE NEED ____

VENDOR STATUS

COST/UNIT (32.25/ft^2) $13,351

Bradcn-Goodbary Corporation

FEB 2 '79 A.O. Laurer

P.O. BOX 1229 • TULSA, OKLAHOMA 74101 • TELEPHONE 918 272-5371

QUOTATION DATED 1/29/79 SHEET 1 OF 1 NUMBER SP-1550

TO: General Electric
Space Systems
P.O. Box 8661 Rm. 7621
Philadelphia, Pa. 19101

ATTENTION: MR. A. LAURER

SUBJECT: YOUR INQUIRY NO. A112-1
SUPPORT ASSEMBLY, POLAR DRIVE
147D9655G1

Gentlemen:

We propose to furnish four (4) of the above subjects parts for the sum of ....$ 206.00 each.

We propose to furnish (196) of the above subject parts for the sum of ....$ 158.00 each.

These prices are F.O.B. Tulsa, Oklahoma.

Our prices do not include any state or local sales or use tax or any other applicable tax.

These prices are good until May, 1979.

TERMS: Net 30 days.

SHIPMENT: As required.

ATTENTION: This quotation is subject to Terms and Conditions printed on attached sheet

ACCEPTED ______________________

BY ______________________

TITLE ______________________

Bradcn-Goodbary Corporation

BY John J. Joyce

John J. Joyce

3 -8

CC: R. ROGAN

QUOTATION

Gears and Fractional Horsepower Gear Motors

NO. 18023

Gear Company

Phone 314-968-2100 • 9353 Watson Industrial Park • St. Louis, Mo. 63126

TO: G. E. Space Division
P.O. Box 8861
Room 7310 - Bldg. 7
Philadelphia, PA 19101

DATE 12/19/78
TERMS Net 30 Days
F.O.B. Our Plant
DELIVERY 18 Weeks

ATTN: Mr. Al Laurer
cc: Mr. Donald Kurgarth
In reply to your inquiry

We submit the following quotation:

ITEM	DESCRIPTION	QUANTITY	PRICE Each
1	Our Model VW8A Gearmotor.	10	78.99
	30 RPM All Steel Gears.		
	TENV - Intermittant Duty.	25	71.48
	1/10 H.P. - 4 Pole PSC Motor with Capacitors and Automatic Thermal Protection.	50	65.05
	1/2" NPT Hole in Case.		
	Sealant at Motor Surface.	100	61.83
	115/60/1		

JAN 4 '79 A.O. Laurer Per Jim Evans
Above includes H.T. STEEL GEAR
10 PC. PRICE WILL APPLY FOR QTY OF 15 EACH.
DEL. 8 WKS

THIS AGREEMENT IS SUBJECT TO ALL PROVISIONS AND CONDITIONS ON THE REVERSE SIDE INCLUDING THOSE LIMITING WARRANTIES.

SALES REPRESENTATIVE

Young-Hager Associates
610 Montgomery Avenue
Narberth, PA 19072

von Weise Gear Company

James H. Evans 3-11
James H. Evans

NOV 6 '78 A.O. Laurer

CC: Don Kugath
Larry Duggins

Duff-Norton
A SUBSIDIARY OF
Amstar
CORPORATION

P. O. BOX 1719, CHARLOTTE, NORTH CAROLINA 28232 • (704) 588-0300

November 6, 1978

YOUR REF. NO.

QUOTATION

IN REPLY REFER TO
District Sales Office
203 Laurel Lane
Broomall, PA. 19008

Mr. Al Laurer, Building 7
General Electric Company
720 Vandenburg Road
King of Prussia, PA. 19406

Subject: Your Inquiry #AL8-5

Dear Mr. Laurer:

Confirming our recent telephone conversations, we are pleased to requote on your subject Inquiry, eliminating the special Aeroshell #6 grease and substituting instead our standard E.P. #1 grease, suitable for use a temperatures from 0°F. to 150° F. At the same time, we are correcting a small error in computation which results in somewhat better overall pricing.

Polar Axis:

10 Special CM-1805-35-B Upright Machine Screw Jactuators, 6:1 Ratio, Standard Clevis Screw End Configuration, 10" closed height from mounting base to centerline of clevis hole, stop disc for overtravel protection, 35" Raise, bellows boot with two internal guides...$317.55 ea. net

400 Same as above..........................$294.55 ea. net

Declination Axis

5 Special Model M-2005-1017-B Double Clevis Jactuator, 6:1 Ratio, stop disc, 27½" maximum travel to stop, minimum closed pin to pin = 37-3/4", Bellows Boot with one internal guide..............................$456.25 ea. net

200 Same as above..........................$376.90 ea. net

Unless otherwise stated above, the proposal herein submitted is subject to the conditions set forth on the reverse side of this sheet.

3-12

NOV 30 '78 A.O. Laurer

KUTZNER METAL FABRICATING COMPANY

Specialists in:

- PRECISION FABRICATING OF ALL METALS
- CERTIFIED WELDING
- COMPLETE MACHINE FACILITIES
- CONTRACT MANUFACTURING

EST. 1939

101 EAST LAUREL AVENUE
CHELTENHAM, PENNA. 19012

AREA CODE 215
PHONE: 379-4614

November 28, 1978

General Electric
Space Division - P. O. Box 8661
Philadelphia, Pa., 19101

Attention: Mr. Al Laurer

Dear Mr. Laurer:

We submit the following quotation for your consideration with regard to RFQ AL8-10

Item 1 - #184C8015 G1 Assembly	- 4 parts	@ $155.00 each
	- 5 "	" 149.00 "
	- 200 "	" 63.75 "

A one-time pattern charge of $190.00 would be required on an initial order. Parts quoted with, 1)casting being machined in bore and holes drilled, 2) with G.E. furnished bearing pressed in place, 3) less any finish. Base to be flat within 1/16.

Delivery: 4 and 5 parts, 6-8 weeks; 200 parts, 8-10 weeks after receipt of order.

F.O.B. delivered, your plant, King of Prussia, Pa.

Item 2 - #184C8015 G2 Assembly	- 4 parts	@ $142.00 each
	- 5 "	" 136.00 "
	- 200 "	" 63.50 "

Parts quoted complete per print with, 1)G.E. furnished bearing pressed in place, 2) less any finish.

Delivery: Same as item #1.

F.O.B. delivered, your plant, King of Prussia, Pa.

We look forward to being of service to you.

Sincerely,

Ed Kutzner

Thank you for the order

Edward Kutzner

3-9

rh
cc/CIV

Al - Please advise if you're going to furnish bearing - Ed

DURO MFG. CO., INC.

ASHLAND & COLUMBIA AVENUES FOLCROFT, PA. 19032

TELEPHONES

215 LUDLOW 6-2982 215 SARATOGA 4-0400

MACHINE COMPONENTS
TOOLS & DIES
PRECISION SHEET METAL PRODUCTS
WELDED ASSEMBLIES
METAL SPINNING

October 5, 1978

General Electric Company
RSDX Space Systems
3198XChestnutXStreet P. O. Box 8048
Philadelphia, Pennsylvania 19101

Re: Inquiry No. AL-8-1 Amended

Attention: Mr. A. Laurer

Dear Sir:

In reference to your recent inquiry requesting a quoting figure on your drawing Below , we are pleased to quote the following:

Item 01------#184C8015 G1 Bearing Block Assy.-------5 pcs.----$160.00 each
Item 02------#184C8015 G2 Bearing Block Assy.-------5 pcs.------$97.50 each
Item 03------#184C8015 G1 Bearing Block Assy.-----200 pcs.------$74.25 each
Item 04------#184C8015 G2 Bearing Block Assy.-----200 pcs.------$62.50 each

Note: GE is to supply all bearings.

Delivery of the above items can be made asxrequired 6 Weeks ARO.

Terms: 1% 10 days - 30 days net

Hoping this meets with your approval, we remain:

Sincerely yours,

DURO MFG. CO., INC.

J. A. Osterheldt
President

JAO:b

Prices are F.O.B. our factory, Charlotte, N.C.
Terms: 2% 10th & 25th prox., net 30 days
Estimated Delivery: Quantities of 10 and 5 in approximately 10-12 weeks from receipt of your order.

Larger quantities can be shipped to meet your assembly requirements, starting within 8-10 weeks from receipt of your order.

Thank you, once again, for your continued interest. We look forward to being of service at your convenience. Please don't hesitate to phone me at (215) 353-3287 if you have any additional questions whatsoever.

Sincerely yours,

DUFF-NORTON COMPANY

T E Sell

Thomas E. Sell
District Sales Manager

New England Instrument Company

NOV 28 '78 A.O. Laurer

Precision Conductive Plastic and Wirewound Potentiometers and Microwave Components

cc: D. Kuhath
L. Douglas

KENDALL LANE
NATICK, MASS. 01760

TEL. 617 - 873-9711
TWX 710 - 346-0398

QUOTATION

REFERENCE NEI: Q1C-4796

DATE 11-21-78

GENERAL ELECTRIC CO.
P.O. BOX 8661
PHILADELPHIA, PA 19101

TO: Attention: Al Laurer - RM 7621

GENTLEMEN:

We solicit your purchase order on the basis of the following information:

ITEM	QUANTITY	MATERIAL	UNIT PRICE	TOTAL PRICE	SHIPMENT
1)	10 400	2" Precision Conductive plastic potentiometer NEI Type 200FL1- .25% Linearity	$93.50 40.68		12-14 wks ARO
2)	10 400	2" Precision Conductive plastic potentiometer NEI Type 200FL1- 0.1% Linearity	$97.50 42.25		12-14 wks ARO

PRICES QUOTED ARE F.O.B. FACTORY, NATICK, MASSACHUSETTS

TERMS: NET 30 DAYS FROM DATE OF INVOICE SUBJECT TO CREDIT APPROVAL PAYABLE AT PAR IN NEW YORK OR BOSTON FUNDS.
QUOTATION SUBJECT TO 30 DAYS ACCEPTANCE BY SUBMISSION OF YOUR PURCHASE ORDER.
PRICES SHOWN WILL BE INCREASED BY THE AMOUNT OF ANY APPLICABLE FEDERAL, STATE OR LOCAL TAX THAT MAY BE IMPOSED ON OR BECAUSE OF THIS TRANSACTION.

STENOGRAPHIC AND CLERICAL ERRORS ARE SUBJECT TO CORRECTION.
DETERMINATION OF PRICES, TERMS AND CONDITIONS OF SALE AND ACCEPTANCE OF ORDERS ARE MADE ONLY AT FACTORY, NATICK, MASS.
SHIPPING PROMISE DATES FROM ACCEPTANCE OF YOUR ORDER SUBJECT TO PRIOR SALES AND TO CONDITIONS BEYOND OUR CONTROL.

OUR REPRESENTATIVE IN YOUR AREA:
MONTEIRO ASSOC. 215-
600 Lewis Road
King of Prussia, PA 19106

new england instrument co.
BY David L. LeBlanc
David L. LeBlanc
Regional Sales Manager

American Alloy Steel, Inc.
2070 Steel Drive, Tucker, Ga. 30084 – Area Code 404-934-1681
In Greater Atlanta

Proposal No. 10-0009-397

To: General Electric Co.
Valley Forge Space Center
P.O. Box 8661
Philadelphia, PA 19101

ATTN: Mr. Al Laurer
(215) 962-2000

Date: October 17, 1978

Project: 77-EG-C-04-3985

American Alloy Steel Inc., proposes to furnish, f.o.b. Tucker, GA

ITEM		DESCRIPTION	PRICE
01	Four (4)	Base Weldment per dwg. #919E117G1 @ $610.97 ea.	$2,443.88
02	Four (4)	Base Weldment per dwg. #919E117G2 @ $201.23 ea.	$ 804.92
03	Four (4)	Structural Assembly per dwg. #184C8021G1 @ $135.82 ea.	$ 543.28
04		Tooling for Items 01, 02, & 03 price included in the above mentioned items.	--
05	196 ea.	Base Weldments per dwg. #919E117G1 @ $580.42 ea.	$113,762.32
06	196 ea.	Base Weldments per dwg. #919E117G2 @ $191.17 ea.	$ 37,469.32
07	196 ea.	Structural Assembly per dwg. #184C8021G1 @ $122.24 ea.	$ 23,959.04
08		Tooling for Items 05, 06 & 07 price included in above mentioned items.	--
		TOTAL PRICE	$178,982.76

The Buyer shall pay, in addition to the purchase price, the amount of all sales, use or other taxes on this purchase that may be imposed upon this transaction by the federal government or any state government, or any subdivision, but only when Seller is required by law to collect or pay such taxes.

THIS PROPOSAL is subject to conditions on back hereof. Use of any material, herein described, shall constitute acceptance of all of the above specified.

ACCEPTED

____

By ______________________

Date ______________________

AMERICAN ALLOY STEEL, INC.

By Carl White

Carl White, Estimator

DATE: ______________

3-15

If Accepted Sign Original and Return

AA003-374

American Alloy Steel, Inc.
2070 Steel Drive, Tucker, Ga. 30084 – Area Code 404-934-1681
In Greater Atlanta

Proposal No. 18-0004-397

General Electric Co.
Valley Forge Space Center
P.O. Box 8661
Philadelphia, PA 19101

ATTN: Mr. Al Laurer
(215) 962-2000

Date October 17, 1978

Project 77-EG-C-04-3985

American Alloy Steel Inc., proposes to furnish, f.o.b. Tucker, GA

TERMS 1% - 10
Net - 30 days

DELIVERY December 15, 1978 if American Alloy Steel is awarded contract and purchase order is in house by November 3, 1978 on first three items.

The Buyer shall pay, in addition to the purchase price, the amount of all sales, use or other taxes on this purchase that may be imposed upon this transaction by the federal government or any state government, or any subdivision, but only when Seller is required by law to collect or pay such taxes.

THIS PROPOSAL is subject to conditions on back hereof. Use of any material, herein described, shall constitute acceptance of all of the above specified.

ACCEPTED

By

Date

AMERICAN ALLOY STEEL, INC.

By Carl White

Carl White, Estimator

DATE:

3-16

If Accepted Sign Original and Return

AA003-374

American Alloy Steel, Inc.
2070 Steel Drive, Tucker, Ga. 30084 -- Area Code 404-934-1681
In Greater Atlanta

Proposal No. 18-0004-406

OCT 30 '78 A.O. Laurer

General Electric
Valley Forge Space Center
P.O. Box 8661
Philadelphia, PA 19101

Date October 19, 1978

Project 77-EG-C-04-3985

ATTN: Mr. Al Laurer AL 9.2

American Alloy Steel, Inc., proposes to furnish, f.o.b. Tucker, GA

ITEM		DESCRIPTION		PRICE
01	Four (4)	Yoke support assemblies per drawing #919E116 Less Fafnir Bearings.	$1,730.39 ea.	$6,921.56
03	196 ea.	Yoke Support assemblies per drawing #919E116 Less Fafnir Bearings.	$1,678.48 ea.	$328,982.08

The above prices includes the prime and finish coat of paint. Units will be painted prior to shipment.

TERMS 1% - 10
Net 30 days

DELIVERY The first four units; sixty (60) days after receipt of purchase order and fifty (50) units per month there after until order is complete.

The Buyer shall pay, in addition to the purchase price, the amount of all sales, use or other taxes on this purchase that may be imposed upon this transaction by the federal government or any state government, or any subdivision, but only when Seller is required by law to collect or pay such taxes.

THIS PROPOSAL is subject to conditions on back hereof. Use of any material, herein described, shall constitute acceptance of all of the above specified.

ACCEPTED

____

By _______________

Date _______________

AMERICAN ALLOY STEEL, INC.

By _______________
Carl White,
Estimator
DATE: _______________

3-17

If Accepted Sign Original and Return

AA003-374

NOV 21 '78 A.O. Laurer

DURO MFG. CO., INC.

·SHLAND & COLUMBIA AVENUES FOLCROFT, PA. 19032

TELEPHONES

215 LUDLOW 6-2982 215 SARATOGA 4-0400

MACHINE COMPONENTS
TOOLS & DIES
PRECISION SHEET METAL PRODUCTS
WELDED ASSEMBLIES
METAL SPINNING

November 17, 1978

General Electric Company
RSDX Space Systems
3XXXXXXXXXXXXXXXX P. O. Box 8661
Philadelphia, Pennsylvania 19101

Re: Inquiry No. AL10-5

Attention: Mr. A. Laurer

Dear Sir:

In reference to your recent inquiry requesting a quoting figure on your drawing Below , we are pleased to quote the following:

Item 01------#147D9637 G1 Drive Assembly----------8 pcs.-------$187.50 each
Item 02------#147D9637 G2 Drive Assembly----------4 pcs.-------$127.50 each
Item 03------#147D9637 G1 Drive Assembly--------392 pcs.-------$127.50 each
Item 04------#147D9637 G2 Drive Assembly--------196 pcs.--------$97.50 each

Delivery of the above items can be made xxxrequired.6-9 Weeks ARO.

Terms: 1% 10 days - 30 days net

Hoping this meets with your approval, we remain:

Sincerely yours,

DURO MFG. CO., INC.

J. A. Osterheldt
J. A. Osterheldt
President

JAO:b

3-18

INQUIRY DATE	INQUIRY NO.	QUOTATION DUE BY	QUOTE F. O. B.
11/15/78	AL9-3	NOTE X	NOTE IX

GENERAL ELECTRIC

SPACE SYSTEMS
P. O. BOX ~~8~~ 8661
PHILADELPHIA, PA. 19101
ATTN: (BUYER LISTED BELOW)

REQUEST FOR QUOTATION
THIS IS NOT AN ORDER

SELLER IS REQUESTED NOT TO DISCLOSE TO OTHERS ANY INFORMATION ABOUT THIS REQUEST FOR QUOTATION.

KUTZNER METAL FABRICATING CO.
101 EAST LAUREL AVE.
CHELTENHAM, PA. 19012

RECEIVED NOV 16 1978

Please quote us immediately, in triplicate, on the following. Indicate whether you can fulfill delivery requirements stated below, and if not, your best shipping promise. If special tooling is required for which GENERAL ELECTRIC COMPANY will be charged, quote the same separately and state the time required for its completion.

NOTE:

1. The Conditions of Purchase on the reverse side will apply to any Purchase Order placed in response to this Request for Quotation. In addition, if so indicated below, the attached Supplementary Provisions will also be applicable to any such Purchase Order.
2. Any knowledge or information which shall have been disclosed to or which may hereafter be disclosed to General Electric Company in connection with, or related to, this Request for Quotation shall not, unless otherwise specifically agreed upon in writing by an authorized representative of the General Electric Company, be deemed to be confidential or proprietary information or be deemed to be submitted in confidence to General Electric Company; and any such knowledge or information shall be acquired by General Electric Company free from any restrictions other than a claim for patent infringement.

ADDRESS REPLY TO	GOVERNMENT CONTRACT NO.	CERTIFIED UNDER DMS REGULATION NO. 1	DATE OF DELIVERY AT DESTINATION
NOTE X	77-EG-C-04-3985	[ ] DXA2 [X] DO XX DOE	

ITEM	DRAWING/PART NO.	REV.	A. N.	DESCRIPTION OF GOODS AND/OR SERVICES	QUANTITY	U/M	UNIT PRICE DOLLARS	CENTS	MO. DAY
				QUOTE A FIRM FIXED PRICE ON THE FOLLOWING:					
01	919E118G1	-	-	HUB ASSEMBLY	5	EA	$5475	.00	ea.
02	---			TOOLING (SEE NOTE I)			$1800	.00	
03	919E118G1	-	-	HUB ASSEMBLY	196 per print	EA	$2730	.00*	ea.
04	---			TOOLING (SEE NOTE I) No additional tool cost					
				With P.9, P.17 and P.18 changed to 3/8" thk. material	-		$2520	.00*	ea.

Terms: Net 30
F.O.B: Our Plant

Delivery: It.#1 approximately 10-12 wks. after receipt of order.
It.#3 to be determined when order is placed.

*Note: Prices based upon current cost of material.

SUPPLEMENTARY PROVISIONS (IF LETTER TYPED IN FOREGOING SPACE) ARE ATTACHED AND ALSO APPLY.

SIGNATURE: [signature] BUYER

FORM 11185-S (REV 3-68)

VENDOR-2

[signature]
Edward Kutzner, President

Amendment #1

INQUIRY DATE	INQUIRY NO.	QUOTATION DUE BY	QUOTE F.O.B.
11/?/73	L 9-3	1?/?1/73	

Kutcher
Metal Fabricating Inc.
101 East Laurel Avenue
Cheltenham, Pa. 19?12
Attn: Mr. E. Ku[illegible]

DEC 11 '78 A.O. Laurer

GENERAL ELECTRIC

SPACE SYSTEMS
P. O. BOX 8?74
PHILADELPHIA, PA. 19101
ATTN: (BUYER LISTED BELOW)

REQUEST FOR QUOTATION
THIS IS NOT AN ORDER

SELLER IS REQUESTED NOT TO DISCLOSE TO OTHERS ANY INFORMATION ABOUT THIS REQUEST FOR QUOTATION.

Please quote us immediately, in triplicate, on the following. Indicate whether you can fulfill delivery requirements stated below, and if not, your best shipping promise. If special tooling is required for which GENERAL ELECTRIC COMPANY will be charged, quote the same separately and state the time required for its completion.

NOTE:

1. The Conditions of Purchase on the reverse side will apply to any Purchase Order placed in response to this Request for Quotation. In addition, if so indicated below, the attached Supplementary Provisions will also be applicable to any such Purchase Order.
2. Any knowledge or information which shall have been disclosed to or which may hereafter be disclosed to General Electric Company in connection with, or related to, this Request for Quotation shall not, unless otherwise specifically agreed upon in writing by an authorized representative of the General Electric Company, be deemed to be confidential or proprietary information or be deemed to be submitted in confidence to General Electric Company; and any such knowledge or information shall be acquired by General Electric Company free from any restrictions other than a claim for patent infringement.

ADDRESS REPLY TO	GOVERNMENT CONTRACT NO.	CERTIFIED UNDER DMS REGULATION NO. 1	DATE OF DELIVERY AT DESTINATION
See Below	77-?G-C-04-3335	☐ DXA2 ☐ DOA2	

ITEM	DRAWING/PART NO.	REV.	A. N.	DESCRIPTION OF GOODS AND/OR SERVICES	QUANTITY	U/M	UNIT PRICE DOLLARS	UNIT PRICE CENTS	MO.	DAY

This RFQ is an amendment #1 to Inquiry AL 9-3 and provides Revision 1 to Drawing 91?113G1. A description of the change is also attached for your information. Please expedite your response and provide a telephone quote on or before 1 Dec. 73 with subsequent written confirmation.

All other terms of the basic RFQ remains unchanged.

PLEASE RESPOND TO : [illegible] CO.
[illegible]
Philadelphia, Pa. 19101
Attn: Al Laurer
Telephone: 962-2357

REQ # 8661
[illegible]

SUPPLEMENTARY PROVISIONS (IF LETTER TYPED IN FOREGOING SPACE) ARE ATTACHED AND [illegible] APPLY.

3-20

SIGNATURE: ____________ BUYER

FORM 11165-S (REV 3-68)

OCT 17 '78 A.O. Laurer

Rosado Design & Manufacturing Co.

Precision Sheet Metal Fabrications - Machine Work
Heavy Steel Fabrication & Erection
ATLANTIC AVE. - P. O. BOX 148
BERLIN, N. J. 08009
(609) 767-6532

DATE: 10-17-78

TO General Electric Company
P. O. Box 8661
Philadelphia, Penna. 19101

Attn: Al Laurer Room 7621

F.O.B. Rosado Design & Mfg. Co., Inc. Location

TERMS: ½% 10 Net 30

DELIVERY: 4 to 5 weeks

GENTLEMEN: THANK YOU FOR YOUR INQUIRY OF 10-5-78 NO. Al-10-1

WE ARE PLEASED TO QUOTE YOU AS FOLLOWS:

QUANTITY	DESCRIPTION	PRICE
5 ea.	147D9652G1 - Swing Arm Assy.	$370.00 each
196 ea.	147D9652G1 - Swing Arm Assy.	$280.00 each
	TOOLING $575.00	
	QUOTE VALID FOR 30 DAYS SUBJECT TO CHANGE BASED ON MATERIAL COSTS.	

We shall be pleased to supply any further information you may desire and trust that you will decide to favor us with this order which will receive our prompt and careful attention.

Per [signature]

ELKAY
MANUFACTURING CORPORATION
P.O. Box 185 Cedar Hill Road Chalfont, Pennsylvania 18914
(215) MI 6-7810 (215) 822-3722
A Complete Precision Metal Service

OCT 12 '78 A.G.L.

October 10, 1978

Mr. Al Laurer
Room 7621
General Electric Co.
P. O. Box 8661
Philadelphia, Pa. 19101

Subject: Inquiry #AL10-2

Dear Mr. Laurer:

Thank you for the above inquiry which we are quoting as follows:

5 Pieces	Bracket, Mounting #221B3015P1	$19.75 Each
196 Pieces	Bracket, Mounting #221B3015P1	1.62 Each

Delivery: As required

F.O.B: Your plant

Terms: 1/2% 10, Net 30

We appreciate this opportunity to quote and look forward to serving you.

Very truly yours,

ELKAY MANUFACTURING CORPORATION

Conrad J. Frisch

Conrad J. Frisch
Manager
Sales Engineering

akk

12/4/78 - Mr. C. Frisch price includes finish.

3-22

NOV 30 '78 A.O. Laurer

KELLETT CORPORATION

November 22, 1978

General Electric
Space Systems
P.O. Box 8661
Philadelphia, Pa. 19101

ATTENTION: Mr. Al Laurer

REFERENCE: General Electric RFQ AL10-3
Kellett KC-12167

Dear Mr. Laurer:

Attached is pricing data requested on the above referenced inquiry. The following terms and conditions apply.

1. Terms: Net 30 on items 01, 02 and 04.

2. Process payments required on item 03.

3. F.O.B.: General Electric - Valley Forge

4. DELIVERY: Nogotiate prior to award.

We again thank you for considering Kellett on your recent inquiry and look forward on being favored with this award.

Very truly yours

KELLETT CORPORATION

Joseph V. Juba
Sales Engineer

JVJ/fr

cc: R.C. Winter
C. McGinnis

P.O. Box 35, Willow Grove, Pennsylvania 19090 • Phone: (215) 675-2930

11/14/78 | AL10-3 | 11/28/78 | DEST.

KELLETT CORPORATION
P.O. BOX 35
WILLOW GROVE, PA. 19090
ATTN: J. V. JUBA

NOV 30 '78 A.O. Laurer

RECEIVED NOV 15 1978

SPACE SYSTEMS
P. O. BOX ~~XXX~~ 8661
PHILADELPHIA, PA. 19101
ATTN: BUYER LISTED BELOW

REQUEST FOR QUOTATION
THIS IS NOT AN ORDER

THE VENDOR IS NOT TO DIVULGE TO OTHERS ANY INFORMATION ABOUT THIS REQUEST FOR QUOTATION.

Please quote us immediately, in triplicate, on the following. Indicate whether you can fulfill delivery requirements stated below, and if not, your best shipping promise. If special tooling is required for which GENERAL ELECTRIC COMPANY will be charged, quote the same separately and state the time required for its completion.

NOTE:

1. The Conditions of Purchase on the reverse side will apply to any Purchase Order placed in response to this Request for Quotation. In addition, if so indicated below, the attached Supplementary Provisions will also be applicable to any such Purchase Order.
2. Any knowledge or information which shall have been disclosed to or which may hereafter be disclosed to General Electric Company in connection with, or related to, this Request for Quotation shall not, unless otherwise specifically agreed upon in writing by an authorized representative of the General Electric Company, be deemed to be confidential or proprietary information or be deemed to be submitted in confidence to General Electric Company; and any such knowledge or information shall be acquired by General Electric Company free from any restrictions other than a claim for patent infringement.

ADDRESS REPLY TO	GOVERNMENT CONTRACT NO.	CERTIFIED UNDER DMS REGULATION NO. 1	DATE OF DELIVERY
SEE BELOW	77-EG-C-04-3985	☐ DXA2 ☒ XX DOE	

ITEM	DRAWING/PART NO.	REV	A.N.	DESCRIPTION OF GOODS AND/OR SERVICES	QUANTITY	U/M	UNIT PRICE DOLLARS	UNIT PRICE CENTS	
				QUOTE A FIRM FIXED PRICE					
01	147D9643G1	1	-	RIB, SUPPORT ASSEMBLY	90	EA	65	00	*
02	147D9643G2	1	-	RIB, SUPPORT ASSEMBLY	15	EA	65	00	*
03	147D9643G1	1	-	RIB, SUPPORT ASSEMBLY	3528	EA	48	15	*
04	147D9643G2	1	-	RIB, SUPPORT ASSEMBLY	588	EA	48	15	*
				Tooling Item 01 and 02			No	Charge	
	DELIVERY			Tooling Item 03 and 04			2100	00	

ITEM 01 & 02 - BY 1/20/79

ITEM 03 & 04 - AWARD 3RD QUARTER 1979 WITH DELIVERY 3RD OR 4TH QUARTER 1979.

NOTE:

1 * Quote based on using 5052-H32 Material
2 Process payments required on Item 03

1. PROVIDE A SEPARATE TOOLING COST TO PRODUCE ITEM 01 & 02 AND ITEM 03 & 04 IF APPLICABLE.

PLEASE TELEPHONE QUOTE: AL LAURER (215) 962-2357

SEND CONF. QUOTE: GENERAL ELECTRIC CO.
P.O. BOX 8661
PHILADELPHIA, PA 19101
ATTN: AL LAURER (ROOM 7621)

SIGNATURE A.O. Laurer

PURCHASING FILE COPY

PHILADELPHIA
ORCHARD 6-3333

HUNTINGDON VALLEY
WILSON 7-2474

Custom Manufacturing Corporation

TOMLINSON & FRANKS ROADS
HUNTINGDON VALLEY, PA. 19006

OCT 2 '78 A.O. Lau...

CC: L. DOUGLAS

September 28, 1978

General Electric Company
Space Systems
P. O. Box 8048
Philadelphia, Penna., 19101

Attention: Mr. Al Laurer

Dear Al:

We are pleased to confirm the following prices on your Inquiry No AL8-9:

P/N 184C8018-P1	40 pcs.	1.05 each
P/N 184C8018-P1	1600 pcs.	.53 each
* Tooling for P/N 184C8018-P2		2,300.00
P/N 184C8018-P2 Blank Length	15 pcs.	16.00 each
P/N 184C8018-P2 90"	600 pcs.	8.20 each

Thank you for the inquiry and we look forward to hearing from you soon.

Sincerely,

CUSTOM MANUFACTURING CORPORATION

Nick Pucci

NJP/ml

Nicholas J. Pucci
Vice President

* Conversation with Nick Pucci 1/2 tooling costs must be paid with award of P.O. Al Laurer 10/3/78

DEC 1 '78 A.O. Laurer

Rosado Design and Manufacturing Company, Inc.

MACHINE WORK -- PRECISION TOOL WORK
HEAVY STEEL FABRICATION & ERECTION

5 ATLANTIC AVENUE / P.O. BOX 148
BERLIN, NEW JERSEY 08009
(609) 767-6532

General Electric Company
P. O. Box 8661
Philadelphia, Penna. 19101

Attn: Al Laurer

November 13, 1978

QUOTATION - INQ. AL 10-6 - DATED 10-26-78

F. O. B. - Rosado Design and Mfg. Co., Inc.
Terms - ½% 10 Net 30
Del. 4 to 5 weeks

PART #	QUANTITY	DESCRIPTION	PRICE
147D9653G1	15 ea.	Strut Assby. Quad	$205.00 each
147D9651G1	588 ea.	Strut Assembly	$162.00 each

TOOLING COST - $675.00
(FOR PRODUCTION QTY 588 EA. ONLY, PER JOHN ROSADO TO AL LAURER + B. WASHINGTON. AL

J. Rosado
John V. Rosado
President

QUOTE VALID FOR 30 DAYS
SUBJECT TO CHANGE BASED ON
MATERIAL COSTS.

INDUSTRIES — QUOTATION — EXPORT CORPORATION

3-28

[X] 9111 RIVER ROAD, DELAIR, NEW JERSEY 08110 U.S.A.
[ ] 2150 McGAW AVE., IRVINE, CALIFORNIA 92714 U.S.A.

TELEPHONE	TELETYPE (TWX)	CABLE ADDRESS
(609) 665-1952	710 892 2920	MILLPOL – DELAIR, NEW JERSEY
(714) 546-8991 (213) 587-2171	910 595 1784	MILLPOL – IRVINE, CALIFORNIA

ISSUED TO:
GENERAL ELECTRIC SPACE SYSTEMS
P.O. BOX 8274
PHILADELPHIA, PA. 19101

SHIP TO: (SAME UNLESS OTHERWISE SPECIFIED)

DATE 2/5/79
ATTENTION OF: Bernard Mashinton
INQUIRY OR BID NO.
QUOTATION NO. 5731
PAGE 1 OF 1

ITEM NUMBER	QTY.	THICKNESS	MAX. THICKNESS ACCEPTABLE	WIDTH (X) LENGTH	ALLOY, HEAT TREAT & SURFACE CONDITION (SEE * BELOW)	PRECISION GRIND TO	TOLERANCE	FINISH –	1 OR 2 SIDES	CHEM. PL.	ADHESIVE PAPER	PLASTIC COATING		PRICE (SEE * BELOW) AMOUNT	PER
1	1 to 5	1/8"		89" DIA. ANNULUS PER DWG. 184C8012 REV.2	1100-0 ALUMINUM	COLOR	+ BUFF		1	NO				$795.00	EA
1A	6 to 196	"		"	"	"	+ –		"	"				760.00	EA
							+ –	SET UP CHARGE						2605.00	NET
				TO BE RESHIPPED IN GENERAL ELECTRIC REUSABLE CONTAINER											
							+ –								
							+ –								

MATERIAL FURNISHED BY: [ ] MPC [X] CUSTOMER (SEE *)

*THE CONDITIONS ON THE REVERSE SIDE ARE INTEGRAL TO OUR CONTRACT. PLEASE READ THEM CAREFULLY.

F.O.B. [X] DELAIR, N.J. [ ] IRVINE, CALIF. [ ] ______

MARINE OR TRANSPORTATION INSURANCE TO BE RESPONSIBILITY OF: [X] CUSTOMER [ ] MPC

DELIVERY: ______ SUBJECT TO AVAILABILITY OF SUITABLE MATERIAL & PRODUCTION SCHEDULE AT TIME OF ACCEPTANCE OF FIRM ORDER.

TERMS: [X] ½ OF 1% 10 DAYS NET 30 [ ] NET CASH [ ] ______

QUOTATION IS VALID FOR: [ ] 30 DAYS [X] 60 DAYS [ ] 90 DAYS [ ] ______

SUBJECT TO COST OF MATERIAL INCREASE (SEE *) [ ] YES [ ] NO

SPECIAL CONDITIONS: [ ] MATERIAL TO BE FLAT AND SUITABLE FOR VACUUM CHUCK GRINDING.
[ ] ______" PERIPHERY OF MATERIAL MAY NOT MEET TOLERANCE SPECIFICATIONS.

Gene Gatti
[signature]

ORIGINAL QUOTATION

INDUSTRIES QUOTATION EXPORT CORPORATION

[X] 9111 RIVER ROAD, DELAIR, NEW JERSEY 08110 U.S.A.
[ ] 2150 McGAW AVE., IRVINE, CALIFORNIA 92714 U.S.A.

TELEPHONE (609) 665-1952 (714) 546-8991 (213) 587-2171

TELETYPE (TWX) 710 892 2920 910 595 1784

CABLE ADDRESS MILLPOL – DELAIR, NEW JERSEY MILLPOL – IRVINE, CALIFORNIA

ISSUED TO: GENERAL ELECTRIC SPACE SYSTEMS
P.O. BOX 8274
PHILADELPHIA, PA. 19101

SHIP TO: (SAME UNLESS OTHERWISE SPECIFIED)

DATE 1/25/79
ATTENTION OF: Bernard Washington
INQUIRY OR BID NO. AL-15
QUOTATION NO. 5721
PAGE 1 OF 1

ITEM NUMBER	QTY.	THICK-NESS	MAX. THICKNESS ACCEPTABLE	WIDTH (X) LENGTH	ALLOY, HEAT TREAT & SURFACE CONDITION (SEE * BELOW)	PRECISION GRIND TO	TOLERANCE	FINISH –	1 OR 2 SIDES	1 OR 2 SIDES	ADHESIVE PAPER			AMOUNT	PER
1	105 4200	to		41 X 92 (Approx)	PETALS ALUMINUM	POLISH TO BRIGHT FINISH AS PREV.			1	NO				$66.00	EA
1A	1			"	"		"		"	"				84.00	EA
													SET UP	130.00	NET
			NOTE:	Areas around any holes or slots will probably have drag out lines from the buffing compound or "starring" effect.											
2	110 4200	to .10		46 X 102	FLAT SHEET ALUMINUM	POLISH TO BRIGHT FINISH AS PREV.			1	NO				$33.00	EA
2A	1	.10		"	"	"			"	"				45.00	EA
													SET UP	84.00	NET

DELIVERY: APPROXIMATELY 15 PER DAY RUNNING 2 SHIFTS, WITH 2 WEEK LEAD TIME REQUIRED.

MATERIAL FURNISHED BY: [ ] MPC [X] CUSTOMER (SEE *)
F.O.B. [X] DELAIR, N.J. [ ] IRVINE, CALIF. [ ]
MARINE OR TRANSPORTATION INSURANCE TO BE RESPONSIBILITY OF: [X] CUSTOMER [ ] MPC
DELIVERY: as above SUBJECT TO AVAILABILITY OF SUITABLE MATERIAL & PRODUCTION SCHEDULE AT TIME OF ACCEPTANCE OF FIRM ORDER.
TERMS: [X] ½ OF 1% 10 DAYS NET 30 [ ] NET CASH [ ]
QUOTATION IS VALID FOR: [ ] 30 DAYS [X] 60 DAYS [ ] 90 DAYS [ ]
SUBJECT TO COST OF MATERIAL INCREASE (SEE *) [ ] YES [ ] NO
SPECIAL CONDITIONS: [ ] MATERIAL TO BE FLAT AND SUITABLE FOR VACUUM CHUCK GRINDING.
[ ] ______" PERIPHERY OF MATERIAL MAY NOT MEET TOLERANCE SPECIFICATIONS.

*THE CONDITIONS ON THE REVERSE SIDE ARE INTEGRAL TO OUR CONTRACT. PLEASE READ THEM CAREFULLY.

Lois J. Rose

3-27

ORIGINAL QUOTATION

LAWRAN
SAND CASTING DIVISION OF Aluminum Casting & Engineering CO.

LAWRAN FOUNDRY COMPANY 4700 West Electric Avenue • Milwaukee, WI 53219 • (414) 645-4070

October 10, 1978

General Electric Co. AEP
P.O. Box 8661
Philadelphia, PA 19101

Attention: Mr. Al Laurer
Buyer

Subject : Quotation on Part Number 919E118G1, Hub Assembly.
Per your Inquiry Number AL9-3.

Gentlemen:

We are pleased to submit our quotation on the above subject part.

This part will be cast in aluminum alloy #319 (B12G27A), at an estimated weight of 375.0 pounds each casting. Prices as follows:

Lots	5 pcs.	$1,406.25 Each
	196 pcs.	$1,237.50 Each

Pattern equipment to consist of 1 mahogany pattern on cope and drag boards with no core boxes, at a cost of $10,980.00, that can be obtained in 8 weeks.

These prices are based on metal cost of $0.570 per pound, with a weight adjustment factor of .878.

These prices are based on the quantities released for shipment by you at any specified time.

Samples will be shipped 30 working days after receipt of pattern equipment. Production castings will be shipped 30 working days after sample approval.

LAWRAN

If there is a variance between the estimated and actual weight, the price will be adjusted accordingly. This price is subject to metal cost at time of shipment of the castings.

Terms net 30 days, F.O.B. Milwaukee, Wisconsin.

Thank you for the opportunity to furnish you with a quotation on your casting requirements. We hope we may be favored with your valued orders.

Very truly yours,

LAWRAN FOUNDRY COMPANY
Division of Aluminum Casting & Engineering Co., Inc.

J Bradley

James Bradley
Sales Manager

JB/dmg

TABLE 3.2-1. STE-LSE SHENANDOAH COLLECTOR COST THROUGH G&A
196 COLLECTORS/414 FT.^{2} PER COLLECTOR

HARDWARE ITEM	COST BUDGET ($)	STATUS 1/12/79 ($)
Collector Mount & Drive Assembly		
Base Support Assembly (1)	1673	920
Bearing Block Assembly	281	140
Yoke Support Assembly (1)	754	1679
Bearing Shoulder Bolts (2)	-	18
Drive Assembly		
Jack Screws - Polar (2)	893	590
Jack Screws - Declination (1)	-	377
AC Gear Motors (3)	149	163
Couplings (3)	211	72
Support Bkts (3)	372	353
Bear Shoulder Bolts (4)	253	48
Pot. Brackets (2)	69	40
Pot. Shaft Adapter (1)	-	5
Journal Bear. (4)	189	24
Swing Arm Assembly (1)	344	280
Fasteners	13	60
SUBTOTAL - $	5201	4769
SUBTOTAL - $/FT.^{2}	12.56	11.52
Reflector Assembly		
Petals (21)		
Material	-	1214
Forming	1008	126
Drilling & Slotting	879	61
Chem. Brite	187	608
RTV Coating	90	801
Annulus (1)	454	-
Material	-	144
Forming & Drilling	-	270
Chem. Brite	-	150
RTV Coating	-	165
Ribs (21)	515	1200
Material	-	-
Forming & Drilling	-	-

TABLE 3.2-1. STE-LSE SHENANDOAH COLLECTOR COST THROUGH G&A
196 COLLECTORS/414 FT.^{2} PER COLLECTOR (Cont'd)

HARDWARE ITEM	COST BUDGET ($)	STATUS 1/12/79 ($)
Hub Assembly (1)	1164	2700
Fittings - R'CVR. Suppt. (6)	511	54
Struts (3)	198	486
Fasteners	34	163
SUBTOTAL - $	5040	8142
SUBTOTAL - $/FT.^{2}	12.18	19.67
Receiver		
Coil Assembly	434	400
Housing Assembly		
Frame	132	426
Liners	533	108
Insulation	108	60
Optics & RTD Cables	116	290
RTD	-	
Fittings	166	-
Fasteners	22	-
Assembly	-	279
SUBTOTAL - $	1511	1563
SUBTOTAL - $/FT.^{2}	3.65	3.78
Controls - CCU		
Attenuator Block	-	-
PWB	-	496
Panel Assembly	-	260
Power Supplies	-	300
Enclosure/Cables	-	400
SUBTOTAL - $	1454	1456
SUBTOTAL - $/FT.^{2}	3.51	3.52

TABLE 3.2-1. STE-LSE SHENANDOAH COLLECTOR COST THROUGH G&A 196 COLLECTORS/414 FT.^{2} PER COLLECTOR (Cont'd)

HARDWARE ITEM	COST BUDGET ($)	STATUS 1/12/79 ($)
Auxiliary Electrical		
Potentiometers	95	50
Battery	32	-
Charger	19	-
Grounding Straps	-	5
SUBTOTAL - $	146	55
SUBTOTAL - $/FT.^{2}	0.35	0.13
COLLECTOR SUBTOTAL - $	13,352	15,985
COLLECTOR SUBTOTAL - $/FT.^{2}	32.25	38.61
	196 Collectors = 196 x 414 x 32.25 = 2,616,894	

COLLECTOR FIELD

3.3 SOLAR COLLECTOR FIELD SUBSYSTEM (CFS)

The Solar Collector Field subsystem consists of the solar collector as discussed in Section 3.2 and the interconnection piping, control valves and manual trim valves. The east-west supply and return lines are installed in a travelway below grade and are insulated as separate lines. At each north-south row the piping will be brought above grade and supported by a structural steel support system at 78 inches above grade. The north-south piping supply and return lines will be insulated in a nested configuration. Table 3.3-1 lists the hardware to be procurred for the collector field. The piping and instrumentation drawing Figure 3.3-1 defines the location of the components in the field.

