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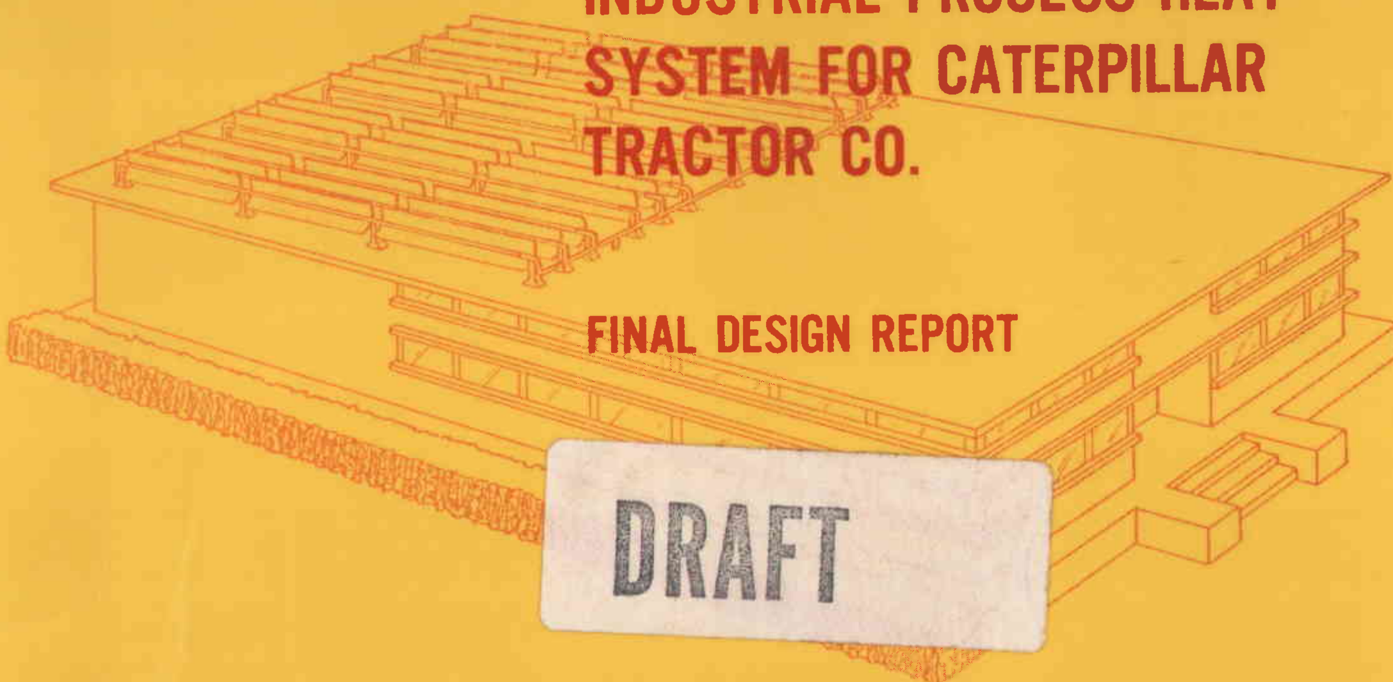
A LARGE-SCALE SOLAR INDUSTRIAL PROCESS HEAT SYSTEM FOR CATERPILLAR TRACTOR CO.



FINAL DESIGN REPORT

DRAFT

PREPARED FOR:
DEPARTMENT OF ENERGY

July 31, 1980

SOUTHWEST RESEARCH INSTITUTE
SAN ANTONIO HOUSTON

A LARGE-SCALE SOLAR INDUSTRIAL PROCESS HEAT SYSTEM FOR CATERPILLAR TRACTOR CO.

FINAL DESIGN REPORT

Prepared by:

D. M. Deffenbaugh

Project No. 02-5821

PREPARED FOR:
DEPARTMENT OF ENERGY

JULY 31, 1980

Approved:

H. Norman Abramson,
Vice President Engineering Sciences

EXECUTIVE SUMMARY

The objective of this project is to design and analyze a large-scale solar industrial process heat system for Caterpillar Tractor Co.'s San Leandro Plant. This system consists of pumping plant process water through a 50,400 ft^2 array of concentrating solar collectors.

The San Leandro plant is being moved into a new facility. The old facility's process heat requirement was supplied by a 100 psi (325°F) steam system. The new facility is having a pressurized hot water system installed (836 gpm at 40°F with process inlet temperature of 235°F and exit temperature of 195°F). This system is an ideal candidate for integrating a solar process heating system. The new plant facility consists of a two-story factory with a flat roof of 360 ft by 1092 ft (393,120 ft^2). The collector field array will be mounted on this plant rooftop right above the point of use.

Located on the east shore of San Francisco Bay, the San Leandro plant site enjoys a relatively mild climate with an average solar radiation of 1536 Btu/ft^2-day. The collector performance, therefore, is estimated to provide 12 billion Btu/yr with a peak output of 9 million Btu/hr (64% of the peak load) and a best day output of 83 million Btu/day (25% of the daily load).

The economic analysis by its very nature is presented in the form of a parameter study of the different assumed values for energy costs, fuel escalation rates, inflation rates, and system life times. As an example, an assumed fuel escalation rate of 15% above a 13% inflation rate, a 10-year system life, a $5 per million Btu fuel cost, a 1% of initial investment for yearly operation and maintenance costs, and a $1 million investment for a 42% industrial contribution of a total $2.5 million system cost would yield a 20% rate of return on the industrial partner's investment. This example shows the cost-effectiveness of this solar application.

The system developed during this program was designed to not only meet Caterpillar specifications and all local building codes, but to provide a safe, reliable, and environmentally compatible process heat system. In addition to the process heat system, an automatic data collector and evaluation system was also designed to verify the energy savings of the system and to provide data for future solar process heat system designers.

The final system configuration was optimized with regard to component selection, collector array layout, piping system layout, and component sizing. The communication of the final design details are given in the two Appendices of this document including all final design drawings and specifications.

The end result of this program is the generation of contract documents that are ready to go out for bids to initiate the construction phase of this program. The construction phase of this program is estimated to start in early 1981 and be completed in mid-1982. As proposed in this document, the Final System Design has shown that solar production of industrial process heat is on the verge of being competitive with all of

the conventional forms of energy used to provide process heat. The major item in the construction of this system is the solar collectors which are hand-made items. When this item is mass produced, the cost of these systems should provide a cost-effective investment for industrial process heat applications. To guarantee that the expertise in designing, constructing and operating these systems is available when this happens, cost-sharing programs like that conducted during this project must be conducted at this time if the United States has any chance to become energy sufficient by the turn of the century.

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I. INTRODUCTION

This document is the Final Design Report for DOE Contract No. DE-FC03-79CS 30309 (SwRI Project No. 02-5821). The project was conducted as a joint effort by Southwest Research Institute (SwRI), Caterpillar Tractor Co. (CTCo.), and Bissell & Karn, Inc. The objective of this project is to design and analyze a large-scale solar industrial process heat system. The system designed during this project is an extension of the current plant process heating system at the Caterpillar San Leandro facility. Process hot water is pumped from the existing plant process hot water return line through a collector array of 50,400 ft^2 consisting of 60 rows of 120 ft long parabolic trough concentrating collectors and then returned to the same process line downstream of the suction point. During clear sky conditions the system provides over 60% of the instantaneous process hot water requirement of the plant by heating process water from 195°F to 235°F. The simplicity of this system provides a cost effective and reliable solar industrial application.

A complete analysis including thermal performance, economics, safety, environmental impact assessment, and wind loading has been conducted and is outlined in this report. These analyses were used in conducting design trade-offs in order to develop an optimized preliminary system design. This preliminary design was then developed into a detailed design in the form of Final Design Drawings and System Specifications. All of these items are discussed in detail in the subsequent sections of this report.

II. INDUSTRIAL PLANT

A. Plant Site

The facility considered for this large-scale solar process heat demonstration project is Caterpillar Tractor Co.'s San Leandro Plant. This plant produces a variety of engine components for use in Caterpillar diesel engines. This operation is currently being moved from the present location to a newer, larger location just down the road. The old facility was supplied with industrial process heat by a 100 psi (325°F) process steam system. In keeping with Caterpillar Tractor Co.'s major energy conservation effort, the new facility is having a pressurized hot water system installed. An analysis was conducted of the plant operation to determine the minimum supply temperature possible. The results of this analysis indicated a process heat supply temperature of 235°F at 15 psig. In this manufacturing operation the major energy consumer is for industrial parts washing. These washers are required to clean parts after critical machining operations so that inspection can be performed for quality control. The impact on energy consumption of these parts washers has necessitated a major effort to investigate ways of reducing the total energy required. A major effort has been underway to replace a large number of high-temperature washers with medium- to low-temperature washers and, wherever possible, with room temperature washers. This investigation has centered on testing the effectiveness of lower temperature detergents. Unfortunately, some of the final machining operations prior to priming the end product still require the high-temperature washers. The process water temperature of 235°F is, therefore, the minimum possible. When this pressurized process water system is successfully integrated with a solar collection system, this project will have widespread implications for all of the other Caterpillar manufacturing facilities.

A drawing of the process heat supply system at the San Leandro plant is shown in Figure 1. Basically, hot water is generated in the hot water "boilers" and is then pumped through a hot water supply header (HHWS) that rings the building. Every 40 feet there is a 2-inch valved outlet for connection to process equipment and an accompanying 2-inch valved inlet to the hot water return header (HHWR). The cooled process water is then returned to the "boilers" via boiler feed pumps. The building circulation pump system consists of four hot water pumps piped in parallel; likewise, the boiler feed pump system also consists of four hot water pumps piped in parallel. The maximum required flow rate for 20°F temperature difference through the process equipment is 1672 gpm and 836 gpm for a 40°F temperature difference. The process hot water generating system is comprised of two natural gas fired hot water heaters (or "boilers") rated at 500 boiler horsepower which is equal to 16,738 MBH (10^3 Btu/hr). A list of the process heating loads is shown in Table I. The maximum total load is 32,528 MBH with a 10% (3000 MBH) reserve. Since most of the process equipment is intermittent service, past plant experience indicates a 14,000 MBH design criteria for the manufacturing process.

This manufacturing operation is located in a two-story factory with a flat roof of 360 ft by 1092 ft (393,120 ft^2). Ths support structure for this roof consists of a truss structure between support columns spaced on 40-ft

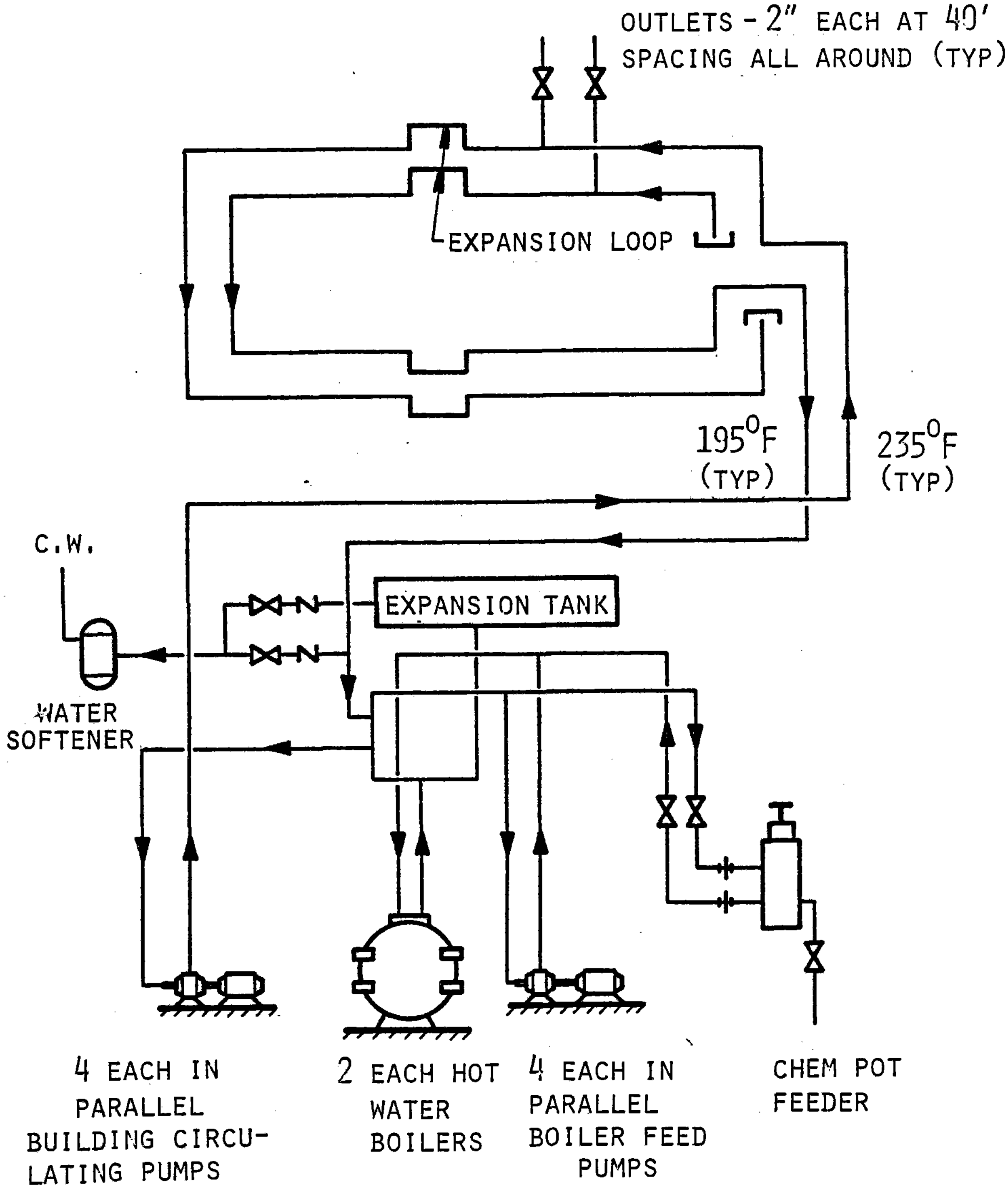

FIGURE 1. PROCESS HOT WATER FLOW DIAGRAM

TABLE I. PROCESS HEATING HOT WATER LOAD

Description	Connected Load*				
	Quantity	Flow Duration	System Type	Heating (MBH)	Water Flow (GPM)
Process washer	1 each	Intermittent	Closed	10,508	525
Process washer	6 each	Intermittent	Closed	8,407	420
Office heating	52,000	Intermittent	Closed	7,800	390
Tumbling area	2 each	Intermittent	Closed	1,201	60
Tacco H.T. unit	4 each	Intermittent	Closed	1,201	60
Wash and test - Met Lab	1 lot	Intermittent	Closed	300	15
Insulation line loss	1 lot	Continuous	N.A.	111	0
Reserve	10%			3,000	150
Total				32,528	2,620

Caterpillar Tractor Co. design criteria (including diversity)
manufacturing process 14,000

* Process heating hot water boiler ratings. Each boiler (500 boiler horsepower) equals 16,737.5 MBH, 1672 gpm flow rate for 20°F temperature difference, or 836 gpm flow rate for 40°F temperature difference.

centers with steel 10-inch I-beam purlins on 6-2/3 ft centers. These purlins are oriented in the north/south direction so that the installation of the collector field will be oriented with the collector axis of rotation in the north/south direction.

Since the collector field is proposed to be installed on the second story roof top of the industrial plant, factors pertaining to topography, geologic stability, hydrologic conditions, adequate open land area, and land use restrictions are not relevant. As with any other application in a large metropolitan area, however, the collector field will be visible to air traffic, but since the type of collector chosen will either be facing the factory roof or pointing directly at the sun focusing all the rays from the sun onto an absorber tube, there is no danger of glare from the collectors causing a hazard to aircraft or vehicular traffic. The only potential problem with the location selected is the severe seismic zone that the plant is located in. The type of collector selected has a much larger horizontal wind load design requirement than the maximum expected seismic load.

B. Climatological Summary

The climatological characteristics of this site have three outstanding features: mild year-round temperatures; low overcast, clearing by noon with almost no rain during the summer; and copious rains during the winter.

good word

Located on the east shore of San Francisco Bay, San Leandro enjoys a climate more equable than would be expected if only latitude were considered. Because of the prevailing westerly winds from the Pacific, where temperature varies very little between winter and summer, winters are mild and summers are cool. On an average of about 4 days a year, when northeasterly winds have overcome the prevailing westerly wind, daytime temperatures may reach into the nineties, and on rare occasions (6 times since 1928) temperatures of 100° or higher have been recorded. Although during the winter about 6 days with minimum temperatures of 32° or below can be expected, some flowers are usually in bloom, and hardy shrubs seldom are damaged due to any prolonged hard freezing. The average date of the last freeze in the spring is February 3, but freezing temperatures have been reported as late as April 6. The average date of the first freeze in the fall is December 12, although temperatures of 32° or lower have been observed as early as November 4.

Since 1928 the total annual rainfall has ranged from a low of 8.34 inches in 1929 to a high of 29.54 inches in 1941. About 90% of the annual total rainfall is received in the six months, November through April. During the 100-day period, June 15-September 22, the normal rainfall is only 0.07 inch. In spite of the almost rainless summers, however, cooling sea breezes, morning overcast and rather high relative humidity prevent any semblance of a desert climate.

Separating San Leandro both geographically and climatically from its neighboring communities to the north and east, is a range of hills 700 to 1900 feet in height, roughly paralleling the Bay shore and lying about 4 miles inland. East of these hills, summers are normally free of fog, have low humidities, and afternoon temperatures 15° to 25° higher than San Leandro. In winter, local variations in temperature are not so apparent, with the entire East Bay area registering daily high and low temperatures comparable to those of San Leandro.

The long-term climatological data for San Leandro is shown in Table II. Since long-term solar radiation has not been measured at San Leandro, the SOLMET weather table for Oakland was used for determining the estimated solar radiation. A summary of the total solar radiation on a horizontal surface is shown in Table III.

C. Caterpillar Design Procedures

The following procedures or "design concepts" were followed during the design phase of this project. While it first appeared to be somewhat cumbersome, these procedures provided all of the necessary checks and balances to assure a successful design and an accurate construction bid package which will greatly minimize the possibility of any construction overruns during that phase of the project.

1. Intent of Concepts

Design concepts are intended to provide the Consultant an understanding of how Caterpillar Tractor Co. (CTCo.) approaches a project and what CTCo. expects from the Consultant. Criteria is issued to the Consultant, who shall review same in preparation for discussion with the CTCo. design staff. A meeting for this discussion will normally be scheduled before detailed design work commences. The total criteria to be presented to the Consultant will include Design Concepts, Guide Specifications, Guide Details, Planning Drawings and Flow Charts.

The Consultant shall familiarize himself with Division A of the Design Concepts and disseminate the information to all discipline group leaders.

Although SwRI has been retained by CTCo.'s Technical Center, D&C will retain control of design reviews and preparation of construction contract documents. If SwRI receives direction from other parties, SwRI should advise that all design direction be relayed through D&C.

2. Definition

a. Owner: Caterpillar Tractor Co. (CTCo.) Note the abbreviation "Co." is always used.

b. Design & Construction (D & C): D & C, a Division of Caterpillar's corporate Facilities Planning Department, is responsible for the design and construction of major facilities.

c. Consultant: The Consultant is Southwest Research Institute (SwRI).

d. Client Plant: The Caterpillar Tractor Co. organization for which the project will be built, i.e., the San Leandro Plant.

TABLE II. CLIMATOLOGICAL DATA FOR SAN LEANDRO

Latitude: 37°44' Longitude: 122°12' Elevation: 6'

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
TEMPERATURE(°F)													
average monthly	48.6	51.9	53.7	56.1	58.9	61.9	63.1	63.5	64.5	61.1	55.3	49.9	57.4
average daily max/min	55/43	58/46	60/47	63/49	65/52	69/55	70/56	70/57	72/57	69/53	62/49	56/44	64/51
extreme max/min	74/32	74/37	82/35	88/39	98/43	94/50	99/52	89/50	96/49	89/42	78/37	73/26	99/26
DEGREE DAYS													
heating (base 65°F)	508	367	350	270	193	114	80	74	59	135	291	468	2909
cooling (base 65°F)	0	0	0	0	0	21	21	28	44	14	0	0	128
WIND													
Mean speed (mph)	6.7	7.3	9.0	9.5	10.0	10.0	9.3	9.0	7.8	6.8	6.3	6.5	8.2
Max. speed* (mph)	46	49	45	35	38	42	28	29	33	43	46	48	49
Prevailing direction	SE	W	W	W	W	W	WNW	WNW	WNW	WNW	WNW	E	W
FREEZE DAYS PER MONTH	<0.5	0	0	0	0	0	0	0	0	0	0	1	1
PRECIPITATION (in. water)													
average	4.03	2.83	2.32	1.58	0.55	0.14	0.01	0.03	0.18	1.08	2.37	3.57	18.69
max/min	8.90/0.65	8.85/0.02	5.69/0.04	4.60/T	3.42/T	1.21/0.00	0.80/0.00	0.34/0.00	3.27/0.00	8.56/T	7.42/0.00	11.3/0.28	11.3/0.00
RELATIVE HUMIDITY(%)													
4 AM	83	81	80	80	83	85	87	87	83	80	82	82	83
10 AM	77	75	72	68	71	74	76	76	73	72	75	75	74
4 PM	72	69	66	63	65	68	68	68	64	64	69	71	67
10 PM	80	79	76	76	79	82	84	84	80	77	78	80	79

*"fastest mile"; speed is fastest observed 1-minute value.

Source of climatological data: NWS climatic summary.

TABLE III. SOLAR RADIATION DATA FOR SAN LEANDRO

MONTH	RADIATION, KBTU/FT^2*
JAN	26.2
FEB	25.3
MAR	44.7
APR	61.2
MAY	70.4
JUN	71.8
JUL	71.5
AUG	64.7
SEP	47.4
OCT	33.7
NOV	25.3
DEC	18.3
YEARLY	560.7 KBTU/FT^2 YR.
AVG	1536.0 BTU/FT^2 DAY

* TOTAL SOLAR RADIATION ON A HORIZONTAL SURFACE BASED ON STANDARD YEAR SOLMET DATA FOR OAKLAND CALIFORNIA (1962)

e.	Project Engineer:	The member of D & C responsible for coordinating the design activities of Design & Construction, the Client Plant and the Consultant.
f.	Staff Engineer: Staff Architect:	The member of D & C responsible for his design discipline and its conformance to CTCo. requirements.
g.	Plant Representative:	The member of the Client Plant responsible for transmitting the Client Plant's requirements to D & C.
h.	Owner's Representative:	The on-site delegate of CTCo. responsible for field administration of the project. Most correspondence during Phase "D" is directed to him.
i.	Planning Drawings:	Drawings prepared by the Client Plant which indicate process requirements.
j.	Design Concepts:	Directions, ideas or philosophies to air in reaching a common understanding with the Consultant for the development of the design.
k.	Guide Specification:	Specifications prepared by D & C to guide the Consultant in his development of final specifications for the Contract Documents.
l.	Guide Details:	Details prepared by D & C intended to guide the Consultant in his development of Contract Documents.
m.	Phase "A":	Phase "A" is the Onwer's feasibility study of the project and includes a feasibility estimate and schedule. Normally the Consultant has no involvement in this phase.
n.	Phase "B":	Phase "B" is normally the first phase involving the work of the Consultant. The intent of this work is to: a. Establish the concepts which define the scope of the project, prove the functional capability of each system and assure that the detailed development in Phase "C" will follow the scope established in Phase "B".

b. Provide an accurate schedule and estimate which will be part of an investment proposal for an administrative decision to proceed with the project.

o. Phase "C": Phase "C" is that portion of the design which develops the Phase "B" Concepts into Contract Documents. The combination of Phase "B" and Phase "C" constitute DOE's Phase I.

p. Phase "D": Phase "D" is the construction phase of the project and begins with awarding the first contract and ends at the time of Owner acceptance of the complete project. This phase corresponds to DOE Phase II.

q. Responsibility List: A list prepared for internal use by the Owner which defines the responsibilities of the Client Plant and D & C in relation to the project.

r. Flow Charts: Charts prepared by D & C which define the routing procedures of Contract Documents, submittals, and administrative paper work between the Client Plant, Owner's Representative, Contractor, Consultant, D & C and others as appropriate.

s. Addendum: A document issued by the Consultant to the bidders during the bidding period, which alters the Contract Documents.

t. Bulletin: A document issued by the Consultant to the Contractor after award of contract indicating contemplated changes in the work on which pricing and scheduling changes are requested.

u. Field Order: A document issued to the Contractor by the Owner's Representative after award of contract authorizing changes in the work, the cost of which will be determined in accordance with applicable provisions of the Contract Documents.

v. Change Order: A document issued by the Consultant, at the direction of the Owner's Representative, authorizing the Contractor to make changes in the work as shown on a Bulletin or approving the pricing of changes in the work required by a Field Order.

w. Logic Network: A network developed for a typical manufacturing facility and portraying the information flow during Phase "B" design between the Owner and the Consultant.

x. Project Manual: That portion of the Contract Documents which consists of the Instructions to Bidders, proposal form, General Conditions and the Specifications.

y. Criteria: That data which is presented to the Consultant upon which the design shall be based. It includes the Design Concepts, Guide Details, Planning Drawings and Flow Charts.