TABLE 3.3-1. SOLAR COLLECTOR FIELD SUBSYSTEM

ITEM NO.	NOMENCLATURE	QUANTITY	COST
2	Control Valves (Modulating)	(20 Ea.)	$45,140.00
3	Control Valves (On/Off)	(20 Ea.)	$27,880.00
4	Isolation Valves	(384)	$19,968.00
5	Trim Valves	(14 ea)	$ 2,338.00
	Sub - Total		$95,326.00
	Level-of-Definition		1.1
	Total		104,858.00

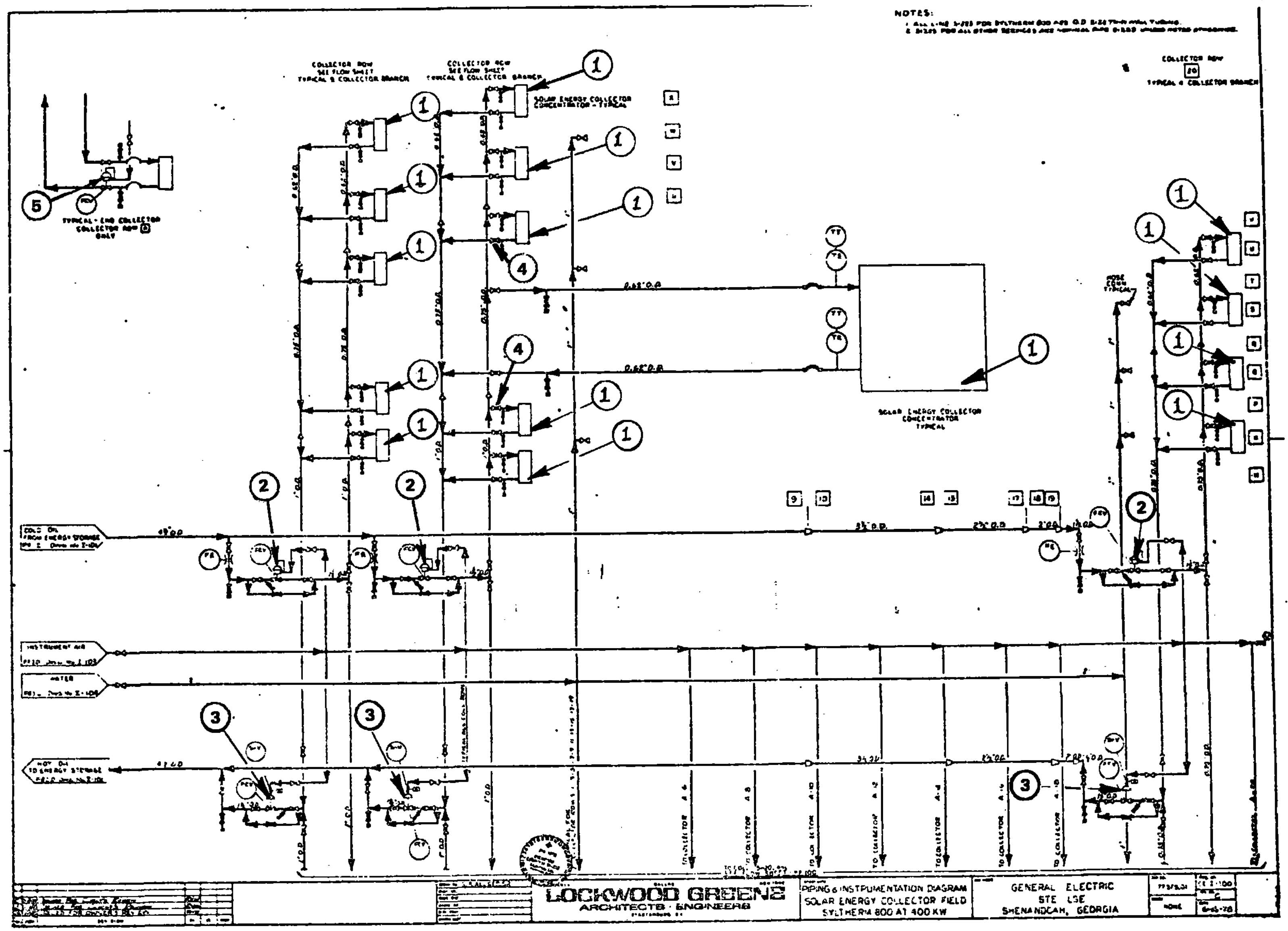


Figure 3.3-1. Piping & Instrumentation Diagram Solar Energy Collector Field Syltherm™ 800 at 400 kW

PART NO. 2

SHEET NO. ____

COMPONENT SHEET

DATE UPDATED ____

SUBSYSTEM: SCF

COMPONENT NOMENCLATURE: Control Valves (Modulating) 3/4"

QUANTITY REQUIRED: 20

REQUIREMENTS: Material: Cast Carbon Steel

Temperature Capability/Pressure: 750°F/150 lbs.

Valve Type: Globe

End Prep: Butt Weld

Pneumatic Actuation: 20 psig (air)

SUGGESTED SOURCES:

1. Masoneilan International
2. Honeywell - Buck Sales
3. Kieley & Mueller
4.
5.

DATES:

RFQ ____

DEL. TIME WKS. 8

POI ____

HARDWARE NEED ____

VENDOR STATUS

COST/UNIT $1300

GENERAL ELECTRIC
MISSILE AND SPACE DIVISION
PHILADELPHIA
PROGRAM INFORMATION REQUEST / RELEASE

PIR NO. | CLASS. LTR. STE | OPERATION LSE | PROGRAM Phase III | SEQUENCE NO. 085 | REV. LTR.

*USE "C" FOR CLASSIFIED AND "U" FOR UNCLASSIFIED

FROM: J. Poland JP

TO: R. Laessig and Distribution #7

DATE SENT	DATE INFO. REQUIRED	PROJECT AND REQ. NO.	REFERENCE DIR. NO.
4-13-78			

SUBJECT: ESTIMATED VALUE COSTS FOR STE-LSE-FIELD AND THERMAL CONVERSION UNIT

INFORMATION REQUESTED/RELEASED

The following is a list of value cost for use in the collector field and mechanical building. All values shown meet the following requirements:

- Material: Cast Carbon Steel
- Temperature-Capability/Press: 750°F/150 LBS
- Valve type: Globe
- End preparation: Butt weld
- Pneumatic Actuation: 20 psig source (air)

3/4" SW 16 wk deliver

Flow meter Vortex Shedd[illegible]

- Fisher Porter
- Foxboro
- Eastex

Pneumatically Operated Field Control Valves

3" Modulating Valves

Carbon Steel 150 lb	$1,442.00	
Grafoil	75.00	
EP Valve Positioner	400.00	
Airset	39.00	
Weld Preparation	120.00	
	$2,076.00 x .75 =	1557
LVDT		+700
		$2257 net

3" Open-Closed (2 Position Valves)

150 lb. Carbon Steel Valve	$1,442.00
Grafoil	75.00
Weld Preparation	120.00
Solenoid	73.00
Solenoid Piping	29.00
Microswitches	120.00
	$1,859.00 x .75 = $1,394.00 net

Distribution #7

PAGE NO. ____ OF ____

RETENTION REQUIREMENTS
COPIES FOR: 1 MO. / 3 MOS. / 6 MOS. / MOS.
MASTERS FOR: 3 MOS. / 6 MOS. / 12 MOS. / MOS. / DO NOT DESTROY

<u>6" Modulating</u>

Carbon Steel 150 lb.	$3,322.00
Grafoil Seals	113.00
EP Valve Positioner	400.00
Airset	39.00
Butt Weld Prep	120.00
	3984.00 x .75 ≃ $3,000 net

<u>6" (Open-Closed) (2 Position Valve)</u>

Carbon Steel 150 lb.	$3,322.00
Grafoil Seals	113.00
Butt Weld Prep	120.00
Solenoid	73.00
Solenoid, Piping	29.00
Microswitches	120.00
	3777.00 x .75 ≃ $2,800 net

<u>8" Modulating</u>

Same Type $4,000.00 net

<u>8" Open-Closed (2 Position Valve)</u>

Same Type $3,800.00 net (est.)

<u>3-Way Diverter Valves</u>

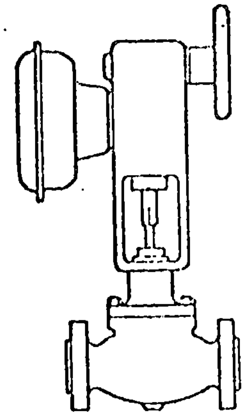
6" Carbon Steel Butt Ends		
80,000 Series Masoneilan		$4,440.00 net
Grafoil	LVDT	700.00
		$5,140.00
8" Carbon Steel Butt Ends		$5,180.00 net
80,000 Series Masoneilan		700.00
Grafoil	LVDT	$5,880.00

With valve quantities and location as shown on the attached sketches, the total field valve costs are:

<u>Branch Valves</u> (2 Valves Per Branch)

20 Modulating 3" Valves			Lambert PIR 070
20 x 2257	=	$45,140.00	(42500)
20 2 Position (Open Closed)			
20 x 1394	=	27,880.00	(Not included)

21000 SERIES CONTROL VALVES
WITH QUICK CHANGE TRIM
ANSI CLASS 150, 300, 600



e 68 Consumed.

MODEL NUMBERS

1st	2nd
4	

1st	2nd	3rd	4th	5th
2	1			4

Actuator Type (1st–2nd digits): 47 Air-to-close; 48 Air-to-open

Body Series (1st–2nd digits): 21

Plug Type (3rd digit): 0. Undefined; 1. Unbalanced contoured; 7. Lo-db

Control Characteristics (4th digit): 0. Undefined; 1. Linear*; 2. Equal percentage*; 3 Modified percentage

Seat Type (5th digit): 0. Undefined; 4. Quick change

*Available with positioner only.

SPECIFICATIONS

BODY	Type	Globe—Single Seat, quick change trim
BODY	Closure Bolting	ASTM A193 Gr B7 Studs ASTM A194 Gr 2H Nuts
BODY	Closure Gasket	Spiral Wound 304 St. St. with Asbestos Filler
BONNET	Guide Bushing	Steel & Chrome—Moly Valves 440C St. St. St. St. Valves—#6 Stellite
BONNET	Packing	Crane 285 (−20F to 450F) Grafoil (−20F to 850F) O
BONNET	Packing Box	Studs: 304 St. St.-ASTM A193 Gr B8 Nuts: 304 St. St.-ASTM A194 Gr 8

Actuator: ΣF		Direct or Reverse—Spring Diaphragm	
Plug Stem		316 St. St. (17-4PH on 3" & 4" with size C actuator)	
TRIM	Size	High, Full & Reduced Capacity	
TRIM	Type	Modified Percentage	
TRIM	Plug Material	416 St. St.	316 St. St. O optional
TRIM	Ring Material	416 St. St.	316 St. St. O optional

Note: Seat Leakage: 0.01% of rated capacity—tested with 50 psi air at a temperature between 50F and 125F per ANSI B16.104, Class IV

PRICES

Size (in.)	Actuator Size	C_v	Carbon Steel ASTM A216 Gr WCB			Chrome-Moly ASTM A217 Gr C5			316 St. St. ASTM A351 Gr CF8M O			Add O for 316 St. St. Trim	O Add for Grafoil
			O Screwed	Flanged 150/300	Flanged 600	O Screwed	Flanged 150/300	Flanged 600	O Screwed	Flanged 150/300	Flanged 600		
¾	A	16 12 6.0 1.7	$567	$641	$659	$771	$1007	$1063	$896	$925	$10[illegible]4	$73	$55
1	A	16 12 6.0 1.7	579	655	673	788	1029	1086	916	945	1026	73	55
1½	A	35 25 13 6.0 1.7	776	870	908	1020	1338	1404	1348	1404	1647	90	55
2	A	55 46 26 15 6.0 1.7	964	1056	1105	1394	1534	1610	1561	1618	1871	110	75
3	B	110 47	—	1442	—	—	2152	—	—	2722	—	155	75
4	B	195 113	—	1[illegible]94	—	—	2845	—	—	3818	—	198	75
6	C	400 [illegible]	—	3322	—	—	4913	—	—	7176	—	247	113

O 316 St. St. Trim included.

O For other end connections, refer to List Price Sheet 4.0.1

21000 SERIES CONTROL VALVES
EXTRAS AND ACCESSORIES

OVERSIZE ACTUATORS

Standard Actuator	Oversize Actuator	Add to Base Price
A	B	$117
B	C	200

SIDE MOUNTED HANDWHEELS

Actuator Size	Add to Base Price
A	$188
B	268
C	328

4601 Series Positioner†

Mounted, Piped and Calibrated. Complete with Internal By-Pass and Gauges $240

Instrument Signals—3-15, 3-27 and 6-30 psi
3-9 and 9-15 psi Split Range
Maximum Positioner Output—35 psi
Pilot-Direct or Reverse, Standard or High Capacity Pilot
Standard with ¼" Copper Tubing and Brass Fittings
For PVC Coated ¼" Copper Tubing and PVC Taped Brass Fittings, add $22
For St. St. Tubing and Swagelock Fittings, add $35
Note: Double these extras if Airset included

8012-3-C Cam Operated Electropneumatic Valve Positioner†

Mounted, Piped and Calibrated $400

Instrument Signals—10-50 ma; 104 ohms
4-20 ma; 173 ohms
Split Range Available
Maximum Positioner Output—35 psi
Direct or Reverse Action

† Add for 77-4 Airset below.

8005A and 8006A Electropneumatic Transducer

Mounted, Piped and Calibrated

Input Signals—10-50 ma; 104 ohms
4-20 ma; 173 ohms
Output Signals (Direct or Reverse)—Model 8005A: 3-15 psi
Model 8006A: 3-15, 6-30, 0-20 or 0-35 psi

Model 8005A $324

Model 8006A (with Relay) $357

77-4 or 77-40 Airset—Mounted and Piped $39

77-6 Lockup Valve—Mounted and Piped $61

2" Gauge 0-30 psi—Mounted and Piped .... $9 each

SOLENOID VALVES (ASCO) Close Coupled to Actuator Pressure Connection

Part No.	Asco Ref.	Voltage	MODP*	Enclosure	Action	Price
972312-001-888	HBX8320A25	120~60 Hz	75 psi	Gen'l Purpose	Normally Closed	$73
972312-017-888	HBX8320A26	120~60 Hz	75 psi	Explosion-Proof and Watertight	Normally Closed	103
972312-024-888	HPX8320A26	125 DC	65 psi		Normally Closed	121
972312-025-888	HBX8320A40	120~60 Hz	75 psi		Normally Open	103

* Maximum Operating Differential Pressure

496 Rotary Switches (per Bulletin No. 357E)

496-1 (1 switch) $209

496-2 (2 switches) $247

2700/3700 Controllers—Integrally Mounted and Piped .... All items with specifications exactly per List Price Sheet 6.1.1 available at prices shown thereon.

Special Body Flanges and Welding Ends

List Price Extra to 21000, 11000 and 41000 Series, also 10000, 20000, 40000 in carbon steel or alloy material for special flange facings or welding end connections. Add price extra to valve price with the specified body rating.

Body Size In.	Welding Ends: Socket Weld Add to Screwed Body Price	Welding Ends: Butt Weld Add to Appropriate Flanged Body Price	Flanged Ends, Ring Type Joint: 150/300 lb.	Flanged Ends, Ring Type Joint: 600 lb.	Flanged Ends, Ring Type Joint: 900/1500 lb.
3/4	$47	---	$112	$ 82	---
1	47	---	112	82	82
1½	47	---	154	103	103
	47		200	121	121
	---	$120	257	141	159
	---	120	329	153	198
4	---	120	446	159	219
6	---	120	757	186	---
8	---	460	757	198	---
10	---	460	757	257	---
12	---				

BUCK SALES of PA., INC.

P. O. BOX 605, LANGHORNE, PENNSYLVANIA 19047
215 · 757-4447

May 11, 1978

General Electric
57 Providence Forge
Royersford, Pa 19468

Attn: Mr. James Poland

Subj: Perliminary Quotation on Honeywell Control Valves for Solar Energy Project.

Gentlemen:

Persuant to our recent conversation we are pleased to submit the attached subject quotation. The valves quoted, meet all of the requirements of your verbal specification and the prices may be used for estimating purposes, until your specifications are finalized. The Honeywell cage valves that we are offering are ideally suited for your application because of your requirement to weld the valves into the lines and the ease with which these valves can be serviced without removing them from the line. Also, these are the same valves we recently supplied on a project very similar to yours.

The standard leakage rate of the valves quoted is .01%, however we can better the leakage rate to .001% with the use of a different actuator at the approximate cost of $70.00 per 3" valve and $190.00 per 6" valve.

We at Honeywell are aware of the importance of your project and your need to select qualified vendors. Therefore we are inviting you to visit our facility at Fort Washington, Pa to inspect our operations and discuss our capabilities.

Thank you for your interest in our products and we look forward to hearing from you soon.

Very truly yours

Sal Di Cesare

Sal Di Cesare

SDC:ac

Honeywell

PROCESS CONTROL DIVISION
VALVE SPECIFICATION SHEET

QUOTATION NO. CSP 1878	DATE 5-11-78	JOB NO. Solar Energy System	
CUST. SPEC NO. VERBAL	DATE 5-10-78	SPEC REVISION	DATE
FOR GENERAL ELECTRIC		CUST. O/N	

REVISIONS

NO.	DATE	ADD

(CIRCLE ONE WHERE MULTIPLE CHOICE GIVEN)

1		ITEM NO.	ONE	TWO	THREE	FOUR
2		QUANTITY	FOUR	TWENTY	TWENTY	TWENTY
3		TAG NO.				
4		LINE SIZE / INLET / OUTLET / SCHEDULE	6"	3"	3"	6"
5		VALVE MODEL NO.	1601	9101	9101	9101
6	BODY	SIZE / MATERIAL	6" CAST STEEL	3" CAST STEEL	3" CAST STEEL	6" CAST ST…
7	BODY	CONSTRUCTION TYPE (SINGLE / BALANCED / 3 WAY)	**3 WAY**	**SINGLE**	**SINGLE**	**SINGLE**
8	BODY	RATING & CONNECTIONS	150 LB / RF FLG	150 LB / BUTT WELD	150 LB / BUTT WELD	150 LB / BUTT…
9	TRIM	MATERIAL	ST. ST.	ST. ST.	ST. ST.	ST. ST.
10	TRIM	PORT SIZE (CV)	320	127	127	440
11	TRIM	FORM & CHARACTERISTICS		LINEAR	LINEAR	LINEAR
12		BONNET CONFIGURATION	PLAIN	PLAIN	PLAIN	PLAIN
13		PACKING	GRAPH OIL	GRAPH OIL	GRAPH OIL	GRAPH OIL
14		LUBRICATION & ISOLATING VALVE (YES / NO)	**NO**	**NO**	**NO**	**NO**
15		TYPE CONTROL (ON OFF / THROTTLING)	**ON OFF**	**THROTTLING**	**ON OFF**	**ON OFF**
16		VALVE MODEL SPECIFICATION NO. (I II III IV V)				
17	ACTUATOR	TYPE ACTUATION (ELECTRIC / PNEUMATIC)	**ELECTRIC** / **PNEUMATIC**	**ELECTRIC** / **PNEUMATIC**	**ELECTRIC** / **PNEUMATIC**	**ELECTRIC** / **PNEUMATIC**
	ACTUATOR	(STANDARD / OVERSIZED)	**STANDARD**			
18	ACTUATOR	MODEL & SIZE	01-13	01-11	01-11	01-13
19	ACTUATOR	SPRING RANGE	3-15	3-15	3-15	
20	ACTUATOR	HANDWHEEL TYPE (TOP / SIDE / NONE)	**NONE**	**NONE**	**NONE**	**NONE**
21	ACTUATOR	ACTUATOR TRAVEL				
22	ACTUATOR	ACTION (AIR-TO-OPEN / CLOSE)	**AIR-TO-OPEN**	**AIR-TO-OPEN**	**AIR-TO-OPEN**	**AIR-TO-OPEN**
23	ACTUATOR	ACTUATOR MODEL SPECIFICATION NO. (I II III IV V)				
24	POSITIONER	TYPE (ELECTRIC / PNEUMATIC)		**ELECTRIC**		
25	POSITIONER	INSTRUMENT SIGNAL	3-15 PSI	4-20 MA		
26	POSITIONER	AIR SUPPLY (PSIG)	18	18	18	18
27	POSITIONER	BYPASS / GAUGES	— / —	— / —	— / —	— / —
28	POSITIONER	POSITIONER MODEL SPECIFICATION NO. (I II III IV V VI)				
29	ACCESSORIES	AIR SET (MTD. / UNMTD. / NONE)	**MTD.**	**MTD.**	**MTD.**	**MTD.**
30	ACCESSORIES	SWITCHES	2		2	2
31	ACCESSORIES	SOLENOID VALVE	1		1	1
	ACCESSORIES	FEED BACK		LVDT		
32	SERVICE CONDITIONS	FLOWING MEDIUM	SYLTHERM 800	SAME	SAME	SAME
33	SERVICE CONDITIONS	TEMPERATURE °F (MIN / NORMAL / MAX)	NORMAL 750	NORMAL 750°	NORMAL 750	NORMAL 750
34	SERVICE CONDITIONS	FLOW RATE (LIQUID ....GPM / GAS ....SCFH / STEAM ....LB/HR)				
35	SERVICE CONDITIONS	PRESSURE DROP (PSI)	30	30	30	30
36	SERVICE CONDITIONS	MAX. SHUT-OFF (PSIG)	30	30	30	30
37	SERVICE CONDITIONS	INLET PRESS. / OUTLET PRESS.				
38	SERVICE CONDITIONS	SP. GRAVITY / @ °F / F.T.				
39	SERVICE CONDITIONS	OPER. VISC. / % FLASH				
40	SERVICE CONDITIONS	VAPOR PRESS. / CRIT. PRESS.				
41	SERVICE CONDITIONS	LEAKAGE ALLOW. (% MAX. CV)				
42	SERVICE CONDITIONS	REQUIRED CV (MAX / MIN)				
43		SHIPPING WEIGHT				
44		DELIVERY SCHEDULE	4/6 WKS ARO	SAME	SAME	SAME
45		PRICE	$ 2522.00 / 10,088.00	$ 1406.00 / 28,128.00	1140.00 / 22,800.00	$ 2375.00 / 47,500.00

F-810 (1-70)

Process Control Division/Fort Washington, 1100 Virginia Drive, Fort Washington, Pa. 19034

TOTAL $108,516

PART NO. 3 SHEET NO. ____

COMPONENT SHEET

DATE UPDATED ____

SUBSYSTEM: SCF

COMPONENT NOMENCLATURE: Control Valve (On/Off)

QUANTITY REQUIRED: 20

REQUIREMENTS: Material: Cast Carbon Steel

Temperature Capability/Pressure: 750°F/150 lbs

Valve Type: Globe

End Prep: Butt Weld

Pneumatic Actuation: 20 psig (Air)

SUGGESTED SOURCES:
1. Masoneilan International
2. Honeywell
3. Powell
4. ____
5. ____

DATES: RFQ ____

DEL. TIME WKS. 8

POI ____

HARDWARE NEED ____

VENDOR STATUS

COST/UNIT $1394 as per attachment

GENERAL ELECTRIC
MISSILE AND SPACE DIVISION
PHILADELPHIA
PROGRAM INFORMATION REQUEST / RELEASE

PIR NO. STE _ LSE _ Phase III _ 085

*USE "C" FOR CLASSIFIED AND "U" FOR UNCLASSIFIED

FROM J. Poland JP

TO R. Laessig and Distribution #7

DATE SENT	DATE INFO. REQUIRED	PROJECT AND REQ. NO.	REFERENCE DIR. NO.
4-13-78			

SUBJECT ESTIMATED VALUE COSTS FOR STE-LSE-FIELD AND THERMAL CONVERSION UNIT

INFORMATION REQUESTED/RELEASED

The following is a list of value cost for use in the collector field and mechanical building. All values shown meet the following requirements:

- Material: Cast Carbon Steel
- Temperature-Capability/Press: 750°F/150 LBS
- Valve type: Globe
- End preparation: Butt weld
- Pneumatic Actuation: 20 psig source (air)

3/4" SW 16 wk delivery

Flow meter Vortex Shedding

- Fisher Porter
- Foxboro
- Eastex

Pneumatically Operated Field Control Valves

3" Modulating Valves

Carbon Steel 150 lb	$1,442.00		
Grafoil	75.00		
EP Valve Positioner	400.00		
Airset	39.00		
Weld Preparation	120.00		
	$2,076.00	x .75 =	1557
LVDT			+700
			$2257 net

3" Open-Closed (2 Position Valves)

150 lb. Carbon Steel Valve	$1,442.00	
Grafoil	75.00	
Weld Preparation	120.00	
Solenoid	73.00	
Solenoid Piping	29.00	
Microswitches	120.00	
	$1,859.00	x .75 = $1,394.00 net

Distribution #7

PAGE NO. ___ OF ___

RETENTION REQUIREMENTS

COPIES FOR	MASTERS FOR
1 MO.	3 MOS.
3 MOS.	6 MOS.
6 MOS.	12 MOS.
MOS.	MOS.
	DO NOT DESTROY

6" Modulating

Carbon Steel 150 lb.	$3,322.00	
Grafoil Seals	113.00	
EP Valve Positioner	400.00	
Airset	39.00	
Butt Weld Prep	120.00	
	3984.00	x .75 ≅ $3,000 net

6" (Open-Closed) (2 Position Valve)

Carbon Steel 150 lb.	$3,322.00	
Grafoil Seals	113.00	
Butt Weld Prep	120.00	
Solenoid	73.00	
Solenoid, Piping	29.00	
Microswitches	120.00	
	3777.00	x .75 ≅ $2,800 net

8" Modulating

Same Type $4,000.00 net

8" Open-Closed (2 Position Valve)

Same Type $3,800.00 net (est.)

3-Way Diverter Valves

6" Carbon Steel Butt Ends		
80,000 Series Masoneilan		$4,440.00 net
Grafoil	LVDT	700.00
		$5,140.00
8" Carbon Steel Butt Ends		$5,180.00 net
80,000 Series Masoneilan		700.00
Grafoil	LVDT	$5,880.00

With valve quantities and location as shown on the attached sketches, the total field valve costs are:

Branch Valves (2 Valves Per Branch)

20 Modulating 3" Valves 20 x 2257	=	$45,140.00	Lambert PIR 070 (42500)
20 2 Position (Open Closed) 20 x 1394	=	27,880.00	(Not included)

j/a moody company
2 pennsylvania Ave., p.o. box 453
malvern, pennsylvania 19355
215 - 647 - 3810

May 10, 1978

Mr. James Poland
57 Providence Forge
Royersford, Pa. 19468

Dear Jim:

As we discussed today, the Y pattern offers the greatest CV factor size for size against the vertical stem globe.

Edwards 848Y in 3/8" give a 3.5 CV
Edwards 848Y in 1-1/2" gives a 32 CV

This covers a carbon steel 600# Y Globe, S/W ends, stellited trim with BB-OS&Y and high temperature packing.

Price 3/8": $52.00
1-1/2": 160.00

Attached are drawings and bill of materials. Be sure to spec us in on the job so we can quote the engineering firm.

I have written to Powell Valve on the 6" and 8" with the specs we discussed for the pneumatic actuator. As soon as I get a reply we will contact you.

Very truly yours,

J. A. MOODY COMPANY

Bob

Robert E. Ennis
President

REE:JE

PART NO. 4

SHEET NO.

COMPONENT SHEET

DATE UPDATED

SUBSYSTEM: SCF

COMPONENT NOMENCLATURE: Isolation Valves

QUANTITY REQUIRED: 384

REQUIREMENTS: Material: Forged Carbon Steel

Manually Operated, "Y" Pattern Globe Valves

750° F, Syltherm™ 800 Fluid

SUGGESTED SOURCES:
1. Moody Valve
2. Honeywell
3. Masonelian
4. Jenkins
5. Powell

DATES:
- RFQ
- DEL. TIME WKS. 6-8
- POI
- HARDWARE NEED

VENDOR STATUS

COST/UNIT $52.00 as per attached quote

PART NO. 5

SHEET NO. ____

COMPONENT SHEET

10/18/78
DATE UPDATED

SUBSYSTEM: SCF

COMPONENT NOMENCLATURE: Collector Field Trim Valves

QUANTITY REQUIRED: 14

REQUIREMENTS: 3/4" Pneumatically Operated Modulating

Fluid: Sylthemr™

Temp. 750° F

Positioner: Modulating

Ends: Butt Weld

Pressure: Low (100 psi)

SUGGESTED SOURCES:
1. ____
2. ____
3. ____
4. ____
5. ____

DATES:
RFQ ____
DEL. TIME WKS. ____
POI ____
HARDWARE NEED ____

VENDOR STATUS

COST/UNIT $167.00 (BCF 15122.0106)

HIGH TEMP
STORAGE

3.4 HIGH TEMPERATURE ENERGY STORAGE SUBSYSTEM (HTS)

The High Temperature Energy Storage Subsystem (HTS) consists of the four HTS tanks and the HTS transfer pumps along with interconnecting piping and valves. Interconnecting flow paths throughout the HTS subsystem allow for the transfer of hot Syltherm™ 800 fluid from the collector field to the HTS tanks, from one tank to another, and from the HTS tank to the steam generator. The HTS tanks are filled with a packed bed of iron ore as a solid storage medium.

Table 3.4-1 contains a list of all of the active and major components of the HTS System. The item numbers of the components are identified on the piping and instrumentation drawing Figure 3.4-1 (Drawing GE1-101)

TABLE 3.4-1. HIGH TEMPERATURE ENERGY STORAGE SUBSYSTEM (HTS)

Item #	Nomenclature	Qty.	Cost
1	Collector Field Pumps	2 ea.	$ 5,000.00
2	Collector Fluid	17,000 gal.	340,000.00
3	Large HTS Tanks	3 ea.	258,942.00
4	Small HTS Tank	1	48,843.00
5	Oil Vapor Condensing Tank	1	155.00
6	Make-up Oil Storage Tank	1	780.00
7	Iron Ore Storage Medium		86,025.00
8	Oil Fill Pump	1 ea.	783.00
9	HTS Transfer Pump	1 ea.	2,500.00
10	Steam Generator Supply Pump	1 ea.	2,500.00
11	Syltherm™ 800 Fossil Fired Heater	1 ea.	200,000.00
12	Nitrogen Regulation Valve	1 ea.	172.00
13	Condensable Back Pressure Valve	1 ea.	165.00
14	Nitrogen Storage System		7,500.00

TABLE 3.4-1. HIGH TEMPERATURE ENERGY STORAGE SUBSYSTEM (HTS) (Cont.)

Item #	Nomenclature	Size	Qty.	Cost
15	Tank Selection Valves Collector Field Return	4-1/2"	4 ea.	$ 7,346.00
16	Tank Selection Valves Steam Gen. Return	4"	4 ea.	7,346.00
17	Steam Gen. Return Selection Valves	4-1/2"	4 ea.	7,346.00
18	Fossil Fuel Heater Supply Selection Valves	4-1/2"	2 ea.	3,656.00
19	Fossil Fuel Heater Return Selection Valves	4"	3 ea.	5,428.00
20	Collector Field Pump Selection Valves	5"	2 ea.	1,760.00
21	Collector Field Pump Throttle Valve	4-1/2"	1 ea.	2,346.00
22	Tank Selection Valves Steam Gen. Supply	4-1/2"	4 ea.	7,346.00
23	Tank Selection Valves Collector Field Supply	4-1/2"	4 ea.	7,346.00
24	Energy Storage Cir. Pump Throttle Valve	4"	1 ea.	2,512.00
25	Circulation Pump Discharge Tank Sel. Valve	4"	4 ea.	2,512.00
26	Circulation Pump Suction Tank Sel. Valve	4-1/2"	4 ea.	7,346.00
27	Storage Tank Flow Control Valves	4 ea. 4-1/2" 4 ea. 2"	8 ea.	12,000.00

All above values

Fluid:	Syltherm™ 800
Temperature:	750°F
Positioner:	Open/Close Pneu. Actuator
Ends:	Butt Weld
Pressure:	Low (100 psi)

TOTAL 1,027,655.00

LEVEL-of-Definition 1.05 1,079,038.00

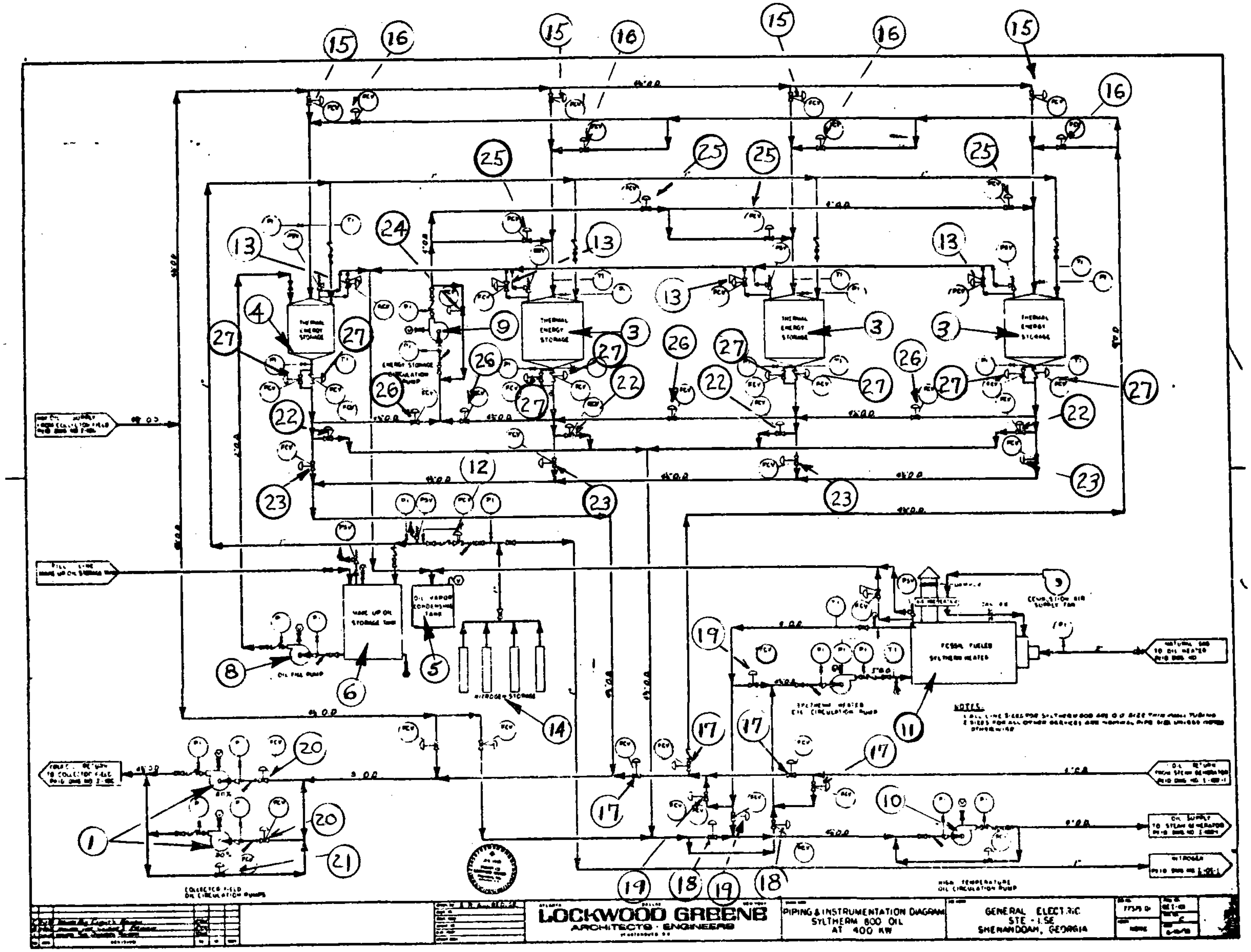


Figure 3.4-1. Piping and Instrumentation Diagram for the HTS Subsystem

PART NO. 1 SHEET NO. ____

COMPONENT SHEET

10/11/78
DATE UPDATED

SUBSYSTEM: HTS

COMPONENT NOMENCLATURE: Collector Field Pump

QUANTITY REQUIRED: 2

REQUIREMENTS:

Rated for 320 GPM @ 160' Head

Operating Temp. 750° F

3 Ø - H.P.

Fluid - Syltherm™ 800

SUGGESTED SOURCES:

1. Dean Bros. Pump (215) 642-2802
2. Gould Pumps, Inc. (215) 353-5955
3. Dorr-Oliver - Equipment Engineers
4. Ingersol Rand - Aircomo (215) 925-3900
5. ____

DATES:
RFQ ____
DEL. TIME WKS. ____
POI ____
HARDWARE NEED ____

VENDOR STATUS

COST/UNIT $2,500 - Cost for "similar to" pump as per following quote

DEAN BROTHERS PUMPS INC.

MANUFACTURERS OF PUMPING MACHINERY FOR INDUSTRY

Please send reply to:

DEAN BROTHERS PUMPS, INC.

Seven Wynnewood Road., Wynnewood, Pa. 19096, Phone (Area Code 215) 642-2802

G.E. Space Systems
#7 Building
Valley Forge, Pa. 19481

March 8, 1978

Attn: Mr. James Poland

Subj: Heat Transfer Pumps - Solar Collectors

Per our conversation of 3/7/78.

Liquid:	Silicone B
Temp:	50°F min. - 500°F norm. - 750°F max.
Capacity:	387 GPM at 30 PSI - 96' at 500°F
Sp.Gr. of Liquid	50°F - .95, 500°F - .72, 750°F - .60
Visc. of Liquid:	50°F - 15cp, 500°F - .62cp, 750°F - .3cp

Our general recommendation for the above.

1 - Dean Brothers Type R434, size 3x4-11½, Material Class 40, Type R434, complete with fab steel baseplate, Woods spacer coupling, OSHA guard and complete with John Crane Type 15WT mechanical seal (carbon vs tung carbide) per Dwg. SK 1420.

3x4x10 ≈ 2750

ESTIMATED PRICE $ 2,900.
1 - 15 HP TEFC driver for above .... 300. + Slot% 7½ hp ≈ 200

A seal guard system may be desirable to extend mechanical seal life. This system would be especially useful if your liquid is subject to chemical breakdown or will precipitate when cooled.

1 - Dean Brothers B500T Seal Guard - Estimated price ..... $ 1,850.

TOTAL ESTIMATE PACKAGE PRICE .... $ 5,050 Each

Normal factory availability of the above .... 14 weeks.

Our experience in heat transfer oil test has shown that heat loss thru the pump feet and spacer cradle (ring connecting pump casing to bearing housing) would be miniscule.

The major heat loss to your liquid will be in the pump stuffing box jacket and seal guard heat exchanger. These values can be determined with the attached charts. These charts are based on Dowtherm A.

ESTABLISHED 1869
DEAN BROTHERS PUMPS INC.
INDIANAPOLIS INDIANA. 46268
P.O Box 68172

March 8, 1978

GE Space Systems
Valley Forge, Pa.

Attn: Mr. Poland

Subj: Heat Transfer Pumps - Colar Collectors

Temperature build up in the pump (due to inefficiency - i.e., friction and recirculation) can be approximated by the following formula:

$$\Delta T \text{ Rise} = \frac{(\text{Head}) \left(\frac{1}{\text{Pump Effy}} - 1 \right)}{(778)\ (\text{Sp. Heat of Liquid})}$$

For your conditions this would amount to approximately:

.08°F per 378 gal. per min.

As you can see, these heat losses and gains thru the pump can essentially be ignored.

We feel sure that our Mr. M. Scales, V.P. Engineering, would be glad to discuss some of our experiences in solar power applications with you. His phone - 317-293-2930.

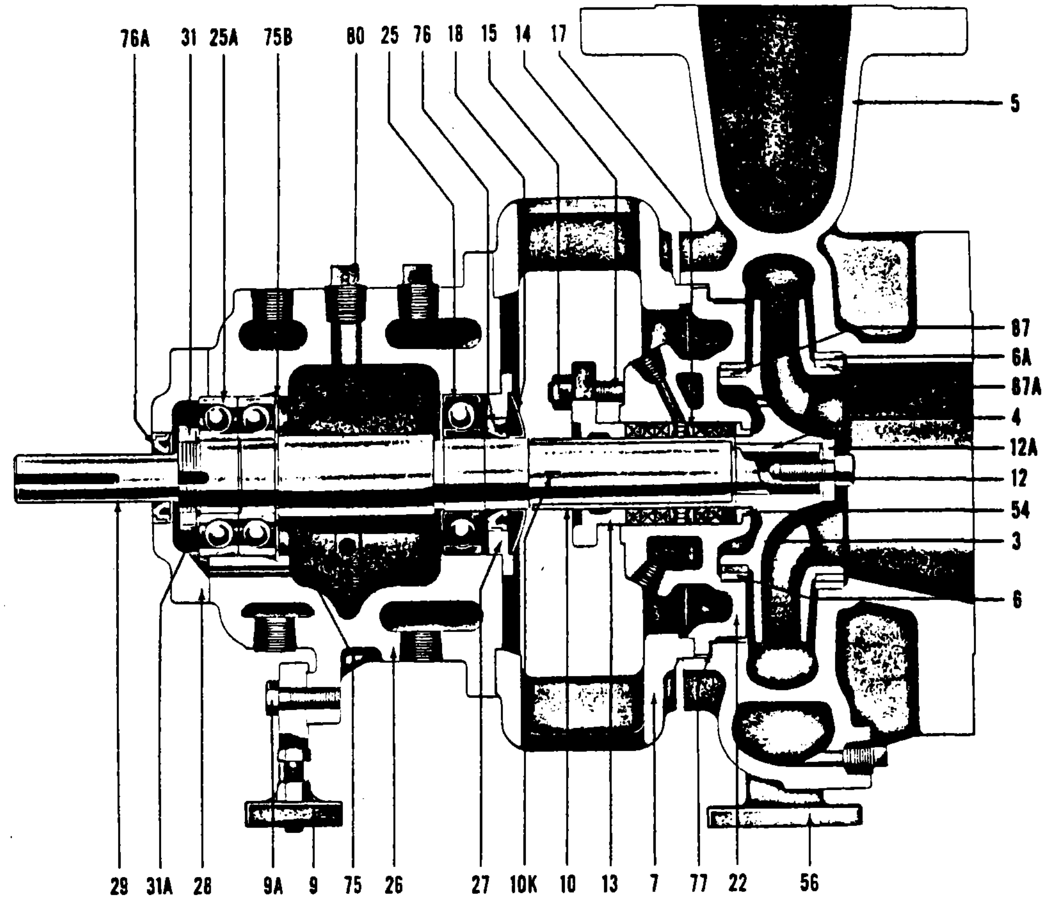
If we can be of any further assistance, please feel free to contact this office.

DEAN BROTHERS PUMPS INC.

Kenneth T. Hull

KTH:rms
cc: File
cc: Mr. M. Scales - DBP - Ind.