3. Project Scope

This section of the Concepts defines the project in general terms for the purpose of outlining the scope of the work.

The general scope for this project was originally developed by SwRI and the Technical Center. However, D & C intends to coordinate SwRI design to produce construction documents which will satisfy both DOE and D & C requirements for competition general contract bidding and award.

4. Consultant's Work

This section is intended to define the extent of the Consultant's work but is subservient to the specific design discipline concepts or later guidance from a discipline. The work will be executed in Phases which may overlap if early construction contracts for certain portions of the work are required.

During Phase C the Consultant prepares Contract Documents for construction. The breakdown of contracts will be determined by D & C and the Consultant. Bids will be received, evaluated and awarded by the owner.

Phase D is the construction phase of the project. The Owner's Representative will administer construction contracts. The Consultant will answer Contractor's questions.

Studies and reports must be identified and approved on an individual basis.

Each design discipline has, within its own design concepts, determined how much detail is requred for Phase B and Phase C work. The Consultant's Project Coordinator, as well as the team members, should become familiar with these requirements before proceeding with detail drawing work.

The Consultant is responsible for determining compliance requirements of CTCo. facilities with respect to the most stringent applicable codes, regulations & standards. The criteria described in the planning drawings, guide details, guide concepts, and guide specifications constitute the minimum standards acceptable to CTCo. The facility shall be designed to meet or exceed the compliance requirements unless directed otherwise by CTCo.

5. Communication

This section is intended to establish the lines of communications for documents used in administrating the design and construction of a project.

The following are the project coordinators. All written communication shall be directed to these individuals unless otherwise indicated on the flow charts:

Consultant Project Coordinator
D. M. Deffenbaugh

Southwest Research Institute
P. O. Drawer 28510
6220 Culebra Road
San Antonio, TX 78284
Phone: (512) 684-5111, Ext. 2384

Client Plant Representative:
W. Divoky

Caterpillar Tractor Co.
San Leandro Plant
800 Davis Street
San Leandro, CA 94577
Phone: (415) 483-6000, Ext. 325

D & C Project Engineer:
J. W. Crow

Caterpillar Tractor Co.
Design & Construction Division
100 NE Adams Street
Peoria, IL 61629
Phone: (309) 675-5504

Technical Center Representative:
W. H. Belke

Caterpillar Tractor Co.
Non-Metallic Meterials
Building E
Technical Center
Peoria, IL 61629
Phone: (309) 578-6775

Transmittals: Items to be transmitted without a formal letter shall be accompanied by a transmittal sheet which identifies the materials and the purpose for which they are being transmitted.

Transcripts: The Consultant shall make transcripts of all meetings and conversations in which directions are given or decisions are made, and shall transmit same to the project engineer within one week of the date of the communication.

Copies of internal meetings and decisions will be sent to the Consultant.

6. Project Manual

This section of the Concepts defines the content of the Project Manual, establishes a format for the Specifications and provides information relative to approved manufacturers.

The Project Manual includes the following:

Specifications

Consultant shall edit the CTCo. guide specifications to suit the project.

A cover sheet which states the name of Owner, the project title, the contract designation, the name and address of the Consultant and the date of issue shall be provided as the first page of the Project Manual. A cover sheet is not required for each individual specification section.

A table of contents shall follow the cover sheet.

An index sheet shall be provided for the General Conditions and each section of the Project Manual, and shall have the following heading:

CATERPILLAR TRACTOR CO.	TITLE OR SECTION NO.
CONSULTANT NAME & PROJECT IDENTIFICATION NO.	PAGE NO.
PROJECT NAME AND CONTRACT IDENTIFICATION	
PROJECT LOCATION	

Specifications are to follow the format of CTCo. Guide Specifications, using the applicable section titles shown in the Index of Guide Specifications, included as part of this Section of the Concepts, CTCo. Guide Specifications are constantly being updated. A current set will be issued to the Consultant as part of the criteria at the beginning of the project. Immediately prior to editing the Guide Specifications during Phase C, the Consultant shall prepare a list of section titles and their respective issue dates. This list shall be transmitted to the Project Engineer who will compare it to the then current CTCo. specification issue dates. Revised specifications will be issued to the Consultant as required.

The product manufacturers currently listed in the Guide Specifications have been investigated, evaluated for quality and performance and approved by CTCo. However, the Consultant may recommend manufacturers to D & C for approval and inclusion in the Specifications. All manufacturers shall be approved prior to bid issue.

Prior to final printing of Specifications, the Consultant shall verify that each manufacturer listed can supply the equipment or product specified and they will perform as intended without major modifications.

The terms "approved equal" or "similar to" shall not be used. A copy of the project manual is included in this report as the Specifications Section of this document.

7. Schedules and Estimates

Schedule No. 2 is prepared by D & C and the Consultant and is the schedule for Phase C design.

Schedule No. 2 sets dates for design reviews, contract package issuances, contract awards, and construction duration. Schedule No. 2 establishes the timing of expenditure on which the Owner's investment proposal is based.

Funding of all major projects requires CTCo. management approval.

An "Investment Proposal Estimate" is prepared by the Consultant and submitted to D & C. D & C may elect to make a parallel estimate for comparison with the Consultant's estimate. Since this estimate establishes the budget, it is expected that the contract costs resulting from the completed design will fall within the budgeted amount. D & C will finalize the estimate and submit it to CTCo. management for final approval.

8. Contract Drawings

Caterpillar Tractor Co. microfilms all final construction drawings. Certain minimum properties required for reduction & reproduction are described in this section.

Original tracings shall be on "Mylar" or Linen.

All sheets shall have a printed border, title block and issuance block. The borders shall be divided and sheet centerline marks shall be provided, as well as title and issue block.

Care shall be used when revising original tracings to maintain legibility when drawings are reduced for microfilming. The Consultant shall verify all tracings for microfilming integrity after updating for as-built drawings, and prior to transmittal to D & C.

Reduced copies of all the final construction drawings are included in this report in the Design Drawings section of this document.

9. Codes, Regulations and Zoning Ordinances

This section describes the work to be performed by the Consultant in his investigation of codes, regulations and zoning, and the effect of these on the proposed project.

Early in Phase "B" the Consultant shall submit a list of all codes, regulations, and zoning ordinances which will govern the proposed project. D & C will advise the Consultant which of those documents listed shall be sent to D & C.

In all cases, the Consultant shall be required to examine all codes, regulations and ordinances to determine the most stringent regulations applicable.

Upon completion of the code analysis the Consultant shall transmit a report of his investigation which is cross-referenced to the applicable codes. The Consultant shall itemize all building features that are non-conforming, and shall indicate the variances required for legal purposes and the government agencies to be contacted. The Owner shall contact the governing agencies for all variances and permits.

10. Assigned Caterpillar Personnel

Caterpillar Tractor Co. maintains a staff of architects and engineers who are assigned to each project. Their responsibilities include:

Providing direction that defines the Owners objectives and requirements of the project.

Monitoring the work as it is developed and certifying that completed work adequately satisfies the Owner's requirements.

The D & C personnel assigned to this project are:

Discipline	Name	Telephone No.
Project Engineer	J. W. Crow (John)	(309) 675-5504
Architect	F. D. Stewart (Floyd)	(309) 675-5513
Electrical Engineer	R. A. Zinkwich (Bob)	(309) 675-4184
Mechanical Engineer	J. W. Crow	(309) 675-5504
Structural Engineer	D. A. Kock (Denny)	(309) 675-5519

11. Confidentiality of Information

All CTCo. projects are considered confidential until an official public announcement is made by CTCo. management.

The Project Engineer will inform the Consultant in writing when such public announcement has been made. Prior to receipt of this letter the Consultant shall not divulge any information about the project to any news media, industry-related reporting service or organizational publications, or any other person or firm. This shall include potential suppliers of materials for the proposed project.

Consultant shall use his best efforts to assure that those to whom he need divulge such information assume the same obligation as the Consultant with respect to preservation of the confidentiality of this project.

12. Energy Conservation

The conservation of energy is a very real concern to Caterpillar Tractor Co. in both the design and operation of its facilities. It is the responsibility of the consultant working with the D&C design staff to adequately evaluate alternate designs or operating characteristics which affect the overall facility efficiency and consumption of energy and incorporate those items approved by D & C into the final design. The resport which the Consultant prepares for the DOE will suffice as the enrgy conservation report.

III. THERMAL PERFORMANCE ANALYSIS

In order to develop an accurate investment proposal, an economic analysis was conducted to determine the rate of return on investment of both the industrial partner's contribution and the total investment for construction. One of the major parameters in this analysis is the energy supplied by the solar collection system. The energy supplied was determined by conducting a thermal performance analysis of the solar IPH system. As a part of this thermal analysis, a number of design trade-offs were investigated, the results of which will be outlined later in this report under the preliminary design section of this document.

The thermal analysis is based on the five equations below used to evaluate collector efficiency and useful energy gained:

$$Q_u = \dot{m}C_p \; (T_{fo} - T_{fi}) \tag{1}$$

$$Q_u = \eta \; A_c \; I_{DN} \tag{2}$$

$$\eta = Ka_o + a_1 \; X + a_2X^2 \tag{3}$$

$$X = \left(((T_{fo} + T_{fi})/2) - T_{amb}\right)/I_{DN} \tag{4}$$

$$K = K_S K_E K_{\tau\alpha} \; K_D K_W \tag{5}$$

where

	Q_u	= useful energy gained, Btu/hr
	$\dot{m}$	= collector transfer fluid mass flow rate, lb/hr
	C_p	= transfer fluid specific heat, Btu/lb-°F
	T_{fo}	= fluid temperature at the collector array outlet, °F
	T_{fi}	= fluid temperature at the collector array inlet, °F
	T_{amb}	= average monthly daily ambient temperature, °F
	η	= collector efficienty, %
	A_c	= collector area, ft^2
	I_{DN}	= direct beam solar radiation, Btu/hr-ft^2
	K	= incident energy correction factor
	X	= operating parameter
	a_o, a_1, a_2	= efficiency curve coefficient
	K_S, K_E, $K_{\tau\alpha}$, K_D, K_W	= incident beam angle correction factors for shading, end losses, transmission-absorption losses, dust buildup losses, and losses due to weathering of optical surfaces.

A computer program was developed to solve the above set of equations. The known parameters in this set of equations are:

T_{fi} = average plant process HHWR line temperature of 195°F

C_p = specific heat of water at the average collector fluid temperature under clear sky conditions equal to 1.005 Btu/lb-°F

m = mass flow rate based on an outlet collector temperature equal to the average HHWS line temperature of 235°F under clear sky conditions equal to 7204 lb/hr per row (15 gpm/row)

A_c = collector aperture area of 840 ft^2 per row and 50,400 ft^2 total

a_o = optical efficiency under ideal test conditions of 0.66 based on Sandia test data (March 1980)

a_1 = 1st order thermal loss coefficient of 0.04106 Btu/hr-ft^2°F based on Sandia test data (March 1980)

a_2 = 2nd order thermal loss coefficient of 0.03990 $(Btu/hr\text{-}ft^2°F)^2$ based on Sandia test data (March 1980)

K_D = dust buildup loss coefficient of 2% based on McDonnell Douglas data at 0.28%/day and a wash cycle of 15 days (using the midpoint of 7-1/2 days)

K_W = optical surface weathering coefficient of 5% based on McDonnell Douglas data at 1%/year and a reflector life of 10 years (using the midpoint of 5 years)

The variables in this set of equations are:

I_{DN} = direct normal solar radiation calculated by reading the total global radiation from the SOLMET weather tape for every hour of the year and using a modified Liu and Jordan technique developed by Collares-Pereira and Rabl.*

T_{amb} = ambient temperature read from the SOLMET weather tape.

K_S = incident beam angle correction factor for shading calculated for the given hour in question

K_E = Incident beam angle correction factor for end losses calculated for the given hour in question.

*Collares-Pereira, M., and Rabl, A., "The Average Distribution of Solar Radiation - Correlation Between Diffuse and Hemispherical and Between Daily and Hourly Insolation Values," Solar Energy, Vol. 22, 1979.

$K_{\tau\alpha}$ = incident beam angle correction factor for transmission-absorption losses calculated for the given hour in question.

The unknown parameters in this set of equations are determined by combining the known parameters as given above with the variables at each hour of the year, then solving the set of five equations and five unknowns. These unknowns are: K, X, η, Q_u, and T_{fo}. The hourly values are then combined to obtain the system performance shown in Table IV for the Solar Kinetics T-700 collector. A similar analysis was employed for conducting design trade-offs as will be outlined in the Preliminary Design section of this report. A summary of system peak performance for both peak hourly collector output and best day collector output is given in Table V. Two potential factors that could lower the above estimation are parasitic power consumption (see Table VI) and thermal losses from the piping system. Both of these factors were investigated and found to be insignificant in comparison to the uncertainty of collect performance data and weather data, i.e., less than 1% each.

TABLE IV

SYSTEM PERFORMANCE FOR THE SOLAR KINETICS T-700 COLLECTOR IN AN ARRAY OF 50,400 FT^2

MONTH	TOTAL HORIZONTAL* RADIATION $KBTU/FT^2$	USEFUL ENERGY** COLLECTED, $KBTU/FT^2$
JAN	26.2	16.0
FEB	25.3	6.4
MAR	44.7	15.0
APR	61.2	28.9
MAY	70.4	35.3
JUNE	71.8	36.6
JULY	71.5	34.9
AUG	64.7	29.8
SEPT	47.4	16.9
OCT	33.7	10.2
NOV	25.3	6.6
DEC	18.3	3.2
YEARLY	560.7 $KBTU/FT^2$ YR	239.8 $KBTU/FT^2$ YR
	1536 BTU/FT^2 DAY	12.084×10^9 BTU/YR

* BASED ON STD SOLMET YEAR (1962)

** MODIFIED SANDIA TEST DATA (MAR 80)
MATERIAL DEGRADATION = 1%/YR (10 YEAR LIFE)
DUST EFFECT = 0.28%/DAY (15 DAY WASH CYCLE)
$\eta = 0.614 - 0.04106\,(\Delta T/E) - 0.0399(\Delta T/E)^2$

TABLE V.
SUMMARY OF PEAK PERFORMANCE

HOURLY

- PEAK HOURLY COLLECTOR OUTPUT = 9 MMBTU/HR
  (NEW AND CLEAN)
- PLANT DESIGN LOAD = 14 MMBTU/HR
- PEAK SOLAR CONTRIBUTION = 64%

DAILY

- BEST DAY COLLECTOR OUTPUT = 83 MMBTU/DAY
  (5 YR OLD AND 7 DAYS SINCE WASHING)
- PLANT DESIGN LOAD = 336 MMBTU/DAY
  (24 HOUR OPERATION)
- BEST DAY SOLAR CONTRIBUTION = 25%

TABLE VI.

SUMMARY OF PARASITIC POWER

- Tracking System (1842 watts continuous)
  - Minimum collector output - 1/4%
  - Maximum collector output - 1/15%
- Pumping System (20 hp)
  - Minimum collector output - 2%
  - Maximum collector output - 1/2%
- Total System Power
  - Average collector output - <1%

IV. ECONOMIC ANALYSIS

A. Analysis Techniques

The capital budgeting technique which will be used to evaluate the economic feasibility of this solar IPH system is the internal rate of return (IROR) or return on investment (ROI) method. To aid the evaluation an annual required revenue and a payback period will also be determined. Each of these assessment techniques are based on a methodology developed at Lawrence Livermore Laboratory.* According to a recent study of a number of large corporations, the preferred evaluation technique for potential investments was an ROI determination, with calculation of a payback period ranking second or third in importance. Therefore, the procedure indicated above is an acceptable, if not favorable, method to follow. Although there are many non-quantitative factors which enter into a potential solar investment decision making process, such as future pricing trends of fossil fuels, and the perceived long-term risk of solar systems, most companies can be expected to begin an analysis by quantitative calculations based on the best financial and performance information available. While this technique will be used for comparison with other projects by DOE, Caterpillar Tractor Co. will conduct a separate internal analysis for use in determining its cost share for Phase II. Its basic technique is also a rate of return analysis, though the input parameter may be somewhat different. The objective of this analysis therefore is to present a parametric evaluation of the project for comparison purposes.

The analysis begins with an expression for the annual required revenue for solar-generated process heat. This evaluation requires sound estimates of total initial capital investment, future replacement costs, operating and maintenance costs, local taxes, insurance costs, and finally useful annual delivered energy. Understandably there are various degrees of uncertainty associated with the parameters involved; however, it should be possible to obtain reasonable estimates for the items mentioned above. It should be understood that the initial capital investment consists of a number of items in addition to the purchasing and installation of a solar collector array, such as piping, wiring, auxiliary equipment, and structural renovation; as well as overhead, design and management fees, interest during construction, and taxes. Major replacement costs, which are normally treated as capital expenditures occurring at specified points in time over the life of the system must be capitalized and depreciated in the required revenue methodology. Of equal importance to the estimation of initial system cost and annual expenses is an accurate estimate of useful solar energy gained by the system, which is provided in the preceding performance analysis chapter of this report.

The total amount of revenue which must be set aside each year to provide the useful solar energy generated is the annual required revenue. The amount must cover the return on the equity portion of the solar investment,

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*Dickinson, W. C., and Brown, K. D., "Economic Analysis of Solar Industrial Process Heat Systems: A Methodology to Determine Annual Required Revenue and Internal Rate of Return," UCRL-52814, Aug. 1979.

principal and interest payments of the debt portion of the investment, taxes, insurance premiums operating and maintenance costs, and major repairs and component replacement costs. The general equation for the levelized required revenue is summarized below:

C_s = expenses + loan repayment + marginal composite income tax rate

*(C_s - expenses - depreciation - loan interest) + equity repayment

- investment tax credit + major replacement costs - net salvage value.

The levelized revenue in current dollars is equivalent to a series of unequal annual revenues since the actual monies for solar generated process heat will vary from year to year. This levelized required revenue (C_s) expressed as a fraction of the initial solar investment (I), is considered to be the M-Factor in the following expression.

$$M = C_s/I = OMPI + \frac{CRF(R,N)}{1-\tau}\left[(1-f) + f(1-\tau)\frac{CRF(r,LP)}{CRF(R,LP)} + \frac{f\tau}{1+r}\ \frac{CRF(r,LP)-r}{CRF(R'',LP)}\right.$$
$$- \frac{TC}{1+R} - \tau * DEP + \left(\frac{1+g}{1+R}\right)^{t_c} * m(t_c) * (1-TC-\tau * DEP)$$
$$\left. - \left(\frac{1+g}{1+R}\right)^{N} * S\right] \tag{6}$$

The nomenclature in this expression is given below along with recommended input parameters:

a) SOYD Depreciation

b) DP = 7 yr

c) E_s: to be estimated

d) ε: to be estimated

e) f = 0

f) g = 6%

g) g' = 8%

h) I: to be estimated

i) $m(t_c)$ = .25(10)

j) N = 10 yr

k) $OMPI_o$: to be estimated

l) P_{fo}: to be estimated

m) S = 0

n) TC = 20%

o) τ = 50%

The levelized price of solar energy is given by the term, P_s, below:

$$P_s = C_s/E_s \tag{7}$$

If P_s is divided by the solar effectiveness factor, ε (fuel energy saved by solar system/solar energy delivered), it represents the levelized price of solar energy per unit of fuel energy saved. This quantity can be directly compared with the levelized price of fuel used in the conventional system which is expressed below with R''' being a function of the discount rate and assumed overall fuel escalation rate:

$$C_f = P_{fo} * LF \tag{8}$$

where: P_{fo} = price of displaced fuel in year 0

LF = fuel levelizing factor = $\dfrac{CRF(R,N)}{CRF(R''',N)}$

To determine the Internal Rate of Return (IROR) on the solar investment a value of the discount rate, R, must be solved for by setting the two above expressions equal to each other:

$$P_s(R)/E = LF(R) * P_{fo} \tag{9}$$

This IROR is the project return on investment, or the annual after-tax rate of return on the unamortized equity investment.

The analysis is set up to be made in terms of current dollars, hence the effect of general inflation and fuel escalation are incorporated into the analysis. The principal reason for utilizing current dollars is that the market values may be used in expressing rates of return on equity and loan interest rates.

The use of a payback period to judge the economic feasibility of an investment is very popular particularly among smaller companies and large ones if the potential investment appears to have a high risk associated with it. Since the payback period calculations are normally based on all equity investments and the depreciation tax deductions are often ignored, and also since escalated fuel savings are not taken into account, the calculations usually show solar systems to be more unfavorable than would a proper discounted case flow assessment. However, there are a number of variations used to calculate the payback period. The one which will be used in this analysis assumes a general inflation rate and fuel escalation rate, and is expressed in the following equation:

$$1-TC = T \times \frac{\tau}{N} + \frac{(1-\tau)\varepsilon E_s P_{fo}}{I} \sum_{t=1}^{T} (1+g')^t - (1-\tau)OMPI_o) \sum_{t=1}^{T} (1+g)^t \tag{10}$$

where T = payback period.

B. Fuel Escalation Rate Study

One of the most critical input parameters and most difficult to estimate is the fuel escalation rate. The selection of the parameter must be made, therefore, with extreme care. To provide some guidance in this selection, a U. S. energy model was employed to predict long range fuel prices. The model used was COAL I. The following assumptions were used as inputs to this program.

1. World oil production peaks out between 70-75 MBD before 1990.

2. OPEC price increase average 10% per year in constant dollars.

3. When U. S. imports exceed 8.5 MBD, U. S. government imposes a 25% tax on all energy imports.

4. In 1983 the price for oil and gas become completely deregulated.

5. Between now and 1990, U. S. spends $100 billion on the development of synthetic fuels.

6. Land availability, environmental issues, state and federal taxes, sulfur dioxide legislation, and high shipping costs raise the prices of delivered surface mined coal more than safety and health issues raise the delivered price of underground mined coal. Relative cost penalty equal $8 per ton.

The results of this program are tabulated in Table VII and plotted in Figures 2 and 3. Figure 2 gives the projected price of electricity, No. 2 fuel oil, natural gas, and low sulfur coal in 1980 dollars per million Btu, excluding inflation. Figure 3 gives the same data including inflation with an assumed average general rate of inflation of 13% during the 1980's and 10% during the 1990's. A number of direct conclusions can be made from this data independently of the current projects and they are:

1. Natural gas and oil for industrial thermal applications will rapidly escalate in price during the remainder of the decade (1980's).

2. Electricity will cost the most of all end-use forms of energy during the remainder of the century (1980 to 2000).

3. Coal prices will remain most stable, and its cost advantage will grow during the remainder of the century (1980 to 2000).

Since the San Leandro plant currently uses natural gas for its process heat requirements, the projected price of natural gas will be used for comparing the benefits of the solar process heat system. In reviewing these data, one may take exception to the end results, but these results cannot be refuted unless the assumptions used are refuted. Since these assumptions seem reasonable at this time, one can only conclude that the results are valid.

TABLE VII.