Enclosures: Pump Perf. Curve: R-30115-A1
Circulars: C-1.4.40 & A 1200
Cooling Water Flow Rate Charts



STANDARD MATERIALS OF CONSTRUCTION—LISTED BY MATERIAL CLASS

PART #	PART NAME	CLASS 40	CLASS 50	PART #	PART NAME	CLASS 40	CLASS 50
3	Impeller	C.I. (1)	316 (3)	25	Shaft Bearing—Radial	Stl.	Stl.
4	Impeller Key	Stl. (2)	316 (8)	25A	Shaft Bearing—Thrust	Stl.	Stl.
5	Casing	Stl. (6)	316 (3)	26*	Bearing Housing	C.I. (1)	C.I. (1)
6*	Backhead Ring	Iron (7)	316 (3)	27*	Seal Ring	C.I. (1)	C.I. (1)
6A	Casing Ring	Iron (7)	316 (3)	28	Bearing End Cover	C.I. (1)	C.I. (1)
7	Cradle Spacer	C.I. (1)	C.I. (1)	29*	Pump Shaft	Stl. (10)	316 (8)
9	Bearing Housing Foot	C.I. (1)	C.I. (1)	31	Bearing Lock Nut	Stl.	Stl.
9A*	Brg. Hsg. Ft. Capscrew	Stl. (2)	Stl. (2)	31A	Bearing Lock Nut Washer	Stl.	Stl.
9F*	Brg. Hsg. Ft. Jack Bolt	Stl. (2)	Stl. (2)	54*	Throat Bushing	C.I. (1)	316 (8)
9G*	Brg. Hsg. Ft. Jack Bolt Nut	Stl. (2)	Stl. (2)	56	Casing Foot	C.I. (1)	C.I. (1)
10*	Shaft Sleeve	316 (8)	316 (8)	75	Snap Ring—Inner Shaft	Stl.	Stl.
10K*	Shaft Sleeve Key	304 (9)	304 (9)	75B	Snap Ring—Inner Housing	Stl.	Stl.
12*	Impeller Bolt	Stl. (2)	316 (8)	76	Oil Seal	Buna	Buna
12A*	Impeller Washer	Stl. (2)	316 (8)	76A	Oil Seal	Buna	Buna
13*	Stuffing Box Gland	Stl. (6)	316 (3)	77	Casing Gasket	Asbestos (11)	Asbestos (11)
14*	Stuffing Box Gland Stud	Stl. (4)	304 (9)	77B*	Bearing End Cover Gasket	Paper (12)	Paper (12)
15*	Stuffing Box Gland Stud Nut	Stl. (5)	304 (9)	80	Oil Vent Plug	C.I.	C.I.
17*	Lantern Gland	C.I. (1)	316 (3)	87*	Impeller Ring—Back (Optional)	C.I. (1)	316 (3)
18*	Splash Collar	Stl. (13)	Stl. (13)	87A	Impeller Ring—Front (Optional)	C.I. (1)	316 (3)
22	Backhead	Stl. (6)	316 (3)				

*Denotes parts interchangeable in all pump sizes of same type.

PART NO. 2

SHEET NO.

COMPONENT SHEET

DATE UPDATED

SUBSYSTEM: HTS

COMPONENT NOMENCLATURE: Collector Fluid

QUANTITY REQUIRED: 17,000 gal

REQUIREMENTS: Sylthermᵀᴹ 800

SUGGESTED SOURCES:
1. Dow Chemical Co.
2.
3.
4.
5.

DATES:
- RFQ
- DEL. TIME WKS.
- POI
- HARDWARE NEED

VENDOR STATUS

COST/UNIT $2.50/# @ 8#/Gal 340,000

PART NO. 3

SHEET NO.

COMPONENT SHEET

DATE UPDATED

SUBSYSTEM: HTS

COMPONENT NOMENCLATURE: Large HTS Tank (See Fig. 3.5-2 through 3.5-5)

QUANTITY REQUIRED: 3

REQUIREMENTS: Material: Carbon Steel

Size: 20.5 feet Dia. x 16 Feet High

Capacity: 40,065 Gal.

w/Manifold & Sump

as per G. E. Drawing 47J240732, 919E108, 919E109

ASME Unfired Pressure Code Section VIII, Division 1 for 16 psig

SUGGESTED SOURCES:
1. All-Steel Fabricators Co., Inc.
2.
3.
4.
5.

DATES:

- RFQ
- DEL. TIME WKS. 24
- POI
- HARDWARE NEED

VENDOR STATUS

COST/UNIT $86,314 as per attached quote

PRICE QUOTATION

7096

PLEASE INDICATE THIS NUMBER WHEN ORDERING

Sheet 1 Of 2

MAILING ADDRESS: 3730 MAIN STREET, PHILADELPHIA, PA. 19127
PLANT: RICHTER'S FERRY ROAD AND SCHUYLKILL RIVER
BALA-CYNWYD, PA. 19004
TEnnyson 9-6435, 6438, 6437

General Electric Corp.
Valley Forge Space Center
P.O. Box 8661
Bldg #7
Phila., PA 19101

attn: Mr. F.G. Hoban

DATE	6/9/73
YOUR INQUIRY DATED	
PROPOSED SHIPPING DATE	14 weeks
TERMS	Net 10 days
F.O.B.	our plant
SALESMAN	
TO BE SHIPPED VIA	Truck
PPD. OR C...	

Here is our quotation on the goods named, subject to the conditions noted:

CONDITIONS: *The prices and terms on this quotation are not subject to verbal changes or other agreements unless approved in writing by the Home Office of the Seller. All quotations and agreements are contingent upon strikes, accidents, fires, availability of materials and all other causes beyond our control. Prices are based on costs and conditions existing on date of quotation and are subject to change by the Seller before final acceptance.*

Typographical and stenographic errors subject to correction. Purchaser agrees to accept either overage or shortage not in excess of ten percent to be charged for pro-rata. Purchaser assumes liability for patent and copyright infringement when goods are made to Purchaser's specifications. When quotation specifies material to be furnished by the purchaser, ample allowance must be made for reasonable spoilage and material must be of suitable quality to facilitate efficient production.

Conditions not specifically stated herein shall be governed by established trade customs. Terms inconsistent with those stated herein which may appear on Purchaser's formal order will not be binding on the Seller.

QUANTITY	DESCRIPTION	PRICE	AMOUNT
	RE: General Electric Dwg. #919E100 Thermal Energy Storage Tank, Drawing dated April 14, 1973:		
	Provide the labor and materials to produce the following:		
One (1)	Tank 20'-6" diameter x 16'-0" Straight Shell Height 3/8" thick Shell and Roof 3/4" thick Bottom Tank to be fabricated per drawing reference above. We include the structural steel supports as shown.		
	Complete tank to be pre-fabricated in our shops and "knocked-down" into six (6) sections for shipment. The sump would also be shipped loose. Tank material to be A516-gr55.		
	We do not include the sparger assemblies in the following pricing.		
	Exterior of tank to be given one (1) coat Hi-temp aluminum. Interior of tank-no paint or coating		
	FOR THE SUM OF:	$61,490.00	
	Note: We do not include any insulation in the above pricing.		

FORM 2040 REGENT FORMS, BELLMAWR, N.J. 08030

-cont'd.-

QUOTE VALID FOR 30 DAYS.

BY
R.L. McCormick
Vice President

3-60
ACCEPTANCE

DATE ACCEPTED

BY

PRICE QUOTATION

7896

MAILING ADDRESS: 3700 MAIN STREET, PHILADELPHIA, PA. 19127
PLANT: FIGHTER'S FERRY ROAD AND SCHUYLKILL RIVER
BALA-CYNWYD, PA. 19004
TEnnyson 9-6485, 6486, 6487

Sheet 2 Of 2

DATE	6/9/78
YOUR INQUIRY DATED	
PROPOSED SHIPPING DATE	14 weeks
TERMS	Net 10 days
F.O.B.	Our Plant
SALESMAN	
TO BE SHIPPED VIA	Truck
PPD. OR CC	

General Electric Corp.
Valley Forge Space Center
P.O. Box 8661
Bldg #7
Phila., PA 19101

Attn; Mr. F.G. Hoban

Here is our quotation on the goods named, subject to the conditions noted:

CONDITIONS: *The prices and terms on this quotation are not subject to verbal changes or other agreements unless approved in writing by the Home Office of the Seller. All quotations and agreements are contingent upon strikes, accidents, fires, availability of materials and all other causes beyond our control. Prices are based on costs and conditions existing on date of quotation and are subject to change by the Seller before final acceptance.*

Typographical and stenographic errors subject to correction. Purchaser agrees to accept either overage or shortage not in excess of ten percent to be charged for pro-rata. Purchaser assumes liability for patent and copyright infringement when goods are made to Purchaser's specifications. When quotation specifies material to be furnished by the purchaser, ample allowance must be made for reasonable spoilage and material must be of suitable quality to facilitate efficient production.

Conditions not specifically stated herein shall be governed by established trade customs. Terms inconsistent with those stated herein which may appear on Purchaser's formal order will not be binding on the Seller.

QUANTITY	DESCRIPTION	PRICE	AMOUNT
	RE: General Electric Dwg. #919E100 Thermal Energy Storage Tank, Drawing dated April 14, 1978 cont'd.		
One (1)	Sparger Pipe Assembly for the above tank (fixed manifold concept) Material- 1¼" diameter Pipe A-106 unit to be shipped in four (4) pcs. FOR THE SUM OF:	$12,412.00	
One (1)	13'-0" diameter tank x 16'-0" Straight Shell Height (same design as above tank) Tank to be shipped in one (1) peice. FOR THE SUM OF:	30,163.00	
One (1)	Sparger Pipe Assembly for the above tank FOR THE SUM OF:	9,340.00	

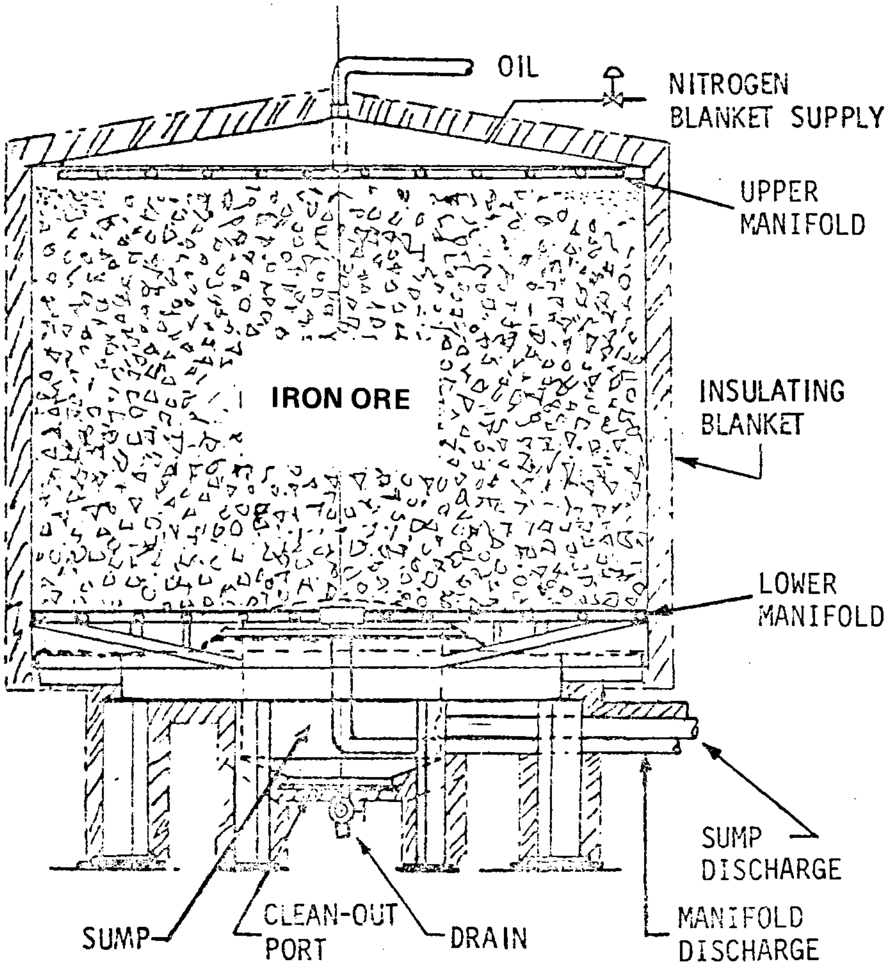
FORM 2040 REGENT FORMS, BELLMAWR, N.J. 08030

QUOTE VALID FOR 30 DAYS.

BY
R.L. McCormick
Vice President

ACCEPTANCE

DATE ACCEPTED



SIZE: <u>LARGE TANK</u> -

20'6" DIA X 16' HIGH
(LESS COVER)
(40,065 GAL/348 TONS TACONITE)

<u>SMALL TANK</u> -

13' DIA X 12' HIGH
(LESS COVER)
(11,860 GAL/103 TONS TACONITE)

Figure 3.5-2. Trickle Oil TES Tank

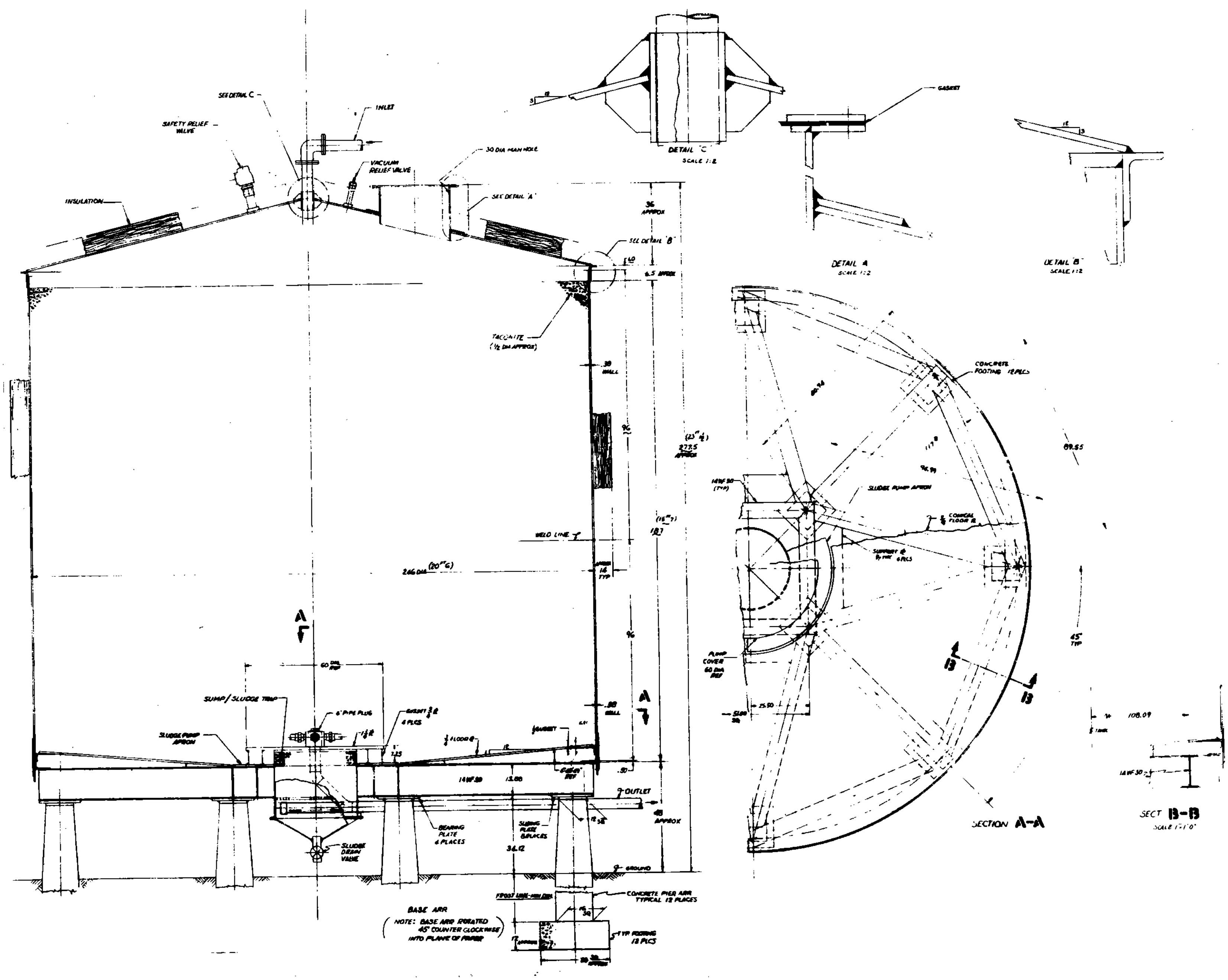
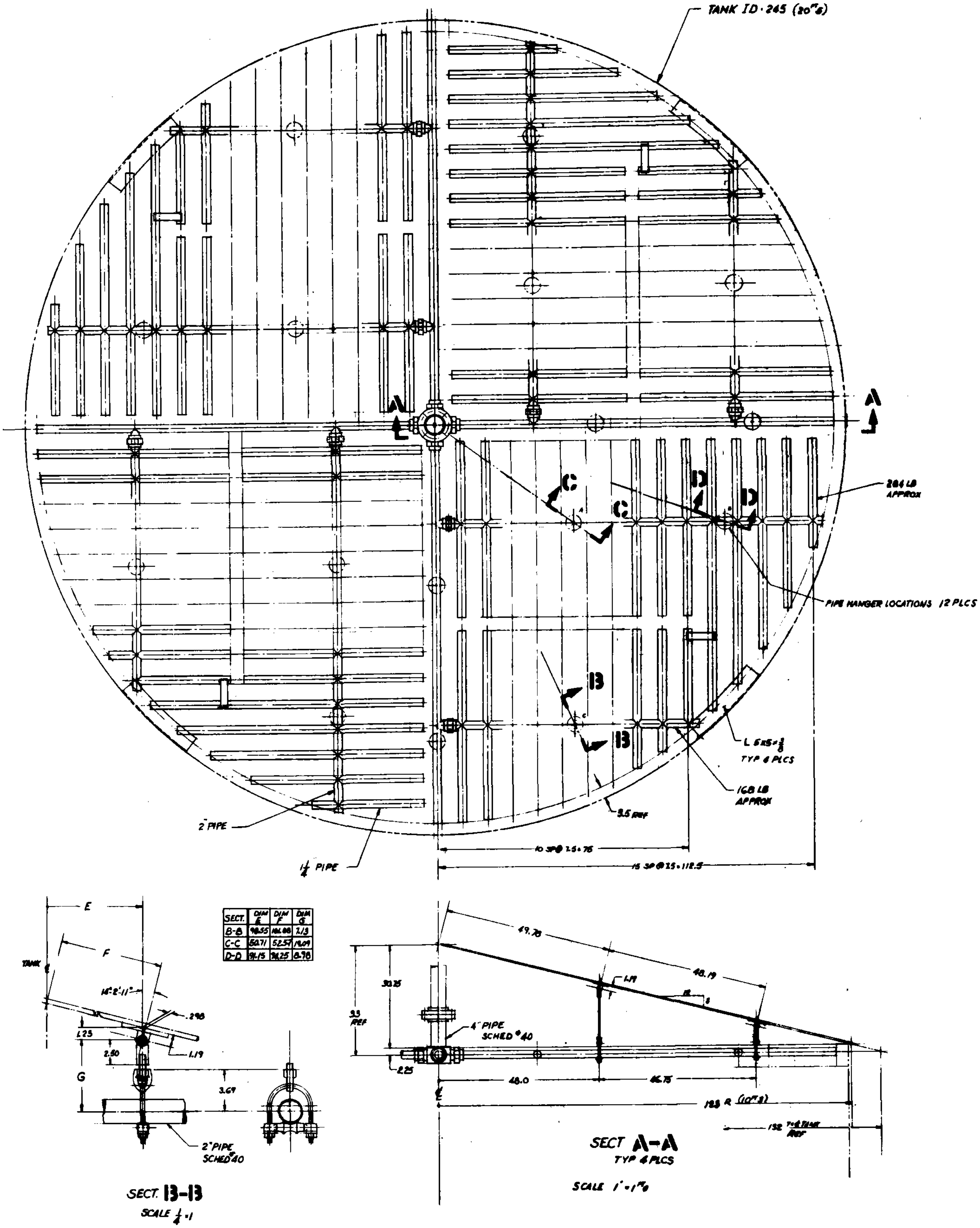


Figure 3.5-3. Layout Oil/Iron Ore Tank (Dwg 919E100)



SECT.	DIM E	DIM F	DIM G
B-B	98.55	[illegible]	[illegible]
C-C	50.71	52.57	[illegible]
D-D	91.15	94.25	[illegible]

Figure 3.5-4. Tank Inlet Piping Arrangement (Dwg 919E108)

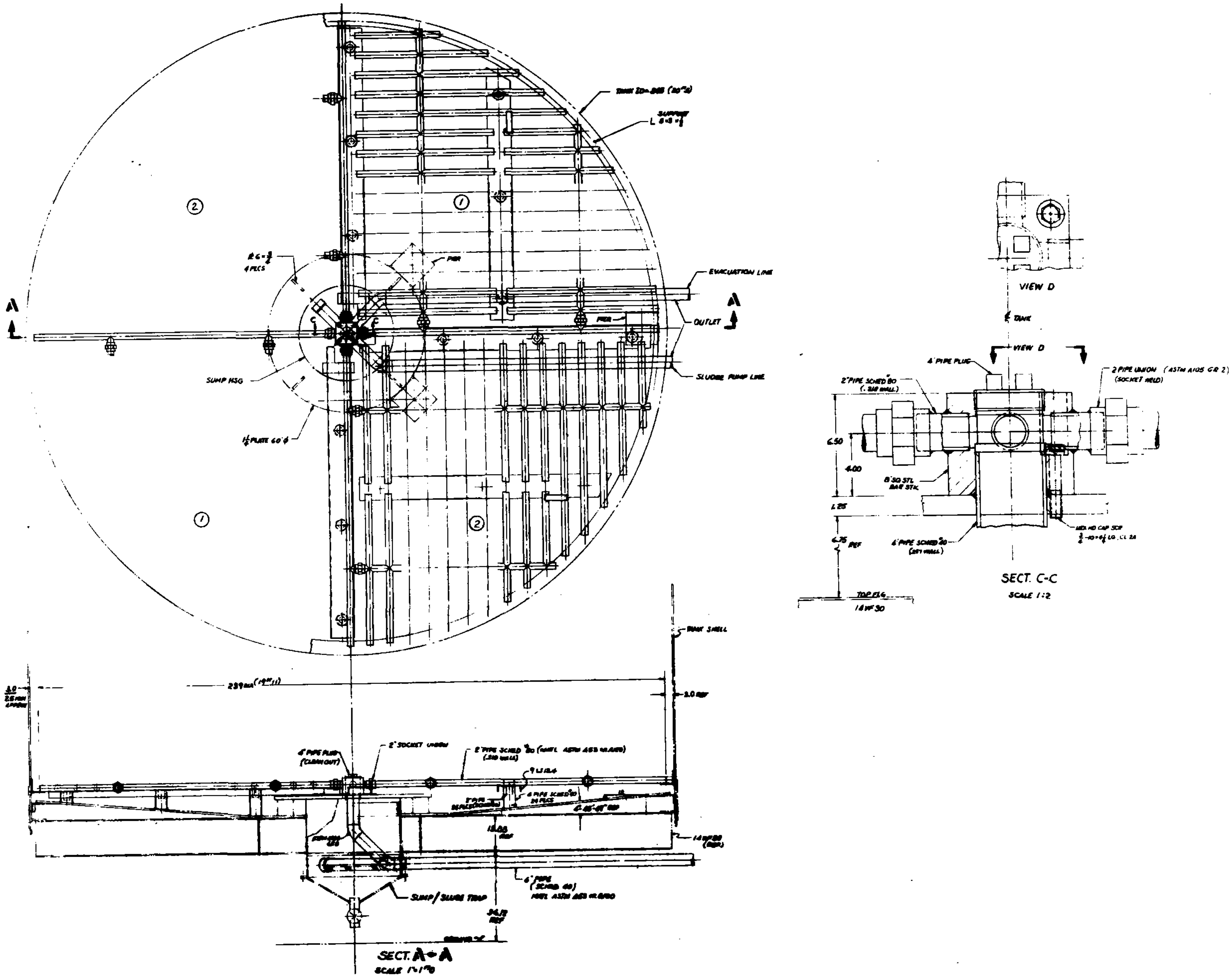


Figure 3.5-5. Tank Outlet Piping Arrangement (Dwg 919E109)

PART NO. 4 SHEET NO. ____

COMPONENT SHEET

____ DATE UPDATED

SUBSYSTEM: HTS

COMPONENT NOMENCLATURE: Small HTS Tanks

QUANTITY REQUIRED: 1

REQUIREMENTS: Material: Carbon Steel

Size: 12 Feet Dia. x 13 Feet High

Capacity: 11,860 Gal.

w/Manifold & Sump

as per GE Drawing

ASME

SUGGESTED SOURCES:
1. All Steel Fabricators, Inc.
2. ____
3. ____
4. ____
5. ____

DATES:

RFQ ____

DEL. TIME WKS. 24

POI ____

HARDWARE NEED ____

VENDOR STATUS

COST/UNIT $48,843 as per attached quote

[illegible] Co., Inc.

[illegible]

MAILING ADDRESS: 3700 MAIN STREET, PHILADELPHIA, PA. 19127
PLANT: RIGHTER'S FERRY ROAD AND SCHUYLKILL RIVER
BALA-CYNWYD, PA. 19004
TEnnyson 0-6485, 6486, 6487

PRICE QUOTATION

7896

PLEASE INDICATE THIS NUMBER WHEN ORDERING

Sheet 1 of 2

General Electric Corp.
Valley Forge Space Center
P.O. Box 8661
Bldg #7
Phila., PA 19101

attn: Mr. F.G. Hoban

DATE	6/9/78
YOUR INQUIRY DATED	
PROPOSED SHIPPING DATE	14 weeks
TERMS	Net 10 days
F.O.B.	our plant
SALESMAN	
TO BE SHIPPED VIA	Truck
PPD OR C...	

Here is our quotation on the goods named, subject to the conditions noted:

CONDITIONS: The prices and terms on this quotation are not subject to verbal changes or other agreements unless approved in writing by the Home Office of the Seller. All quotations and agreements are contingent upon strikes, accidents, fires, availability of materials and all other causes beyond our control. Prices are based on costs and conditions existing on date of quotation and are subject to change by the Seller before final acceptance.

Typographical and stenographic errors subject to correction. Purchaser agrees to accept either overage or shortage not in excess of ten percent to be charged for pro-rata. Purchaser assumes liability for patent and copyright infringement when goods are made to Purchaser's specifications. When quotation specifies material to be furnished by the purchaser, ample allowance must be made for reasonable spoilage and material must be of suitable quality to facilitate efficient production.

Conditions not specifically stated herein shall be governed by established trade customs. Terms inconsistent with those stated herein which may appear on Purchaser's formal order will not be binding on the Seller.

QUANTITY	DESCRIPTION	PRICE	AMOUNT
	RE: General Electric Dwg. #919E100 Thermal Energy Storage Tank, Drawing dated April 14, 1978:		
	Provide the labor and materials to produce the following:		
One (1)	Tank 20'-6" diameter x 16'-0" Straight Shell Height 3/8" thick Shell and Roof 3/4" thick Bottom Tank to be fabricated per drawing reference above. We include the structural steel supports as shown.		
	Complete tank to be pre-fabricated in our shops and "knocked-down" into six (6) sections for shipment. The sump would also be shipped loose. Tank material to be A516-gr55.		
	We do not include the sparger assemblies in the following pricing.		
	Exterior of tank to be given one (1) coat Hi-temp aluminum. Interior of tank-no paint or coating		
	FOR THE SUM OF:	$61,490.00	
	Note: We do not include any insulation in the above pricing.		

FORM 2040 REGENT FORMS, BELLMAWR, N.J. 08030

-cont'd.-

QUOTE VALID FOR 30 DAYS.

BY ____________________
R.L. McCormick
Vice President

3-67

ACCEPTANCE DATE ACCEPTED BY

MAILING ADDRESS: 3700 MAIN STREET, PHILADELPHIA, PA. 19127
PLANT: RIGHTER'S FERRY ROAD AND SCHUYLKILL RIVER
BALA-CYNWYD, PA. 19004
TEnnyson 9-6435, 6436, 6437

PRICE QUOTATION

7896

PLEASE INDICATE THIS NUMBER WHEN ORDERING

Sheet 2 of 2

DATE 6/9/78

YOUR INQUIRY DATED

PROPOSED SHIPPING DATE 14 weeks

TERMS Net 10 days   F.O.B. Our Plant

SALESMAN

TO BE SHIPPED VIA Truck   PPD. OR

General Electric Corp.
Valley Forge Space Center
P.O. Box 8661
Bldg #7
Phila., PA 19101

Attn; Mr. F.G. Hoban

Here is our quotation on the goods named, subject to the conditions noted:

CONDITIONS: *The prices and terms on this quotation are not subject to verbal changes or other agreements unless approved in writing by the Home Office of the Seller. All quotations and agreements are contingent upon strikes, accidents, fires, availability of materials and all other causes beyond our control. Prices are based on costs and conditions existing on date of quotation and are subject to change by the Seller before final acceptance.*

Typographical and stenographic errors subject to correction. Purchaser agrees to accept either overage or shortage not in excess of ten percent to be charged for pro-rata. Purchaser assumes liability for patent and copyright infringement when goods are made to Purchaser's specifications. When quotation specifies material to be furnished by the purchaser, ample allowance must be made for reasonable spoilage and material must be of suitable quality to facilitate efficient production.

Conditions not specifically stated herein shall be governed by established trade customs. Terms inconsistent with those stated herein which may appear on Purchaser's formal order will not be binding on the Seller.

QUANTITY	DESCRIPTION	PRICE	AMOUNT
	RE: General Electric Dwg. #919E100 Thermal Energy Storage Tank, Drawing dated April 14, 1978 cont'd.		
One (1)	Sparger Pipe Assembly for the above tank (fixed manifold concept) Material- 1¼" diameter Pipe A-106 unit to be shipped in four (4) pcs. FOR THE SUM OF:	$12,412.00	
One (1)	13'-0" diameter tank x 16'-0" Straight Shell Height (same design as above tank) Tank to be shipped in one (1) peice. FOR THE SUM OF:	30,163.00	
One (1)	Sparger Pipe Assembly for the above tank FOR THE SUM OF:	9,340.00	

FORM 2040 REGENT FORMS, BELLMAWR, N.J. 08030

QUOTE VALID FOR 30 DAYS.

BY
R.L. McCormick
Vice President

3-68
ACCEPTANCE   DATE ACCEPTED   BY

PART NO. 5 SHEET NO.

COMPONENT SHEET

DATE UPDATED

SUBSYSTEM: HTS

COMPONENT NOMENCLATURE: Oil Vapor Condensing Tank

QUANTITY REQUIRED: 1

REQUIREMENTS: 50 gal.

SUGGESTED SOURCES:
1. Wood Bros.
2. C. J. Schmidt
3. Tank Fabricators - Atlanta, GA
4.
5.

DATES:
- RFQ
- DEL. TIME WKS. 6-8
- POI
- HARDWARE NEED

VENDOR STATUS

COST/UNIT $155.00 (Means 15, 6520)

PART NO. 6 SHEET NO. ____

COMPONENT SHEET

DATE UPDATED ____

SUBSYSTEM: HTS

COMPONENT NOMENCLATURE: Make-up Oil Storage Tank

QUANTITY REQUIRED: 1

REQUIREMENTS:

8000 Gal. ASME Coded Tank

SUGGESTED SOURCES:
1. Wood Bros.
2. C. J. Schmidt
3. Tank Fabricators - Atlanta, GA area
4.
5.

DATES:
- RFQ ____
- DEL. TIME WKS. 8
- POI ____
- HARDWARE NEED ____

VENDOR STATUS

COST/UNIT $780 (Lockwood Greene Estimate)

PART NO. 7

SHEET NO.

COMPONENT SHEET

DATE UPDATED

SUBSYSTEM: HTS

COMPONENT NOMENCLATURE: Iron Ore Storage Medium

QUANTITY REQUIRED: 1147 ton

REQUIREMENTS: Nominal Sizes 3/8 - 11/16 inch

Bulk Density: 10-130 #/Ft^3

SUGGESTED SOURCES:

1. Hanna Mining Co. Pilot Knob, MI
2.
3.
4.
5.

DATES: RFQ

DEL. TIME WKS. 8

POI

HARDWARE NEED

VENDOR STATUS

COST/UNIT $75/Ton

PART NO. 8

SHEET NO. ____

COMPONENT SHEET

DATE UPDATED ____

SUBSYSTEM: HTS

COMPONENT NOMENCLATURE: Oil Fill Pump

QUANTITY REQUIRED: 1

REQUIREMENTS:

Rated Capacity - 20 GPM

Head: 30'

Fluid: Syltherm™ 800

Motor: 2 HP, 3 Ø 440 volts

SUGGESTED SOURCES:
1. Dean Bros.
2. Gould
3. Ingersol - Rand
4. Dorr - Oliver Equip. Eng.
5. ____

DATES:
- RFQ ____
- DEL. TIME WKS. 6
- POI ____
- HARDWARE NEED ____

VENDOR STATUS

COST/UNIT $783 (BCF 15.712.1508)

PART NO. 9

SHEET NO.

COMPONENT SHEET

DATE UPDATED

SUBSYSTEM: HTS

COMPONENT NOMENCLATURE: HTS Transfer Pump

QUANTITY REQUIRED: 1

REQUIREMENTS:

Rated Capacity: 415 GPM @ 152' Head

Operating Temp.

----Ø----HP

Fluid Syltherm™ 800

SUGGESTED SOURCES:
1. Dean Bros.
2. Gould Pumps
3. Dorr-Oliver-Equip. Eng.
4. Ingersoll-Rand - Air Cong.
5.

DATES:
- RFQ
- DEL. TIME WKS.
- POI
- HARDWARE NEED

VENDOR STATUS

COST/UNIT $5050 (Similar to)

PART NO. 14 SHEET NO. ____

COMPONENT SHEET

DATE UPDATED ____

SUBSYSTEM: HTS

COMPONENT NOMENCLATURE: Steam Generator Supply Pump

QUANTITY REQUIRED: 1

REQUIREMENTS:

Rated Capacity: 325 GPM @ 192' Head

Operating Temp. 750° F

Power: ----Ø----H. P.

Fluid: Syltherm™ 800

SUGGESTED SOURCES:
1. Dean Bros. Pumps
2. Gould
3. Ingersoll-Rand
4. ____
5. ____

DATES:
- RFQ ____
- DEL. TIME WKS. ____
- POI ____
- HARDWARE NEED ____

VENDOR STATUS

COST/UNIT $5050 (Similar to)

PART NO. 11

SHEET NO. ____

COMPONENT SHEET

DATE UPDATED ____

SUBSYSTEM: HTS

COMPONENT NOMENCLATURE: Syltherm™ 800 Fossil Fired Heater

QUANTITY REQUIRED: 1

REQUIREMENTS: 325 GPM or 122,070 #/Hr. from 500° F to 750° F

Net Output 11 MM BTU, Efficiency ≈85%

Material: Carbon or Stainless Steel

SUGGESTED SOURCES:

1. Struthers Wells
2. UIP Engineered Products
3.
4.
5.

DATES: RFQ ____

DEL. TIME WKS. 39

POI ____

HARDWARE NEED ____

VENDOR STATUS

COST/UNIT $200,000

Struthers

Struthers Wells Corporation

P. O. BOX 8 • WARREN, PENNSYLVANIA 16365 • 814/726-1000

April 26, 1978

General Electric Company
Building D
Mail Drop 0-2
Cincinnati, Ohio 44215

Attention: Mr. C. Ehde

Subject: Indirect Fired Heaters

Gentlemen:

It was a pleasure talking to you today and discussing your possible requirement for a 16 MM Btu/hour, 750°F fluid outlet temperature heater.

This type of heating system is well within our capabilities, and we would welcome the opportunity of working with you on this project.

To introduce you to the heater activities of Struthers, enclosed for your use is a copy of our Bulletin E-45, Indirect Heating Systems. In addition to showing many of the different heaters we design and manufacture, the bulletin also discusses some of the principles of heater design.

For a 16 MM Btu/hour heater, the budget price would be $200,000. This price is f.o.b. Midwest area and includes the following Scope of Supply:

- -- Circular heater with shop installed radiant and convection section.
- -- Burner - natural gas and #6 oil firing.
- -- Oil pumping and heating set, steam heated.
- -- Temperature controls, combustion controls, flame safeguard system, and safety interlocks.
- -- Air preheater to provide a thermal efficiency of about 90% based on lower heating value of fuel.
- -- Forced draft fan, ductwork, and stack.
- -- Valve train prepiped and control panel prewired.

Struthers

General Electric Company
April 26, 1978
Page -2-

Shipment for this system could be made in about 8 months after order receipt.

When your requirements firm up, we would welcome the chance to give you a complete technical and commercial proposal.

In the meanwhile if we can be of further help or if there are any questions, please do not hesitate to contact us.

Very truly yours,

STRUTHERS WELLS CORPORATION

Edward D Burns Jr.

Edward D. Burns, Jr., Manager
Special Products Department

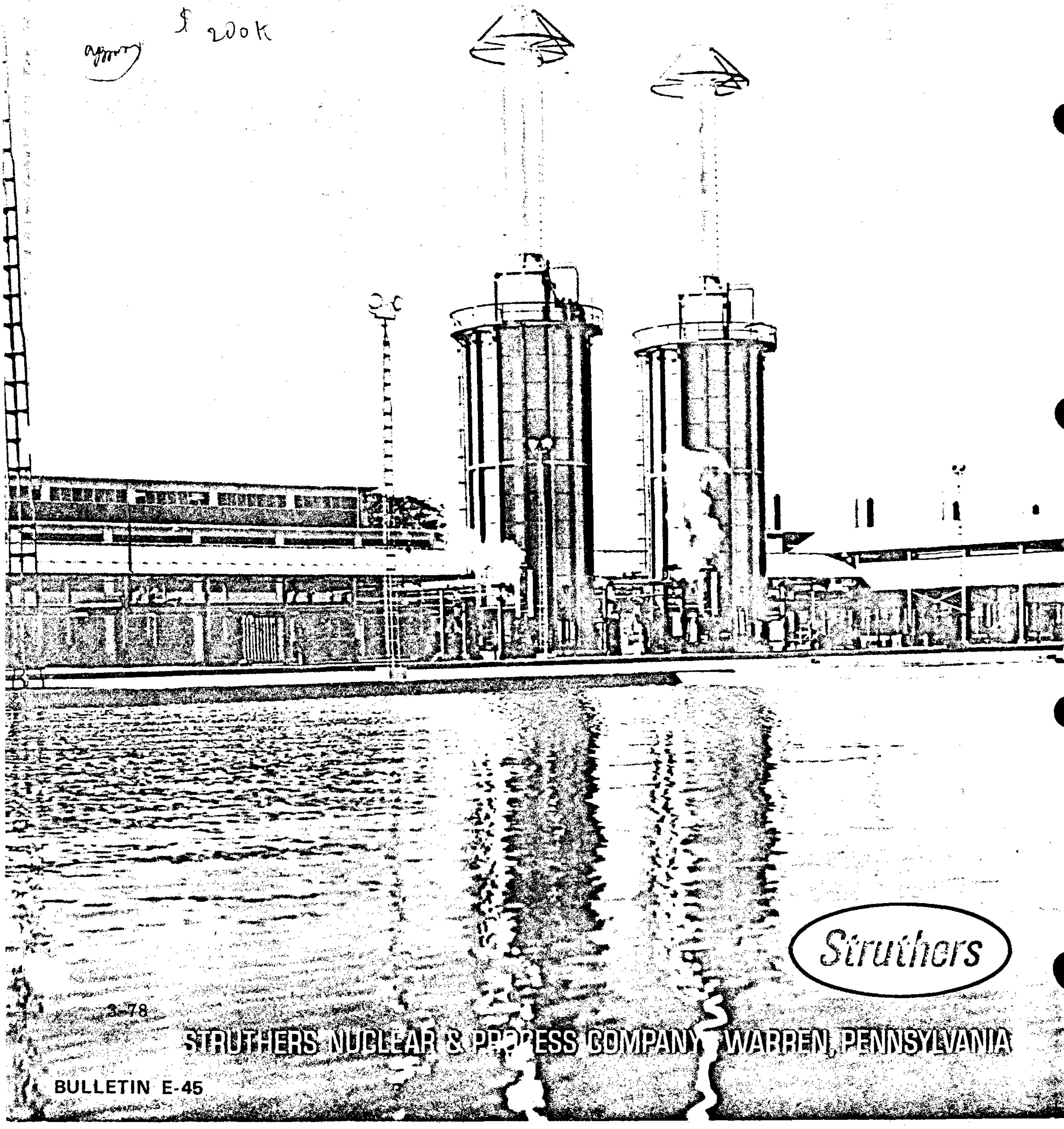
EDB:pam

Burn's Telephone estimate $200K ??

Encl.

Indirect heating systems

$ 200K



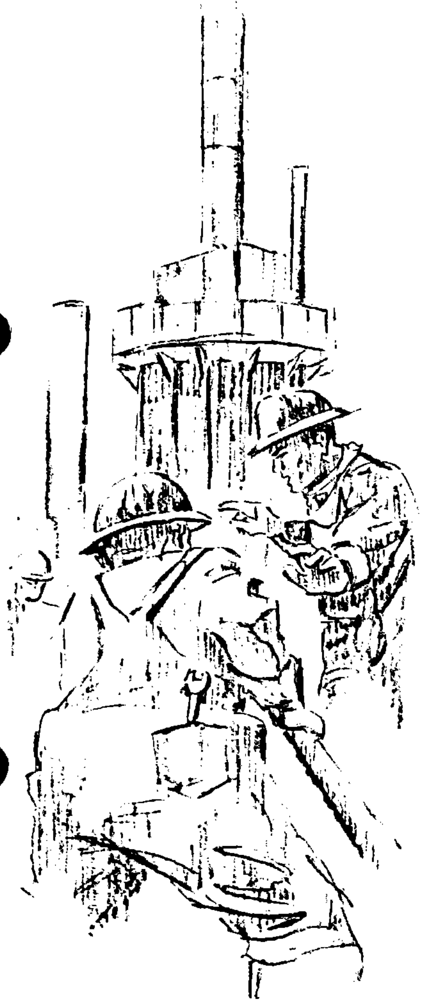
Struthers

3-78

STRUTHERS NUCLEAR & PROCESS COMPANY WARREN, PENNSYLVANIA

BULLETIN E-45

INTRODUCTION



This bulletin describes the primary design features and inherent advantages of the Struthers Wells Indirect Heating Systems for high temperature heating applications. About 700 of these systems have been designed and constructed to date; each year adds substantially to this number. Struthers Wells Indirect Heating Systems are recognized throughout the world for their outstanding performance and reliability.

High temperature heating covers the range above the temperatures which are normally available from the average steam boiler. The trend to high temperature process heating has resulted in an increased demand for reliable and well designed heating equipment.

The Struthers Wells Indirect Heating Systems have been designed and engineered specifically to meet these demands. Standard systems are available for use with all of the commercial heat transfer mediums, both liquid and vapor phase types. In this bulletin, we describe our standard equipment and variations of basic designs which provide arrangements suitable for a wide variety of services. Unusual applications may require special designs or particular consideration. Struthers Wells, a leader in the field of high temperature heating, places years of experience and background at your service. Some of our systems have been in continuous operation for over 25 years.

Size is no problem. Heating systems are available from a pilot plant unit of 300,000 BTU/Hr. to large commercial units of 100,000,000 BTU/Hr.; larger if required. We offer complete systems including the heater, combustion system, circulating pump, flash tank or expansion tank, control system, accessories and safety devices. Each item of the system is carefully designed and selected for maintenance-free operation and reliability. Complete operating and installation instructions are provided. Engineering assistance is available, if desired.

If your process requires heat above available steam temperatures; if the steam pressure required for your process will unduly increase the cost of your steam facility; if the cost of the process users will rise sharply because of high steam pressures; if heat is required at a remote location—Struthers Wells has a heating system which will meet your requirements and which merits your consideration.