SAN LEANDRO ENERGY PRICE PROJECTIONS
(1980 DOLLARS PER MILLION BTU)

YEAR	ELECTRICITY	No. 2 DISTILLATE OIL	A NATURAL GAS	LOW SULFUR COAL	B INFLATION MULTIPLIER
80	15.0	7.2	5.0	2.4	1.00
81	17.9	8.7	6.5	2.4	1.13
82	18.5	9.8	8.4	2.5	1.28
83	19.8	14.7	10.8	2.5	1.44
84	20.8	16.3	14.0	2.6	1.63
85	21.6	18.1	18.1	2.6	1.84
86	22.2	20.4	20.4	2.6	2.08
87	22.6	21.2	21.2	2.7	2.35
88	22.6	21.4	21.4	2.7	2.66
89	22.6	19.5	19.5	2.8	3.00
90	22.6	19.5	19.5	2.8	3.40
91	22.6	19.3	19.3	2.9	3.74
92	22.6	18.9	18.9	2.9	4.11
93	22.6	18.5	18.5	2.9	4.52
94	22.6	18.0	18.0	3.0	4.98
95	22.6	17.1	17.1	3.0	5.47
96	22.6	16.9	16.9	3.1	6.02
97	22.6	16.8	16.8	3.1	6.62
98	22.6	16.8	16.8	3.2	7.29
99	22.6	16.8	16.8	3.2	8.02
2000	22.6	16.8	16.8	3.3	8.82

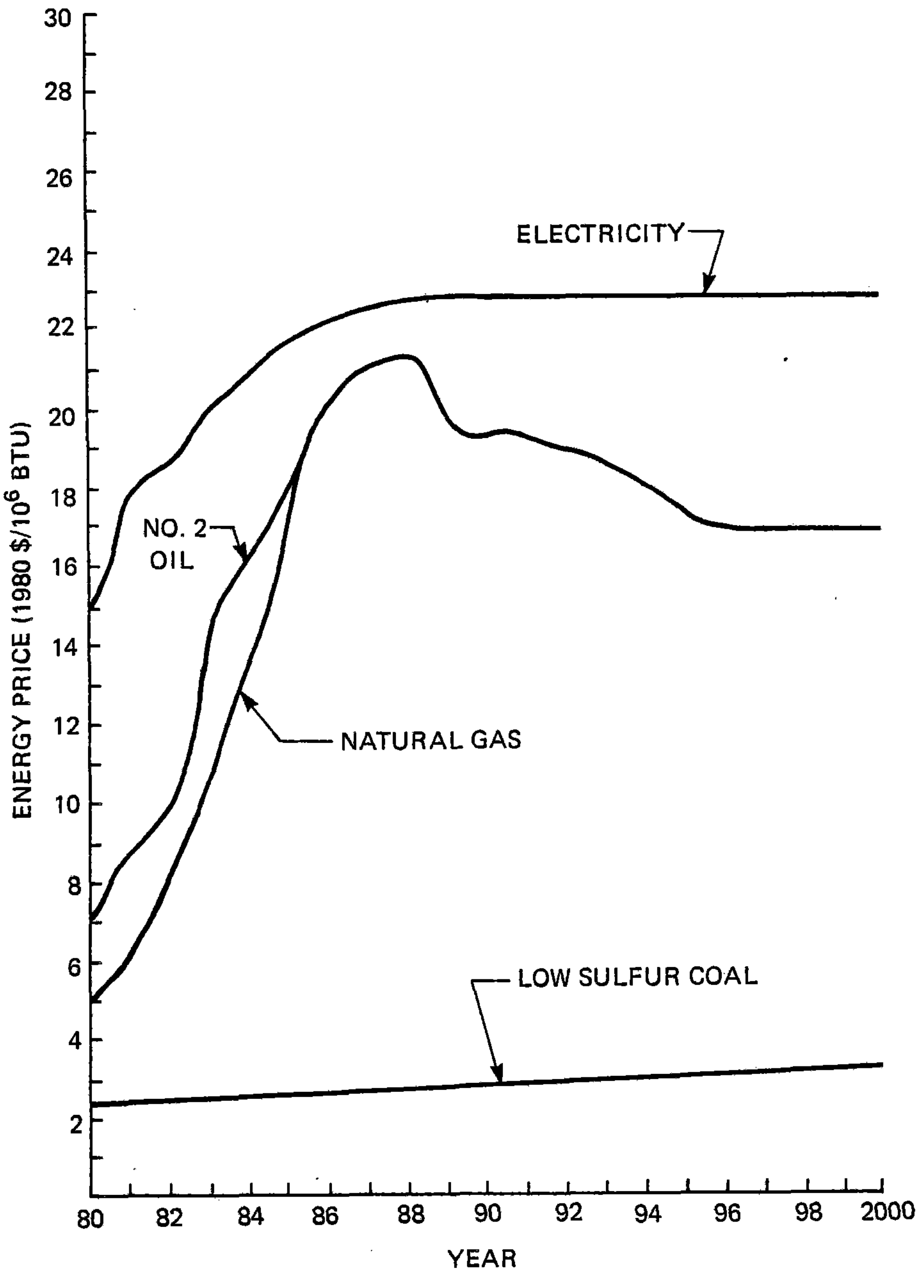


FIGURE 2. SAN LEANDRO ENERGY PRICE PROJECTIONS
(CONSTANT DOLLARS - INFLATION <u>NOT</u> INCLUDED

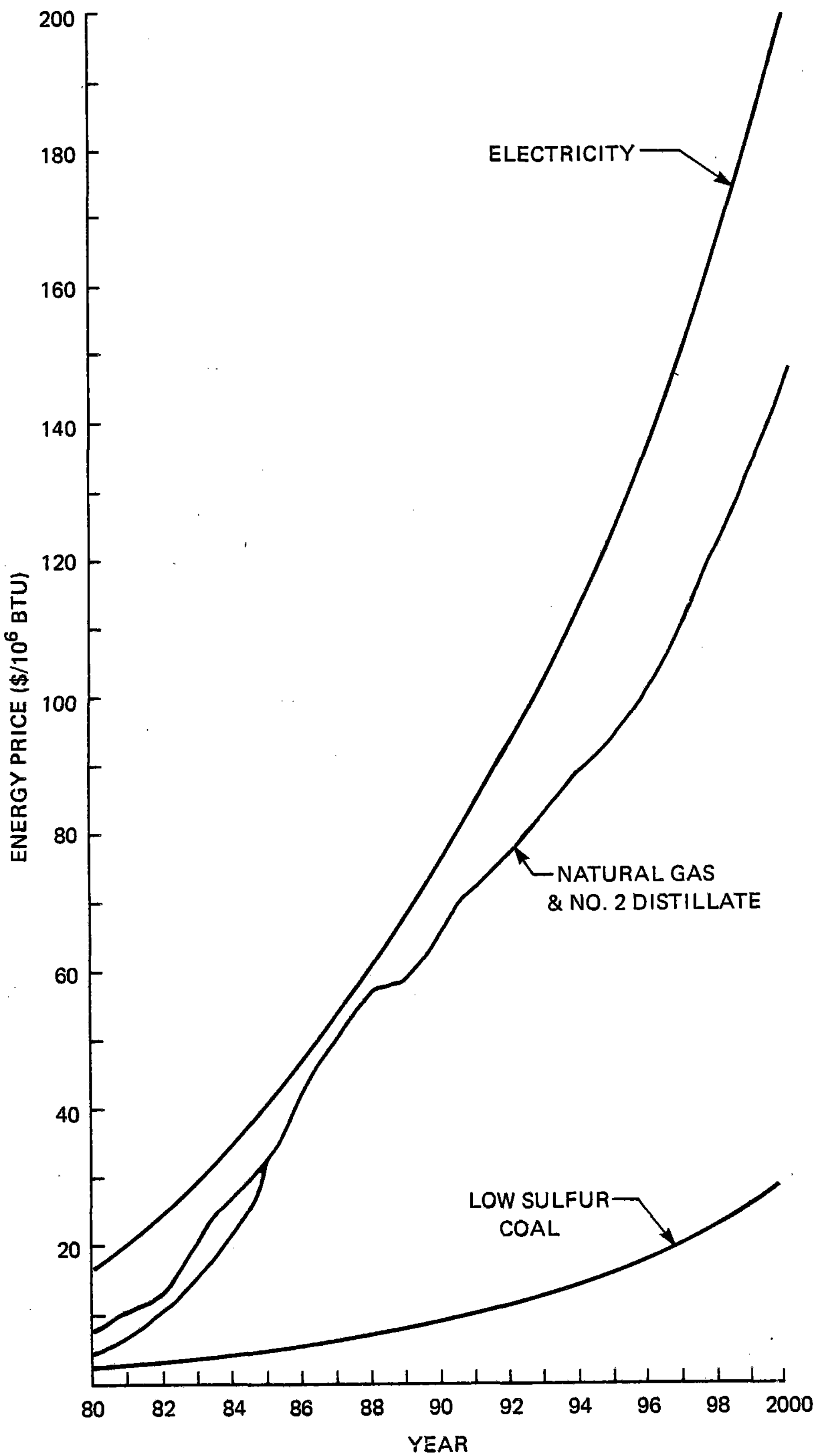


FIGURE 3. SAN LEANDRO ENERGY PRICE PROJECTIONS (END OF YEAR PRICES IN CURRENT DOLLARS PER MILLION BTU - INFLATION INCLUDED)

C. Parametric Analysis

In order to provide sufficient data to the industrial partners for their decision process and to provide data to DOE in evaluating this application, a parametric analysis was conducted with the following assumptions:

1. System life of 10 years

2. Initial fuel cost of $5 per million Btu (MMBtu)

3. Operation, maintenance, property tax, and insurance (OMPI) of 1% per year

4. Energy delivered by the Solar System of 12 billion Btu per year (BBtu/yr)

5. General inflation rate of 13%.

The results of this analysis are shown in Figures 4, 5, and 6. In these figures, the rate of return is plotted versus fuel escalation rate including and excluding inflation as a function of percent contribution by the industrial partner. Figure 4 assumes a $2 million system cost with Figures 5 and 6 assuming $2.5 million and $3 million, respectively.

These curves can be used by the industrial partner to make an investment decision by assuming a fuel escalation rate using the previous study for guidance and selecting an acceptable "hurdle rate" for rate of return, once a system cost estimate is approved. For example, assume an average fuel escalation rate of 15% above inflation, a hurdle rate of 20% ROI, and a system cost of $2.5 million. By entering the plot at an abscissa of 15% and an ordinate of 20%, a point will be found between the 20% contribution and 50% contribution lines. Linear interpolation between these values yields a value of industrial contribution of 42% or about $1 million.

One of the assumptions in this analysis that could be questioned is the assumed system life. Since there is no long-term experience with these types of systems and since the longer the assumed life the less reliable the financial assumptions, a 10-year life was assumed previously to test the sensitivity of this assumption. The rate of return was plotted versus industrial contribution for a 10- and 20-year life. This plot (shown in Figure 7) was generated with a fuel escalation rate 15% above inflation and the same assumptions as used in Figures 4, 5, and 6. If the system life is extended to 15 years with a hurdle rate of 20%, Figure 7 shows that a contribution by the industrial partner could be increased to $1.5 million. This investment decision would be independent of the actual system cost, but would correspond to a 50% contribution even if the total cost turned out to be $3 million.