We will be pleased to discuss types of equipment with you and provide cost estimates. As manufacturers of a wide variety of heating system designs, we are in position to offer impartial recommendations on the equipment best suited for each application.

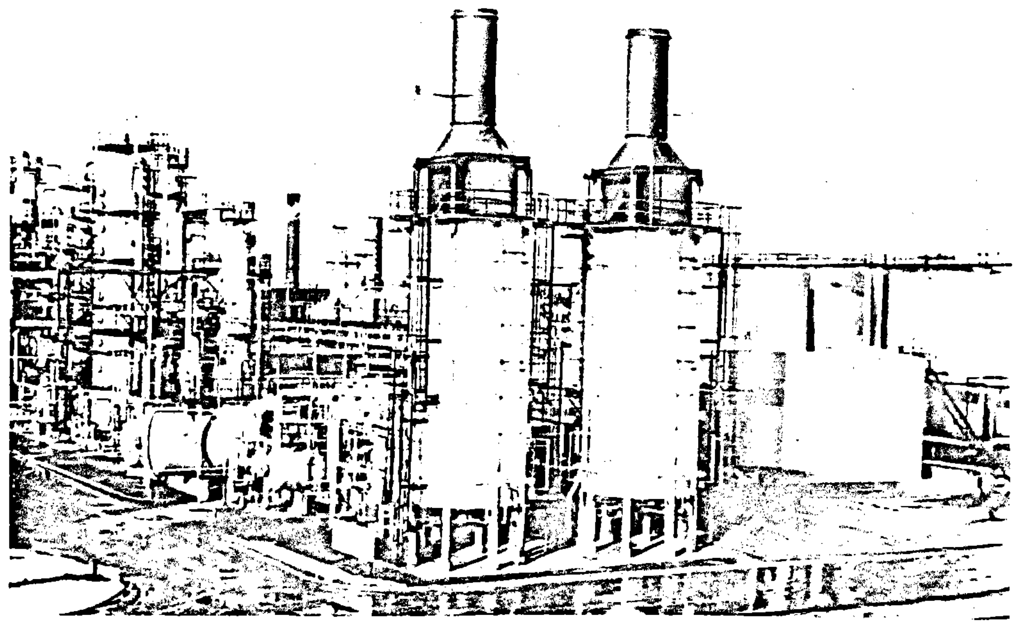


Fig. 1 Two Dowtherm heaters installed in a modern lubricating oil plant of a major Canadian refiner. The total capacity of the liquid Dowtherm System is 60,000,000 BTU/Hr. at 700° F, making it one of the largest installations of this type.

THE INDIRECT HEATING SYSTEM

An indirect heating system is one in which a heat transfer fluid absorbs heat in a furnace, then transfers the heat to process streams in various types of units. Struthers Wells Indirect Heating Systems are all of the forced circulation type, in which a pump is used to circulate the heat transfer fluid through the coils of the heater at a preselected high velocity.

Since velocities are controlled, heat transfer coefficients are maintained at optimum conditions. High velocity forced circulation is the preferred means to safely heat a heat transfer medium to its maximum allowable main body temperature, with a minimum temperature rise across the fluid film. This is graphically shown in Fig. 26.

There are three basic types of Struthers Wells Indirect Heating Systems:

a. The atmospheric system—one using a heat transfer medium at temperatures below its atmospheric boiling point.
b. The pressurized liquid system—one using a heat transfer medium in the liquid phase at temperatures above its atmospheric boiling point, but with vaporization suppressed by hydrostatic head or the pressure of an inert gas.
c. The vapor system—one using the heat transfer medium in the vapor phase.

Each system has its own area of application. These areas may overlap to some extent, but the service and equipment layout will usually dictate the selection of the optimum heat transfer medium and the type of system.

The various heat transfer mediums are recommended for use within the following temperature limits:

a. Heat transfer petroleum oils - 600°F.
b. Organic fluids - 600 to 750°F.
c. Organic fluids in the vapor phase - 575 to 750°F.
d. High temperature salts - 1000°F.
e. Liquid metals - 2000°F.

Reference is made to the manufacturers' handbooks or bulletins for specific data on the various heat transfer mediums.

Struthers Wells Indirect Heating Systems have been used for many years with all of the commercially available heat transfer mediums. Some have been in continuous operation for over 25 years without coking or operating difficulties. Many of these systems are operating at the manufacturers' recommended maximum main body temperatures for the particular heat transfer medium.

Many of the difficulties encountered with competitive types of heating systems are due to their failure to meet the fundamental requirements of good heater design. This has resulted in excessive heat transfer fluid thermal decomposition, continuing high replacement cost, tube burnout as a result of coke formation, excessive maintenance and downtime. Struthers Wells' many years of experience in high temperature process heater design have been incorporated in the design of a standard line of indirect heating systems which eliminates these problems.

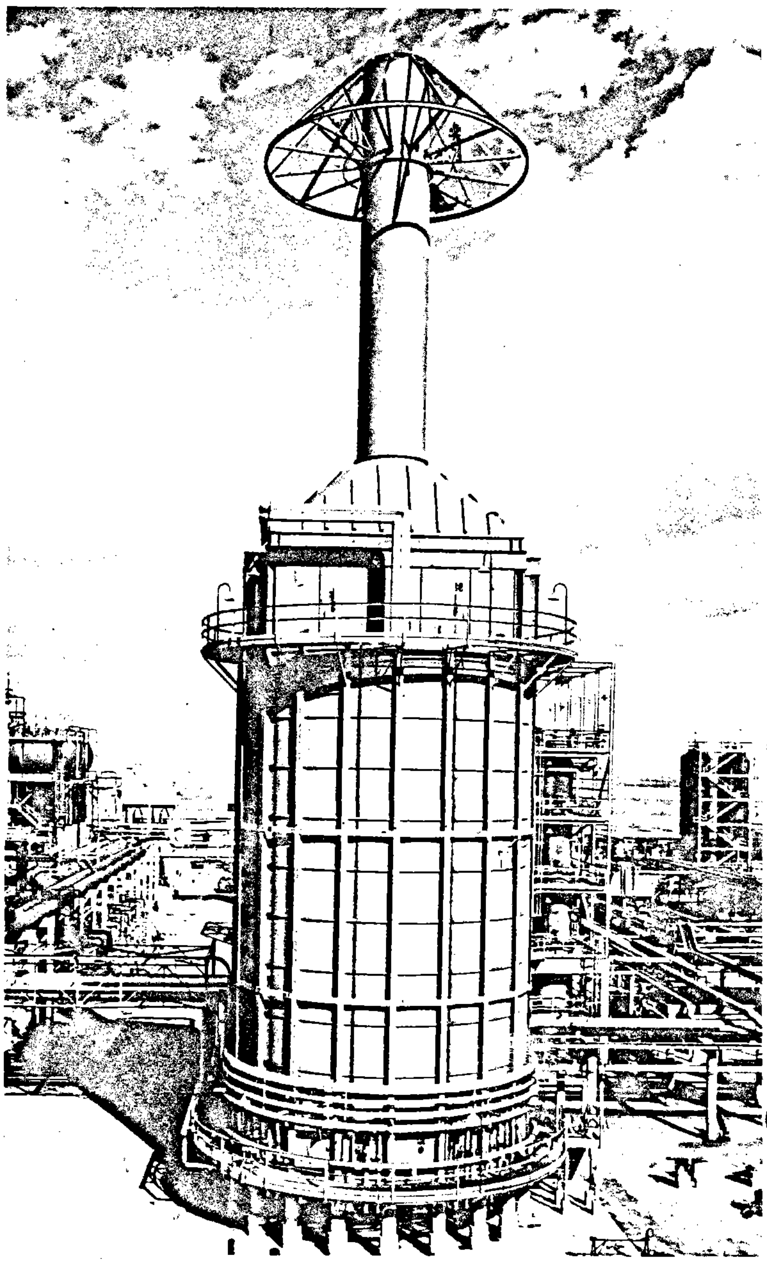
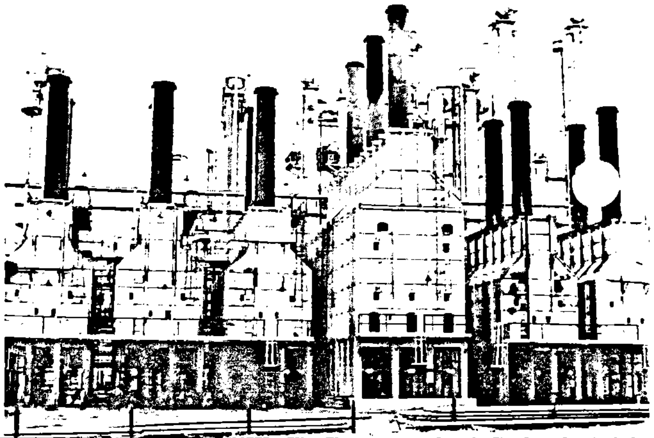


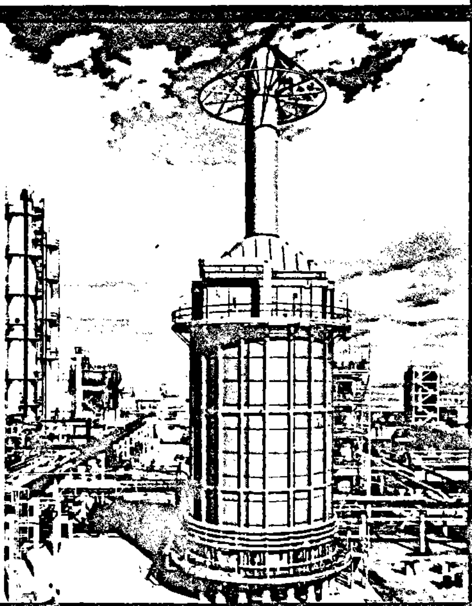
Fig. 2 Hot oil heater rated at 117,000,000 BTU/Hr. installed at a major mid-west refinery.

Struthers

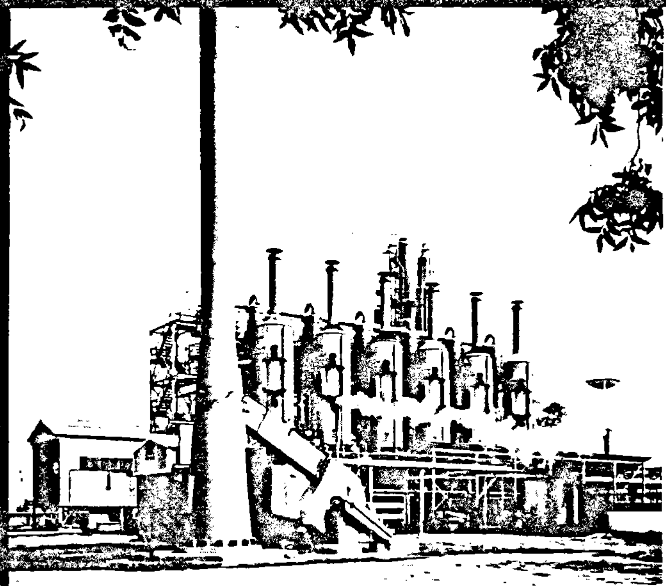
SPECIALIZING IN HIGH PRESSURE AND HIGH TEMPERATURE HEATING



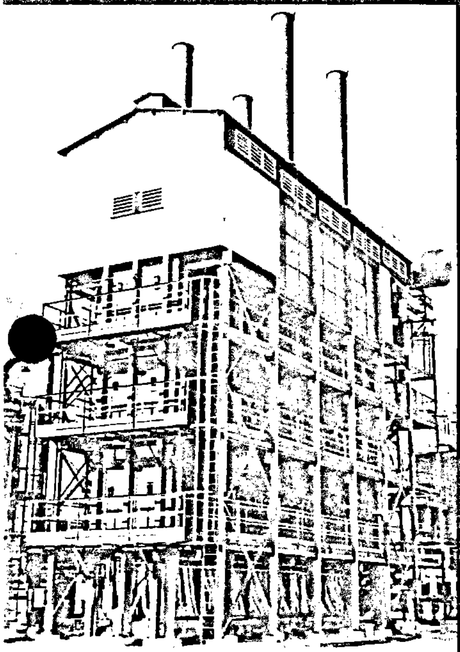
Hydrocarbon cracking furnaces operating at 1400° F.

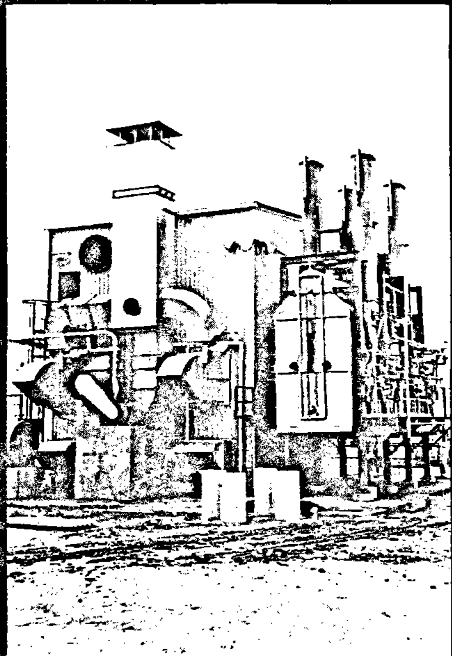


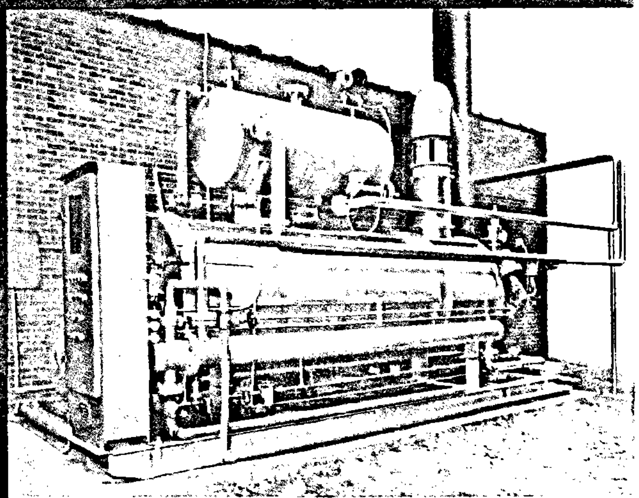
Refinery heater designed for 117 MM BTU/HR



Battery of oxygen-methane heaters for an acetylene plant.







Above: Packaged indirect circulating heating and cooling system.

Left: Potassium vaporizer operating at 1600° F.

Extreme left: Steam-methane reformer operating at 1450° F, and provided with integral waste heat boiler.

STRUTHERS NUCLEAR & PROCESS COMPANY · WARREN, PENNSYLVANIA 16365

PART NO. 12 SHEET NO. ____

COMPONENT SHEET

10/18/78
DATE UPDATED

SUBSYSTEM: HTS

COMPONENT NOMENCLATURE: Nitrogen Regulation Valve

QUANTITY REQUIRED: 1

REQUIREMENTS: 1" Pneumatic

SUGGESTED SOURCES:
1. ____
2. ____
3. ____
4. ____
5. ____

DATES:
RFQ ____
DEL. TIME WKS. ____
POI ____
HARDWARE NEED ____

VENDOR STATUS

COST/UNIT $172.00 (BCF 15122.0108)

PART NO. 13 SHEET NO. ____

COMPONENT SHEET

10/18/78
DATE UPDATED

SUBSYSTEM: HTS

COMPONENT NOMENCLATURE: Condensable Back Pressure Valve

QUANTITY REQUIRED: 1

REQUIREMENTS: 1" Pneumatic

SUGGESTED SOURCES:
1. ____
2. ____
3. ____
4. ____
5. ____

DATES: RFQ ____
DEL. TIME WKS. ____
POI ____
HARDWARE NEED ____

VENDOR STATUS

COST/UNIT $165 (15122.0104)

PART NO. 14

SHEET NO. ___

COMPONENT SHEET

10/15/78
DATE UPDATED

SUBSYSTEM: HTS

COMPONENT NOMENCLATURE: Nitrogen Storage System

QUANTITY REQUIRED: 1

REQUIREMENTS: ___

SUGGESTED SOURCES:
1. ___
2. ___
3. ___
4. ___
5. ___

DATES: RFQ ___

DEL. TIME WKS. ___

POI ___

HARDWARE NEED ___

VENDOR STATUS

COST/UNIT $7,500 EST.

PART NO. 15

SHEET NO.

COMPONENT SHEET

10/18/78
DATE UPDATED

SUBSYSTEM: HTS

COMPONENT NOMENCLATURE: Tank Selection Valves (Collector Field Return)

QUANTITY REQUIRED: 4

REQUIREMENTS: 4-1/2" Pneumatic Syltherm™ Fluid, 750°F op. temp.

Open/Close Butt Weld Ends, Low Pressure (100 psi)

SUGGESTED SOURCES:

1. Powell
2. Jenkins
3. Kieley & Mueller
4. Honeywell
5.

DATES:

RFQ

DEL. TIME WKS. 16

POI

HARDWARE NEED

VENDOR STATUS

COST/UNIT $1,828 Quote

-------- Company, Inc.

February 13, 1979

Quote #AC-4919-K

MANAGEMENT & TECHNICAL SERVICES COMPANY
Sub. of General Electric
P. O. Box 8661
Philadelphia, Pennsylvania 19101

Attention: Mr. Mario Bongiovanni

Gentlemen:

RE: KIELEY AND MUELLER VALVES

In accordance with your recent request, we are pleased to submit our quotation on the enclosed sheets and as follows.

All valves are carbon steel bodies, with stainless steel trim. All valves on syltherm are model 6650 cage type, and price includes solid stellite seat rings of 316 S.S., 316 chrome plated cages, and all other surfaces are either 316 S.S. or 17-4PH also stellited.

All on-off valves include top mounted handwheels, Kieley and Mueller type 460 airset and filter regulator, Micro model BZE-62-RN limit switches, and Asco 8320A89 or 91 solenoid valves. All equipment is mounted and piped.

All modulating valves include top mounted handwheel, Kieley and Mueller type 460 airset and filter regulator, a Honeywell model 685435 E/P positioner, and a Fisher model 3582 remote position indicator with a 0-1 MA in 2000 ohm impedence output. (for LVDT).

Prices are quoted F.O.B. our factory in Middletown, New York. Our terms of sale are net 30 days. Delivery can be made in eighteen (18) to twenty (20) weeks after receipt of order.

We sincerely appreciate this opportunity to quote on your requirements. Should you have any questions, I would be most happy to discuss them with you.

Very truly yours,

KIELEY AND MUELLER, INC.
c/o Arobone and Company, Inc.

Kenneth C. Arobone

KCA:en

TO GENERAL ELECTRIC

ITEM #	SIZE	TYPE CONTROL	QTY	MODEL #	NET PRICE EA.
PCS-14, SCS-23, 24, 25, 26, 27, 28, 30, 31, 33, 34, 36	4" BUTT WELD	ON-OFF	39	6650	$1,828.00
SCS-29, 32, 35	4"-BUTT WELD	MODULATING	6	6650	$2,346.00
SCS-35 PART TWO	2" SOCKET WELD	MODULATING	4	6650	$1,604.00
PCS-15 WATER	1"-SCW. ENDS	MODULATING	1	1456	$1,093.00
TUS-14, TUS-16 WATER	3"-150# FLG	MODULATING	2	6650	$1,540.00
TUS-14 A WATER	4"-150# FLG	MODULATING	1	6650	$1,853.00
TUS-15 WATER	6"-150# FLG.	MODULATING	1	6650	$2603.00

PAGE 2 GENERAL ELECTRIC

ITEM	SIZE + CONN.	TYPE-OF CONTROL	QTY	MODEL #	PRICE EA. NET
PCS-18 STEAM VALVES PER HAND NOTES.	2" - 150# FLG.	ON-OFF	2	1456	$813.00
	1½" - 150# FLG	ON-OFF	2	6650	$717.00
	3" - 600# FLG	ON-OFF	2	6650	$1882.00
	8" - 150# FLG	ON-OFF	1	1450	$3,314.00
	TOTAL	NET =	$110,551.00		

3-88

PART NO. 16 SHEET NO. ____

COMPONENT SHEET

DATE UPDATED ____

SUBSYSTEM: HTS

COMPONENT NOMENCLATURE: Tank Selection Valves (Steam Generator Return)

QUANTITY REQUIRED: 4

REQUIREMENTS: 4" Pneumatically Operated

Temp: 750° F

Fluid - Syltherm™ 800

End - Butt Welded

Positioner - Pneumatic

Press: 100 psi

SUGGESTED SOURCES:
1. Powell
2. Jenkins
3. Kieley & Mueller
4. Honeywell
5. ____

DATES:
- RFQ ____
- DEL. TIME WKS. 16
- POI ____
- HARDWARE NEED ____

VENDOR STATUS

COST/UNIT $1,828 Quote

PART NO. 17 SHEET NO. ___

COMPONENT SHEET

10/18/78
DATE UPDATED

SUBSYSTEM: HTS

COMPONENT NOMENCLATURE: Steam Gen. Return Selection Valve

QUANTITY REQUIRED: 4

REQUIREMENTS: 4-1/2" Pneumatic

Temp.: 750° F

Fluid: Syltherm™ 800

Ends: Butt Welded

Positioner, Pneumatic; Position SW

Press: 100 psi

SUGGESTED SOURCES:
1. Jenkins
2. Powell
3. Kieley & Mueller
4. Honeywell
5.

DATES:
- RFQ ___
- DEL. TIME WKS. 16
- POI ___
- HARDWARE NEED ___

VENDOR STATUS

COST/UNIT $1,828 Quote

PART NO. 18

SHEET NO. ___

COMPONENT SHEET

10/18/78
DATE UPDATED

SUBSYSTEM: HTS

COMPONENT NOMENCLATURE: Fossil Fired Heater Supply Selection Valves

QUANTITY REQUIRED: 2

REQUIREMENTS: 4-1/2" Pneumatic

Temp. 750° F

Fluid Syltherm™ 800

End Conn. Butt Weld

Press 100 psi

Positioner

SUGGESTED SOURCES:
1. Powell
2. Jenkins
3. Kieley & Mueller
4. Honeywell
5.

DATES:
- RFQ ___
- DEL. TIME WKS. 16
- POI ___
- HARDWARE NEED ___

VENDOR STATUS

COST/UNIT $1,828 Quote

PART NO. 19

SHEET NO. ____

COMPONENT SHEET

10/18/78
DATE UPDATED

SUBSYSTEM: HTS

COMPONENT NOMENCLATURE: Fossil Fuel Heater Return Selection Valves

QUANTITY REQUIRED: 3

REQUIREMENTS: 4" Pneumatic Actuator

Temp: 525° F

Fluid: Syltherm™ 800

End Conn. Butt-Weld

Positioner: Pneumatic

Press: 100 psi

SUGGESTED SOURCES:

1. Powell
2. Jenkins
3. Honeywell
4. Kieley & Mueller
5. ____

DATES: RFQ ____

DEL. TIME WKS. ____

POI ____

HARDWARE NEED ____

VENDOR STATUS

COST/UNIT $1, 828 Quote

PART NO. 20

SHEET NO. ____

COMPONENT SHEET

10/18/78
DATE UPDATED

SUBSYSTEM: HTS

COMPONENT NOMENCLATURE: Collector Field Pump Selection Valves

QUANTITY REQUIRED: 2

REQUIREMENTS: 5" Manual

Temp: 500° F

Fluid Syltherm™ 800

End Conn: Butt Weld/Split Body

Positioner: Pneumatic

Press: 100 psi

SUGGESTED SOURCES:
1. Powell
2. Jenkins
3. Kieley & Mueller
4. Honeywell
5. ____

DATES: RFQ ____

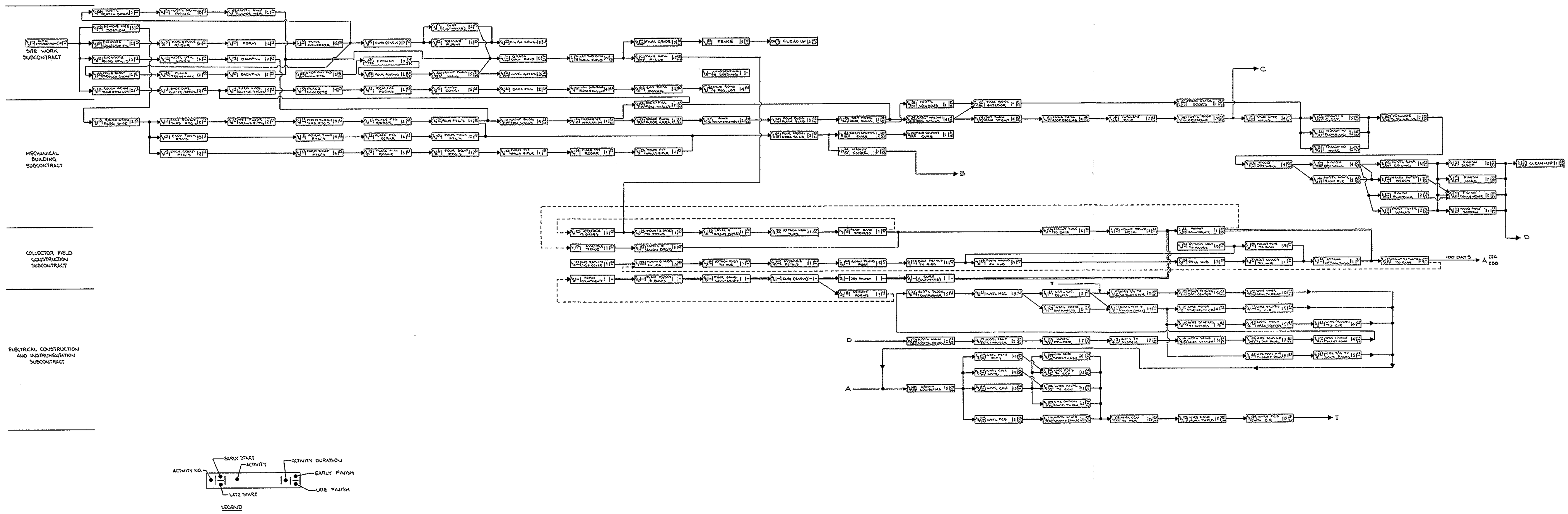
DEL. TIME WKS. 10

POI ____

HARDWARE NEED ____

VENDOR STATUS

COST/UNIT $880.00 (BCF 15122.0205)



SYSTEM INSTALLATION NETWORK DIAGRAM - SHEET 1
2/7/79

PART NO. 21

SHEET NO. ____

COMPONENT SHEET

10/18/78
DATE UPDATED

SUBSYSTEM: HTS

COMPONENT NOMENCLATURE: Collector Field Pump Throttle Valve

QUANTITY REQUIRED: 1

REQUIREMENTS: 4-1/2" Pneumatic Actuator

Temp: 500° F

Fluid Syltherm™ 800

End Conn. Pneumatic/Split-Body

Positioner Pneumatic

Press: 100 psi

SUGGESTED SOURCES:
1. Powell
2. Jenkins
3. Kieley & Mueller
4. Honeywell
5. ____

DATES:
RFQ ____
DEL. TIME WKS. 10
POI ____
HARDWARE NEED ____

VENDOR STATUS

COST/UNIT $2,346 Quote

PART NO. 22 SHEET NO. ___

COMPONENT SHEET

10/18/78
DATE UPDATED

SUBSYSTEM: HTS

COMPONENT NOMENCLATURE: Tank Selection Valve (Steam Generator Supply)

QUANTITY REQUIRED: 4

REQUIREMENTS: Temp: 750° F

Fluid: Syltherm™ 800

End Conn: Butt-Welded/Split Body

Positioner: Pneumatic

Press: 100 psi

SUGGESTED SOURCES:
1. Powell
2. Honeywell
3. Kieley & Mueller
4. Jenkins
5. ___

DATES:
- RFQ ___
- DEL. TIME WKS. 8
- POI ___
- HARDWARE NEED ___

VENDOR STATUS

COST/UNIT $1,828 Quote

PART NO. 23

SHEET NO. ____

COMPONENT SHEET

10/18/78
DATE UPDATED

SUBSYSTEM: HTS

COMPONENT NOMENCLATURE: Tank Selection Valve (Collector Field Supply)

QUANTITY REQUIRED: 4

REQUIREMENTS: 4-1/2" Pneumatic Actuator

SUGGESTED SOURCES:
1. ____
2. ____
3. ____
4. ____
5. ____

DATES:
- RFQ ____
- DEL. TIME WKS. ____
- POI ____
- HARDWARE NEED ____

VENDOR STATUS

COST/UNIT $1, 828 Quote

PART NO. 24 SHEET NO. ____

COMPONENT SHEET

10/18/78
DATE UPDATED

SUBSYSTEM: HTS

COMPONENT NOMENCLATURE: Energy Storage Cir. Pump Throttle Valve

QUANTITY REQUIRED: 1

REQUIREMENTS: 4" Pneumatic Actuator

SUGGESTED SOURCES:
1. ____
2. ____
3. ____
4. ____
5. ____

DATES:
RFQ ____
DEL. TIME WKS. ____
POI ____
HARDWARE NEED ____

VENDOR STATUS

COST/UNIT $1,828 Quote

PART NO. 25

SHEET NO. ____

COMPONENT SHEET

10/18/78
DATE UPDATED

SUBSYSTEM: HTS

COMPONENT NOMENCLATURE: Circulation Pump/Discharge, Tank Selection Valve

QUANTITY REQUIRED: 4

REQUIREMENTS: 4" Pneumatic Actuator

SUGGESTED SOURCES:
1. ____
2. ____
3. ____
4. ____
5. ____

DATES:
- RFQ ____
- DEL. TIME WKS. ____
- POI ____
- HARDWARE NEED ____

VENDOR STATUS

COST/UNIT Quote $1,828

PART NO. 26 SHEET NO. ___

COMPONENT SHEET

10/18/78
DATE UPDATED

SUBSYSTEM: HTS

COMPONENT NOMENCLATURE: Circulation Pump/Suction, Tank Selection Valve

QUANTITY REQUIRED: 4

REQUIREMENTS: 4-1/2" Pneumatic Actuator

SUGGESTED SOURCES: 1.
2.
3.
4.
5.

DATES: RFQ
DEL. TIME WKS.
POI
HARDWARE NEED

VENDOR STATUS

COST/UNIT $1,828 Quote

PART NO. 27

SHEET NO. ____

COMPONENT SHEET

10/18/78
DATE UPDATED

SUBSYSTEM: HTS

COMPONENT NOMENCLATURE: Storage Tank Flow Control Valves

QUANTITY REQUIRED: 8

REQUIREMENTS: 4 Ea. - 4-1/2", 4 Ea. - 2"

SUGGESTED SOURCES:

1. ____
2. ____
3. ____
4. ____
5. ____

DATES:

RFQ ____

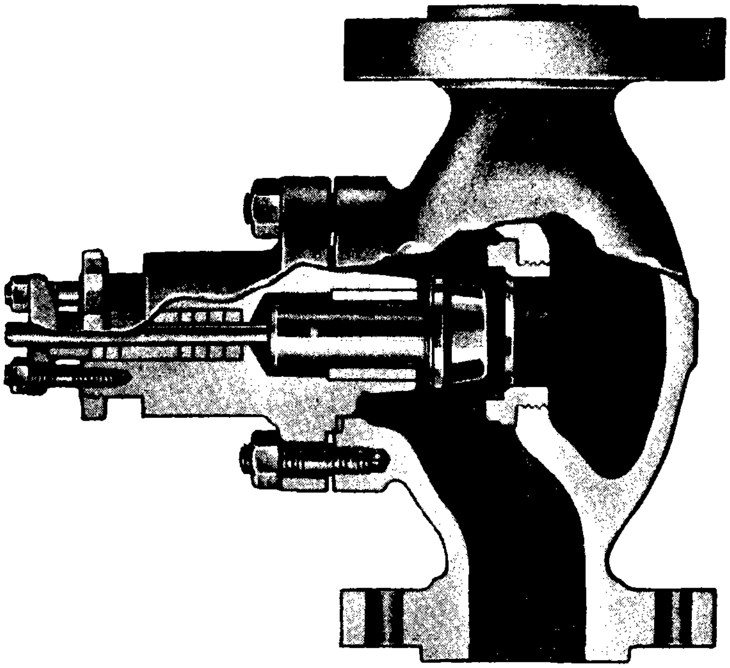
DEL. TIME WKS. ____

POI ____

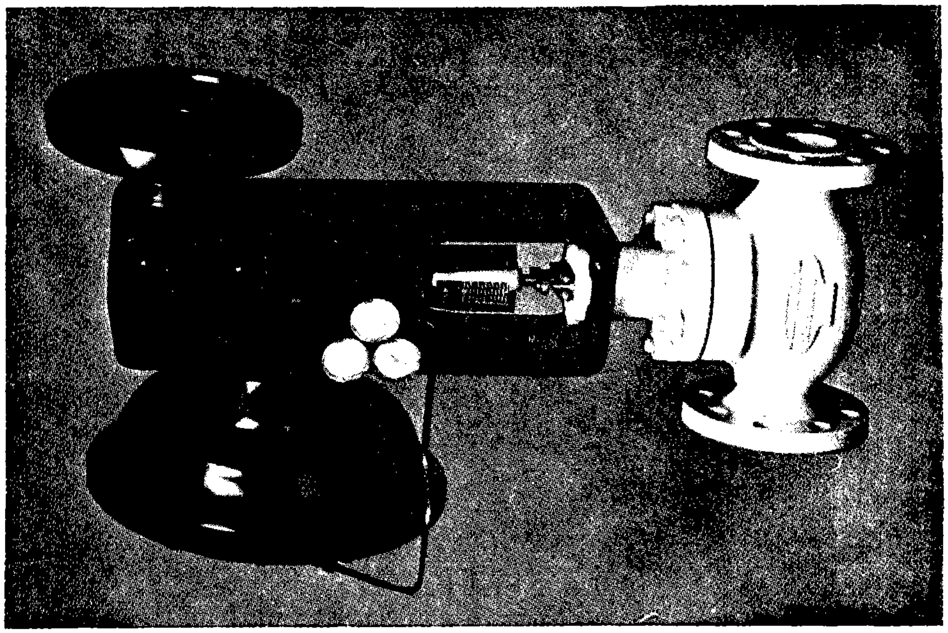
HARDWARE NEED ____

VENDOR STATUS

COST/UNIT 4-1/2" - $2,000 est.
2" - $1,000 est.



Full Capacity Trim



POWER
CONVERSION

3.5 POWER CONVERSION SUBSYSTEM (PCS)

The Power Conversion Subsystem uses the steam generated in the solar steam generator to drive the turbine generator set. A portion of the steam is extracted at a mid-point in the turbine expansion to provide steam for process use in the Bleyle Plant. At the turbine discharge, steam flow to the condenser provides the source of heat for the Thermal Utilization Subsystem. The Power Conversion Subsystem (PCS) has direct interface connections with various other subsystems. The steam generator serves as the boundary between the PCS and Thermal Energy Storage Subsystem. The condenser forms the boundary between the PCS and the Thermal Utilization Subsystem. The turbine generator set links the PCS with the Electrical Subsystem, and the process steam lines of the PCS connect with the Bleyle Plant steam distribution system.

The major components of the PCS are the steam generator, steam turbine, deaerator, condenser, condensate storage tank and boiler feed pump.

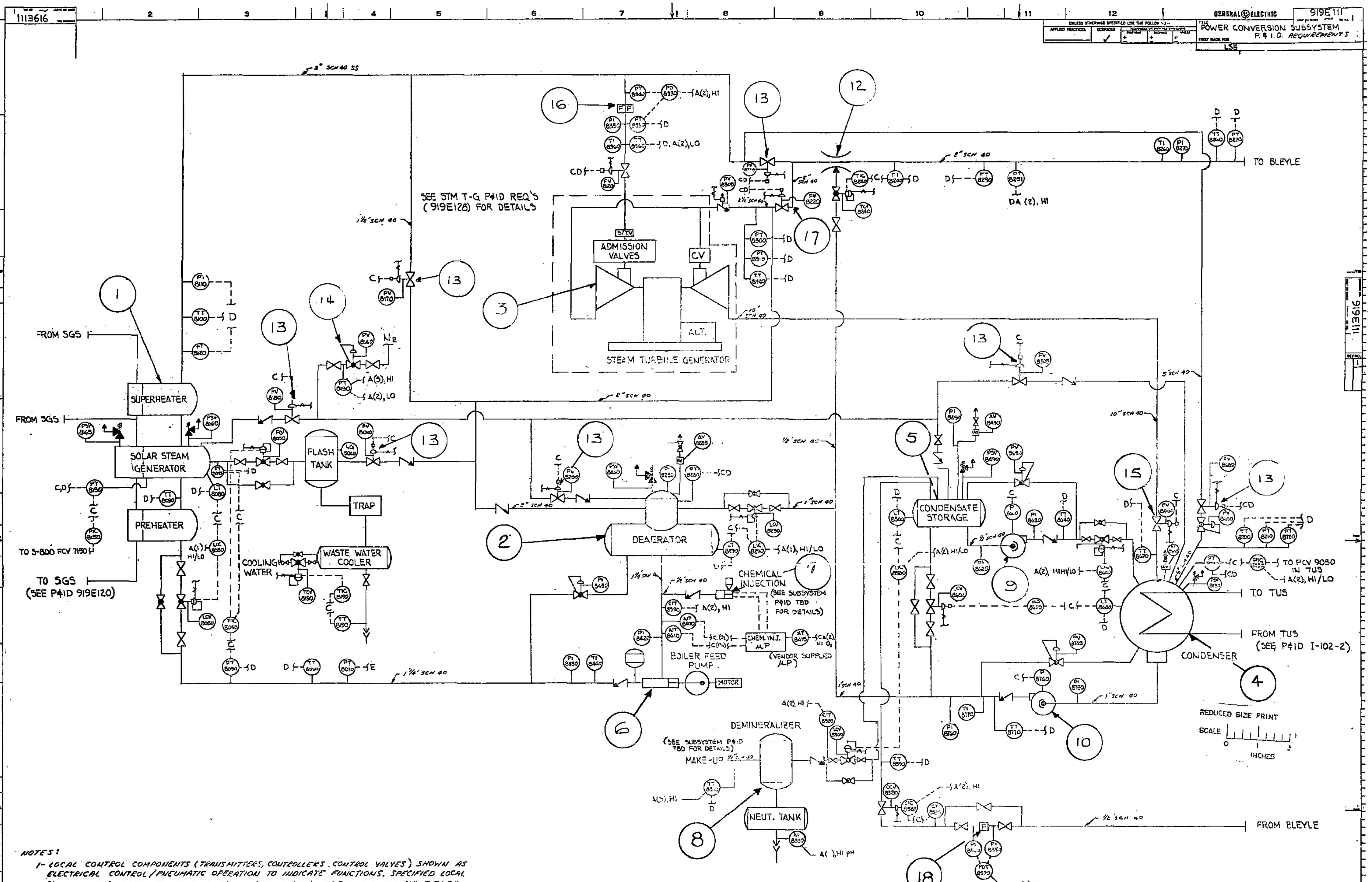
Table 3.5-1 lists all active components contained in the PCS system. The item numbers refer to the components as located on the piping and instrumentation figure 3.5-1 (Drawing 919E111).

TABLE 3.5-1. POWER CONVERSION SUBSYSTEM

ITEM #	NOMENCLATURE	QUANTITY	COST
1	Steam Generator	1	90,000.00
2	Deaerator	1	40,000.00
3	Turbine/Generator	1	GFE
4	Condenser	1	10,238.00
5	Condensate Storage Tank	1	6,000.00
6	Boiler Feed Pump	1	39,722.00
7	Chem Injection system	1	2,000.00
8	Demineralizer	1	25,000.00
9	Condensate Storage Pump	1	809.00

TABLE 3.5-1. POWER CONVERSION SUBSYSTEM (Cont)

ITEM#	NOMENCLATURE	QUANTITY	COST
10	Condensate Pump	1	3,000.00
11	Syltherm™ By-Pass Valve	1	1,828.00
12	Desuperheater	1	6,500.00
13	Mode Selection Valve	7	10,138.00
14	Nitrogen Regulator	1	144.00
15	Turbine Extraction Non Return Valve	1	1,093.00
16	Inlet Steam Filter	1	3,000.00
17	Steam Pressure Regulator	1	144.00
18	Process Return Filter	1	250.00
	Sub Total		239,866.00
	Level-of-Definition Factor		1.05
	Total		251,859.00



NOTES:

1- LOCAL CONTROL COMPONENTS (TRANSMITTERS, CONTROLLERS, CONTROL VALVES) SHOWN AS ELECTRICAL CONTROL/PNEUMATIC OPERATION TO INDICATE FUNCTIONS. SPECIFIED LOCAL CONTROLS MAY BE OTHERS, HOWEVER TRANSMITTER INTERFACE WITH PCS MICROPROCESSOR IS TO BE ELECTRICAL (4-20 mA)

2- MODE SELECTION VALVES (POSITIONED VIA PCS µP) TO BE ELECTRICAL CONTROL/PNEUMATIC OPERATION. VALVES TO BE EQUIPPED WITH POSITION SENSORS.

3- VENT, DRAIN, SMALL PIPE SIZES; AND ADDITIONAL SPECIALTIES NOT SHOWN. STANDARD ENGINEERING PRACTICE TO BE EMPLOYED.

4- ADDITIONAL COOLING WATER CONNECTIONS NOT SHOWN.

5- ELECTRICAL SYSTEM/INSTRUMENTATION SHOWN ON GPC INTERFACE DRAWING E3.

6- COMPONENT LOCAL CONTROL/PANEL INTERFACE TBD. REFER TO COMPONENT SPECIFICATIONS.

7- SEE INSTRUMENTATION LIST (63A136372) FOR DETAILS.

KEY TO NON-STANDARD DESIGNATIONS

AV - AUTO VENT
X - COMPONENT CONTROL/STATUS
MICROPROCESSOR (µP) OR LOCAL CONTROLLER SIGNALS
C - CONTROL
D - DATA FOR SYSTEM PERFORMANCE EVALUATION
E - DATA FOR EXPERIMENT
A(1) - ALARM, REMOTE READOUT (PANEL LIGHT) EMERGENCY
A(2) - ALARM, REMOTE PRINTOUT (CRT), OPERATOR ACTION
A(3) - ALARM, LOCAL, MAINTENANCE RESOLUTION

Fig 3.5-1

APPROVALS

AEP PHILA, PA 919E111

PART NO. 1

SHEET NO. ____

COMPONENT SHEET

____________ DATE UPDATED

SUBSYSTEM: PCS

COMPONENT NOMENCLATURE: Steam Generator

QUANTITY REQUIRED: ____________

REQUIREMENTS: 10,500 lb/hr Superheated steam at 700 psig and 720° F water when supplied with 750° F Syltherm[TM] 800 fluid ΔT minimum (200° F)

SUGGESTED SOURCES:

1. Patterson-Kelley Co.
2. Aerco International Inc.
3.
4.
5.

DATES: RFQ ____________

DEL. TIME WKS. 38

POI ____________

HARDWARE NEED ____________

VENDOR STATUS

COST/UNIT $90,000 as per attached quote

PATTERSON-KELLEY CO.
Division of HARSCO Corporation
P.O. BOX 458, EAST STROUDSBURG, PA 18301

ESTABLISHED 1880

PHONE: 717-421-7500
CABLE: PATTERKEL
TELEX: 84-7313

DISTRICT OFFICE
BEAVER HILL WEST, 100 WEST AVENUE
JENKINTOWN, PA 19046
TEL. 215-927-6900

August 15, 1978

Management and Technical Services Co.
c/o General Electric Company
Valley Forge Space Center
P. O. Box 8661
Philadelphia, Pa. 19101

Attention: Mr. Carl Romig
Room 7554

Re: Ref. No. 78-STE-0103

Gentlemen:

In accordance with your request of August 10th, we are pleased to give you a budget cost estimate on the P-K Series 380 Syltherm 800 Steam Generator System as outlined in the preliminary specification and shown on our drawing given to you at our meeting of June 8, 1978.