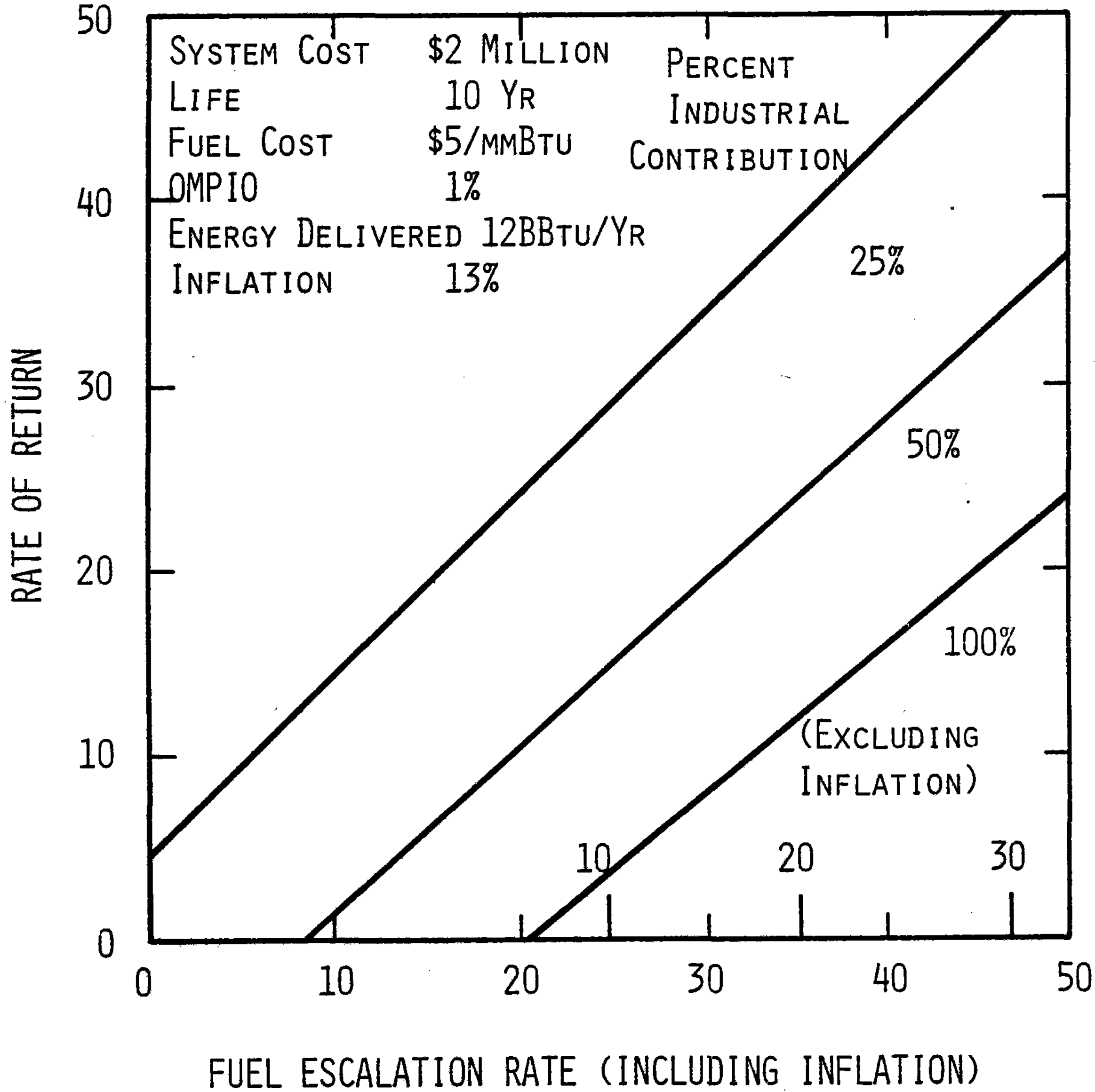


FIGURE 4. ECONOMIC ANALYSIS FOR A $2 MILLION SYSTEM

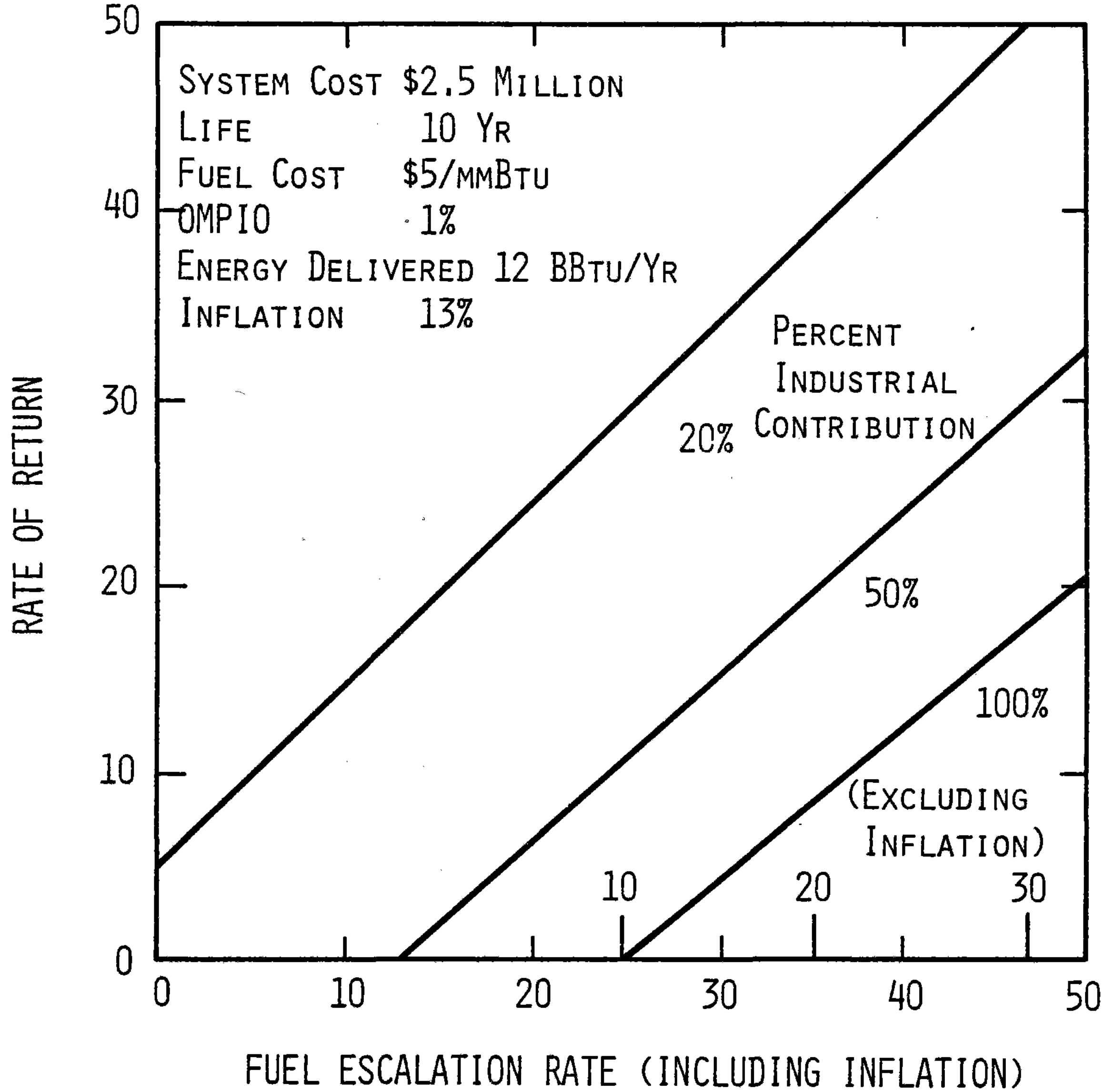


FIGURE 5. ECONOMIC ANLAYSIS FOR A $2.5 MILLION SYSTEM

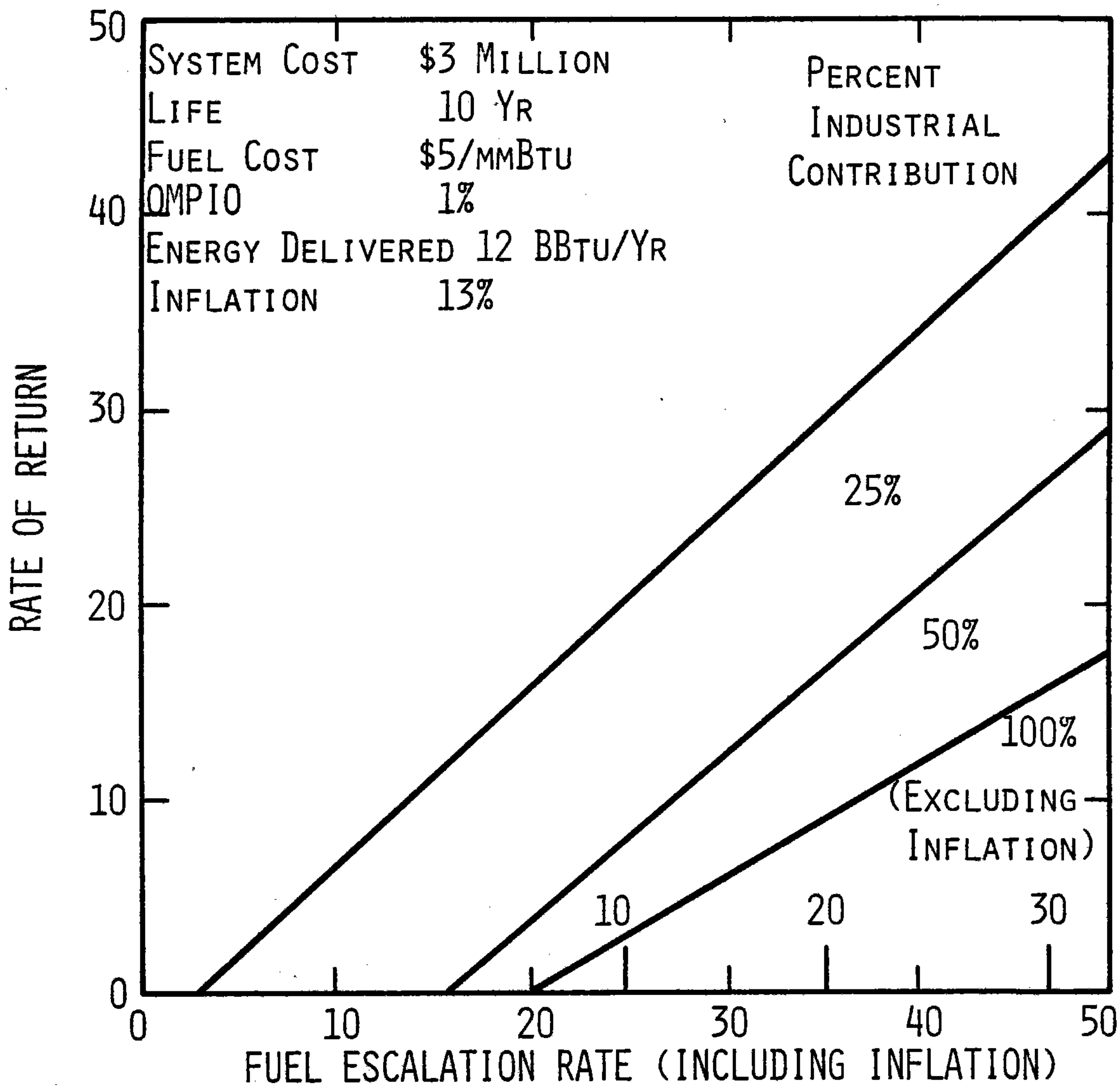


FIGURE 6. ECONOMIC ANALYSIS FOR A $3 MILLION SYSTEM

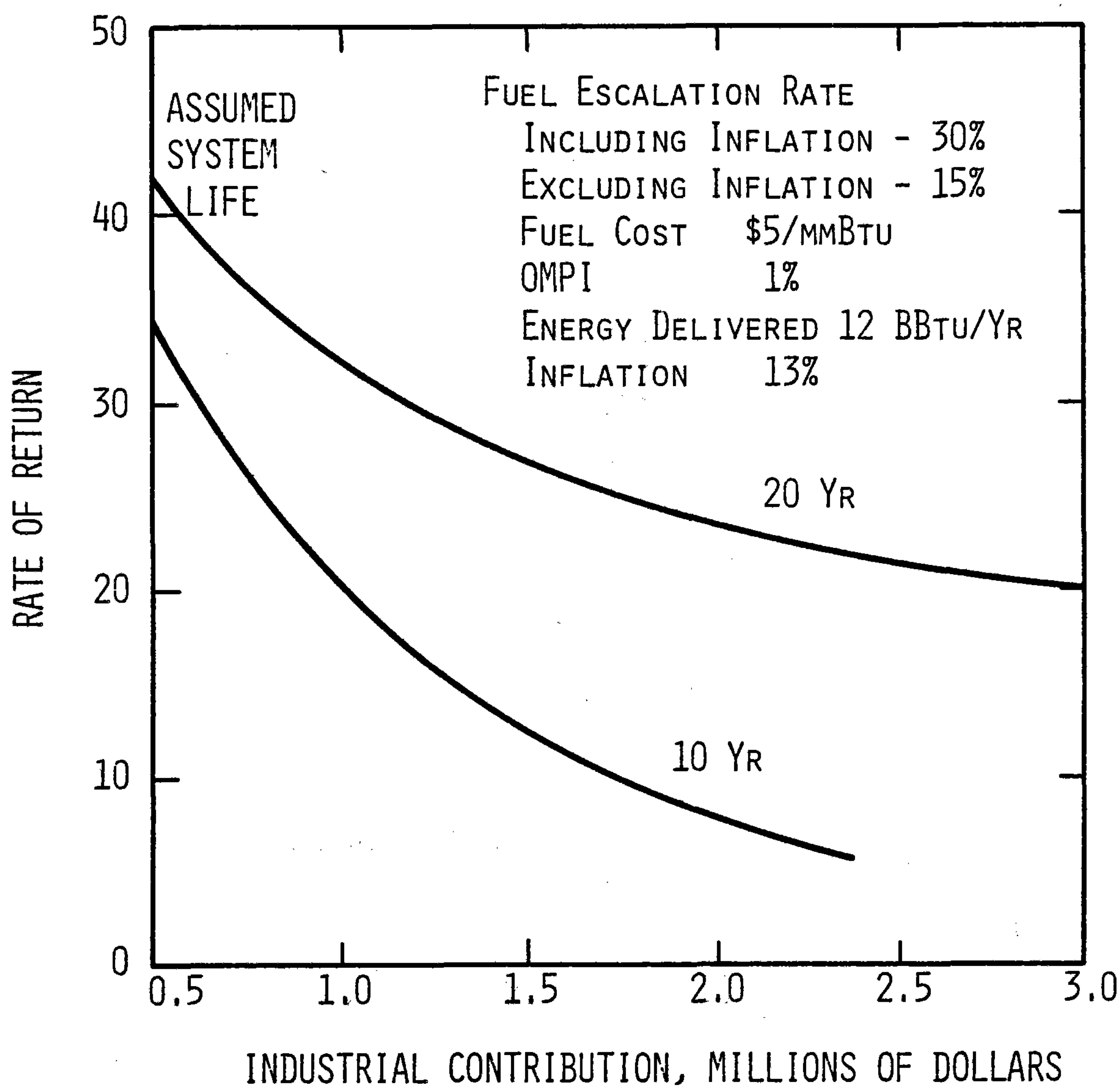


FIGURE 7. ECONOMIC ANALYSIS FOR DIFFERENT ASSUMED SYSTEM LIFES

V. WIND LOAD ANALYSIS

One of the major additional expenses in roof-mounting collectors is the modification of the roof structure. Since the dead weight of the collectors is low, the critical factor is obviously the wind loads. The wind loading has three dominant components: lift force, drag (lateral) force, and pitching moment. In addition to these dominant components, there are also three secondary components: axial force, rolling moment, and yawing moment. The following analysis will be divided into a discussion of each of the specific load components, and analysis of the resultant loads transmitted to the building. The load coefficients in this analysis were supplied by Mr. Duane E. Randall of Sandia Laboratories. The basis of these data were two sets of wind tunnel tests. One set of tests was obtained at the Vought Corporation Low-Speed Wind Tunnel, and the second set was obtained at the Fluid Dynamics Diffusion Laboratory of the Colorado State University. The coordinate system for this work is shown in Figure 8.