The controls included would be as shown on P-K Preliminary Drawing No. 578116.

The budget price of $80,000.00 given to you in our June 8th meeting was based on a 1979 delivery date. If your procurement schedule is presently based on delivery for June 1980, we suggest you use a $85,000.00 to $90,000.00 budget estimate.

If you require any additional information, please feel free to contact us.

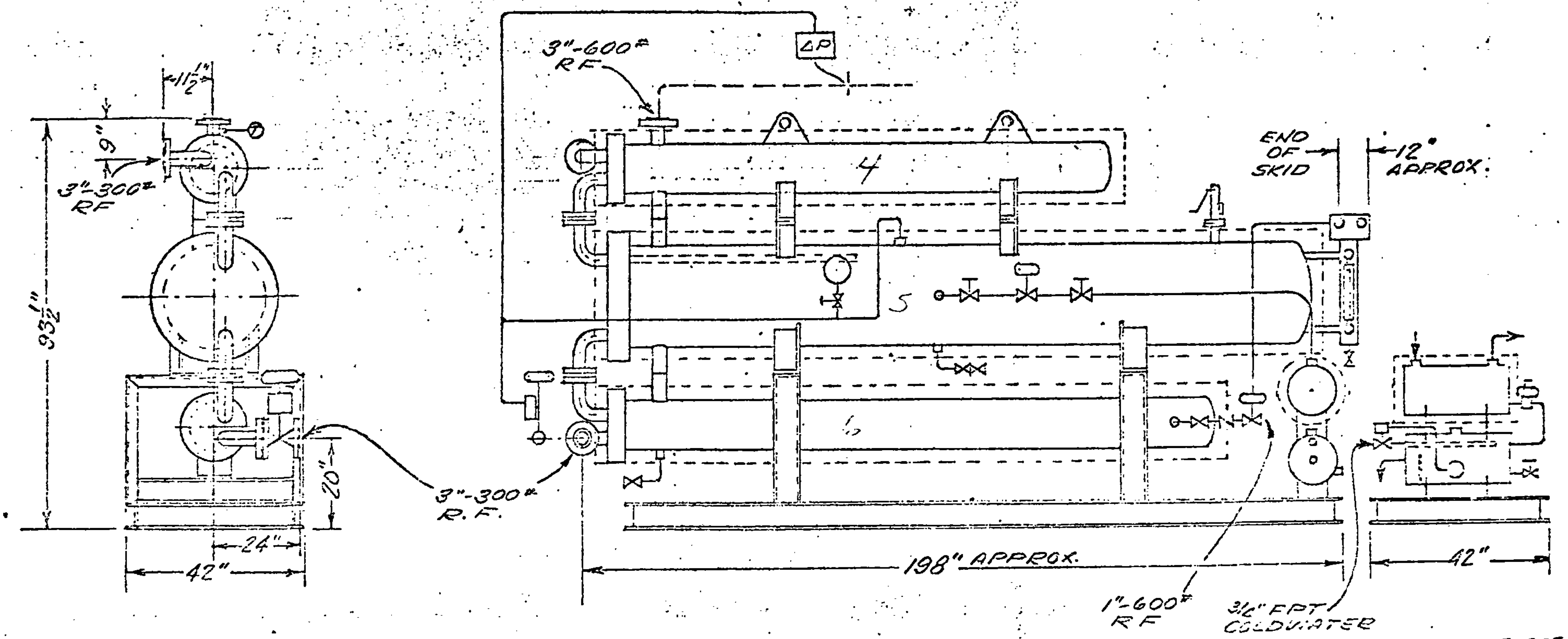
Very truly yours,

PATTERSON-KELLEY COMPANY

L. R. Correll

LRC/jcj
cc: Mr. W. S. Mertz
Mr. J. A. Clark

3-109



GENERAL ELECTRIC ENERGY SYSTEM
FOR WILHELM BLEYLE CO.
SHENANDOAH, GEORGIA

TO GENERATE 8386 LBS/HR OF STEAM @ 700 PSIG & 720°F. FROM FEEDWATER @ 338°F WITH 70,643 LBS/HR OF SYLTHERM 800 FLUID ENTERING @ 750°F., LEAVING @ 500°F.

MK	REVISION RECORD	DATE	BY	CK. BY	NO. PRINTS

PK SERIES 380 SYLTHERM 800
STEAM GENERATOR SYSTEM

PATTERSON-KELLEY COMPANY
Div. of Taylor Wharton Co.-HARSCO Corporation
EAST STROUDSBURG, PA. 18301

	BY	DATE	FILE SIZE	REFERENCE NO E#578116	REV.
DRAWN					
CHECKED			B	DWG. NO	
APPROVED					

PART NO. 2

SHEET NO.

COMPONENT SHEET

DATE UPDATED

SUBSYSTEM: PCS

COMPONENT NOMENCLATURE: DeAerator

QUANTITY REQUIRED:

REQUIREMENTS: Sized for 11,000 #/Hr. Pressure 105 psig

Feedwater Storage Capacity 50 Gal. Min

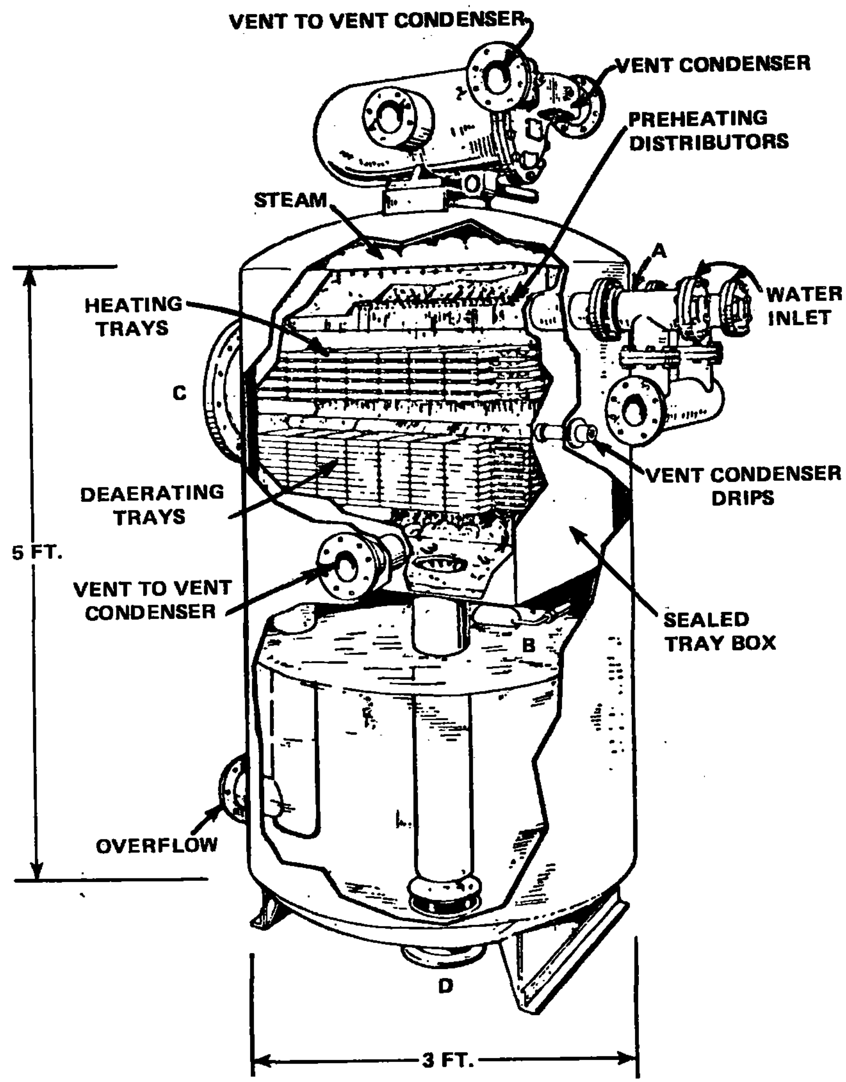
SUGGESTED SOURCES:
1.
2.
3.
4.
5.

DATES:
- RFQ
- DEL. TIME WKS.
- POI
- HARDWARE NEED

VENDOR STATUS

COST/UNIT $40,000 (Lockwood Greene Estimate)

DEAERATING HEATER



PART NO. 3 SHEET NO.

COMPONENT SHEET

DATE UPDATED

SUBSYSTEM: PCS

COMPONENT NOMENCLATURE: Turbine/Generator

QUANTITY REQUIRED:

REQUIREMENTS: 400 kW output at (700 psig ± 25 psi)
(720°F + 25°F) Steam Inlet
- 70°F)

SUGGESTED SOURCES:
1. MTI
2.
3.
4.
5.

DATES: RFQ
DEL. TIME WKS.
POI
HARDWARE NEED

VENDOR STATUS

COST/UNIT GFE

PART NO. 4 SHEET NO. ____

COMPONENT SHEET

DATE UPDATED ____

SUBSYSTEM: PCS

COMPONENT NOMENCLATURE: Condenser

QUANTITY REQUIRED: 1

REQUIREMENTS: 7500 #/Hr 6 PSIG = 1 psi 230°F

SUGGESTED SOURCES:
1. PEMCO - Elizabeth, NJ
2. Graham
3.
4.
5.

DATES:
- RFQ ____
- DEL. TIME WKS. 26
- POI ____
- HARDWARE NEED ____

VENDOR STATUS

COST/UNIT $10,238 as per attached quote

SURFACE CONDENSER

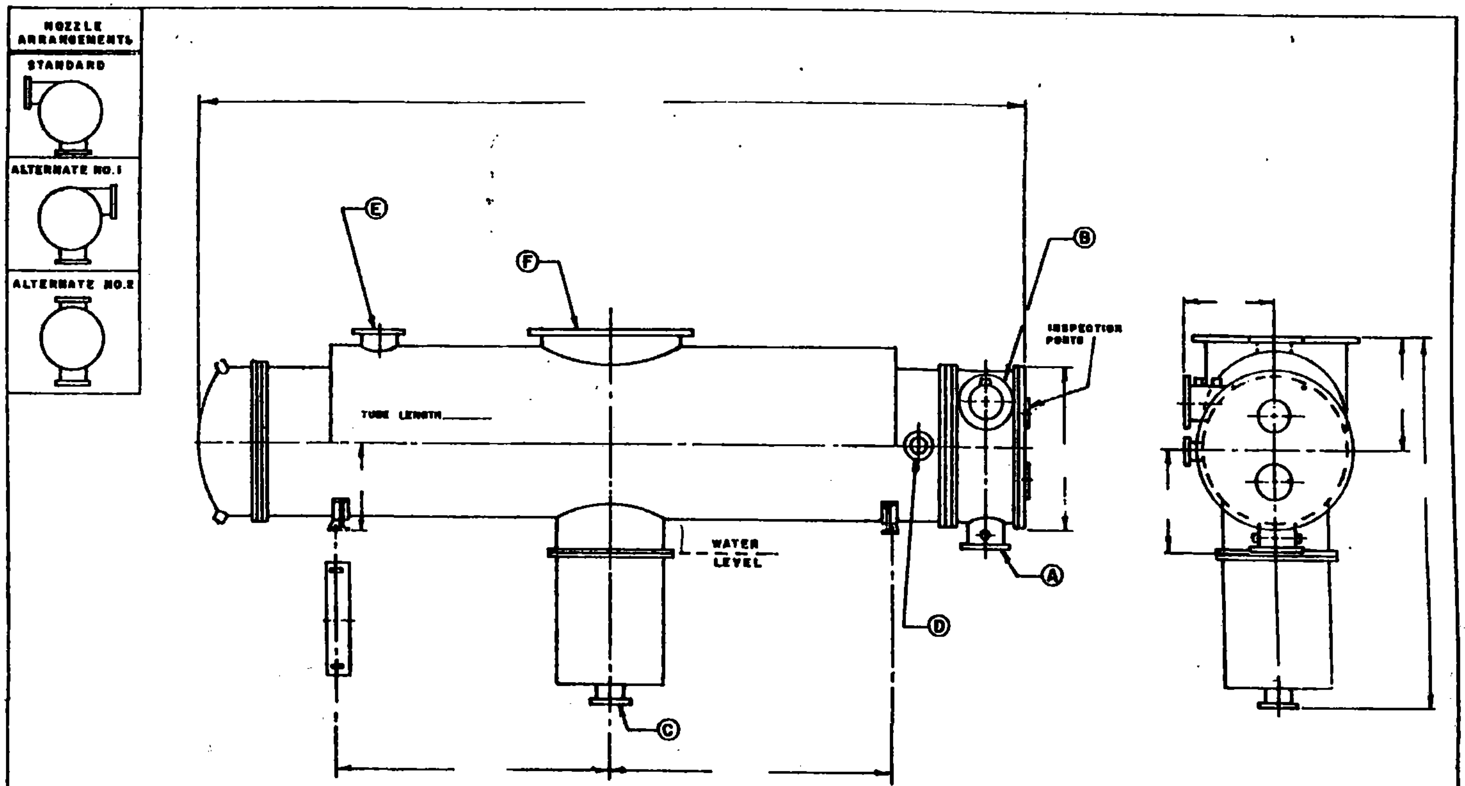


FIG. 18

A	"-150" ANSI (FF) COOLING WATER INLET
B	"-150" ANSI (FF) COOLING WATER OUTLET
C	"-150" ANSI (FF) CONDENSATE OUTLET
D	"-150" ANSI (FF) AIR OFF TAKE
E	"-150" ANSI (FF) RELIEF VALVE
F	STEAM INLET

	MAWP	TEST PRESSURE	DESIGN TEMP
SHELL SIDE	PSIG	PSIG	F
TUBE SIDE	PSIG	PSIG	F

graham
Vacuum and Heat Transfer

SURFACE CONDENSER

DWG NO

7-20-78

Pemco YORK STREET AT DOWD AVENUE, ELIZABETH, NJ 07201
PHONE: 201-354-9222 TWX: 710-743-4776
ECOLAIRE

Date June 15, 1978 Page No. 1
Quotation No. QH-12493 Rev. No.
Cust. Ref. No. Verbal 5/24/78

General Electric Company
Schenectady, New York 12301

Attention: Mr. R. Schnacke
Building #2, Room #502

Gentlemen:

We are pleased to quote on the equipment and/or services described below, subject to the terms and conditions on the reverse hereof and the attached form Q:

Item No. 1

One (1) PEMCO Model #CVL 17-144 BEU R-2 3/4-18 A Z-3 Condenser/Preheater with 12" steam inlet dome and hot well, 560 sq. ft. of surface, size 17-144, horizontal, type "BEU", TEMA Class "C", containing 119 - 3/4" O.D. X #18 BWG, average wall, welded, SA-249 type 304 stainless steel "U-tubes" on 15/16" triangular pitch, arranged for two-pass tubeside flow, all per PEMCO Exchanger Specification Sheet dated 5/26/78.

Price: $10,238.00

Estimated shipping weight: .... 3,340 lbs.

Our shipping promise is based on our being authorized to order material prior to drawing submission and approval based on the sizes, configurations and materials of construction on which we quoted. After receipt of an order, we will proceed with the ordering of such material unless you specifically notify us to the contrary.

Very truly yours,

PEMCO
By: J. G. Miller
Vice-President, Sales & Marketing

JGM:pd
Attachment

3-116

THIS IS A FOLLOW-UP

...; SHIPMENT; DRAWINGS; F.O.B. POINT; FREIGHT ALLOWANCE; NOTES APPLICABLE TO

PEMCO a subsidiary of ECOLAIRE INC.

☐ GRISCOM-RUSSELL division of PEMCO

Date June 15, 1978

Quotation No. QH-12490 Rev. No. ______

Cust. Ref. No. Verbal 5/24/78

PAYMENT TERMS

1. Net 30 days

SHIPMENT

☒ 2. 12 to 14 weeks after drawing approval. (Setting Plan Drawing)

☐ 3. The later of ______ to ______ weeks after drawing approval, or

______

☐ 4. ______ to ______ days/weeks after order award.

DRAWINGS

☒ 5. We will submit drawings for approval within 10 working days of order award. (Setting Plan Drawing)

☐ 6. We will begin to submit drawings for approval within ______ working days of order award. Submission will be complete within ______ additional working days of order award.

☐ 7. Drawings will not be submitted for approval. Certified dimension prints will be furnished within ______ working days of our receiving your order.

F.O.B. POINT

☒ 8. The f.o.b. point is our shop, Elizabeth, New Jersey.

☐ 9. The f.o.b. point is our shop, Elizabeth, New Jersey with motor/rail freight allowed to ______ (at LTL/TL; LCL/CL rates).

☐ 10. This quotation is F.A.S. ______

NOTES

☒ 11. This quotation is firm for 30 days acceptance.

☐ 12. This quotation is firm for ______ days acceptance, except for

______, subject to escalation in the net difference between the prices published or quoted us on this date and on the date we are billed. Such escalation will be limited to ______% of the total.

☒ 13. No Sales/Use or other local tax is included.

☐ 14. Sales/Use tax of ______% is included.

☐ 15. Our guarantee is for materials and workmanship only.

☒ 16a. Our guarantee is for mechanical design to ensure adequate strength of parts, materials and workmanship only.

☐ 16b. After we are awarded an order, if we find the design which you submitted to be suitable, we will guarantee the performance. If the design does not appear to be suitable, we may suggest alternatives that we can guarantee. We will advise you of any corresponding price differences.

☒ 17. The equipment is guaranteed to perform the service shown on our exchanger specification sheet in accordance with TEMA requirements.

☐ 18. All other terms and conditions remain as previously quoted.

☒ 19. Interest will be charged at 1½% per month on past due accounts.

4Q

3-117

COPY

PART NO. 5

SHEET NO. ____

COMPONENT SHEET

DATE UPDATED ____

SUBSYSTEM: PCS

COMPONENT NOMENCLATURE: Condensate Storage Tank

QUANTITY REQUIRED: ____

REQUIREMENTS: Non-Pressurized Vertical Tank

Tank Fittings

2 - 1" - Level Control (Top; Bottom)

3 - 1" Bottom - Fill & Drain

1 - 1-1/2" - Outlet

SUGGESTED SOURCES:
1. Wood Bros.
2. C. J. Schmidt
3. Local Tank Manufacturer - Atlanta, GA area
4. ____
5. ____

DATES:
- RFQ ____
- DEL. TIME WKS. 24
- POI ____
- HARDWARE NEED ____

VENDOR STATUS

COST/UNIT $6000 (Lockwood Greene Estimate)

PART NO. 6 SHEET NO.

COMPONENT SHEET

DATE UPDATED

SUBSYSTEM: PCS

COMPONENT NOMENCLATURE: Boiler Feed Pump

QUANTITY REQUIRED:

REQUIREMENTS: 21 gpm @ 1620' 15' NPSH

Triplex Plunger

SUGGESTED SOURCES:

1. Process-Pneumatics Corp.
2. Ingersol-Rand
3.
4.
5.

DATES: RFQ

DEL. TIME WKS. 26

POI

HARDWARE NEED

VENDOR STATUS

COST/UNIT $39,722 as per attached quote to LGE

RECEIVED
APR 12 1978
REF. TO
ACK.

JCOR

Process-Pneumatics Corporation

200C North Pleasantburg Drive
Greenville, South Carolina 29607
Telephone (803) 235-1648

April 10, 1978

Lockwood Greene
Post Office Box 491
Spartanburg, S. C. 29301

Attention: Mr. Bob Weir

SUBJECT: G. E. Solar
GRNV - 0417.

Dear Mr. Weir:

This letter is offered in confirmation of my phone quotation of April 10, 1978.

Two (2) - Ingersoll Rand Model 2x3 HS3, plunger pump rated at 7.01 Hp at 188 RPM with an efficency of 96%. Unit to have standard fitted power end, 316 SS fluid end, 316 SS colmony No. 6 coated plunger, durabla valves, bronze bushings, teflon "o" rings, grafoil packing, full pressure lubrication.

PRICE: $27,946.00 net each.

Also recommended for your application are the following:

V-Belt and Guard..................$ 1,189.00 net each.

Electric motor 3/60/230-460, 10 Hp, TEFC mill and chemical ....$ 259.00 net each.

Fluid Kinetics Suction Stabilizer-$ 5,429.00 net each.

Fluid Kinetics Pulsation Dampner -$ 4,899.00 net each.

(Cont'd)

PRICE: Total $39,722.00
net each.

DELIVERY: 6 months.

Terms are 1% 10 net 20 days.

Delivery is F. O. B. Allentown, Pa.

Prices are firm for 90 days.

Should you have any questions, please contact us.

Sincerely,

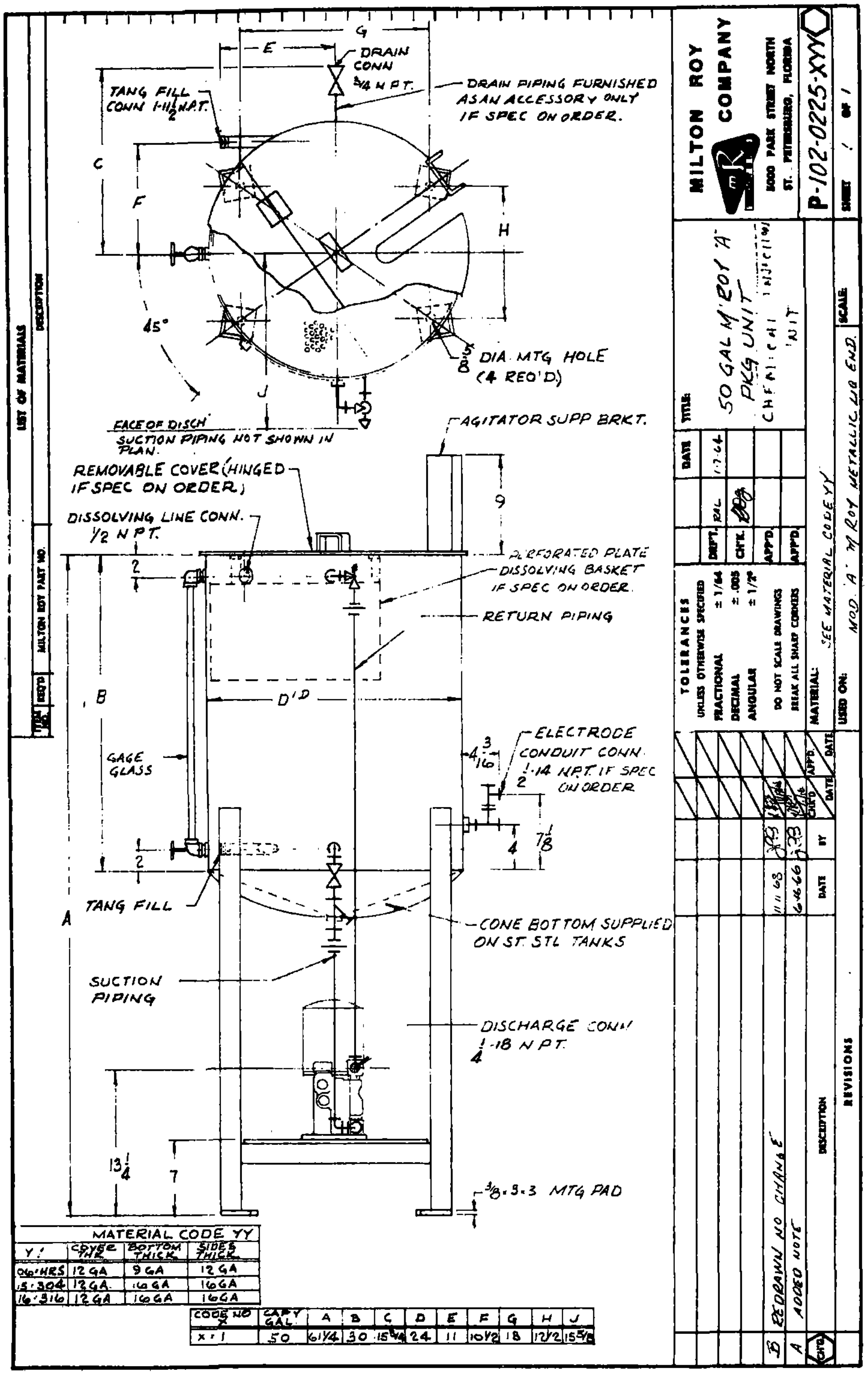
Larry K. Seitz
Sales Engineer

LKS/fr

cc: Mr. Ron Adams, Ingersoll Rand, 7909 Oakbark lane,
Charlotte, N. C. 28210.

Mr. Tom Haas, Ingersoll Rand, 2731 Starbrook Dr.,
Charlotte, N. C. 28210.

CHEMICAL INJECTION UNIT



MATERIAL CODE YY			
Y !	COVER THK.	BOTTOM THICK.	SIDES THICK.
06-HRS	12 GA	9 GA	12 GA
15-304	12 GA.	16 GA	16 GA
16-316	12 GA	16 GA	16 GA

CODE NO X	CAPY GAL	A	B	C	D	E	F	G	H	J
X-1	50	61 1/4	30	15 3/4	24	11	10 1/2	18	12 1/2	15 5/8

PART NO. 7

SHEET NO.

COMPONENT SHEET

DATE UPDATED

SUBSYSTEM: PCS

COMPONENT NOMENCLATURE: Chemical Injection System

QUANTITY REQUIRED:

REQUIREMENTS: Dissolved O-Limit - .005 ppm
Ph Limits - 9.0 - 10.0
Hydrozine Sol Tank Cap. - 50 gal.
Ammonia Sol Tank Cap. - 50 gal.
Sensor/Transducer Cap. 0.7 + Ph.
Metering Pump - Diaphram
Controls - By Pass Valve Phasing

SUGGESTED SOURCES:
1. Milton Roy. Co., - St. Petersburg, FL
2.
3.
4.
5.

DATES:
RFQ
DEL. TIME WKS. 16
POI
HARDWARE NEED

VENDOR STATUS

COST/UNIT $2000 Eng'r Est.

PART NO. 8

SHEET NO.

COMPONENT SHEET

DATE UPDATED

SUBSYSTEM: PCS

COMPONENT NOMENCLATURE: Demineralizer

QUANTITY REQUIRED: 1

REQUIREMENTS: Make-up - 1450 #/Hr. 2 Bed Unit

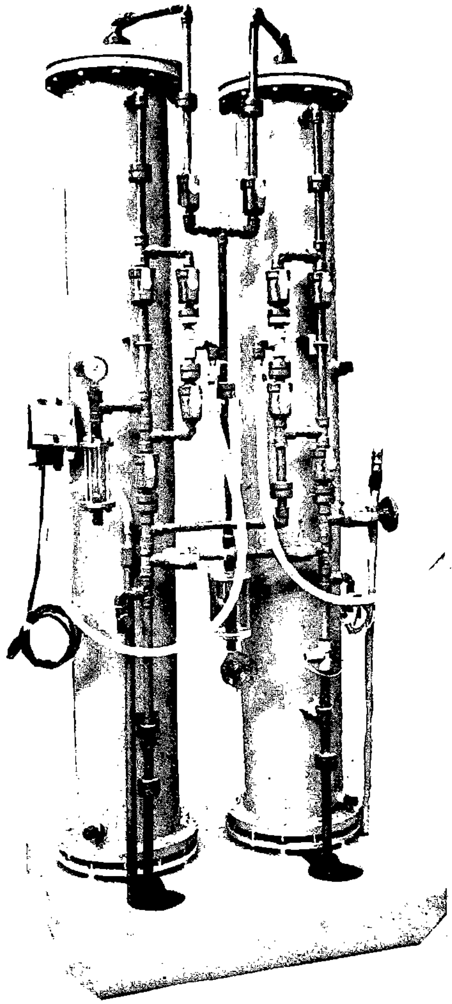
SUGGESTED SOURCES:
1. Cochrane, Div. of Crane
2. AMF
3.
4.
5.

DATES:
- RFQ
- DEL. TIME WKS. 32
- POI
- HARDWARE NEED

VENDOR STATUS

COST/UNIT $25,000 (Lockwood Greene Estimate)

DEMINERALIZER



PART NO. 9

SHEET NO. ____

COMPONENT SHEET

DATE UPDATED ____

SUBSYSTEM: PCS

COMPONENT NOMENCLATURE: Condensate Storage Pump

QUANTITY REQUIRED: 1

REQUIREMENTS: 15 GPM @ 60' Head

2 HP 3 Ø 1750 RPM

SUGGESTED SOURCES:
1. Gould Pumps
2. TACO
3. Ingersoll-Rand
4. Bell & Gossett
5. ____

DATES:
- RFQ ____
- DEL. TIME WKS. 24
- POI ____
- HARDWARE NEED ____

VENDOR STATUS

COST/UNIT $809 (Phone Quote to LGE)

LES

TELEPHONE CALL REPORT

☐ INCOMING ☒ OUTGOING

JOB NO. 77375.01

COMPANY Gould Pumps

ADDRESS

DATE 13 April 78

TIME

REF.

TELEPHONE NO. 1-404-455-4800

NAME J.B. Holiday

CHARGE CODE

TITLE

DATA

① Condensate Storage Pump - 15 GPM @ 60 FT
(1×1½-8) Model # 3196 2 H.P. @ 1800 RPM
Pump $728.00 Motor $81.00

② Condensate Pump - 25 GPM @ 730 FT
Model # 3333 15 H.P. @ 3600
Pump & Motor - $1669.00

③ Low Temp. Storage Pump - 900 GPM @ 110 FT
(4×6-13) Model # 3196 40 H.P. @ 1800
Pump $1789.00 Motor $490.00

④ Condenser Cool. Tower Pump - 1700 GPM @ 40 FT.
(6×8-13) Model # 3196 25 H.P. @ 1800
Pump $3175.00 Motor $519.00

⑤ A/C Cool. Tower Pump - 900 GPM @ 50 FT.
(4×6-10) Model # 3196 20 H.P. @ 1800
Pump $1648.00 Motor $280.00

All Motors To Be Open - Drip Proof

BY R. Weir

PART NO. 10 SHEET NO.

COMPONENT SHEET

DATE UPDATED

SUBSYSTEM: PCS

COMPONENT NOMENCLATURE: Condensate Pump

QUANTITY REQUIRED:

REQUIREMENTS: 25 GPM @ 250 psi 5' NPSH

SUGGESTED SOURCES:

1. Gould Pumps
2. TACO
3. Ingersoll-Rand
4. Bell & Gossett
5. Smith-Koch, Inc., Phila., PA

DATES:

RFQ

DEL. TIME WKS. 24

POI

HARDWARE NEED

VENDOR STATUS

COST/UNIT $3000 Eng. Est.

TELEPHONE CALL REPORT

☐ INCOMING ☒ OUTGOING

JOB NO. 77373.01

COMPANY Gould Pumps
ADDRESS

DATE 13 April 78
TIME
REF.

TELEPHONE NO. 1-404-455-4800
NAME J.B. Holiday

CHARGE CODE
TITLE

DATA

① Condensate Storage Pump - 15 GPM @ 60 FT
(1×1½-8) Model # 3196 2 H.P. @ 1800 RPM
Pump $728.00 Motor $81.00

② Condensate Pump - 25 GPM @ 130 FT
Model # 3333 15 H.P. @ 3600
Pump & Motor - $1669.00

③ Low Temp. Storage Pump - 900 GPM @ 110 FT
(4×6-13) Model # 3196 40 H.P. @ 1800
Pump $1789.00 Motor $490.00

④ Condenser Cool. Tower Pump. - 1700 GPM @ 40 FT.
(6×8-13) Model # 3196 25 H.P. @ 1800
Pump $3175.00 Motor $519.00

⑤ A/C Cool. Tower Pump - 900 GPM @ 50 FT.
(4×6-10) Model # 3196 20 H.P. @ 1800
Pump $1648.00 Motor $280.00

All Motors To Be Open - Drip Proof

BY R. Weed

PART NO. 11 SHEET NO. ____

COMPONENT SHEET

DATE UPDATED ____

SUBSYSTEM: PCS

COMPONENT NOMENCLATURE: Syltherm^{tm} By-Pass Valve

QUANTITY REQUIRED: ____

REQUIREMENTS: Fluid: Syltherm^{TM} 800; Temp; 750° F, Flow 0-325 gpm

5" O. D. Tube End Connections Butt/Socket Weld

SUGGESTED SOURCES:
1. Honeywell
2. Jenkins
3. Powell
4. Kieley & Mueller
5. ____

DATES:
- RFQ ____
- DEL. TIME WKS. ____
- POI ____
- HARDWARE NEED ____

VENDOR STATUS

COST/UNIT $1, 828 Quote

PART NO. 12

SHEET NO. ____

COMPONENT SHEET

____ DATE UPDATED

SUBSYSTEM: PCS

COMPONENT NOMENCLATURE: Desuper Heater

QUANTITY REQUIRED: 1

REQUIREMENTS: Steam Flow Rate - 1246 #/Hr

Pressure - 105 psig

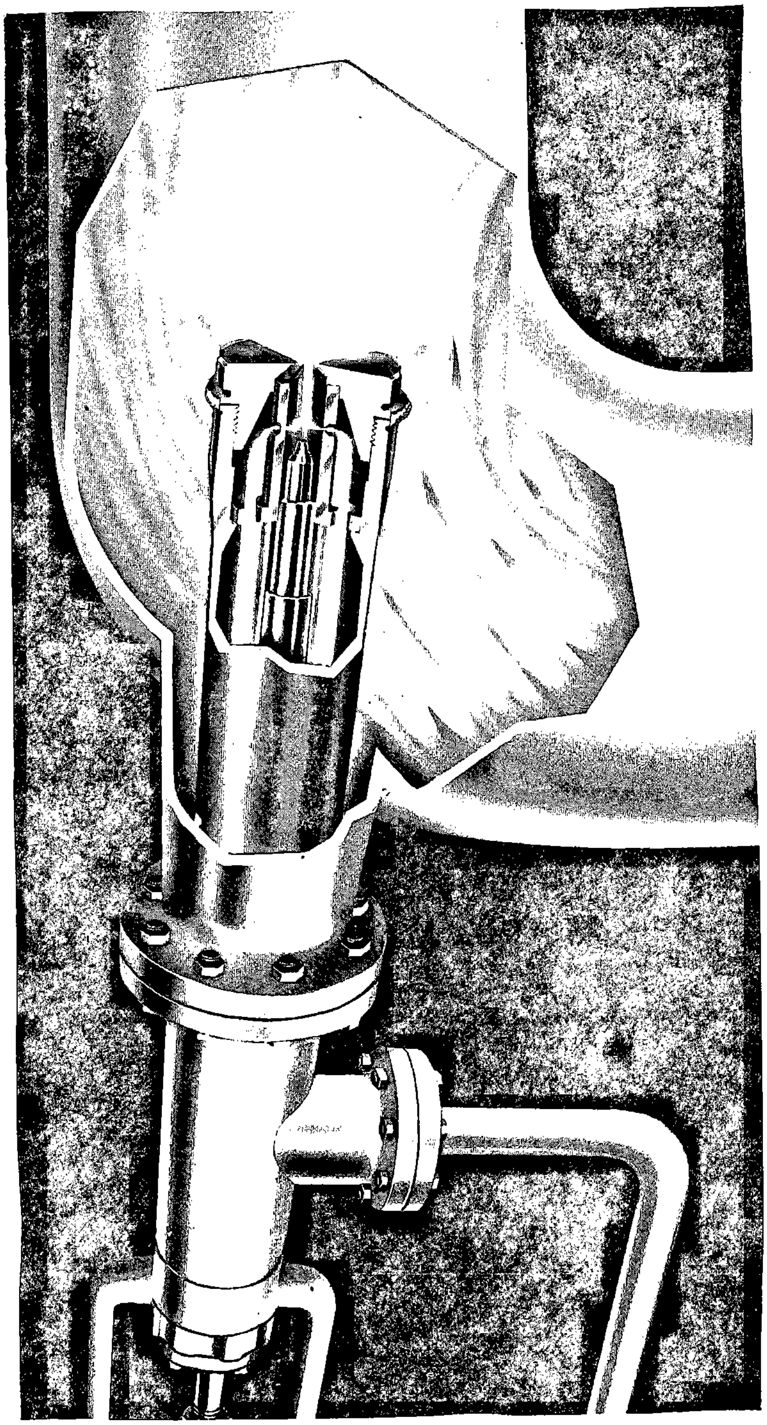
Temp: 341°F

SUGGESTED SOURCES:
1. Yarway
2. ____
3. ____
4. ____
5. ____

DATES:
- RFQ ____
- DEL. TIME WKS. ____
- POI ____
- HARDWARE NEED ____

VENDOR STATUS

COST/UNIT $6500 (Phone Estimate from Yarway)



PART NO. 13

SHEET NO.

COMPONENT SHEET

DATE UPDATED

SUBSYSTEM: PCS

COMPONENT NOMENCLATURE: Mode Selection Valve

QUANTITY REQUIRED: (7) 2 ea - 2" - 2 ea - 1-1/2; 2 ea - 3", 1 ea - 8"

REQUIREMENTS: Steam Valve 0-1330 lb/hr @ 720 ± 25° F and 700 ± 25 psig

Valve Positioner Modulating; Material: Carbon Steel

SUGGESTED SOURCES:

1. Powell
2. Jenkins
3. Honeywell
4. Kieley & Mueller
5.

DATES:

RFQ

DEL. TIME WKS. 12

POI

HARDWARE NEED

VENDOR STATUS

COST/UNIT 2" - 813.00 3" - 1882.00

1-1/2" - 717.00 8" - 3,314.00

PART NO. 14

SHEET NO.

COMPONENT SHEET

DATE UPDATED

SUBSYSTEM: PCS

COMPONENT NOMENCLATURE: Nitrogen Regulator

QUANTITY REQUIRED: 1

REQUIREMENTS: Size: 1; Fluid: Nitrogen: Pressure 5 psig

Flow: Intermittant

SUGGESTED SOURCES:
1. Air Products
2. Airco
3. Masoneilan
4.
5.

DATES: RFQ

DEL. TIME WKS. 8

POI

HARDWARE NEED

VENDOR STATUS

COST/UNIT $144. 00 (BCF 15443. 0808)

PART NO. 15 SHEET NO. ____

COMPONENT SHEET

DATE UPDATED ____

SUBSYSTEM: PCS

COMPONENT NOMENCLATURE: Turbine Extraction Power Operated, Non Return Valve

QUANTITY REQUIRED: 1

REQUIREMENTS: Size: 3"; Fluid: Steam; Pressure:

End Econnections Flanged

SUGGESTED SOURCES:
1. Kieley & Mueller
2.
3.
4.
5.

DATES:
RFQ ____
DEL. TIME WKS. 12
POI ____
HARDWARE NEED ____

VENDOR STATUS

COST/UNIT 2000 Eng'r Est

PART NO. 16

SHEET NO. ____

COMPONENT SHEET

____ DATE UPDATED

SUBSYSTEM: PCS

COMPONENT NOMENCLATURE: INLET STEAM FILTER

QUANTITY REQUIRED: 1

REQUIREMENTS: ____

SUGGESTED SOURCES:
1. ____
2. ____
3. ____
4. ____
5. ____

DATES:
RFQ ____
DEL. TIME WKS. ____
POI ____
HARDWARE NEED ____

VENDOR STATUS

COST/UNIT 3,000 Eng. Est.

PART NO. 17 SHEET NO. ___

COMPONENT SHEET

___ DATE UPDATED

SUBSYSTEM: PCS

COMPONENT NOMENCLATURE: Steam Pressure Regulator

QUANTITY REQUIRED: 1

REQUIREMENTS: ___

SUGGESTED SOURCES:
1. ___
2. ___
3. ___
4. ___
5. ___

DATES:
- RFQ ___
- DEL. TIME WKS. ___
- POI ___
- HARDWARE NEED ___

VENDOR STATUS

COST/UNIT 144 Eng. Est.

PART NO. 18 SHEET NO. ____

COMPONENT SHEET

____
DATE UPDATED

SUBSYSTEM: PCS

COMPONENT NOMENCLATURE: Process return filter

QUANTITY REQUIRED: 1

REQUIREMENTS: ____________

SUGGESTED SOURCES:
1. ____________
2. ____________
3. ____________
4. ____________
5. ____________

DATES:
- RFQ ____________
- DEL. TIME WKS. ____________
- POI ____________
- HARDWARE NEED ____________

VENDOR STATUS

COST/UNIT 250 Eng. Est.

THERMAL
UTILIZATION

3.6 THERMAL UTILIZATION SUBSYSTEM (TUS)

The Thermal Utilization Subsystem serves as the condensing medium for the steam condensor and the heat source for the heating and cooling of the Bleyle Plant and the Mechanical Building. The exhaust heat from the steam turbine provides the heat input to the TUS. When the turbine is out of service, steam will be provided directly to the condensor. A large, Low Temperature Storage (LTS) tank is included in the TUS for the storage of thermal energy. Excess energy is dissipated through two cooling towers. Chilled and heated water are pumped to the Bleyle Plant and the Mechanical Building for cooling and heating purposes.

The major components in the system are; low temperature storage tank, absorption air conditioner, cooling towers (2), and condenser cooling tower heat exchanger.

The active components are listed in Table 3.6-1 and the component item numbers are shown on the piping and instrumentation diagram Figure 3.6-1 (Drawing GE 1-102.2)

TABLE 3.6-1. THERMAL UTILIZATION SUBSYSTEM

Item #	Nomenclature	Qty.		Cost
1	Absorption Air Cond.	1		70,000.00
2	Cond. Cooling Tower	1		24,000.00
3	A.C. Cooling Tower	1		8,400.00
4	Cond. Cooling Tower H/E	1		5,673.00
5	Low Temperature Storage Tank Pump	1		2,279.00
6	Low Temperature Storage Tank	1		59,500.00
7	Bleyle Heating H/E	1		495.00
8	Hot Water Pump	1		6,477.00
9	Chilled Water Pump	1		6,477.00
10	A/C Cooling Tower Pump	1		1,928.00
11	Condenser Cooling Tower Pump	1		3,694.00
12	Heating Water Supply Pump	1		1,177.00
13	Chemical Mix Tank	1		250.00
14	Hot Water Flow Control Valve	2	1 ea. 1 ea.	1,540.00 1,853.00
15	Chilled Water Temp. Control Valve	1		2,603.00
16	Hot Water Supply Temp. Control Valve	1		1,540.00
	TOTAL			197,886.00
	Level-of-Definition 1.1			217,675.00

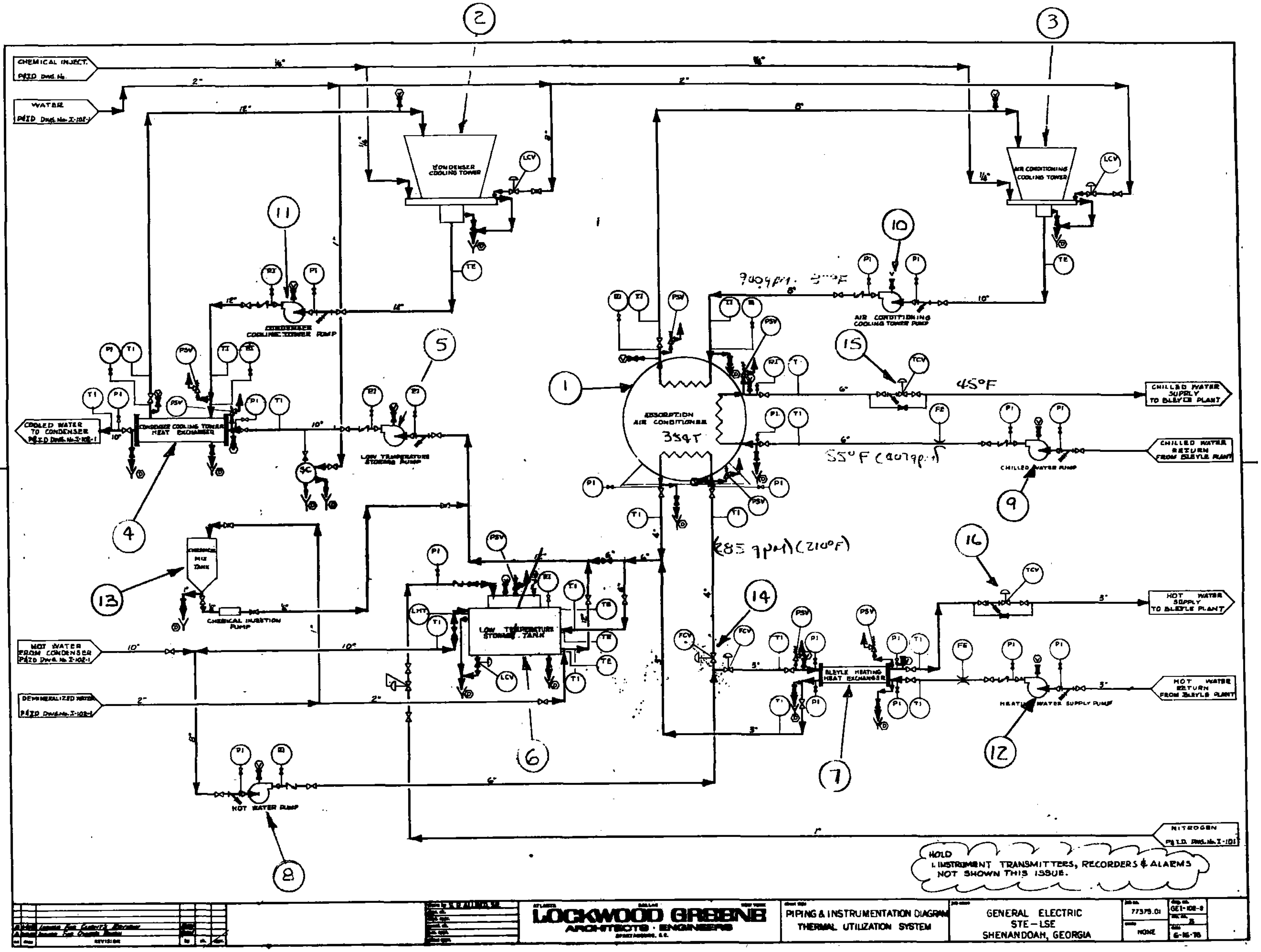


Figure 3.6-1. Piping & Instrumentation Diagram Thermal Utilization Subsystem

PART NO. 1

SHEET NO.

COMPONENT SHEET

DATE UPDATED

SUBSYSTEM:

COMPONENT NOMENCLATURE: Absorption Air Conditioner

QUANTITY REQUIRED:

REQUIREMENTS: Max Capacity of 174 Tons. When supplied with Condenser Cooling water outlet temp. of 210°F - Nominal Unit Capacity = 354

SUGGESTED SOURCES:
1. Trane
2. Carrier
3. York
4.
5.

DATES:
- RFQ
- DEL. TIME WKS. 32
- POI
- HARDWARE NEED

VENDOR STATUS

COST/UNIT $70,000 (Lockwood-Greene Estimate)

PART NO. 2 SHEET NO. ____

COMPONENT SHEET

DATE UPDATED ____

SUBSYSTEM: TUS

COMPONENT NOMENCLATURE: Condenser Cooling Tower

QUANTITY REQUIRED: 1

REQUIREMENTS: 480 Ton Capacity @ 78°F WBT 7.2×10^6 BTU/HR 215-195°F

Double Flow Unit, 696 gpm at 95°F at -10°F, 40 HP Fan

Provided with an overflow, Make up System and chemical treatment systems

SUGGESTED SOURCES:
1. Marley
2. ____
3. ____
4. ____
5. ____

DATES:
- RFQ ____
- DEL. TIME WKS. 19
- POI ____
- HARDWARE NEED ____

VENDOR STATUS

COST/UNIT $24,000 (Lockwood Greene Estimate)

PART NO. 3 SHEET NO. ____

COMPONENT SHEET

DATE UPDATED ____

SUBSYSTEM: TUS

COMPONENT NOMENCLATURE: Air Conditioning Cooling Tower

QUANTITY REQUIRED: 1

REQUIREMENTS: 5.5×10^6 BTU/HR @ 78°F WBT

Provided with an overflow, Makeup system and chemical treatment system

SUGGESTED SOURCES:

1. Marley
2.
3.
4.
5.

DATES: RFQ ____

DEL. TIME WKS. 19

POI ____

HARDWARE NEED ____

VENDOR STATUS

COST/UNIT $8400 (Lockwood Greene Estimate)

PART NO. 4 SHEET NO. ___

COMPONENT SHEET

DATE UPDATED ___

SUBSYSTEM: TUS

COMPONENT NOMENCLATURE: Condenser Cooling Tower Heat Exchanger

QUANTITY REQUIRED: 1

REQUIREMENTS: Tube side (water) 696 gpm entering at 85°F

Leaving at 95°F. Shell side (water) 950 gpm entering at 215°F

American-Standard Model 12-120

SUGGESTED SOURCES:
1. American Standard
2. Patterson - Kelley
3.
4.
5.

DATES:
- RFQ ___
- DEL. TIME WKS. 16
- POI ___
- HARDWARE NEED ___

VENDOR STATUS

COST/UNIT $5673 (Lockwood Greene Estimate)

PART NO. 5 SHEET NO.

COMPONENT SHEET

DATE UPDATED

SUBSYSTEM: TUS

COMPONENT NOMENCLATURE: Low-Temperature Storage Pump

QUANTITY REQUIRED: 1

REQUIREMENTS: 900 gpm @ 110 Ft Head, Water, 200°F

4 x 6 - 13L - 40 @ 1800 RPM

SUGGESTED SOURCES:
1. Gould
2. TACO
3. Ingersoll-Rand
4. Bell & Gossett
5.

DATES:
RFQ
DEL. TIME WKS. 24
POI
HARDWARE NEED

VENDOR STATUS

COST/UNIT $2279 (Lockwood Greene Estimate)

TELEPHONE CALL REPORT

☐ INCOMING ☒ OUTGOING

JOB NO. 77373.01

COMPANY Gould Pumps

ADDRESS

DATE 13 April 78

TIME

REF.

TELEPHONE NO. 1-404-455-4800

CHARGE CODE

NAME J.B. Holiday

TITLE

DATA

① Condensate Storage Pump - 15 GPM @ 60 FT
(1×1½-8) Model # 3196 2 H.P. @ 1800 RPM
Pump $728.00 Motor $81.00

② Condensate Pump - 25 GPM @ 730 FT
Model # 3333 15 H.P. @ 3600
Pump & Motor - $1669.00

③ Low Temp. Storage Pump - 900 GPM @ 110 FT
(4×6-13) Model # 3196 40 H.P. @ 1800
Pump $1789.00 Motor $490.00

④ Condenser Cool. Tower Pump - 1700 GPM @ 40 FT.
(6×8-13) Model # 3196 25 H.P. @ 1800
Pump $3175.00 Motor $519.00

⑤ A/C Cool. Tower Pump - 900 GPM @ 50 FT.
(4×6-10) Model # 3196 20 H.P. @ 1800
Pump $1648.00 Motor $280.00

All Motors To Be Open-Drip Proof

BY [signature]

PART NO. 6

SHEET NO.

COMPONENT SHEET

DATE UPDATED

SUBSYSTEM: TUS

COMPONENT NOMENCLATURE: Low-Temperature Storage Tank

QUANTITY REQUIRED: 1

REQUIREMENTS: 120,000 Gallon Tank (30 Ft. Dia. x 23 Ft High)

Fluid: Water

Max. Temp.: 215

Three main connections: 10" Top, 6" Middle, 12" Bottom - <15 psig operating pressure

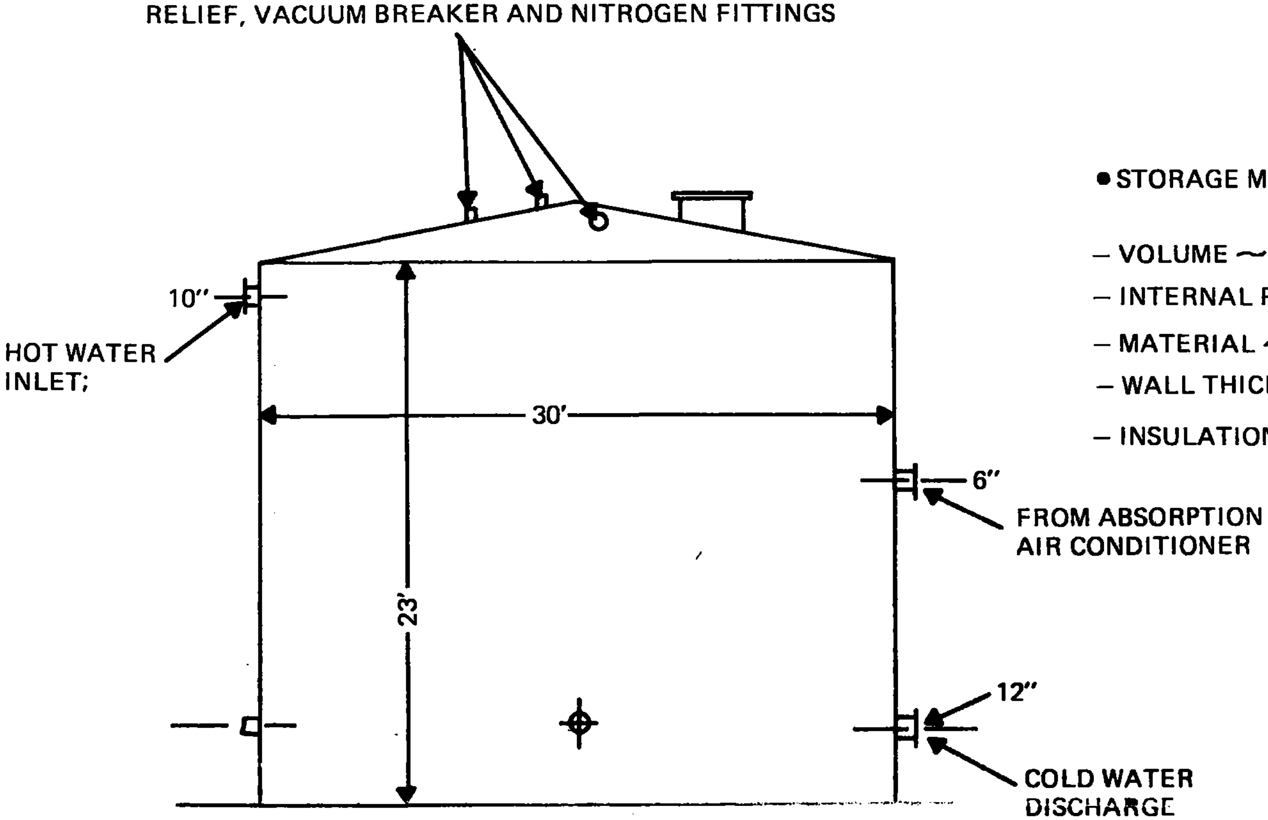
SUGGESTED SOURCES:
1. All Steel Fabricators Co., Inc.
2. RECO
3.
4.
5.

DATES:
- RFQ
- DEL. TIME WKS. 24
- POI
- HARDWARE NEED

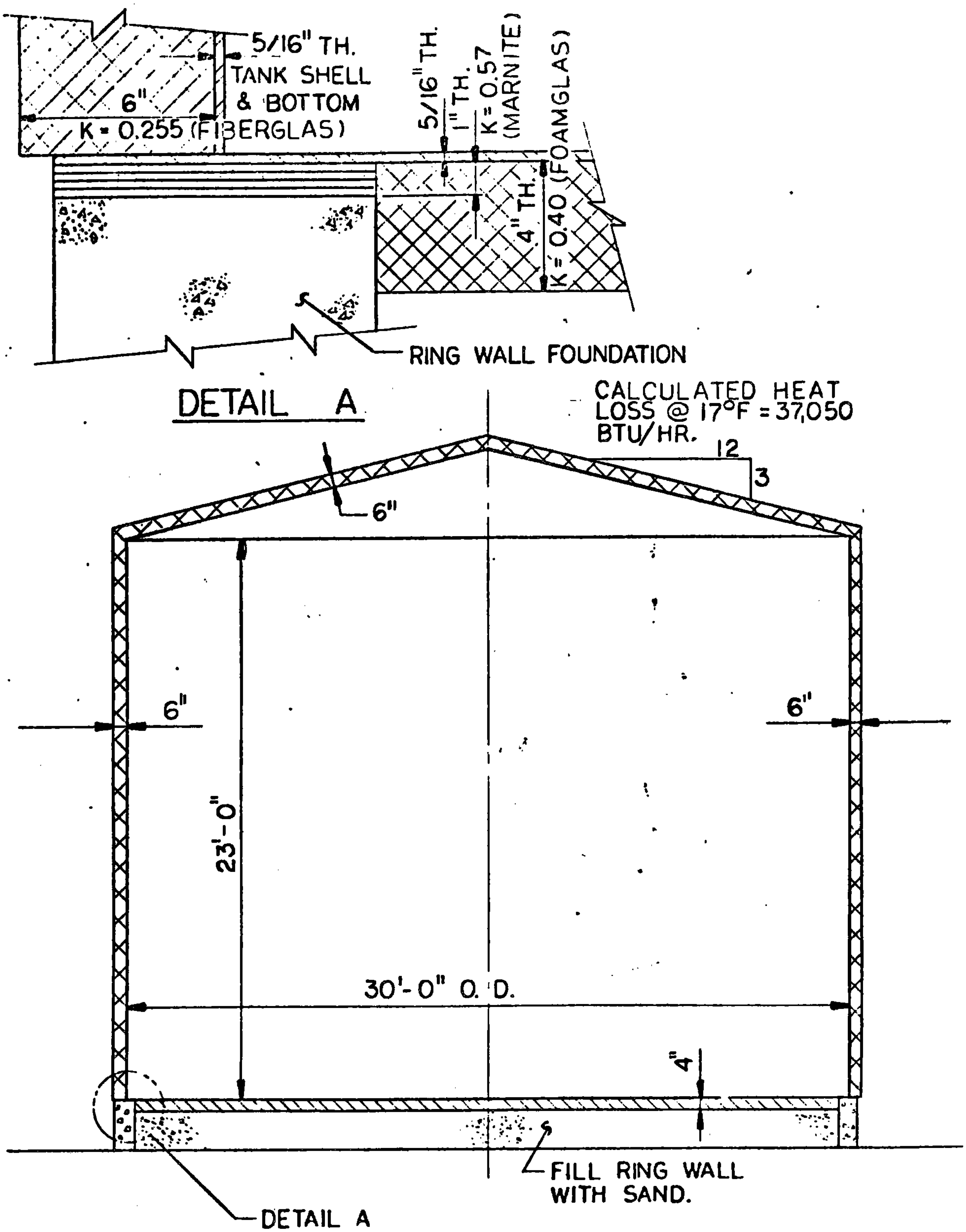
VENDOR STATUS

COST/UNIT $91,780 (Lockwood Greene Estimate)
59,500 (Means 13.1.100)

LOW TEMPERATURE TANK



- STORAGE MEDIA – WATER WITH CORRISON INHIBITORS
  - VOLUME ~ 121,600 GALLONS
  - INTERNAL PRESSURE ~ 15 PSIG
  - MATERIAL ~ CARBON STEEL
  - WALL THICKNESS ~ 5/8 INCH
  - INSULATION – FIBERGLASS BLANKET WITH WEATHER SHIELD



LOW TEMPERATURE STORAGE TANK INSULATION

PART NO. 7 SHEET NO. ____

COMPONENT SHEET

DATE UPDATED ____

SUBSYSTEM: TUS

COMPONENT NOMENCLATURE: Bleyle Heating Heat Exchanger

QUANTITY REQUIRED: 1

REQUIREMENTS: 559×10^3 BTUH

SUGGESTED SOURCES:
1. American - Standard
2. ____
3. ____
4. ____
5. ____

DATES:
- RFQ ____
- DEL. TIME WKS. 12
- POI ____
- HARDWARE NEED ____

VENDOR STATUS

COST/UNIT $495.00 (BCF 15732.0603)

PART NO. 8

SHEET NO.

COMPONENT SHEET

DATE UPDATED

SUBSYSTEM: TUS

COMPONENT NOMENCLATURE: Hot Water Pump

QUANTITY REQUIRED: 1

REQUIREMENTS: 250 gal/Min; 40-ft head; Fluid: water

Temp: 210°F nominal

SUGGESTED SOURCES:
1. Gould
2. TACO
3. Ingersoll-Rand
4. Bell & Gossett
5.

DATES:

RFQ	
DEL. TIME WKS.	24
POI	
HARDWARE NEED	

VENDOR STATUS

COST/UNIT $6477.00 (BCF 15711.0840)

PART NO. 9 SHEET NO. ____

COMPONENT SHEET

DATE UPDATED ____

SUBSYSTEM: TUS

COMPONENT NOMENCLATURE: Chilled Water Pump

QUANTITY REQUIRED: 1

REQUIREMENTS: Flow: 407 gpm

Head: 40 ft.

Fluid: Water

Temp: 55°F

SUGGESTED SOURCES:
1. Gould
2. TACO
3. Bell & Gossett
4. Ingersoll-Rand
5. ____

DATES: RFQ ____

DEL. TIME WKS. 24

POI ____

HARDWARE NEED ____

VENDOR STATUS

COST/UNIT $6,477.00 (BCF 15711.0840)

PART NO. 10 SHEET NO. ____

COMPONENT SHEET

DATE UPDATED ____

SUBSYSTEM: TUS

COMPONENT NOMENCLATURE: Air Conditioning Cooling Tower Pump

QUANTITY REQUIRED: 1

REQUIREMENTS: Flow: 900 gpm

Head: 50 ft.

Fluid: Water

Temp: 85°F 20 Hp @ 1800 RPM

SUGGESTED SOURCES:

1. Gould
2. Bell & Gossett
3. TACO
4. Ingersoll-Rand
5. ____

DATES:

RFQ ____

DEL. TIME WKS. 24

POI ____

HARDWARE NEED ____

VENDOR STATUS

COST/UNIT $1928 (Phone Quote to LGE)

TELEPHONE CALL REPORT

☐ INCOMING ☒ OUTGOING

JOB NO. 77375.01

COMPANY Gould Pumps

ADDRESS

DATE 13 April 78

TIME

REF.

TELEPHONE NO. 1-404-455-4800

CHARGE CODE

NAME J.B. Holiday

TITLE

DATA

① Condensate Storage Pump - 15 GPM @ 60 FT
(1×1½-8) Model # 3196 2 H.P. @ 1800 RPM
Pump $728.00 Motor $81.00

② Condensate Pump - 25 GPM @ 730 FT
Model # 3333 15 H.P. @ 3600
Pump & Motor - $1669.00

③ Low Temp. Storage Pump - 900 GPM @ 110 FT
(4×6-13) Model # 3196 40 H.P. @ 1800
Pump $1787.00 Motor $490.00

④ Condenser Cool. Tower Pump. - 1700 GPM @ 40 FT.
(6×8-13) Model # 3196 25 H.P. @ 1800
Pump $3175.00 Motor $519.00

⑤ A/C Cool. Tower Pump - 900 GPM @ 50 FT.
(4×6-10) Model # 3196 20 H.P. @ 1800
Pump $1648.00 Motor $280.00

All Motors To Be Open - Drip Proof

BY R. Weir

PART NO. 11

SHEET NO. ____

COMPONENT SHEET

DATE UPDATED ____

SUBSYSTEM: TUS

COMPONENT NOMENCLATURE: Condenser Cooling Tower Pump

QUANTITY REQUIRED: 1

REQUIREMENTS: Flow: 1700 gpm; Head: 40 ft.; Fluid: Water

Temp: 85°F 25 Hp. @ 1800 gpm

SUGGESTED SOURCES:

1. Gould Pumps
2. Bell & Gossett
3. Ingersoll-Rand
4. TACO
5. ____

DATES: RFQ ____

DEL. TIME WKS. 24

POI ____

HARDWARE NEED ____

VENDOR STATUS

COST/UNIT $3694 (Phone Quote to LGE)

PART NO. 12 SHEET NO. ____

COMPONENT SHEET

____ DATE UPDATED

SUBSYSTEM: TUS

COMPONENT NOMENCLATURE: Heating Water Supply Pump

QUANTITY REQUIRED: ____

REQUIREMENTS: Flow: 100 gpm: Head: 40 ft.; Fluid: Water

Temp: 170°F

SUGGESTED SOURCES:
1. Gould
2. Bell & Gossett
3. Ingersoll Rand
4. TACO
5. ____

DATES:
RFQ ____
DEL. TIME WKS. 24
POI ____
HARDWARE NEED ____

VENDOR STATUS

COST/UNIT $1177.0 (BFC 15711.0320)

TELEPHONE CALL REPORT

☐ INCOMING ☒ OUTGOING

JOB NO. 77575.01

COMPANY Gould Pumps

ADDRESS

DATE 13 April 78

TIME

REF.

TELEPHONE NO. 1-404-455-4800

CHARGE CODE

NAME J.B. Holiday

TITLE

DATA

① Condensate Storage Pump - 15 GPM @ 60 FT

(1×1½-8) Model # 3196 2 H.P. @ 1800 RPM

Pump $728.00 Motor $81.00

② Condensate Pump - 25 GPM @ 730 FT

Model # 3333 15 H.P. @ 3600

Pump & Motor - $1669.00

③ Low Temp. Storage Pump - 900 GPM @ 110 FT

(4×6-13) Model # 3196 40 H.P. @ 1800

Pump $1789.00 Motor $490.00

④ Condenser Cool. Tower Pump - 1700 GPM @ 40 FT.

(6×8-13) Model # 3196 25 H.P. @ 1800

Pump $3175.00 Motor $519.00

⑤ A/C Cool. Tower Pump - 900 GPM @ 50 FT.

(4×6-10) Model # 3196 20 H.P. @ 1800

Pump $1648.00 Motor $280.00

All Motors To Be Open - Drip Proof

BY R. Weed

3-158

PART NO. 13

SHEET NO. ____

COMPONENT SHEET

DATE UPDATED ____

SUBSYSTEM: TUS

COMPONENT NOMENCLATURE: Chemical Injection System (Including Pump & Controls)

QUANTITY REQUIRED: 1

REQUIREMENTS: ____

SUGGESTED SOURCES:
1. ____
2. ____
3. ____
4. ____
5. ____

DATES:
- RFQ ____
- DEL. TIME WKS. 10
- POI ____
- HARDWARE NEED ____

VENDOR STATUS

COST/UNIT $250 Estimate

PART NO. 14 SHEET NO. ____

COMPONENT SHEET

DATE UPDATED ____

SUBSYSTEM: TUS

COMPONENT NOMENCLATURE: Hot Water Flow Control Valve

QUANTITY REQUIRED: 2

REQUIREMENTS: Fluid: Water; Flow: 285 gpm; Temp.: 210°F

Pressure: 100 psi; End Connections: 150 lb flanged

Body: Carbon Steel. Positioner: pneu.

1 - 3" Size

1 - 4" Size

SUGGESTED SOURCES:
1. ____
2. ____
3. ____
4. ____
5. ____

DATES: RFQ ____

DEL. TIME WKS. 16

POI ____

HARDWARE NEED ____

VENDOR STATUS

COST/UNIT 3" - $419 (BCF 15122.0124)
4" - $628 (BCF 15122.0204)

PART NO. 15

SHEET NO. ____

COMPONENT SHEET

____
DATE UPDATED

SUBSYSTEM: TUS

COMPONENT NOMENCLATURE: Chilled Water Temp. Control Valve

QUANTITY REQUIRED: 1

REQUIREMENTS: Fluid: Water; Flow: 0-409 gpm; Temp.: 45-55°F

Press: 100 psig End Connections: 150# Flanged; Body: Carbon Steel;

Positioner: Pneu. Size: 6"

SUGGESTED SOURCES:
1. ____
2. ____
3. ____
4. ____
5. ____

DATES:
- RFQ ____
- DEL. TIME WKS. 24
- POI ____
- HARDWARE NEED ____

VENDOR STATUS

COST/UNIT $895.00 (BCF 15122.0206A)

PART NO. 16

SHEET NO. ___

COMPONENT SHEET

DATE UPDATED ___

SUBSYSTEM: TUS

COMPONENT NOMENCLATURE: Hot Water Supply Temp. Control Valve

QUANTITY REQUIRED: 1

REQUIREMENTS: Fluid: Water; Flow: 0-100 gpm; Temp.: 200°F

Press: 100 psi End Connections; 150# flanged;

Body: Carbon Steel; Positioner: Pneumatic Size 3'

SUGGESTED SOURCES:
1.
2.
3.
4.
5.

DATES:

RFQ	
DEL. TIME WKS.	24
POI	
HARDWARE NEED	

VENDOR STATUS

COST/UNIT $419.00 (BCF 15122.0124)

3.7 ELECTRICAL SYSTEM

3.7.1 MECHANICAL AREA

Major components of the electrical system will be installed in the mechanical equipment area. A switchboard will be located in the control room with circuit breaker control devices, protective relaying, indicating meters, and related devices factory installed, wired and tested.

The 500 KVA 480 volt generator will be provided as GFE with the turbine. A set of instrument transformers and surge protection equipment is provided by the manufacturer as specified by GE for ease of field integration and wiring. Control wiring runs to the switchboard area.

Located near the generator will be a metal enclosed Power Equipment assembly housing the Delta-WYE connected isolation transformer, instrument transformers, and two power circuit breakers for the generator and Solar Total Energy System auxiliaries. The main power circuit will have 2-300 MCM cables per phase and be run in 4" conduit from the generator to the Power Equipment and then to the Georgia Power Company intertie at the Bleyle plant substation. A neutral grounding resistor for the generator will be part of the Power Equipment.

Adjacent to the Power Equipment, a Motor Control Center will be installed, housing all motor combination starters and feeder circuit breakers for the system. This factory assembly includes an indicating lamp for each starter and a local-remote transfer switch for operational control at each motor manually.

Power circuits and local control wires are run in lay-in wireway from the motor control center in a North-South direction to a point adjacent to each motor or controlled load. The circuits continue in individual 1" conduit to the load with outdoor NEMA 4 lever operated control switches installed for local control.

The power circuits to the collector field are backed-up by an auxiliary 70 KW gas fueled engine generator in order to provide high reliability of power for collector defocus. This unit is an outdoor housed self-contained package and will be mounted with a step down transformer, automatic transfer switch and primary feeder circuit breakers for a separate 208Y120 volt circuit to each Field Control Enclosure (FCE).

An outdoor packaged 125V DC battery and charger will be mounted just outside the building to provide switchgear control power. Environmental control heaters and venting are built into the package.

A micro-processor based Energy Utilization Processor (EUP) provides control and data acquisition and is located, with an interface wiring rack, in the Control Room. Control and instrumentation wiring, using multiple pair cable, is run in a manner similar to the power wiring, utilizing lay-in wireway and conduit branches near the devices. Motor control wiring will operate control relays at the Motor Control Center. Building lighting and receptacles are installed by the contractor per standard practice.

3.7.2 COLLECTOR FIELD

Collector field control and power distribution is provided from two Field Control Enclosures (FCE). Each FCE will be a self supporting walk-in enclosure housing two micro-processor based Energy Collection Processors (ECP) and related interface wiring racks as a factory installation. A Load Center and magnetic contactor assembly will be mounted in each FCE to distribute power with a separate circuit to each collector.

The FCE's will be mounted over an East-West wiring trench duct for ease of bringing all wiring in from below without added conduiting. A subfloor wiring space is provided for internal field wiring. Each ECP has a dual co-ax cable connecting it with the Control Room and each FCE is provided with a 4 wire power circuit input from the auxiliary generator package.

All Field wiring will be laid-in the trench duct, separated by power and signal from the FCE's to the appropriate branch and then run in conduit to each Collector Control Unit (CCU) along the piping support I beams. Branch valve and instrumentation controls will be run in conduit out of the electrical trench duct into the adjacent piping duct area.

A field ground grid consisting of driven rods and buried cable interconnections will be installed for static and lightning discharge. Collector bases will be tied to this grid and to the piping.

Field control and instrumentation wiring will utilize the same multiple pair cable as the mechanical area, with one wire pair cable for each CCU on valve location.

Table 3.7-1 lists the purchased parts that will be procured.

TABLE 3.7-1. ELECTRICAL SUBSYSTEM

Item #	Nomenclature	Qty.	Cost
1	Switchboard	1	56,500
2	Isolation Transformer	1	8,765
3	Power Equipment (Circuit Breakers and Instrument Transformers)	1	20,175
4	Motor Control Center	1	22,202
5	Auxiliary Generator	1	17,670
6	Auxiliary Transformer	2	3,262
7	Load Centers (FCE)	6	1,260
8	Contactors (FCE)	4	852
9	Battery Assembly	1	3,200
10	Local Motor Switches	20	701
	TOTAL		134,587
	Level-of-Definition 1.05		141,316

PART NO. 1 SHEET NO.

COMPONENT SHEET

2/16/79
DATE UPDATED

SUBSYSTEM: Electrical

COMPONENT NOMENCLATURE: Switchboard

QUANTITY REQUIRED: 1

REQUIREMENTS: Specification 295A4048

NEMA 12 Switchboard with 21 relays, 45 miscellaneous devices assembled and tested

SUGGESTED SOURCES:
1. GE
2. Westinghouse
3. Basler
4. Gould - ITE
5. McGraw Edison

DATES:
- RFQ
- DEL. TIME WKS. 30
- POI
- HARDWARE NEED

VENDOR STATUS Telecon - GE Burlington, Iowa 2/16/79

COST/UNIT $56,500 Est.

PART NO. 2

SHEET NO. ____

COMPONENT SHEET

2/16/79
DATE UPDATED

SUBSYSTEM: Electrical

COMPONENT NOMENCLATURE: Isolation Transformer

QUANTITY REQUIRED: 1

REQUIREMENTS: Part of Specification 295A 4054

500 KVA Req'd (750 KVA Possible)

480 V Delta to 480Y277V

Estimated on GE 9T 23B3859

SUGGESTED SOURCES:
1. GE
2. Westinghouse
3. Gould - ITE
4. Niagara
5. McGraw Edison

DATES:
- RFQ ____
- DEL. TIME WKS. 20
- POI ____
- HARDWARE NEED ____

VENDOR STATUS

COST/UNIT 8765 Catalog

PART NO. 3 SHEET NO. ____

COMPONENT SHEET

2/16/79
DATE UPDATED

SUBSYSTEM: Electrical

COMPONENT NOMENCLATURE: Power Equipment

QUANTITY REQUIRED: 1

REQUIREMENTS: Part of Spec 295A 4054

(2) Circuit Breakers and Instrument Transformers in NEMA 12 Enclosure

Estimated on GE Handbook Section 2030

SUGGESTED SOURCES:
1. GE
2. Westinghouse
3. Gould - ITE
4. McGraw Edison
5. ____

DATES:
RFQ ____
DEL. TIME WKS. 26
POI ____
HARDWARE NEED ____

VENDOR STATUS

COST/UNIT $20175 Est.

PART NO. 4

SHEET NO.

COMPONENT SHEET

DATE UPDATED

SUBSYSTEM: Electrical

COMPONENT NOMENCLATURE: Motor Control Center

QUANTITY REQUIRED: 1

REQUIREMENTS: Spec 295A 4032

27 Starters and Misc. Devices in NEMA 12 Enclosure

Estimated on GE Handbook Section 2030

SUGGESTED SOURCES:
1. GE
2. Westinghouse
3. Gould - ITE
4. McGraw Edison
5.

DATES: RFQ

DEL. TIME WKS. 20

POI

HARDWARE NEED

VENDOR STATUS

COST/UNIT 22,202 Est.

PART NO. 5

SHEET NO. ____

COMPONENT SHEET

2/16/79
DATE UPDATED

SUBSYSTEM: Electrical

COMPONENT NOMENCLATURE: Auxiliary Generator

QUANTITY REQUIRED: 1

REQUIREMENTS: Spec (TBD)

70 KW, 208Y 120V 3Q, Gas Engine 0.8 PF, ATS, Controls, Housing, Metering

Cost based on Katolight 80 KW Unit 9/12/78

SUGGESTED SOURCES:
1. Onan
2. Katolight
3. Kohler
4. O'Brien
5. ____

DATES:
- RFQ ____
- DEL. TIME WKS. 20
- POI ____
- HARDWARE NEED ____

VENDOR STATUS

COST/UNIT 17,670 Est.

PART NO. 6

SHEET NO.

COMPONENT SHEET

2/16/79
DATE UPDATED

SUBSYSTEM: Electrical

COMPONENT NOMENCLATURE: Aux. Transformers

QUANTITY REQUIRED: 2

REQUIREMENTS: 751KVA 480 - 208Y120

Based on

GE 9T23B3874 @ 1540

9T23B3874G62 @ 1722

SUGGESTED SOURCES:
1. GE
2. Westinghouse
3. Gould - ITE
4. McGraw Edison
5.

DATES:
RFQ
DEL. TIME WKS. 12
POI
HARDWARE NEED

VENDOR STATUS

COST/UNIT 3,262 Catalog

PART NO. 7

SHEET NO. ___

COMPONENT SHEET

2/16/79
DATE UPDATED

SUBSYSTEM: Electrical

COMPONENT NOMENCLATURE: Load Centers

QUANTITY REQUIRED: 6

REQUIREMENTS: 42 CKT 208Y120

GE TL24-415WS w/ THQP115

SUGGESTED SOURCES:
1. GE
2. Westinghouse
3. Gould - ITE
4. McGraw Edison
5.

DATES:
- RFQ
- DEL. TIME WKS. 10
- POI
- HARDWARE NEED

VENDOR STATUS

COST/UNIT $210 Est.

PART NO. 8 SHEET NO.

COMPONENT SHEET

2/16/79
DATE UPDATED

SUBSYSTEM: Electrical

COMPONENT NOMENCLATURE: Contactors

QUANTITY REQUIRED: 4

REQUIREMENTS: 3Ø90A NEMA 12 Can

Size 3

GE CR205E223

SUGGESTED SOURCES:
1. GE
2. Westinghouse
3. Gould - ITE
4. McGraw Edison
5.

DATES:
RFQ
DEL. TIME WKS. 12
POI
HARDWARE NEED

VENDOR STATUS

COST/UNIT $213 Catalog

PART NO. 9

SHEET NO.

COMPONENT SHEET

2/16/79
DATE UPDATED

SUBSYSTEM: Electrical

COMPONENT NOMENCLATURE: Battery ASM

QUANTITY REQUIRED: 1

REQUIREMENTS: Spec 295A8049

125 VDC 20AA, Charger Enclosure

Est. based on related job

SUGGESTED SOURCES:
1. C & D
2. Gates
3.
4.
5.

DATES:
- RFQ
- DEL. TIME WKS. 28
- POI
- HARDWARE NEED

VENDOR STATUS

COST/UNIT 3200 Est.

PART NO. 10 SHEET NO. ____

COMPONENT SHEET

2/16/79
DATE UPDATED

SUBSYSTEM: Electrical

COMPONENT NOMENCLATURE: Control Switches

QUANTITY REQUIRED: 20

REQUIREMENTS: On-Off Weatherproof

Based on GE CR2940AJ201C

SUGGESTED SOURCES:
1. GE
2. Allis Chalmers
3. Gould - ITE
4.
5.

DATES:
- RFQ ____
- DEL. TIME WKS. 10
- POI ____
- HARDWARE NEED ____

VENDOR STATUS

COST/UNIT 35

CONTROL AND
INSTRUMENTATION

3.8 CONTROL AND INSTRUMENTATION SUBSYSTEM

3.8.1 MASTER CONTROL CONSOLE

PURPOSE

The Solar Total Energy - Large Scale Experiment(STE-LSE) at Shenandoah, Georgia, is a highly flexible system. This requirement results in the need for an automatic, digital-computer based control system, augmented by an integrated system-operator interface that allows the operator to maintain supervisory control over STE-LSE system performance via the computer. That interface will be provided by the Master Control Console located within the Central Control Complex.

Several design guidelines have been established to support The Master Control Console design. The primary guideline is to incorporate human factors engineering and previous console operational experience into the design of the console.

Another major design guideline is to integrate control and display functions into a console which can be operated by a single operator. This simplifies operating personnel requirements and reduces operating costs.

The Master Control Console (MCC) will be designed to optimize the quantity of data the operator must continuously survey, comprehend, and analyze. This will improve operator response time which, in turn, will decrease the likelihood of operator error.

Console equipment will be designed to facilitate testing and installation. This will minimize installation costs and enhance the overall availability of the STE-LSE system.

CONSOLE DESCRIPTION

The operating console, located in the control room, has been configured for one person operation with the capability to accommodate a second operator for software update and experimentally oriented functions.

The panel layouts are based on good human engineering practice and incorporate static mimics to give the operator(s) system recall for the various subsystems.

A combination of conventional panel components and color graphic displays are utilized to allow the operator flexibility of control and monitoring. This combination results in an "operator paced" control system which is desirable due to the experimental nature of the STE - LSE.

The Master Control Console is composed of: two standard vertical equipment racks which house an Energy Management Panel (two sections); a communications panel; a CCTV Control panel; and two CCTV monitors; a custom work surface with storage; two color graphics monitors as shown in Figure 3.8-1.

The left hand position is the preferred single operator position. This places the writing surface to the right when using the alpha numeric keyboard. Space is adequate for the second operator (plant engineer, experiment operator or operator trainee) to use the right hand side (with color graphic monitor and keyboard) without interfering with the prime operator. Also, there may be circumstances during which it would be effective to have a second operator assist the prime operator (i.e. maintenance and diagnostic activity).

The Energy Management Panel, as shown in Figure 3.8-2, is divided into an upper and lower section which provides the operator with conventional controls and displays arranged on the basis of static mimics (graphics) of the subsystem. Each subsystem is outlined with a heavy border and appropriately labeled resulting in visually discernible "function areas". The static mimics connect these areas to form a system flow picture and gives the operator a constant reminder of the total system.

a) Solar collectors functional area, as shown in Figure 3.8-3, within this upper section of the panel are:

- Indicators for each of the 192 solar collectors. Each indicator displays; HI = high temp; TR = tracking; DF = defocused; ST = stowed.
- Indicators for each valve to indicate an open condition and an operating condition for the modulating valves.