A. Individual Components

1. Lift or Vertical Force Component

The lifting force (L_f) which is positive for vertical upward forces along the Z-axis, is calculated from the following relationship:

$$L_f = C_\ell \cdot Q \cdot S \cdot C \cdot n \tag{11}$$

and

$$Q = 1/2\ \rho\ V^2 \tag{12}$$

where: L_f = lift force

C_ℓ = lift coefficient

Q = dynamic pressure

S = span per module

C = chord

n = number of modules

ρ = density of air

V = wind speed

The lift coefficient is a function of the collector aspect ratio (which is equal to the span over the chord), the pitch angle (θ), and the yaw angle (ψ). There has been discussion in the past as to what length constitutes the

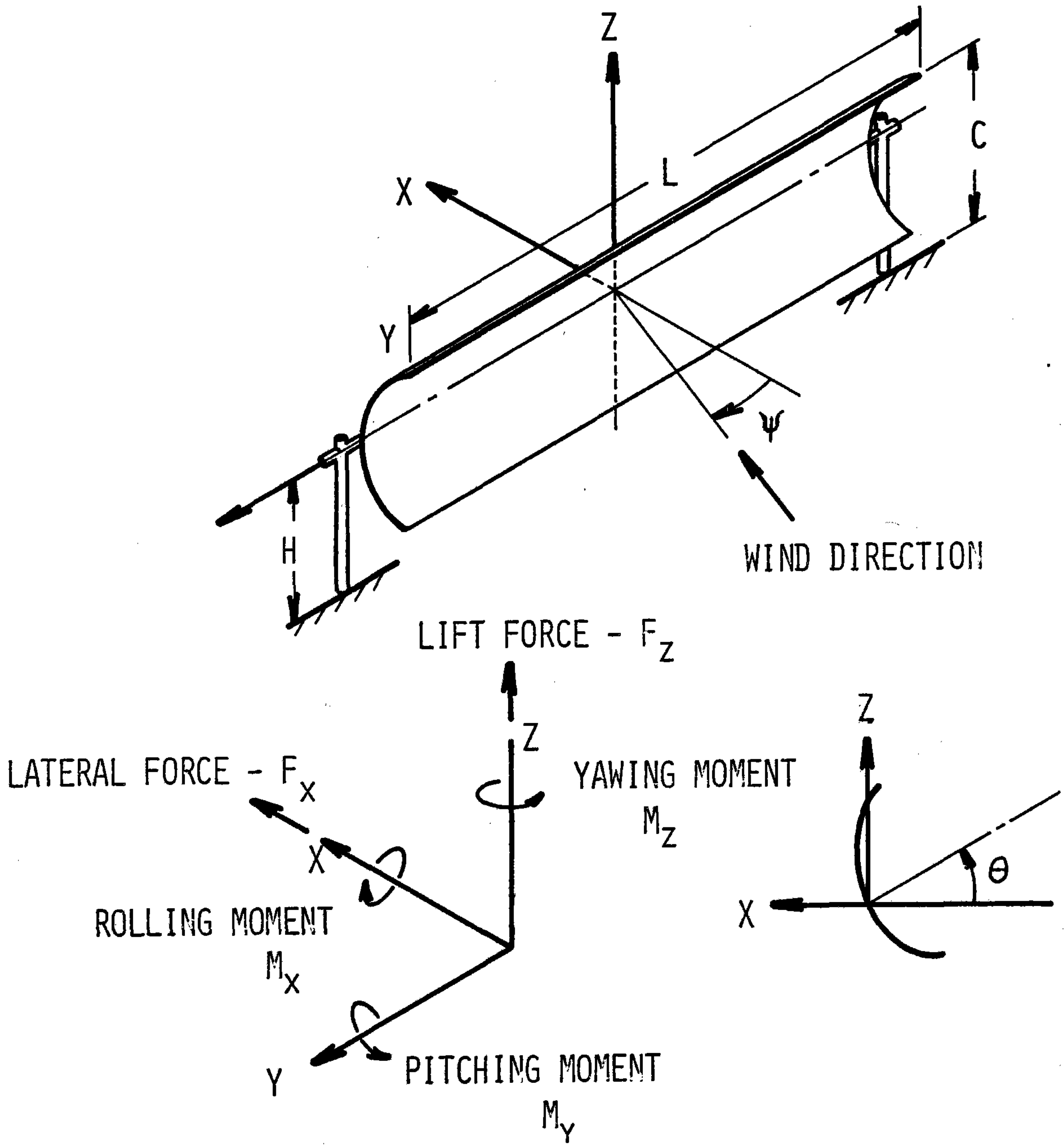


FIGURE 8. WIND LOAD ANALYSIS COORDINATE SYSTEM

correct span, i.e., the module length or the row length. The CSU data shows that down to a gap-to-chord ratio of 1/10th, each module acts independently, so that for the Solar Kinetics T-700 with a gap-to-chord ratio of about 0.11, the span will be the collector module length. The aspect ratio (AR) is, therefore, equal to 2.86 for the determination of the force and moment coefficients. The total lift force is determined by multiplying the module lift by the number of modules per row, and then dividing this load into that carried per pylon by proportioning the load as a function of the reflector area between pylons. For a six-module row, the middle pylons will carry 1/6th of the total load and the end pylons will carry 1/12th of the total load.

2. Drag or Lateral Force Component

The drag or lateral force component is a horizontal force in the X-direction with a positive force in the same direction as the wind vector. This force is determined as follows:

$$D_F = C_d \cdot Q \cdot S \cdot C \cdot n \tag{13}$$

where: D_F = drag force

C_d = drag coefficient

with the remainder of the terms as defined above. The drag coefficient is a function of aspect ratio, pitch angle, and yaw angles. The total load and load per pylon is determined in the same manner as the lift force.

3. Axial Force Component

The axial force component is horizontal in the Y-direction. This force is calculated by

$$A_f = C_a \cdot Q \cdot S \cdot C \cdot n \tag{14}$$

where: A_f = axial force

C_a = axial coefficient

with the remaining terms as defined above. The axial coefficient is practically zero at zero yaw and increases as yaw angles increase. The absolute magnitude of this force, however, is almost negligible even at high yaw angles in comparison to the drag force. The total load and load per pylon is determined in the same manner as the lift force.

4. Static Load

The collector weight is the only static load and it is 3.7 lb/ft^2 of mirror surface or 3-1/3 lb/ft^2 of module width. So that

$$W_F = 3\frac{1}{3}\cdot S\cdot C\cdot n \qquad (15)$$

where W_F = collector weight.

The total weight and weight per pylon is determined in the same manner as the lift force.

5. Pitching Moment

The collector row pitching moment is the turning moment about the Y-axis. This moment is only imparted to the drive pylon since all of the other pylons are supported in pillow block bearings which are assumed frictionless. The moment for this drive pylon is, therefore, equal to

$$M_y = C_m\cdot Q\cdot S\cdot C^2\cdot n \qquad (16)$$

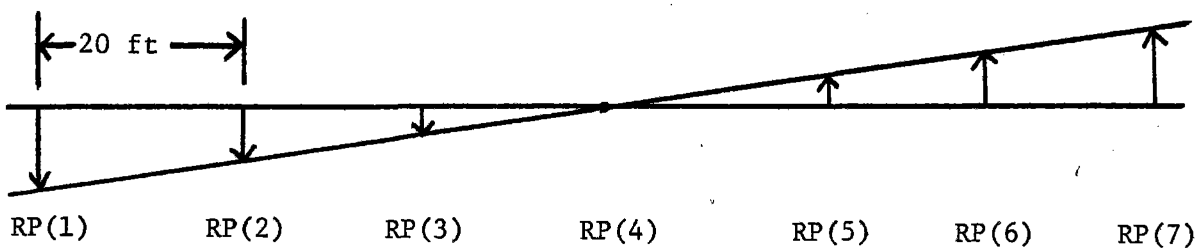
where: M_y = pitching moment

C_m = pitching moment coefficient

The positive direction for this moment is with a torque that tries to twist the Z-axis into the X-axis.

6. Rolling Moment

The rolling moment is the turning moment about the X-axis, with the positive direction for a torque which tries to twist the Y-axis into the Z-axis. This analysis will assume the pylon reactions due to a rolling moment will be linearly distributed along the collector row. The collector row length is 120 ft long with seven support pylons spaced on 20 ft centers. The rolling moment can be determined by considering the following free body diagram.



If the maximum force at the first pylon is given by R_F and the remaining forces vary at a constant k(lb/ft), then for 20-ft long modules:

$$RP(1) = R_F \qquad (17)$$

$$RP(2) = RF - 20\cdot k$$

$$RP(3) = R_F - 40\cdot k$$

$$RP(4) = R_F - 60 \cdot k$$

$$RP(5) = R_F - 80 \cdot k$$

$$RP(6) = R_F - 100 \cdot k$$

$$RP(7) = R_F - 120 \cdot k$$

where RP is the force expected on each pylon as a result of the rolling moment. The summation of all the forces are zero since these forces are due only to a rolling moment.

$$\sum_{n=1}^{7} RP(n) = 7R_F - 420k = 0 \tag{18}$$

therefore,

$$k = \frac{1}{60} R_F$$

and

$$RP(1) = R_F \tag{19}$$

$$RP(2) = 2/3\ R_F$$

$$RP(3) = 1/3\ R_F$$

$$RP(4) = 0$$

$$RP(5) = -1/3 R_F$$

$$RP(6) = -2/3\ R_F$$

$$RP(7) = -R_F$$

The rolling moment reaction forces about the X-axis can therefore be determined by summing the moment for each pylon, and equating them to the total wind-induced rolling moment.

$$M_x = \tag{20}$$

$$-20\ RP(2)$$

$$-40\ RP(3)$$

$$-60\ RP(4)$$

$$-80\ RP(5)$$

$$-100\ RP(6)$$

$$-120\ RP(7)$$

so

$$M_x = (560/3)R_F \tag{21}$$

where M_x = rolling moment.

The value for this moment can be determined from the wind tunnel data as

$$M_x = C_R \cdot Q \cdot S \cdot C^2 \cdot n \tag{22}$$

where C_R = roll moment coefficient.

The maximum load on the first pylon is therefore equal to

$$R_F = (3/560) \cdot C_R \cdot Q \cdot S \cdot C^2 \cdot n \tag{23}$$

These forces add or subtract from the lifting force and weight.