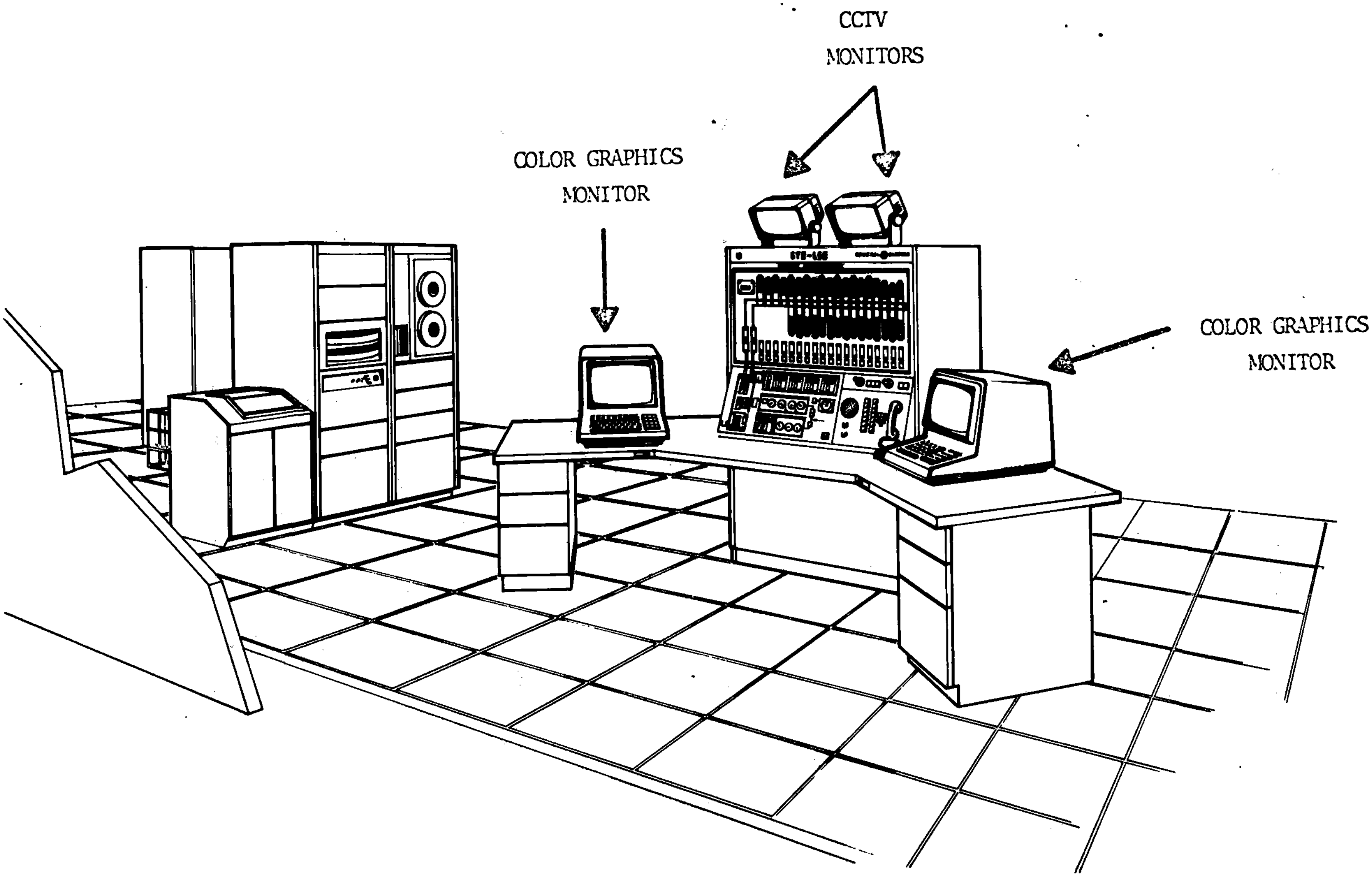


Figure 3.8-1. Control Complex Layout

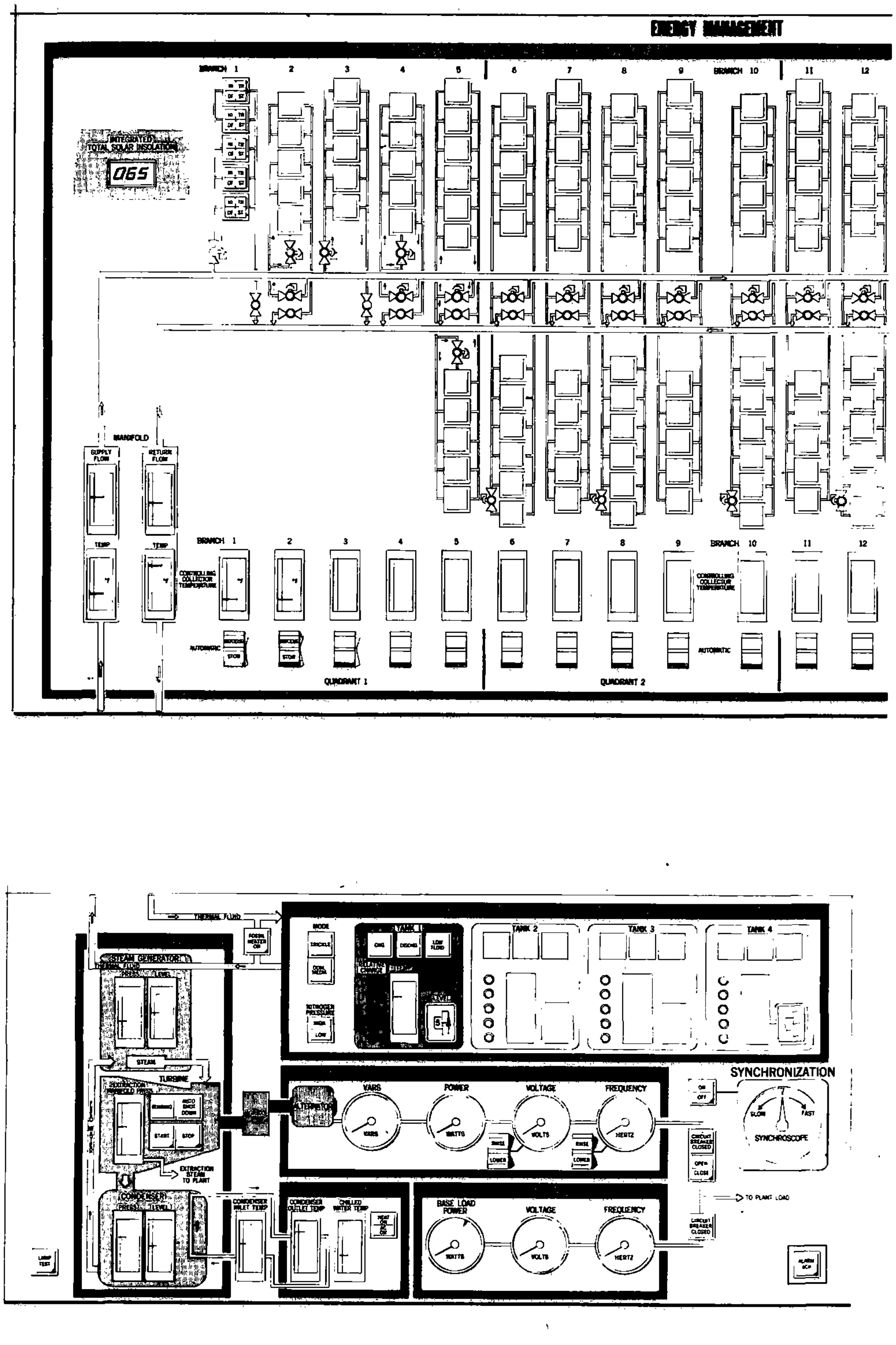


Figure 3.8-2. Energy Management Panel

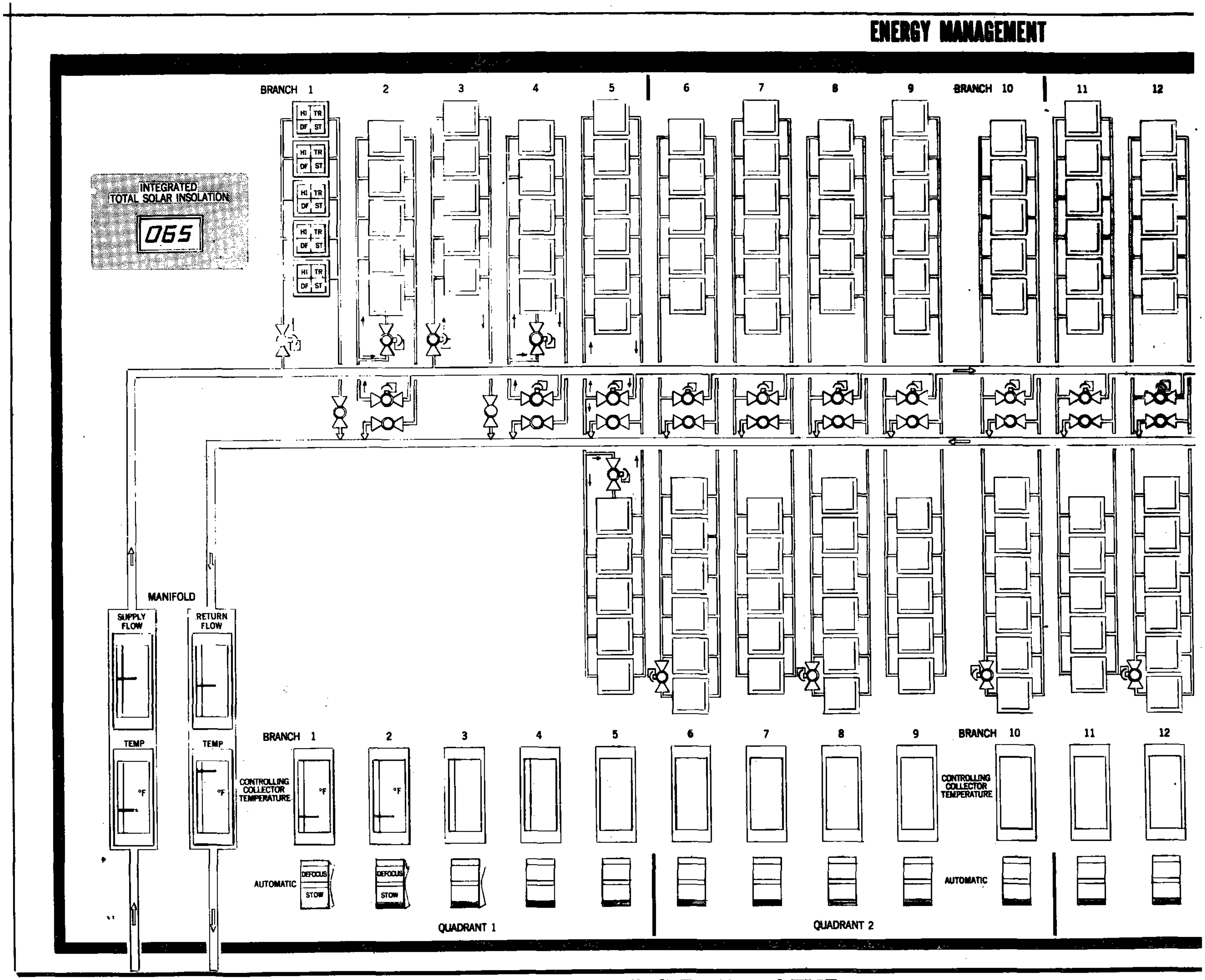


Figure 3.8-3. Upper Left Portion of EMP

- A meter for each of the 20 branches to indicate the temperature of the hottest (control line) collector.
- A three-position switch for each of the 20 branches to allow selection of automatic defocus or stow (on a branch basis).
- Meters for indicating the supply and return manifold "flow" and "temperature".
- Meteorological data including solar insolation wind speed and direction, and outside ambient air temperature.

b) Thermal Energy Storage Functional Area as shown in Figure 3.8-4 in the lower left panel are:

- An indicator for "trickle" or "dual media" mode
- Nitrogen pressure "high/low" indicator
- Indications for each of the four tanks which include "charging", discharging, low fluid, relative charge and tank temperature (selectable for any of eight different levels).

c) Power Conversion Functional Area as shown in Figure 3.8-4 in the lower left section are:

- Meters for Steam Generator pressure and level
- Meter for turbine extraction manifold pressure
- Indicators for turbine "running" and "auto shutdown"
- Controls for turbine "start" and "stop"
- Meters for condenser "pressure" and "level".

d) Electrical Output Functional Area as shown in Figure 3.8-4 in the lower left panel are:

- Meters for VARS, Power, Voltage and Frequency
- Controls for raising and lowering voltage and frequency
- Adjacent to this area - Syncroscope, and distribution controls

e) Thermal Utilization Functional Area as shown in Figure 3.8-4 in the lower left panel are:

- Meters for condenser inlet and outlet temperature
- Meter for chilled water temperature
- Indicators for heat and/or air conditioning (cooling) "on".

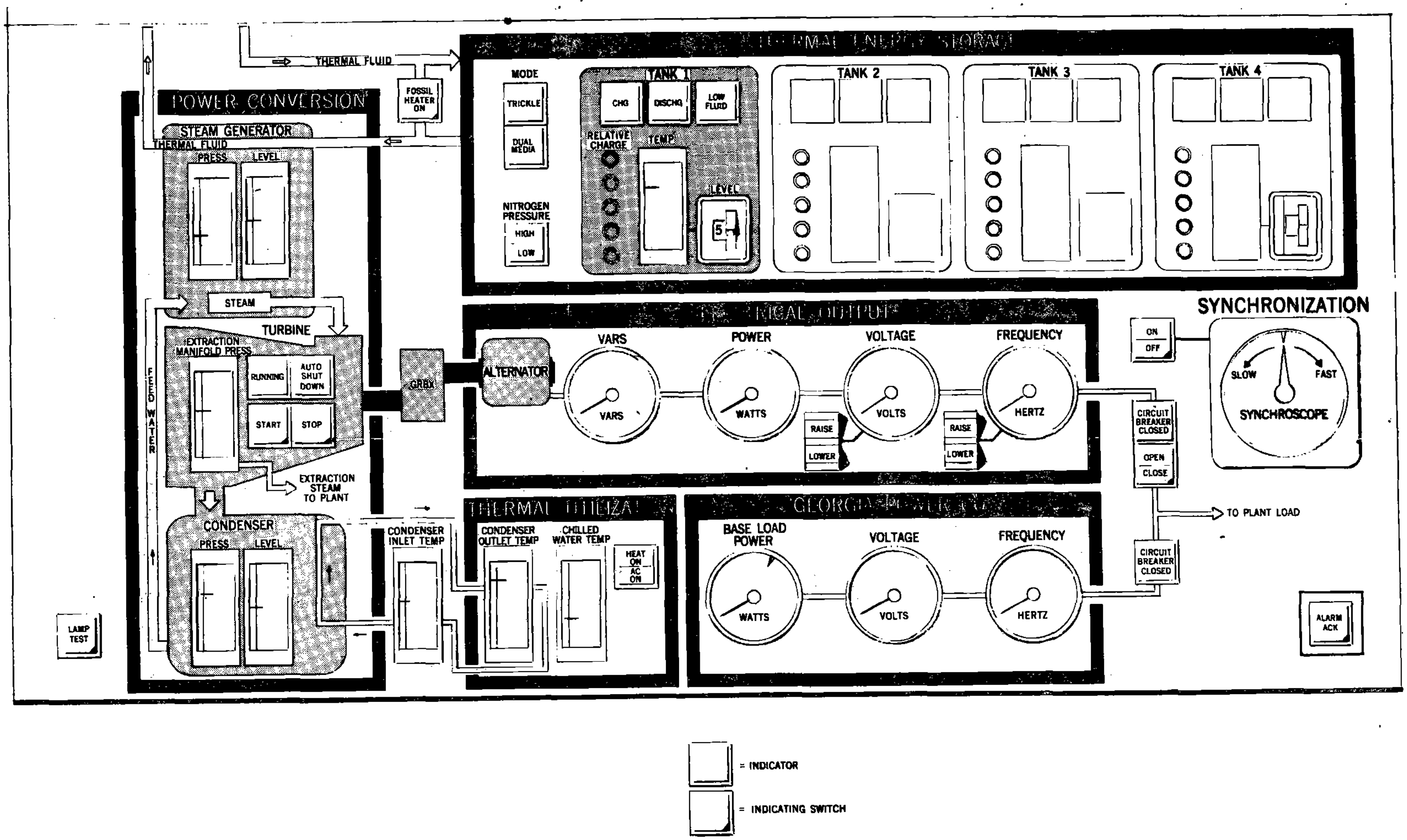


Figure 3.8-4. Lower Left Portion of EMP

f) Georgia Power Co. Functional Area as shown in Figure 3.8-4 in the lower left panel are:

- Meters for Base Power Load, Voltage and Frequency
- Indicator for "Circuit Breaker Closed".

The monitor and keyboard are used to set up the initial modes for operation, to monitor and isolate faults, to analyze parameters and trends, to call up schematic and diagnostic data, and to issue discrete commands (i.e. open and close valves, stow a particular collector, etc.).

Faults would be "faced" on the monitor along with the keyboard address for the next level of detail for that fault. An operator would sequentially request the proper format, isolate the fault, make comparisons and decisions and take corrective actions.

The color monitor in conjunction with the Energy Management Panel will provide the operation flexibility and efficiency needed for the STE - LSE.

SUPPORTING SOFTWARE

The Energy Management Panel functions incorporated in the supervisory software are to present a dynamic diagram of the plant, continuous display of key parameters, and allow the operator to exercise limited control from this panel. The supervisory computer develops binary codes that are sent to the EMP to illuminate lights that reflect the current status of the plant, digital values are transmitted to D/A converters for continuous displays, and discrete inputs are received for limited control functions.

Color displays are presented also as a part of the supervisory functions. Each display is functionally grouped into two parts: (1) a static background, and (2) a dynamic data portion that is updated to reflect the current status, position, or values. The background data originates from mass memory while the dynamic data is generated by the computers.

AUTOMATIC DATA
PROCESSING EQUIP

The color display operation is partitioned between the mini-computer and the smart color display terminal. For mimic displays, a background system is "rolled" into the terminal; then, the mini-computer sends codes and data to the color terminal for it to generate data, lines, symbols, or values that reflect the current state of the subsystem being displayed. The mini-computer can selectively update this display in real time as well as presenting current operator options.

3.8.2 AUTOMATIC DATA PROCESSING EQUIPMENT (ADPE)

INTRODUCTION:

The General Electric Company Ground Systems Department, Daytona Beach, Florida, is providing the Control and Instrumentation Subsystem (CAIS) for the Solar Total Energy - Large Scale Experiment (STE-LSE) at Shenandoah, Georgia. It is the function of the CAIS to provide safe and reliable control signal information to the operational components of the STE-LSE equipment and to interface with, interpret and record all necessary instrumentation signals provided to it. The major operational subsystems with which the CAIS interfaces are the:

- Solar Collector Subsystem (SCS)
- High Temperature Energy Storage Subsystem (HTES)
- Power Conversion Subsystem (PCS)
- Thermal Utilization Subsystem (TUS)

In addition, the CAIS interfaces in a data gathering mode with a Doric Data Logger, which is an existing instrumentation interface at the Bleyle Textile Mill.

ADPE FUNCTION:

The major elements of Automatic Data Processing Equipment (ADPE) incorporated in the CAIS are a minicomputer and five microprocessors. These will be arranged in a distributed star configuration as shown in Figure 3.8-5. The CAIS is configured in this manner to provide for cost effective and reliable control to the entire STE - LSE. The minicomputer

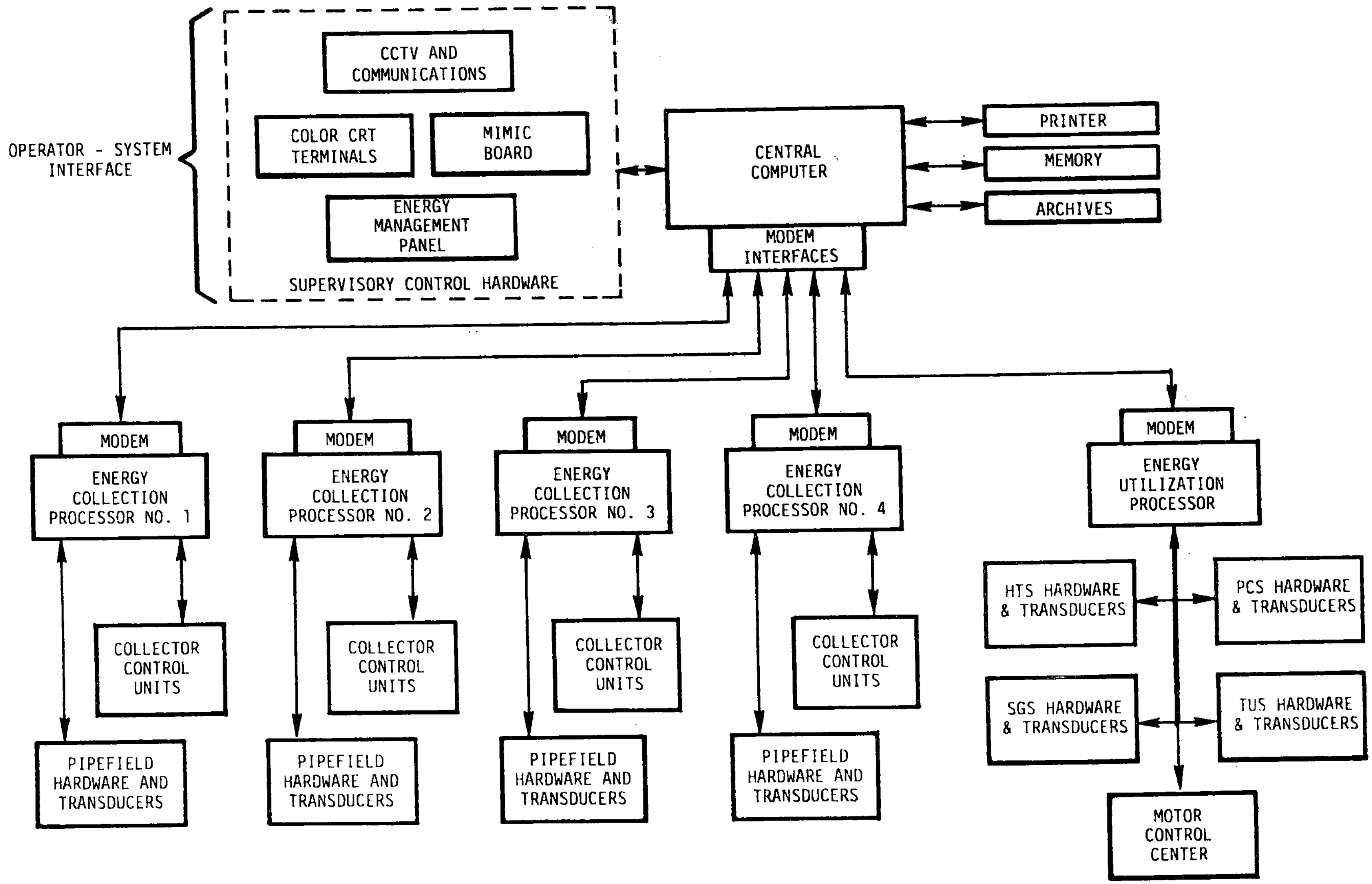


Figure 3.8-5. Control And Instrumentation Subsystem Block Diagram

oversees the entire operation and is the primary operator interface with the Shenandoah equipment. It also provides display and data archiving capability via peripherals for evaluation of the operational efficiency and health of the System. The energy utilization microprocessor controls the high temperature energy storage subsystem. Thermal utilization subsystem, and Power Conversion Subsystem.

The Solar Collector Subsystem is made up of 192 large parabolic mirrors or solar collectors. Approximately 48 Collectors are controlled by each microprocessor as well as overall flow control of the energy transfer fluid throughout the Solar Collector Field. All operational modes of the Solar Collection Subsystem are provided by the Control System including various protective and failsafe modes and an overall supervisory control function.

The High Temperature Energy Storage Subsystem is comprised of four storage tanks containing a heat storage media. Heat energy is transferred from the SCS to the HTS via a heat transfer fluid which circulates through the storage tanks. A portion of the Energy Utilization microprocessor monitors temperatures at numerous points throughout the storage tanks as well as inlet and outlet temperatures. The various flow modes into and out of the HTS are controlled, and decisions as to the ready status of the system are made.

The Power Conversion Subsystem is also under the control of the Energy Utilization microprocessor. When all conditions are satisfied to initiate operation of the PCS, heat is transferred from the HTS to the PCS to boil water as a source of steam. Electricity is generated by the steam turbine generator according to demands from the Doric Data Logger at the Bleyle Plant and the peak load electrical demands of the plant. The control system interfaces with the many safety control and monitor features provided by the steam turbine manufacturer.

The Thermal Utilization Subsystem uses the waste hot water from the PCS for heating and absorption air conditioning the Bleyle Plant and the STE-LSE building. The electrical demands and responses of these services are under microprocessor control.

CAIS FAB BREAKDOWN BY DELIVERABLE ITEM

	Display Panel		ADP Equipment		Software		Control Console		RDU's	
	Hr.	K$	Hr.	K$	Hr.	K$	Hr.	K$	Hr.	K$
Program Management	140	4.5	—	—	94	3.0	94	3.0	94	3.0
Manufacturing	875	16.3	—	—	—	—	1520	28.3	4220	78.6
QC	343	8.3	—	—	—	—	338	8.2	347	8.4
Materials	—	19.0	—	91.4	—	—	—	19.0	—	33.9
Purchasing Labor	186	5.0	—	—	—	—	182	4.9	186	5.0
Test	777	20.0	—	—	—	—	746	19.2	870	22.4
Design	424	13.0	—	—	—	—	343	10.5	424	13.0
Drafting	—	—	—	—	—	—	—	—	—	—
Systems	—	—	—	—	—	—	—	—	—	—
Software	—	—	—	—	3235	113.7	—	—	—	—
Program Control/ Project Eng'r	95	4.5	—	—	95	4.5	84	4.0	95	4.5
I&CO Support	212	7K	—		120	6K	120	6K	120	6K
594 K	3052	97.6	—	91.4	3544	127.2	3427	103.1	6356	174.8

Raw Material Breakdown	Display Panel K$	ADP Equip K$	SW	Control Console K$	RDU's K$
RDU A (4)	—	—		—	18.4
RDU B (1)	—	—		—	6.3
Control Console	—	—		14.0	—
Display Panel	13.7	—		—	—
Computers	—	68.5		—	—
Total	13.7	68.5		14.0	24.7
6% Escalation	.9	4.1		.8	1.5
	14.6	72.6	—	14.8	26.2
Variance 1.5%/4.5%	.6	1.1	—	.6	1.1
Computers/Others	15.2	73.7	—	15.5	27.3
as Req'd 2.5%	.4	1.8	—	.4	.7
Total Base Materials	15.6	75.5	—	15.9	28.0
BPS (1%) B&P, G&A, IR&D (20%)	3.4	15.9	—	3.1	5.9
TOTAL	19.0	91.4	—	19.0	33.9

3.8.3 CONTROL AND INSTRUMENTATION MATERIAL JUSTIFICATION

Collector Field RDU

Logic Assy "A" Parts	$ 1,500	(1) Per
Logic Assy "B" Parts	$ 600	(1) Per
Power Assy Parts	$ 600	
Misc. Piece Parts	$ 1,900	
	$ 4,600	
	x (4) RDU's	
	$18,400K	

Power Monitoring & Control RDU

Logic Assy "A" Parts	$1,700
Logic Assy "B" Parts	$1,500
Logic Assy "C" Parts	$1,100
Power Assy Parts	$ 600
Misc. Piece Parts	$1,400
	$6,300

Control Console

Logic Assy "A" Parts	$ 1,200
Logic Assy "B" Parts	$ 1,100
Power Assy Parts	$ 600
Enclosure	$ 2,500
Misc. Piece Parts	$ 8,600
	$14,000

Display Panel

Collor Graphic CRT's (2)	$12,500
Misc. Piece Parts	$ 1,200
	$13,700

Note - MTL $ for ADP includes processors for RDU's

EQUIPMENT CORPORATION

MAYNARD, MASSACHUSETTS 01754

PHONE AC 617 897 5111 TWX 710 347 0212 CABLE DIGITAL MAYN. TELEX 94 8457

PRODUCT LINE CODE.

DATE May 24, 1978

REFERENCE CAIS - Control an[d] Instructor Subsystem

NEAREST DIGITAL SALES OFFICE

TO General Electric Co.
P. O. Box 2500
Daytona Beach, Fla. 32015

Attn: Mr. R. A. Baenninger
CC: Mr. Bill Cartwright

Digital Equipment Corporation
6000 Lake Ellenor Drive, Suite 130
Orlando, Fla. 32809

Phone: (305) 851-4450

GENTLEMEN THANK YOU FOR YOUR INQUIRY WE ARE PLEASED TO QUOTE AS FOLLOWS

ITEM	QTY	MODEL NO.	DESCRIPTION	[illegible]	[illegible]	UNIT PRICE	NET AMOUNT
1	7	11/03-LC	16K MOS in 5¼" box	280.	35	3,995.00	18,177.25
2	7	KEV11	Fixed and floating point instruction set	Ø	35	190.00	864.50
3	7	DRV11-B	Parallel line DMA interface	56.	35	580.00	2,639.00
4	7	DLV11-EB	Modem controlling EIA/ CCITT serial line plus BC01-25 cable	49.	35	400.00	1,820.00
5	7	DLV11	Serial interface unit	35.	35	250.00	1,137.50
6	7	BC05M-04	20mA cable	Ø	28	46.00	231.84
7	1	VT50-AA	Keyboard CRT, 20mA	22.	35	1,450.00	942.50
8	1	1134A-LE	32K word MOS memory system with DL11 interface and KY11 operator's console	96.	35	13,440.00	8,736.00
9	1	RL11-AK	Unibus control and RL01 disk	58.	35	5,100.00	3,315.00
10	1	DR11-B	General purpose direct memory access interface	13.	28	1,620.00	1,166.40
11	1	LP11-VA	132 column, 64 char. line printer and control unit. 300 lpm	95.	10	11,800.00	10,620.00

THIS QUOTATION SHALL REMAIN FIRM FOR 60 DAYS FROM THE DATE HEREOF, UNLESS MODIFIED IN WRITING BY DIGITAL EQUIPMENT CORPORATION PRIOR TO OUR ACCEPTANCE OF YOUR CONTRACT OFFER AND IS SUBJECT TO CREDIT APPROVAL AND TO THE TERMS AND CONDITIONS HEREOF AND ON THE REVERSE SIDE EXCEPT THAT THE TERMS AND CONDITIONS UNDER WHICH DIGITAL SELLS COMPUTERS [illegible] OF THE PLCsystem TO COMPUTER SYSTEM ARE THE TERMS AND CONDITIONS ON THE FACE HEREOF AND IN THE STANDARD [illegible] AGREEMENT IN EFFECT ON THE DATE HEREOF. ANY CONTRACT RESULTING FROM THE QUOTATION MUST BE SIGNED IN MAYNARD MASSACHUSETTS BY AN AUTHORIZED REPRESENTATIVE OF DIGITAL EQUIPMENT CORPORATION. INSURANCE WILL BE PROVIDED ON PROPERTY WHILE IN TRANSIT AND A CHARGE OF [illegible] PERCENT OF EQUIPMENT VALUATION WILL BE MADE UNLESS INSTRUCTIONS TO THE CONTRARY ARE CLEARLY STATED ON THE FACE OF THE PURCHASER'S PURCHASE ORDER

DELIVERY SCHEDULE

SUBTOTAL	
PLUS INSTALLATION	
PLUS INSURANCE	
NET TOTAL AMOUNT	

TERMS: F.O.B. DIGITAL PLANT

FREIGHT CHARGES COLLECT

DIGITAL EQUIPMENT CORPORATION

By PAUL G. DOWNEY, Sales Repr. 3-191

EN 01079 10 0975 (101)

EQUIPMENT CORPORATION
MAYNARD, MASSACHUSETTS 01754
AC 617 897 5111 TWX 710 347 0212 CABLE DIGITAL MAYN TELEX 94-84 57

DATE May 24, 1978

ITEM	QTY	MODEL NO.	DESCRIPTION	[illegible] MAIN	[illegible] CHG	[illegible] %	UNIT PRICE	NET AMOUNT
12	1	TMB11-MA	Magnetic tape transport and control unit.	75.		28	7,650.00	5,508.00
13	1	VT52-AA	Alphanumeric CRT terminal	20.		35	1,900.00	1,235.00
14	1	CR11	Punched card reader and control unit. 300 cpm	53.		10	6,170.00	5,553.00
15	7	DL11-E	Modem controlling EIA/ CCITT serial line interface	42.		35	770.00	3,503.50
16	1	BA11-LE	Rack mountable extension mounting box	10.		28	1,600.00	1,152.00
17	1	DD11-DK	Backpanel mounting unit.	Ø		35	660.00	429.00
18	1	DD11-CK	Backpanel mounting unit.	Ø		35	330.00	214.50
19	1	H960-CA	Standard PDP-11 cabinet	Ø		28	1,210.00	871.20
20	1	QJ013-AQ	RT11 V3B on RL01	Ø		56	2,760.00	1,214.40
21	1	QJ980-AQ	FORTRAN IV on RL01	Ø		56	880.00	387.20
22	6	RL01K-DC	Data Cartridge for RL01	Ø		28	149.00	643.68
23	1	TUM06-SL	10 rolls magtapes	Ø		28	150.00	108.00
24	4	30-11688	line printer ribbons	Ø		28	30.00	86.40
25	A/R		Installation and 30-day on-site warranty	Ø		Ø	2,896.41	2,896.41
			TOTAL					73,452.28

SENSOR COSTS

Item No.	Description	Sensor	Quantity	Cost
SOLAR COLLECTOR FIELD				
1	Flow Rate	Flow Transducer	3 (1120)*	3,360
2	Temperature	RTD	213 (B)	—
3	Temperature	Thermocouple	84 (1.65)	139
4	Valve Position	Potentiometers	35 (A)	—
5	Valve Position	Switch (OLS)	20 (A)	—
6	Valve Position	Switch (CLS)	20 (A)	—
7	Collector Position	Potentiometers	384 (B)	—
HIGH TEMP. STORAGE				
8	Pump On/Off Monitor	Switch	3 (50)	150
9	Pump Enable/Disable	Switch	3 (25)	75
10	Valve Position	Switch (OLS)	32 (A)	—
11	Valve Position	Switch (CLS)	50 (A)	—
12	Valve Position	Switch (MLS)	5 (A)	—
13	Level Indicator	Float	4 (100)	400
14	Pressure	Press Transducer	12 (36)	432
15	Strain	Strain Gage	30 (10)	300
16	Temperature	Thermocouple	217 (27)	5,859
17	Flow Rate	Flow Transducer	3 (1980)*	5,940
18	Insolation	Pyrheliometer	4 (1980)*	7,920
STEAM GENERATOR SUPPLY				
19	Pump On/Off Monitor	Switch	2 (A)	—
20	Pump Enable/Disable	Switch	2 (A)	—
21	Valve Position	O.L. Switch	11 (A)	—
22	Valve Position	C.L. Switch	11 (A)	—
23	Fossile Htr. Status	Switch	1 (A)	—
24	Temperature	Thermocouple	6 (27)	162
25	Flow	Diff. Press. Trans.	1 (980)	980

SENSOR COSTS (Cont.)

Item No.	Description	Sensor	Quantity	Cost
POWER CONVERSION				
26	Valve Position	O.L. Switch	11 (A)	—
27	Valve Position	C.L. Switch	11 (A)	—
28	Alarm	Switch	13 (A)	—
29	Level	Float	2 (100)	200
30	Temperature	Thermocouple & Trans.	11 (127)*	1,397
31	Pressure	Bourdon Tube & L.V.D.T.	7 (360)	2,520
32	Pressure	Diff. Press. Trans.	1 (360)	360
33	Flow	Flow Transducer	6 (1120)	6,720
34	Conductance	Conductance Probe	1 (300)	300
35	Gen. Rotational Spd.	Magnetic	1 (GFE)	—
36	Power	PT, CT & Transducer	7 (A)	—
37	Voltage	PT & Transducer	3 (A)	—
38	Gen. Field Current	DC Current Sensor	1 (A)	—
THERMAL UTILIZATION				
39	Valve Position	O.L. Switch	5 (A)	—
40	Valve Position	C.L. Switch	5 (A)	—
41	Alarm	Switch	2 (50)	100
42	Temperature	Thermocouples	16 (27)	432
43	Flow	Turbine Flow Meter	4 (1120)*	4,480
44	Pump On/Off Monitor	Switch	7 (A)	—
45	Pump Enable/Disable	Switch	7 (A)	—
			SUBTOTAL	42,226
			Level of Definition - 1.5 =	63,339

A - Included in component cost
B - Included in collector cost

*Includes signal conditioning

CONSTRUCTION MANAGEMENT

4.0 CONSTRUCTION MANAGEMENT

4.1 ORGANIZATION AND RESPONSIBILITIES

4.1.1 CONSTRUCTION MANAGER

Authority and responsibility for construction at the STE-LSE site is placed under the Construction Manager as shown in Figure 4.1-1. The Construction Manager is an integral part of the STE-LSE program team, reporting directly to the STE-LSE Program Manager. He is assigned from GE-MATSCO (Management and Technical Services Company, a wholly owned construction management subsidiary of General Electric Co.). MATSO personnel will be assigned to the Construction Manager's staff. He is authorized to award and manage construction procurement including equipment, construction contracts and architect and engineering services.

4.1.2 PROGRAM ORGANIZATION - CONSTRUCTION PHASE

The program team for the Definitive Design phase carries over to the Construction Phase, differing only by the addition of the Construction Manager, Figure 4.1-1. The relationship and responsibilities of other team members during the Construction Phase is shown in Figure 4.1-2.

Technical continuity is assured by STE-LSE engineering and Lockwood Greene participation in the Construction Phase. Key contributors to the Definitive Design will be available to resolve construction problems as they arise and assure that the facility meets the design objectives.

4.1.3 EXECUTIVE PROGRAM OVERVIEW

Executive Overview is provided by a system in-place on all programs within GE Space Div., including STE-LSE, called PAR (Program Appraisal and Review). The PAR is presented quarterly to the Division General Manager, Mr. L. L. Farnham, a General Electric

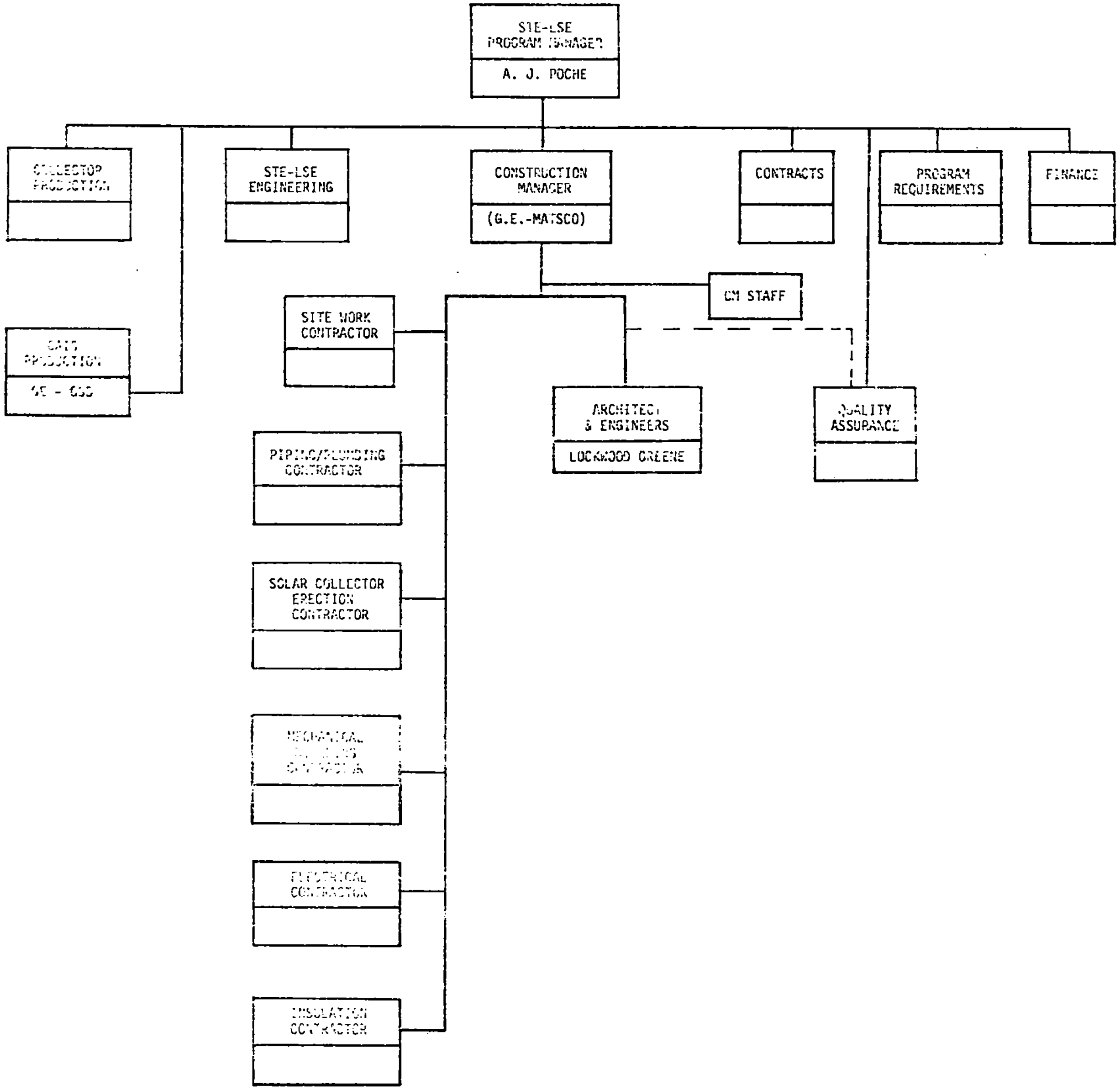


Figure 4.1-1. STE-LSE Program Organization

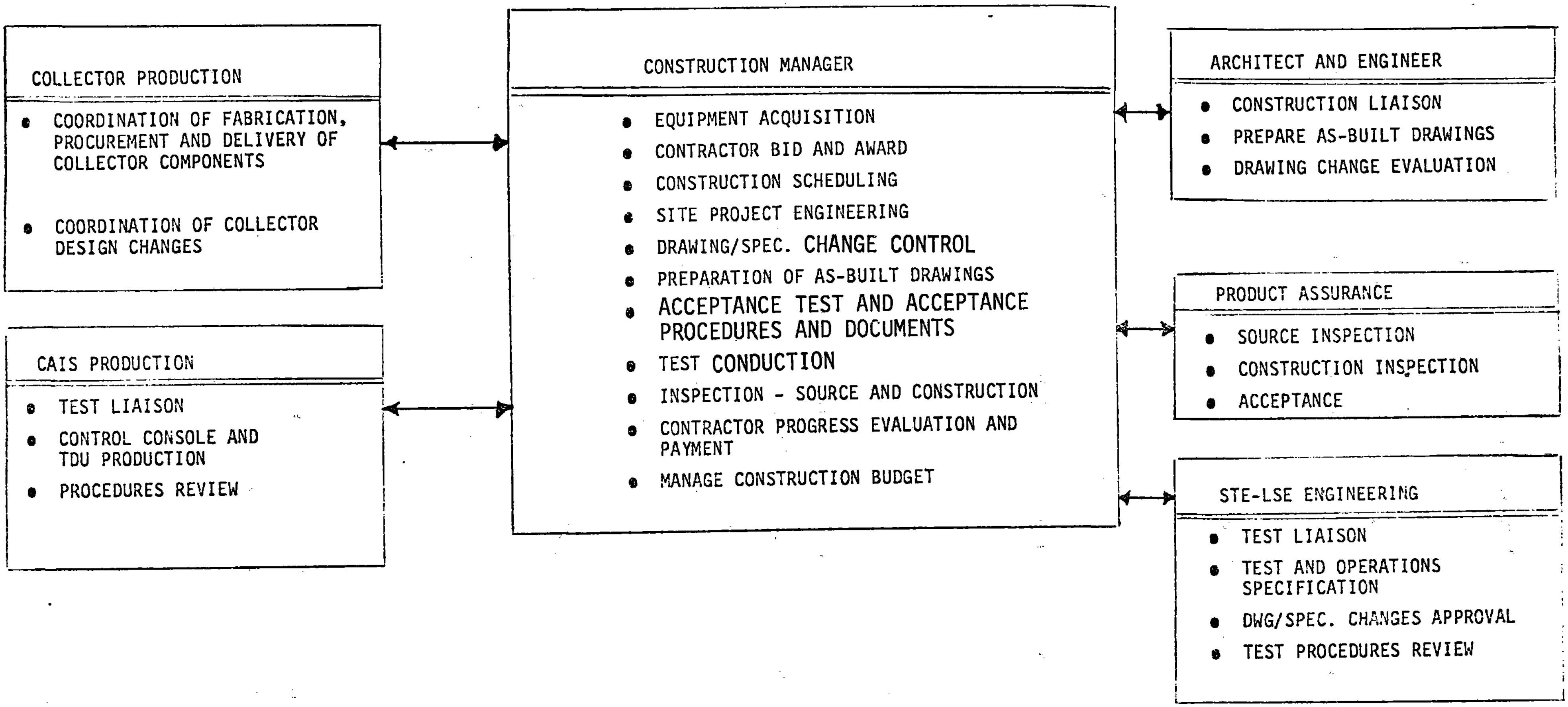


Figure 4.1-2. Construction Management Responsibilities

Company Vice President. Mr. Farnham has executive responsibility for the STE-LSE program as shown in Figure 4.1-3 and is also Chairman of the Board for MATSCO.

PAR is a concise method of providing top management with program information on a uniformly structured format of integrated inputs. The PAR concept is addressed to answering the four basic questions which vitally concern Mr. Farnham. These questions are:

a) How does the customer think we are doing?
b) How do our program control systems indicate we are doing?
c) What are our critical problems?
d) What else do I need to know to keep informed on program status?

Structured, quarterly presentations are being made by Mr. Poche on STE-LSE and will continue through the Construction Phase.

4.2 PROGRAM TEAM RESPONSIBILITIES

The Program Manager, Mr. Poche, will delegate the responsibility and authority to the program team to perform their responsibilities as defined on Figure 4.1-2. Through daily status meeting exchanges, reviews and across-the-desk discussions at all program levels, Mr. Poche receives information needed for effective decision making. Program direction to all team members except the Construction Manager will be by Program Directive.

Construction work will be initiated with a purchase order to MATSCO including a work statement delineating MATSCO responsibilities and based on the equipment specifications and construction drawings generated in the Definitive Design Phase. Program direction to the Construction Manager will therefore take the form of change orders to the purchase orders.

The Construction Manager is responsible for STE-LSE Construction Management, including all site management, construction scheduling and construction budget control; procurement of all site equipment; contractor selection and awards; equipment and construction drawing

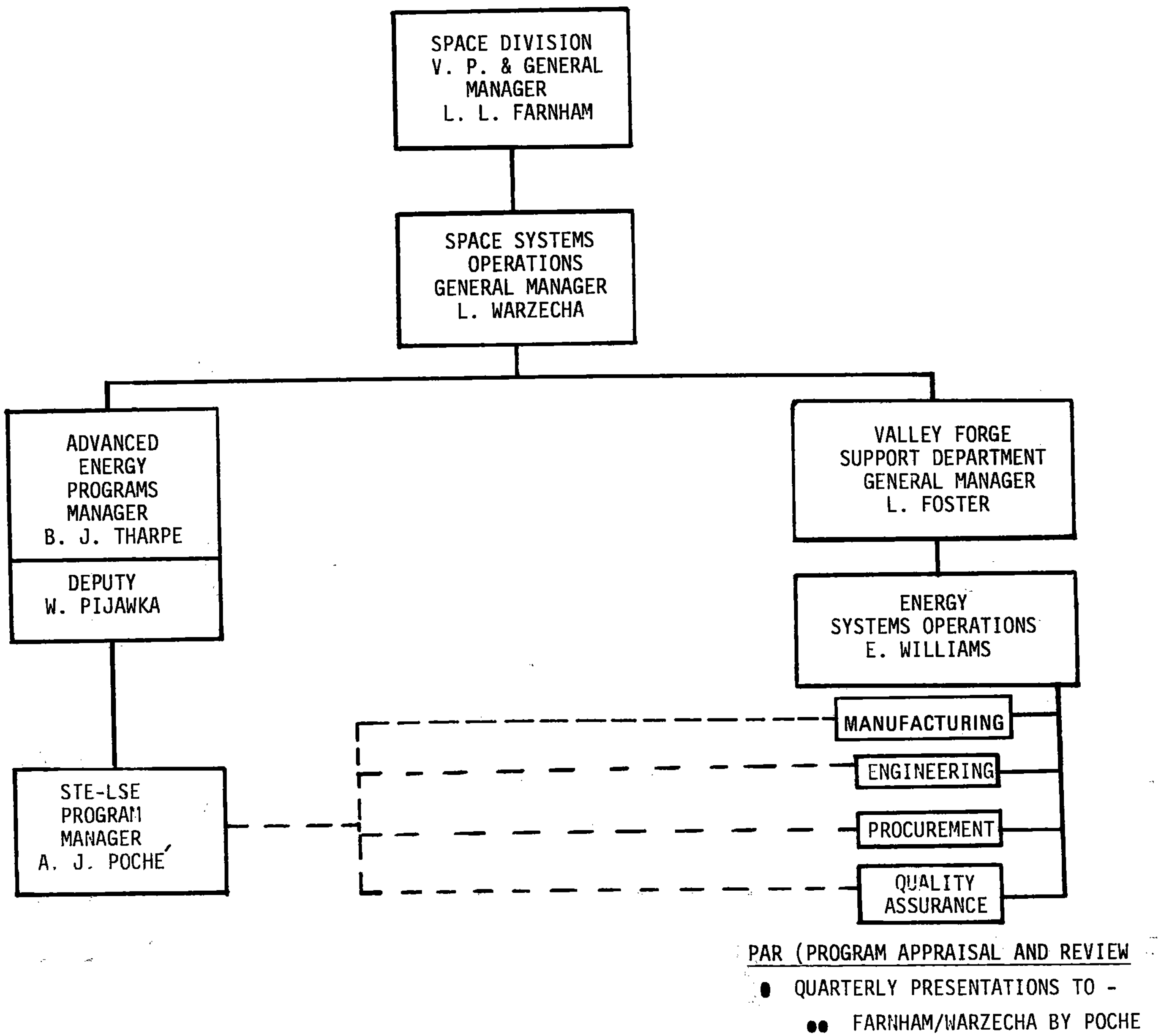


Figure 4.1-3. Space Division Organization - STE-LSE Executive Overview

and specification control; source inspection of procured equipment; construction inspection and acceptance; acceptance tests and as-built drawings. Definition of these responsibilities follows -

Construction Management -

- Contractor Direction
- Preparation and Maintenance of CPM Schedules
- Maintenance of the Construction Budget including status of expended, committed and contingency fund budgets

Procurement of Site Equipment -

- Procurement of all Site Equipment from sources identified in the construction work statement

Contractor Selection and Awards -

- Screened bidders list
- Preparation of bid package
- Bid evaluation and award

Drawing and Specification Control -

- Cost Evaluation of Proposed Changes
- A&E Direction to Implement Changes
- Coordination of Change Approval
- Change Direction to Contractors and Suppliers

Source Inspection

- Direction to Quality Assurance for Pre-Delivery Equipment Inspection

Construction Inspection

- Contractor Progress Inspections
- Contractor Acceptance

SCHEDULE

Acceptance Tests

- Prepare Test Procedures According to Test and Operations Specifications from STE-LSE Engineering
- Conduct Acceptance Tests

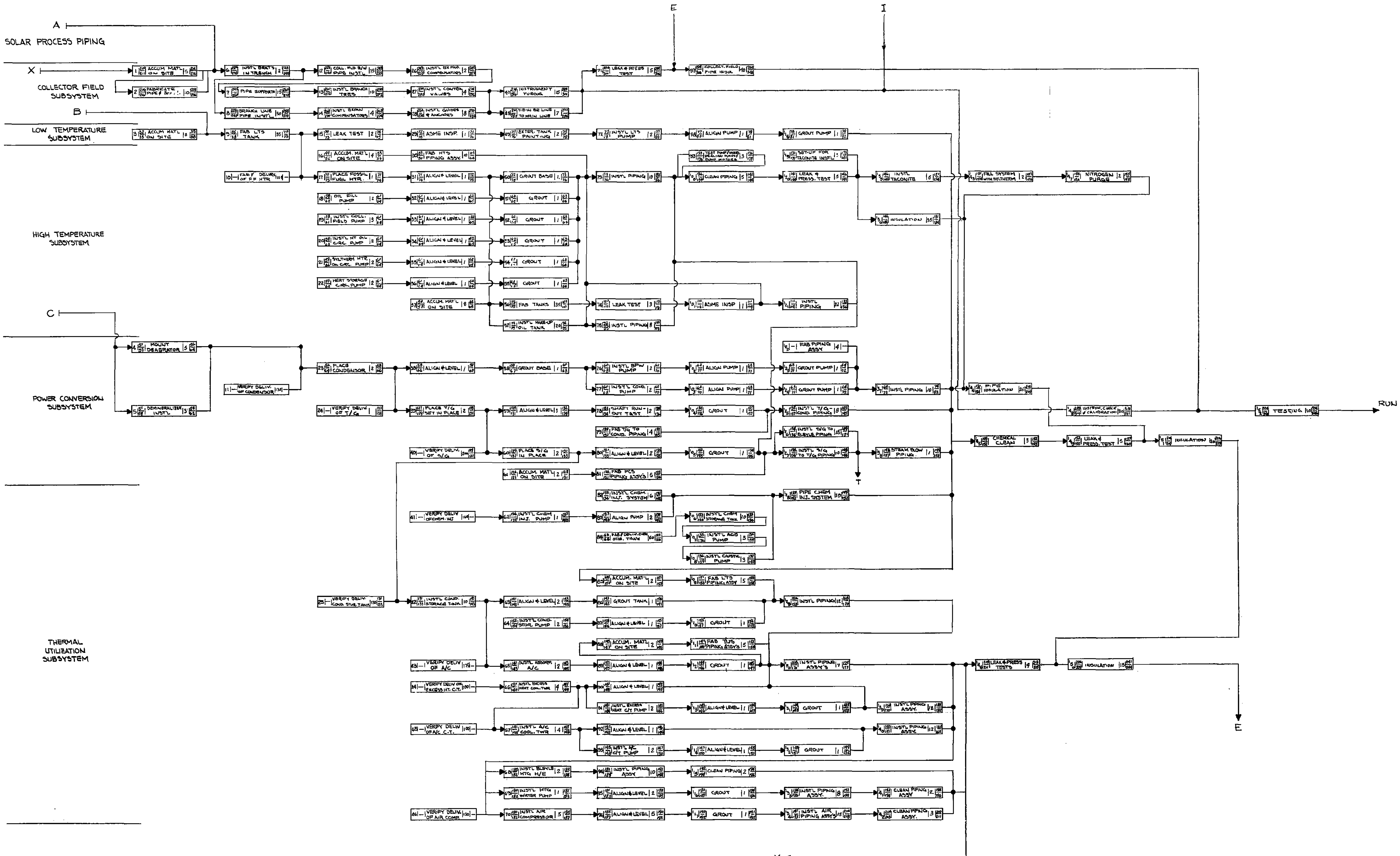
As-Built Drawings

- Direct A&E in preparation of As-Built Drawings

4.3 SCHEDULE

Enclosed are the CPM (Critical Path Management) Schedules for the STE-LSE Program Construction Cycle. These schedules contain the logic sequence of performing all contractor tasks. Each task is identified in each block by name and coded task number. The scheduled dates for start and completion of each task is shown. These schedules will be used for construction estimates and program schedules and will be available to bidders as a reference.

The STE-LSE CPM schedules will be updated prior to construction start and will be the primary tool for schedule management by the construction manager and contractors.



SYSTEM INSTALLATION NETWORK DIAGRAM - SHEET 2

2/7/79

PROCUREMENT

4.4 PROCUREMENT

4.4.1 INTRODUCTION

This Procurement Plan describes the procedures for procurement of all equipment and services required to install and erect the Solar Total Energy Large Scale Experiment (STE-LSE) at Shenandoah, Georgia. This plan is based on the procurement policies and regulations as recorded in the MATSCO Procurement Instructions, dated March 1976. The MATSCO procurement organization will coordinate its efforts with the cognizant STE-LSE program personnel. The components of the procurement activity are shown in the logic sequence of Figure 4.4-1. These activities are described in subsequent sections.

4.4.2 PROCUREMENT PROCEDURES

4.4.2.1 Procurement Administration

The MATSCO Procurement Organization for the STE-LSE will be comprised of those key personnel with procurement backgrounds based on experience derived from similar program activity. The following are the classifications and responsibilities of those individuals who comprise the procurement ogranization.

Construction Manager - That indivdual who is assigned purchasing and subcontracting administrative responsibilities for the STE-LSE construction phase.

MATSCO Project Specialist - That individual reporting to the construction manager who has responsibility for implementation of this procurement plan for the requisition of purchase parts and the negotiation and administration of subcontracts for the STE-LSE.

Purchasing Agent - That individual reporting to the construction manager who has responsibility for all purchase orders issued for the STE-LSE construction phase.

Subcontract Administrator - That individual assigned to the project specialist who assists in the administration STE-LSE construction contracts.

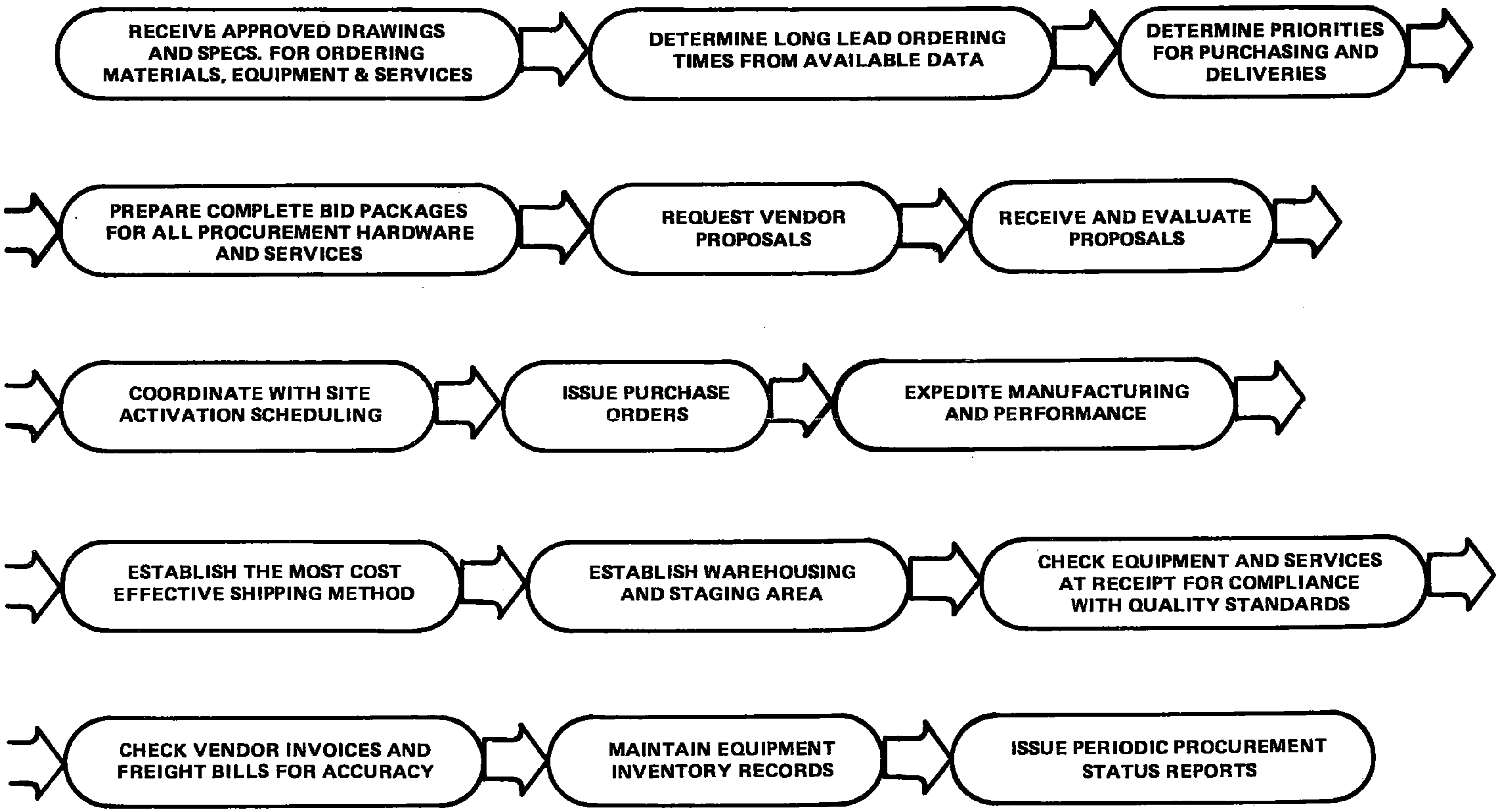


Figure 4.4-1. Procurement Flow

In accordance with General Electric Space Systems Policy 4.15 and MATSCO Procurement Instruction 1.2, Subcontractor/Vendor Contacts will be strictly and rigidly controlled by the construction manager (CM). Contacts by other individual will not be recognized as contractually binding unless authorized by the CM.

In accordance with MATSCO Procurement Instruction 2.1 all proposals must be solicited on the Request for Quotation, Form 11185-S (3/68) since the supplier must fully understand and comply with all terms and conditions. Each Request for Quotation shall include applicable specifications, drawings and purchase order supplements or special and general provisions for major procurements. If other than standard terms and conditions are to be included, such shall be attached and incorporated by reference. If an RFP entails a proposal involving technical considerations, the supplier will be requested to segregate price information and submit on separate pages for control of pricing data.

4.4.2.2 Special Governmental Requirements

It is the policy of DOE that small business concerns be afforded an equitable opportunity to compete for subcontracts within their capabilities. It is Procurement's policy to encourage participation of small business concerns in our programs and procure from small business concerns and maximum amount consistent with the efficient performance of prime contracts.

It is the policy of MATSCO to assure Company compliance with Executive Orders 1124 and 11375 by presenting the Equal Employment Opportunity Clause to suppliers. MATSCO procurement shall include reference to Equal Employment Opportunity, ASPR 12-802, in Requests for Quotation and Requests for Proposal and Purchase for subcontract orders which will exceed estimated $10,000.

Under the provisions of the Secretary of Labor Order No. 169, MATSCO is required to have on file a "Certification of Non-Segregated Facilities", prior to placing an order in excess of $10,000. Certificates will be sent with the Request for Quotation to suppliers if the certificate is not already on file with the company. Any supplier that fails to comply will not be considered for subcontracts.

MATSCO will comply with all provisions of the Labor Surplus Area Procurement Program as set forth in the Armed Services Procurement Regulations.

4.4.3 CONTRACTOR/SUPPLER SELECTION

The government approved MATSCO procurement system will be employed for hardware procurement and for site contracting tasks relative to STE-LSE.

Potential bidders for hardware procurements and site contracts will be selected on the basis of their ability to perform within technical, quality, schedule and cost parameters for a particular procurement. Potential suppliers and contractors will be considered from the following groups:

- Those who have performed satisfactorily to similar requirements in the past.
- Those on the qualified products list
- Responses from screening letters

Selected bidders will be solicited considering the following:

- Small business firms
- Companies in labor surplus areas
- Past performance as reflected in Vender Rating reports
- Firms who have expressed an interest in participating as a supplier for MATSCO
- Cost and schedule performance on similar contracts

After a list of qualified bidders has been established for individual procurements, a Request for Quotation (RFQ) will be issued in compliance with MATSCO Procurement Instructions 2.1. For material and equipment procurement the RFQ will be accompanied by a bid form and approved specifications and drawings to form a complete bid package. For construction and installation contracts, the bid package will be comprised of the RFQ, bid Form, MATSCO contract, general conditions, special provisions, statement of work and specifications approved drawings and DD Form 633 - Contract Pricing Proposal.

All vendor quotes will be received in the MATSCO office (room 7554, Bldg. 7, Valley Forge) and held in a closed file until the specified date of opening. No disclosures of any price information will be made to any personnel until the close of bidding and then only on a need to know basis. Upon close of bidding, a proposal review board will be convlened to review and evaluate all proposals. The proposal review board will meet under the direction of the manager or his designated representative. The following organizations will be requested to provide representation on the proposal.

Review Board:

1.) STE/LSE Program Management
2.) STE/LSE Program Engineering
3.) STE/LSE Quality Control
4.) Lockwood Greene Engineers

The Proposal Review Board will evaluate individual vendor proposals on the basis of the following criteria:

1.) Compliance with bidding requirements
2.) Technical proficiency
3.) Compliance with scheduling requirements
4.) Compliance with quality requirements

If, in the opinion of the construction manager, a cost breakdown is required the vendors will be requested to complete a "Subcontractor Proposal Data Sheet". Failure to submit a "Proposal Data Sheet" will be deemed sufficient grounds to invalidate a vendors proposal. The construction manager will determine which bidders are in the competitive range.

The proposal review board will recommend the three most desirable bidders in the competitive range. The board will then enter a fact finding phase during which credit reviews and vendor facility surveys will be conducted to aid in the final vendor selection. Fact finders will provide inputs to the construction manager who will make the final selection with approval by the STE-LSE program manager.

When a vendor has been selected the MATSCO project representative will notify the vendor and issue a Material Request duly authorized by a MATSCO corporate official, to the purchasing agent. For equipment procurements the Material Request will be accompanied by approved and issued drawings and specifications which will serve as a basis for the purchasing agent to issue a Purchase Order to the selected vendor. For construction and installation contracts the MATSCO project representative will first negotiate a contract with the selected vendor and then issue a Material Request to the purchasing agent. For contracts the Material Request will be accompanied by a copy of the executed contract between MATSCO and the respective contractor as well as the approved drawings and specifications. For that respective portion of work the MATSCO contract and approved drawings and specifications will serve as a basis for the purchasing agent to issue a Purchase Order to the selected contractor.

4.4.4 PURCHASED PARTS RECEIVING

Purchased hardware will be received at the MATSCO warehouse at the job site. Receiving will include accepting or rejecting material from the carrier on the basis of external condition of the material being received, verifying by physical count the quantity of material delivered as compared with the quantity ordered and issuing a notification of material received to required individuals. Receiving will also verify that received hardware part numbers agree with the purchase order. All hardware will be logged-in at the time of receipt with the following invormation:

- P. O. number of addressee
- Number of packages
- Weight of packages
- Vendor's name
- Carrier's name
- Part number

At this point, Quality Control will inspect received hardware to verify it complies with P. O. and specifications/drawings. Completed purchase orders are forwarded to MATSCO for disposition.

COST CONTROL

4.5 COST CONTROL

4.5.1

Cost control of a construction project starts prior to contractor site operations and continues until the facility is accepted by DOE. The major tool for cost control will be the accurate and timely development of a realistic Budget and Schedule, including appropriate contingencies for site changes as they occur. In the following paragraphs, the general areas affecting construction cost will be examined and the various methods for controlling costs will be discussed. The following comments are based on firm fixed pricing by contractors.

4.5.2 DESIGN

Design Support - The CM or his representative will be available to attend meetings during the definitive design and also design reviews to provide recommendations on construction feasibility, time requirements for construction, suggestions for alternate design, and areas of possible cost savings. The continuous review of the project as the designs evolve, will give the CM opportunities to suggest alternates based on his construction experience.

Construction Schedule - The construction schedule will be continuously updated during the definitive design phase. An effective construction schedule would therefore be available at the start of the construction phase. This schedule would form the basis for CM construction planning.

Construction Cost - Construction costs will be updated so that at the start of the construction Phase a realistic construction budget can be established.

4.5.3 CONTRACTS

This paragraph deals with all contracts let by the CM and starts with an approved bidders list and terminates with final payment. It is extremely important that contractors be carefully selected. Effective cost control depends on responsible, cost-conscious contractors.

Bidders List - Information will be acquired from A&E and General Electric facility sources. In conjunction with the above, the CM will send a work statement and a screening letter to prospective bidders with the following list of questions:

1.) Willingness to submit a proposal as outlined in the attached work statement.
2.) Plans for executing work on the project.
3.) Total technical and craft personnel available.
4.) Current backlog and availability of technical personnel and craft.
5.) Recent experience in performing similar projects.
6.) Experience in construction of facilities in the Southeastern United States.

The answers to the above questions will be evaluated and an approved bidders list will be developed.

RFQ and Bid Review

A request for quotation will be sent to all approved bidders. A bid review procedure is then established to select the best contractor for managing and performing the work. The bid review objective on fixed price projects is to determine the contractor who offers the lowest price and acceptable schedule and meets all technical, project execution and business requirements requested in the RFQ. The CM will use all the standard methods for testing and evaluation of each bidder, but some of the key items to look for during a visit to the company's facility are:

a.) Attitude of company officers (do they want the business).
b.) Recent change in key personnel and why
c.) Labor problems and how handled. They key items do not appear in a D&B report but are critical for a realistic appraisal.

4.5.4 LABOR RELATIONS

Labor relations is another area which is extremely important in maintaining program costs. The capability of the contractor in dealing with relations problems on similar sites is of great importance. During the evaluation phase and prior to contract award, emphasis will be given to the bidder's track record in dealing with labor problems.

4.5.5 CONSTRUCTION SCHEDULE AND CONSTRUCTION BUDGET

These are the two basic tools used by the CM to monitor fiscal condition and job progress. These are living documents which will be continually changed and updated to reflect the current condition of the project. The CM will closely monitor these documents for an early warning of any schedule or cost over runs.

4.5.6 HARDWARE AND CHANGE ORDERS

All contracts will be fixed price. Two conditions which can affect a fixed price contract are late delivery of hardware and change orders.

Hardware - Late delivery of hardware not only affects the construction schedule, but has a major cost impact. The CM will set-up a program to track hardware through the pipeline. All hardware need dates will be reviewed at predetermined time intervals. Vendor progress will be monitored by expediters on the CM staff and as the need date approaches, delivery dates will be verified. Delivery schedule slack will be maintained to assure hardware availability as required by the contractors. Where hardware delivery problems are identified, contractor work-around will be developed to continue work in a cost effective manner.

4.5.7 CLAIMS

Whenever slaims arise out of any contract, the CM shall furnish all reports with supporting information necessary to resolve the dispute or defend against the claim, participate in meetings or negotiations with the calimant or its representatives, appear before the Board of Contract Appeals or court of law, and other assistance as may be appropriate.

4.5.8 FINAL PAYMENT

On completion of the contract and the acceptance in writing thereof, the CM will make the final payment within 30 days provided that contractor has furnished evidence of payment of all taxes, subcontractors and material and with the release of any and all claims; against the Owner.

4.6 QUALITY ASSURANCE

4.6.1 INTRODUCTION

This Quality Assurance Plan describes the policies that will apply to the STE-LSE Construction Program to assure satisfactory quality of delivered hardware and site construction. This document shall be applicable to hardware procurement by the Construction Manager and hardware procurement and site construction by each of the site contractors.

Section 4.6.2 covers Quality Assurance Requirements for site contractors and will form the basis for the Contractor Quality Requirement of contractor bid packages. Section 4.6.3 contains the Quality Assurance Plan for purchased items.

4.6.2 CONTRACTOR QUALITY ASSURANCE REQUIREMENTS

4.6.2.1 General

Each contractor shall plan, maintain and implement a Quality Assurance Program for this contract. These Quality Assurance Requirements shall apply to all site activities.

QUALITY ASSURANCE

4.6.2.1.1 Quality Assurance Plan

The contractor shall implement a Quality Assurance Plan, which describes how he will ensure compliance with the requirement shown in the work statement. The plan shall be submitted to CM for approval. The plan shall cover all Quality Assurance Program activities for the program and serve as the master planning and control document. The order of the plan shall be the same as the order in which the requirements are given in this Document. The plan shall include:

a. A description of the contractor's organization, which implements the Quality Assurance Program.

b. A narrative describing each Quality Assurance Task and the contractor's execution and management approach to satisfy the requirements of this Document.

4.6.2.1.2 Management

The contractor shall designate one individual responsible for directing and managing the Quality Assurance Program. He shall have direct access to higher management.

4.6.2.1.3 Government/CM Review

The Quality Assurance System of the contractor is subject to continuous evaluation, review and verification by the CM and government.

4.6.2.2 System Safety

The contractor shall provide a Safety Plan (as part of the Quality Assurance Program Plan), for site preparation, construction, assembly and checkout of the task.

Safety analyses shall be performed and shall specifically encompass the following safety areas:

Personnel and Equipment Safety

Installation, operation, and maintenance procedures shall minimize human error or failure of equipment, injury to personnel, and damage to the owner's equipment.

Mechanisms involved shall be designed to eliminate or minimize hazards to personnel in areas where maintenance will be performed.

4.6.2.3 Quality Assurance

4.6.2.3.1 Quality System

The contractor shall maintain an effective and timely quality system to provide that defects or other unsatisfactory conditions are discovered and corrected at the earliest practical point. The system shall provide recorded evidence of quality in the form of inspection and test results. The contractor shall make this recorded evidence of quality readily available to CM, General Electric Co., and the Department of Energy.

4.6.2.3.2 Drawing and Change Control

The contractor shall ensure that articles are fabricated, inspected, and tested to the latest available drawing or specification, and that necessary changes, as directed by the CM, are accomplished and so evidenced on the inspection records of the part, component, or assembly.

4.6.2.3.3 Procurement Source Control

The contractor shall be responsible for adequate and effective control over his procurement sources to ensure that materials, supplies, components, and services purchased for use on this contract meet all quality requirements. Adequate records of inspections and tests performed at source shall be maintained, and, if required, Mill Test Reports for Rebar, anchor bolts, piping, and fittings shall be available.

4.6.2.3.4 Government Source Inspection Requirements

All orders shall include a statement which assures the following right: The government reserves the right to inspect any or all of the materials included in this Task at the supplier's plant. This also includes site inspections of all site work performed by the contractor.

4.6.2.3.5 Inspections and Tests

The contractor shall perform sufficient inspections and tests of all parts, components, and assemblies to ensure, prior to test or delivery, that all articles conform to applicable drawings and specifications with respect to all details, such as workmanship, finish, construction, functional performance, weight, interchangeability, identification, and marking. These inspections and tests shall include receiving, processing, fabrication, assembly, end item, and shipping phases. Written inspection and test procedures shall be prepared, when necessary, to make clear the details of the inspection and measuring equipment requirement, the detailed operations to be performed, and the criteria for determining quality conformance or rejection of articles.

The contractor shall perform all necessary site inspections and test to verify that the installation is in accordance with approved and issued construction drawings and specifications which define the contractor's task. Written inspection reports shall be required which define the tests conducted and the test results. The contractor has the option of using his own testing group, if qualified, or an independent testing company which has been approved by the CM.

4.6.2.3.6 Non-Conforming Articles

All deliverable materials, parts, assemblies, fabrications or placements connected with the site construction which does not conform to the specifications or drawings shall be designated as non-conforming. All non-conforming items shall be identified, segregated, and controlled until disposition is made. Disposition shall be classified as repair, use as is, or scrap. Disposition shall be based on technical assessments of the non-conforming items to perform intended functions. Decisions to accept or continue work on non-conforming articles shall be by mutual agreement between the contractor and GE. Decisions shall be documented and the documentation shall show the details of the nonconformity and the appropriate disposition along with a statement of cause and corrective action.

4.6.2.3.7 Inspection, Measuring and Test Equipment Control

The contractor shall provide and maintain suitable inspection, measuring, and test equipment of range, accuracy, and type, necessary to ensure conformance of articles to contract requirements. At intervals established to ensure continued accuracy, each unit of inspection, measuring, and test equipment shall be calibrated against certified standards, which have known valid relationships in the National Bureau of Standards. Records of calibrations performed shall be maintained. The due data, or other identification attesting to the due data, of the next calibration shall be displayed on each unit of inspection, measuring and test equipment.

Tools, gages, jigs, or fixtures which measure dimensions, contours or locations affecting quality characteristics shall be initially checked for accuracy prior to use. Periodic check and recalibration shall be made at predetermined intervals to ensure continued accuracy.

4.6.2.3.8 Inspections Status Indication

The contractor shall maintain a system for indicating the inspection status of all items under construction. This shall be accomplished by means of tags, Dwg Reference, Part No., or log books.

4.6.2.3.9 Inspections and Test Records

The contractor shall maintain adequate records of all inspections and tests performed. The records shall provide evidence that the required inspections and tests have been performed, including part or component identification, inspection or test involved, test data, nature of defects if any and basic causes for rejection. These data must cover both conforming and defective items.

4.6.2.3.10 Failure Reporting

For each functional failure occuring during construction, the contractor shall prepare an individual failure report. This report shall contain a complete description of the circumstances of the failure, analysis of causes, recommendations for corrective action, and corrective action taken. It will be reviewed by the CM and a mutually agreeable disposition reached.

4.6.2.3.11 Cleanliness Control

Assembly, inspection, storage, and test areas shall be controlled to prevent the entrapment of foreign material detrimental to system operation and life in any article used in the system. The level of storage facilities will depend on the hardware stored. The controls shall include environments, work surface tools, fixtures, test and inspection equipment, personal items, handling storage and shipping. The requirement applies to storage of contractor procured parts.

4.6.3 PURCHASED PARTS QUALITY ASSURANCE PLAN

The following requirements apply to purchased parts procured by the CM.

4.6.3.1 Procurement Documents

The responsible Quality Engineer will delineate on the Material Request (MR) the quality requirements required on the applicable purchase order. Procurement documents shall contain the following information:

- Identification of the GE drawing and specification, including revision status.
- Identification of supplier drawing and part number for commercial items.
- Applicable Quality Assurance provisions to be imposed on the supplier or subcontractor such as:
  - Material certification requirements
  - Inspection and test requirements
  - Identification and traceability requirements
  - Requirements for special cleaning, packaging, etc.

4.6.3.2 Receiving Inspection

Receiving Inspection will be performed in accordance with written inspection checklists. Receiving Inspection will verify that the data and requirements on the P.O. have been met, as defined in the Inspection Checklists Material may be accepted based upon Certificates of Compliance from accredited suppliers, unless specified otherwise in the procedures. Any tests to be performed to verify certifications will be specified in the Inspection Checklists.

Material and articles in the Shenandoah Receiving Inspection area will be segregated into three areas; those awaiting inspection, those accepted, and those rejected. Upon completion of the inspection, the inspection checklists and the purchase order will be marked with the applicable stamp and the date inspected. The inspected items or the container in the case of small items, will be marked with the appropriate stamp. For items inspected 100%, the conventional acceptance stamp will be applied. For items accepted on a lot sampling basis, the stamp may be applied to those items actually inspected and a note added to the checklist indicating that the remainder of the lot was accepted on the basis of the sample. A copy of the checklist should remain with the lot until depleted. Lots should not be mixed in order that traceability may be maintained. The markings should be visable when the material is placed on the storage racks.

The checklists, certifications and other applicable documentation will be filed in the Receiving Inspection area.

4.7 CHANGE CONTROL

Performance within the Construction Budget is largely dependent on control of changes. This is particularly true for an R&D demonstration program. Changes may be required to adjust to site condition, minor design refinements and correction of minor errors and omissions in construction drawings and specifications. Changes may be initiated by the A&E, by STE-LSE Engineering or by the Contractors. Changes with minor cost or schedule impact require only the A&E and Construction Manager approval. Changes with performance impact require the approval of the STE-LSE Engineering Manager. Changes which potentially impact the Construction Cost Budget or the Final Completion Schedule must receive Program Manager approval. The Construction Manager will be responsible for coordination and disposition of all requested changes.

4.8 ACCEPTANCE

4.8.1 CONTRACTOR ACCEPTANCE

Prior to final contractor payment, all work will be completed, all deficiencies corrected, and no outstanding work or corrective items will remain. Jointly with the A&E, the CM will make a full inspection of the site and prepare a detailed report of all work items outstanding.

4.8.2 ACCEPTANCE TEST

Acceptance tests will be performed according to the STE-LSE Acceptance Test Specification. Tests will be performed to written procedures. The system will be accepted by criteria defined in the ATS.

4.8.3 SYSTEM ACCEPTANCE

After completion of contractor acceptance and system test, the CM will prepare the final documents for system acceptance by DOE;

- Certification of payment subject to receipt of final payment to all contractors, vendors, and material suppliers.
- Waiver of liens by all contractors.
- Submission of all required operating and maintenance manuals, equipment manuals, and parts lists.
- Completion of as-built record drawings, showing details of the project as actually built.
- Summary of claims, if any, that remain for resolution of negotiation or through legal or arbitration processes.

SHIPPING COST

Item No.	Item	Shipping Route	Qty	Wt.	Size	Cost	Remarks
1	Syltherm^{TM} 800	Midland, MI	300	66 tons	55 gal. drums	8,333	8 truck loads
2	Cooling Towers	Phila., PA	2	5 tons	8' dia. x 12'	955	
3	Steam Generator	Allentown, PA	1	7.5 tons	18' x 8' x 4'	988	
4	Condenser	Newark, NJ	1	2 tons	20' x 6' x 3'	975	
5	Dearator	Chicago, IL	1	2 tons	4' dia. x 7'	370	
6	Chem Inj Unit	St. Petersburg, FL	1	200#	6' x 3' x 4'	33	
7	Control Console	Daytona Beach, FL	1	1000#	10' x 4' x 6'	266	
8	Fossil Fuel Heater	Warren, PA	1				Shipping cost included in quote
9	HTS Tanks		3				Shipping cost included in quote
10	LTS Tanks		1				Shipping cost included in quote
11	Iron Ore	Atlanta, GA		1150 tons	58 truck loads	11,500	
12	Pumps	Phila., PA	20	200#	2' x 3' x 6'	520	
13	Absorption A/C		1				Shipping cost included in quote
14	Valves	Phila., PA	100	20# each		400	
15	Make Up Oil Tank	Phila., PA	1	1500#	6' dia. x 10'	150	
16	Oil Vapor Cond. Tank	Phila., PA	1	1800#	6' dia. x 12'	160	
17	Cond. Storage Tank	Phila., PA	1	1.5 ton	8' dia. x 14'	370	

SHIPPING COST (Cont.)

Item No.	Item	Shipping Route	Qty	Wt.	Size	Cost	Remarks
18	Yoke Assy.	Trucker, GA	196	59 tons	8' x 8' x 6'	7,800	
19	Hub Assy.		196	34 tons	6' dia. x 2'	6,080	
20	Annulus		196			4,300	4 truck loads
21	Petals	Dekalb, GA → Clanton, AL College Park, GA → Site	4200			19,500	30 truck loads
22	Ribs		4200			5,200	
23	Struts					5,700	
24	Misc. Brackets					675	
25	Drive Assy.		196			4,750	5 truck loads
26	Base Assy.					6,650	7 truck loads
27	Misc. Equipment					1,500	2 truck loads
					Subtotal	87,175	
					Level of Definition Factor (1.2)		
						$104,610	

APPENDIX B

CONSTRUCTION MANAGEMENT
&
TEMPORARY FACILITIES COST

MATSCO CONSTRUCTION MANAGEMENT AND
TEMPORARY FACILITIES COST

Function	Man Hrs.	Rate	Total
I. Hardware Procurement			
A. Review Bid Packages	300	18.33	$ 5,499
B. Prepare RFQ's	400	18.33	7,332
C. Evaluate Proposals	325	18.33	5,957
D. SSO - QC Support	—	—	28,491
E. Proposal Negotiation	415	18.33	7,607
F. Vendor Progress Monitoring	310	18.33	5,682
G. T&L	—	—	18,000
H. MR & PO Activity	200	18.33	3,666
I. Purchasing Support	300	22.89	6,867
J. Finance Support	100	17.00	1,700
K. Contracts Support	100	21.00	2,100
	Hardware Procurement Total		$ 92,901
II. Contract Administration			
A. Review Bid Backages	480	18.33	$ 8,798
B. Prepare RFQ's	240	18.33	4,399
C. Evaluate Proposals	600	18.33	10,998
D. A&E QC Services	—	—	90,000
E. Contract Negotiations	175	18.33	3,208
F. MR & PO Activity	300	18.33	5,499
G. T&L	—	—	8,400
H. Purchasing Support	200	22.89	4,578
I. Finance Support	250	17.00	4,250
J. Contracts Support	350	21.00	7,350
	Contract Administration Total		$147,480

MATSCO CONSTRUCTION MANAGEMENT AND
TEMPORARY FACILITIES COST (Cont.)

	Function	Man Hrs.	Rate	Total
III.	Site Management			
	A. Site Manager	3334	18.33	$ 61,112
	B. T&L	—	—	14,000
	C. Administrative Assistant	3334	8.28	27,605
	D. Field Engineer	3334	13.53	45,109
	Site Management Total			$147,826
IV.	Temporary Facilities & Equipment			
	A. Warehouse & Staging, Area - 15,000 Ft^2 15,000 Ft^2 @ $0.14/$Ft^2$/Month for 20 Mos.			$ 42,000
	B. Site Storage Trailer - 20 Mo. @ $85/Mo.			1,700
	C. Site Office Trailer - 20 Mo. @ $240/Mo.			4,800
	D. Warehouse Security			10,000
	E. Lift Truck - 20 Mo. @ $470/Mo.			9,400
	F. Inventory Clerk	3334	8.28	27,605
	Temp. Facilities & Equip. Total			$ 95,505

I.	HARDWARE PROCUREMENT	$ 92,901
II.	CONTRACT ADMINISTRATION	$147,480
III.	SITE MANAGEMENT	$147,826
IV.	TEMPORARY FACILITIES & EQUIPMENT	$ 95,505
		$483,712

APPENDIX C

TOOLING & ONE-TIME ENGINEERING COSTS

APPENDIX C

Tooling and One-Time Engineering Costs - $486,728

11,480 Hours of Engineering Support, over a 14-month period.

Labor	$207,000
OH @ 86.5%	178,900
S/T	385,900
G&A @ 20%	77,180
	$463,080

Assembly Tooling, 4 sets @ $5,912 = $23,648

Labor Categories

E1	1200 Hours
E2	2320
E3	5160
E4	640
T5	2160
	11,480

Support Activities

1. Hardware Fabrication Support
   MRB Activity
2. Construction/Installation Support
   Design Updating
3. System/Subsystem Checkout Support

STE-LSE SHENANDOAH

GENERAL ELECTRIC

SPACE DIVISION

GENERAL ELECTRIC

SPACE DIVISION

GENERAL ELECTRIC CO., VALLEY FORGE SPACE CENTER, KING OF PRUSSIA PARK
P.O. BOX 8661, PHILADELPHIA, PA. 19101, Phone (215) 962-2000

SPACE SYSTEMS OPERATIONS

In Reply Please Refer To
Reference No. 79-STE-0241

March 5, 1979

Mr. R. A. Merkle, Staff Engineer
Energy Systems Group
The Aerospace Corporation
Suite 4000
955 L'Enfant Plaza, S.W.
Washington, D. C. 20024

Dear Bob,

A copy of the complete Original Issue of the Construction Plan for the Solar Total Energy-Large Scale Experiment at Shenandoah, Georgia is enclosed. We believe we have made changes in response to each of the comments we received from you (and others), after review of the Construction Plan draft. The enclosed pages are punched for direct insertion in the 3-ring binder you received with the Construction Plan draft. All pages of the Construction Plan draft are superseded by the enclosed Original Issue.

Please give me a call if you have comments, questions, etc. on this Original Issue of the Construction Plan, or other areas of the Solar Total Energy-Large Scale Experiment at Shenandoah, Georgia. Thanks again for your thorough and constructive review of the Construction Plan draft.

Sincerely yours,

A. J. Poche, Program Manager
Solar Total Energy-Large Scale-
Experiment at Shenandoah, Georgia
Room 7246, Building 7
(215) 962-4934

trm
Enclosure

cc: M. E. Resner, DOE-HQ
R. W. Hunke, Sandia-Albuquerque

GENERAL ELECTRIC

SPACE DIVISION

SPACE SYSTEMS OPERATIONS

GENERAL ELECTRIC CO., VALLEY FORGE SPACE CENTER, KING OF PRUSSIA PARK
P.O. BOX 8661, PHILADELPHIA, PA. 19101, Phone (215) 962-2000

In Reply Please Refer To
Reference No. 79-STE-0242

March 5, 1979

Mr. Steve Kaplan
Energy Division
4500 South Street
Oak Ridge National Laboratories
Post Office Box X
Oak Ridge, Tennessee 37830

Dear Steve,

A complete copy of the Original Issue of the Construction Plan for the Solar Total Energy-Large Scale Experiment at Shenandoah, Georgia is enclosed. It is punched for direct insertion in the 3-ring binder you received with the Construction Plan draft. All pages of the Construction Plan draft are superseded by the enclosed Original Issue.

Please give me a call if you have questions on the Construction Plan, or any other area of the Solar Total Energy-Large Scale Experiment at Shenandoah, Georgia.

Sincerely yours,

A. J. Poche, Program Manager
Solar Total Energy-Large Scale
Experiment at Shenandoah, Georgia
Room 7246, Building 7
(215) 962-4934

trm
Enclosure

cc: M. Resner, DOE-HQ
R. Hunke, Sandia-Albuquerque

GENERAL ELECTRIC

SPACE DIVISION

GENERAL ELECTRIC CO., VALLEY FORGE SPACE CENTER, KING OF PRUSSIA PARK
P.O. BOX 8661, PHILADELPHIA, PA. 19101, Phone (215) 962-2000

SPACE SYSTEMS OPERATIONS

In Reply Please Refer To
Reference No. 79-STE-0243

March 5, 1979

Mr. George N. Pappas
Government Technical Representative
U. S. Department of Energy
Albuquerque Operations Office
Special Programs Division
Post Office Box 5400
Albuquerque, New Mexico 87115

Dear George,

A complete copy of the Original Issue of the Construction Plan for the Solar Total Energy-Large Scale Experiment at Shenandoah, Georgia is enclosed. It is punched for direct insertion in the 3-ring binder you received with the Construction Plan draft. All pages of the Construction Plan draft are superseded by the enclosed Original Issue.

In the future, change pages will be sent to you as they are developed, so that your copy of the Construction Plan can be kept up-to-date.

Thanks for the help you gave us in scoping and developing the Construction Plan.

Sincerely yours,

A. J. Poche, Program Manager
Solar Total Energy-Large Scale
Experiment at Shenandoah, Georgia
Room 7246, Building 7
(215) 962-4934

trm
Enclosure

cc: M. Resner, DOE-HQ
R. W. Hunke, Sandia-Albuquerque

GENERAL ELECTRIC

SPACE DIVISION

GENERAL ELECTRIC CO., VALLEY FORGE SPACE CENTER, KING OF PRUSSIA PARK
P.O. BOX 8661, PHILADELPHIA, PA. 19101, Phone (215) 962-2000

SPACE SYSTEMS OPERATIONS

In Reply Please Refer To
Reference No. 79-STE-0248

March 9, 1979

Mr. Joe T. Ator
Manager, Solar Thermal Projects
Energy Systems Group
Aerospace Corporation
101 Continental Boulevard
El Segundo, California 90245

Dear Joe,

A copy of the Original Issue of the Construction Plan for the Solar Total Energy-Large Scale Experiment at Shenandoah, Georgia is enclosed. Bob Hunke thought it might be of interest to you.

This document is current, having just been updated to include the latest information, and changes and extensions suggested by the several persons/agencies which reviewed the first draft of the Construction Plan last fall. Bob Merkle of Aerospace was most thorough in his review and provided many helpful comments which we reflected in the enclosed document. (Bob Merkle has also been sent a copy of the enclosed document.)

Sincerely yours,

A. J. Poche, Program Manager
Solar Total Energy-Large Scale
Experiment at Shenandoah, Georgia
Room 7246, Building 7
(215) 962-4934

trm
Enclosure

cc: R. W. Hunke

STE-LSE
SHENANDOAH

GENERAL ELECTRIC
SPACE DIVISION