7. Yawing Moment

The yawing moment is the turning moment about the Z-axis with the positive sense defined when the X-axis is crossed into the Y-axis. The force that results from this moment will add or subtract from the drag force. The development of the distribution of these forces is the same as outlined above for the rolling moment so that

$$\begin{aligned} NP(1) &= N_F \\ NP(2) &= 2/3\ N_F \\ NP(3) &= 1/3\ N_F \\ NP(4) &= 0 \\ NP(5) &= -1/3\ N_F \\ NP(6) &= -2/3\ N_F \\ NP(7) &= -N_F \end{aligned} \tag{24}$$

where NP is the force exerted on the pylon as a result of the yawing moment, and

$$M_Z = C_N \cdot Q \cdot S \cdot C^2 \cdot n \tag{25}$$

where: M_Z = yawing moment

C_N = yaw moment coefficient

so that

$$N_F = (3/560)\cdot C_N\cdot Q\cdot S\cdot C^2\cdot n \tag{26}$$

B. Reactions at the Roof Structure

The reaction transmitted to the roof structure is composed of a vertical force, a horizontal force, an overturning moment about an axis parallel to the Y-axis at the base of the pylon (Y'-axis), and an overturning moment about an axis parallel to the X-axis at the base of the pylon (X'-axis). The vertical force, FV, is determined by summing the components of weight, lift and rolling force as follows for each pylon:

$$FV(I) = W_F(I) - L_F(I) - RP(I) \tag{27}$$

where all the terms are as defined previously. The horizontal or shear force, FH, at the base of the pylons in the direction of the X-axis is

$$FH(I) = D_F(I) - NP(I) \tag{28}$$

The overturning moment about the Y'-axis is a result of the drag force, the force due to yawing moment and the pitching moment on the center drive pylon. This gives

$$MBY(I) = M_y(I) + H\cdot D_F(I) - H\cdot NP(I) \tag{29}$$

and since only the drive pylon can exert a pitching moment, $M_y(4)$, then

$$M_y(1) = M_y(2) = M_y(3) = M_y\ (5) = M_y(6) = M_y(7) = 0$$

H = height of the pylon

The overturning moment about the X'-axis is a result of the axial force, so that

$$MBX(I) = H\cdot A_F(I) \tag{30}$$

All of the above equations were combined for use in a computer program. This program was then used to conduct a parametric analysis for the collector system in question, as outlined in the following section.

C. Parametric Analysis

A parametric analysis was conducted to investigate the effect of three different parameters on the forces and moments acting on the building truss structure for a 120 ft long parabolic trough collector. The geometric parameters used were those of the Solar Kinetics T-700 collector. These parameters are: (a) collector pitching angle (θ), (b) wind speed (V), and (c) collector row spacing.

1. Effect of Pitch Angle

The three different reactions acting on the building structure, FV, MBY, and MBX were plotted as a function of pitching angle, θ. Figure 9 shows a plot of FV(4) versus θ for a yaw angle of zero, a collector row spacing of 13.3 ft, and four wind speeds (10, 20, 30, and 40 mph). It is interesting to note from this plot that the vertical loads decrease with increasing wind speed. This occurs because at low wind speed the predominant vertical load is the collector system weight, as the wind speed increases the lift increases which has the effect of decreasing the effective weight of the collectors. This effect will be discussed in greater detail later in this analysis. The relationship of the vertical force with pitching angle is a distinct function of the lifting surface under different angles of attack. The geometry is not symmetric because of the effect of the ground plan, so that the sinusoidal shape of the lift coefficient curve is shifted with a net positive lifting force at a pitch angle of zero. The vertical force at the neutral position of θ = 0 (with the focal line on the negative X-axis) is about equal to the collector weight at low wind speeds but shifts down to lower values as the lift component becomes significant. The range of velocities investigated were selected because the collector system will be in the stow position with any wind speed greater than 30 mph. In the operating mode the only relevant conditions are for pitching angles between 0 and 180°. The maximum load under operating conditions occurs at a pitch angle of 60° with a minimum load at 150°. The coefficients selected for these loads were the worst case of three different conditions. These conditions include one, two, and four rows ahead of the row in question, which gave the effect of wind blockage effects.

The drive pylon pitching moment MBY(4) is plotted in Figure 10 as a function of pitching angle. In this plot the torque on the collector row around the Y'-axis increases with wind speed. The odd shape of this curve is attributed to the complex vortex shedding characteristics of parabolic trough at different angles of attack. The pitching moment coefficient as a function of pitch angle does not show a uniform variation with the number of rows upstream of the collector in question. The coefficients selected were, therefore, the worst case for each pitch angle. This procedure is probably the main reason for the irregular shape of the MBY(4) versus θ curves. The maximum pitching moment occurs at both zero and -90° pitch angles with a minimum occurring between +60° and +90°. The moment on the drive pylon consists of the components due to pitching and induced by the drag force. The drag force component can be separated from this moment by plotting MBY(3) versus θ for the third pylon. This plot is shown in Figure 11. The maximum drag load occurs at -90° and -120°. In Figures 10 and 11, which are plots with wind speeds of 10 to 40 mph, the only relevant pitch angles are zero to 180°.

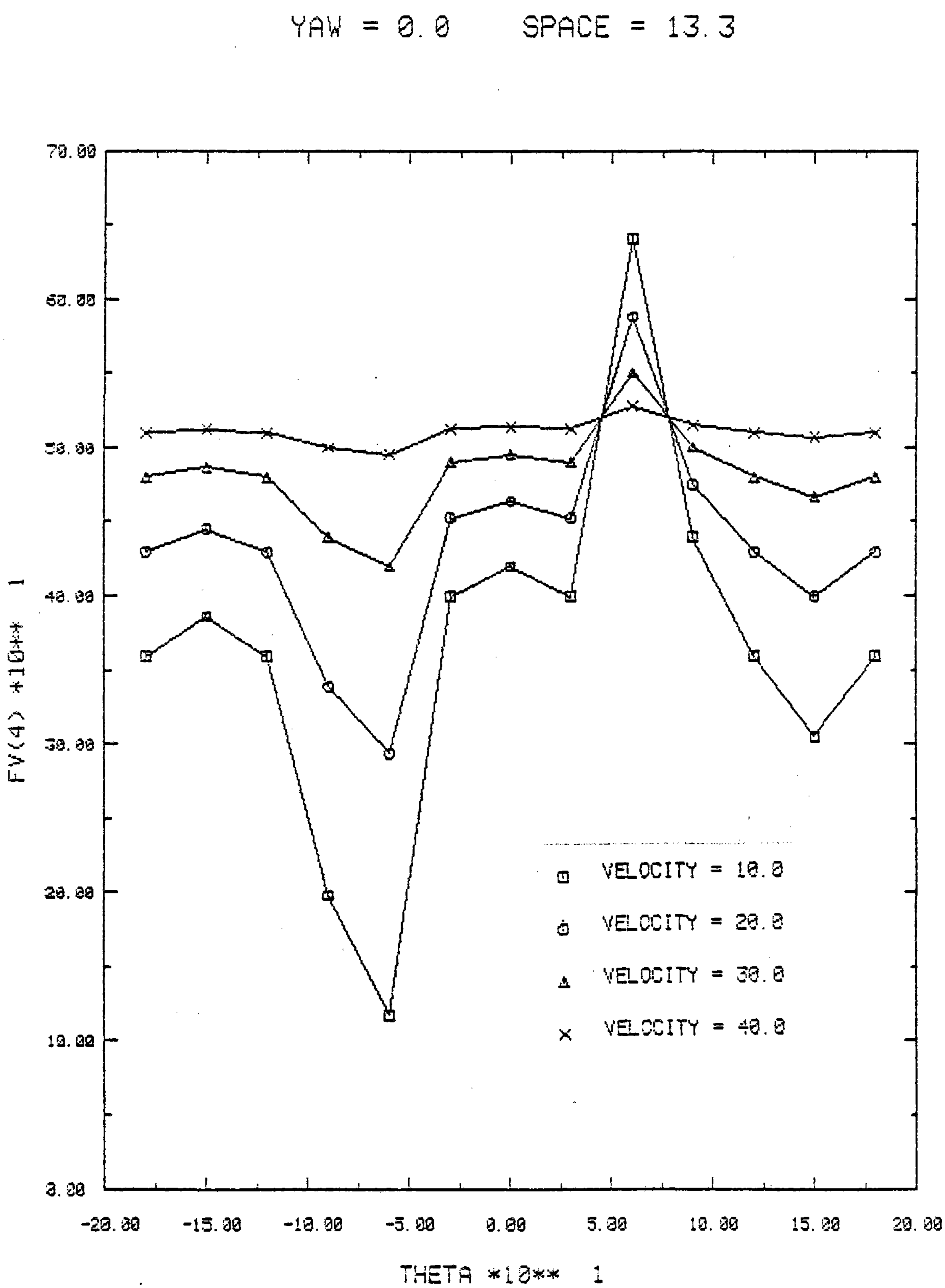


FIGURE 9. FV(4) VERSUS THETA FOR YAW = 0, SPACE = 13.3, LENGTH = 120 FT

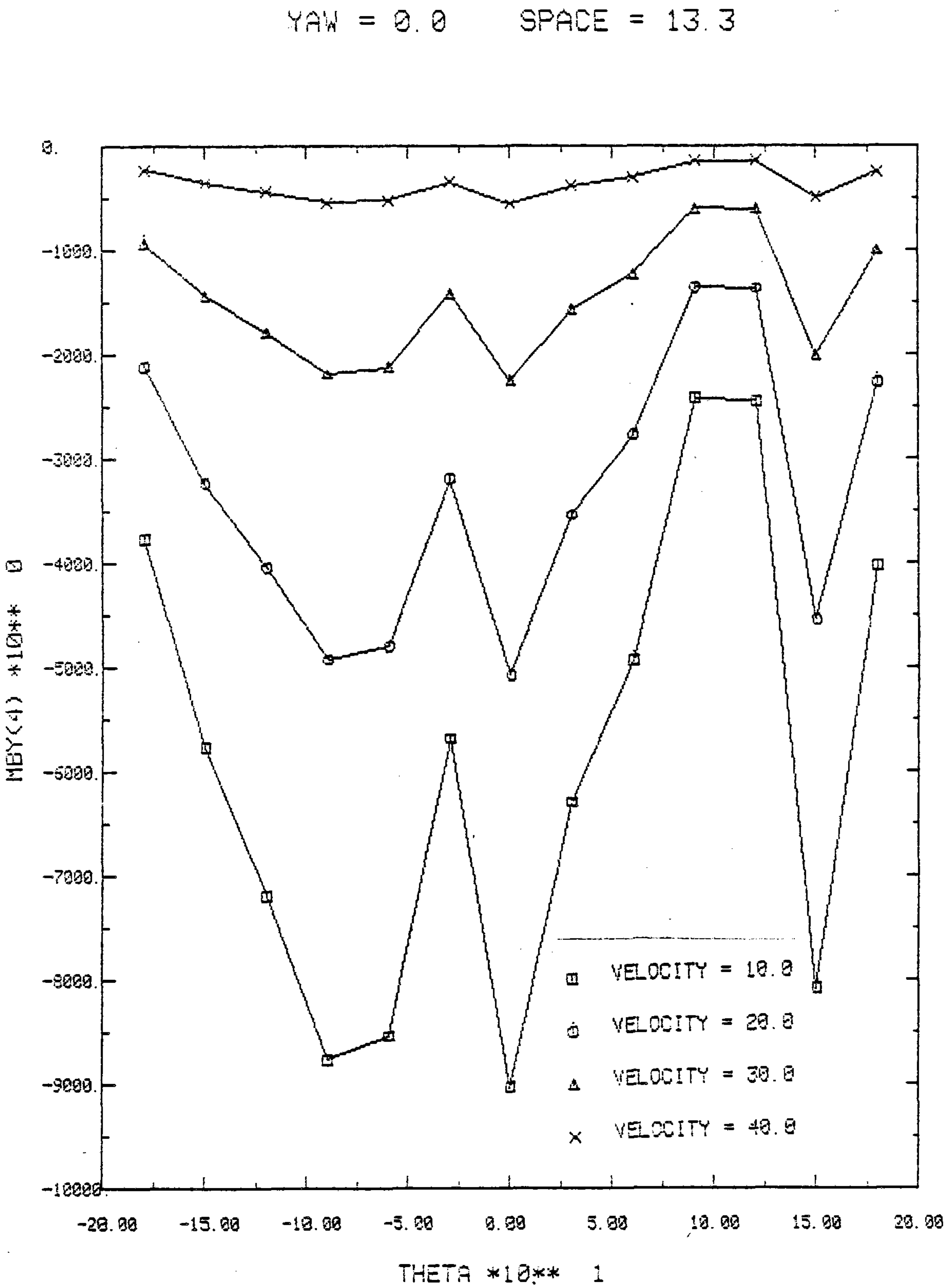


FIGURE 10. MBY(4) VERSUS THETA FOR YAW = 0, SPACE = 13.3, LENGTH = 120 FT

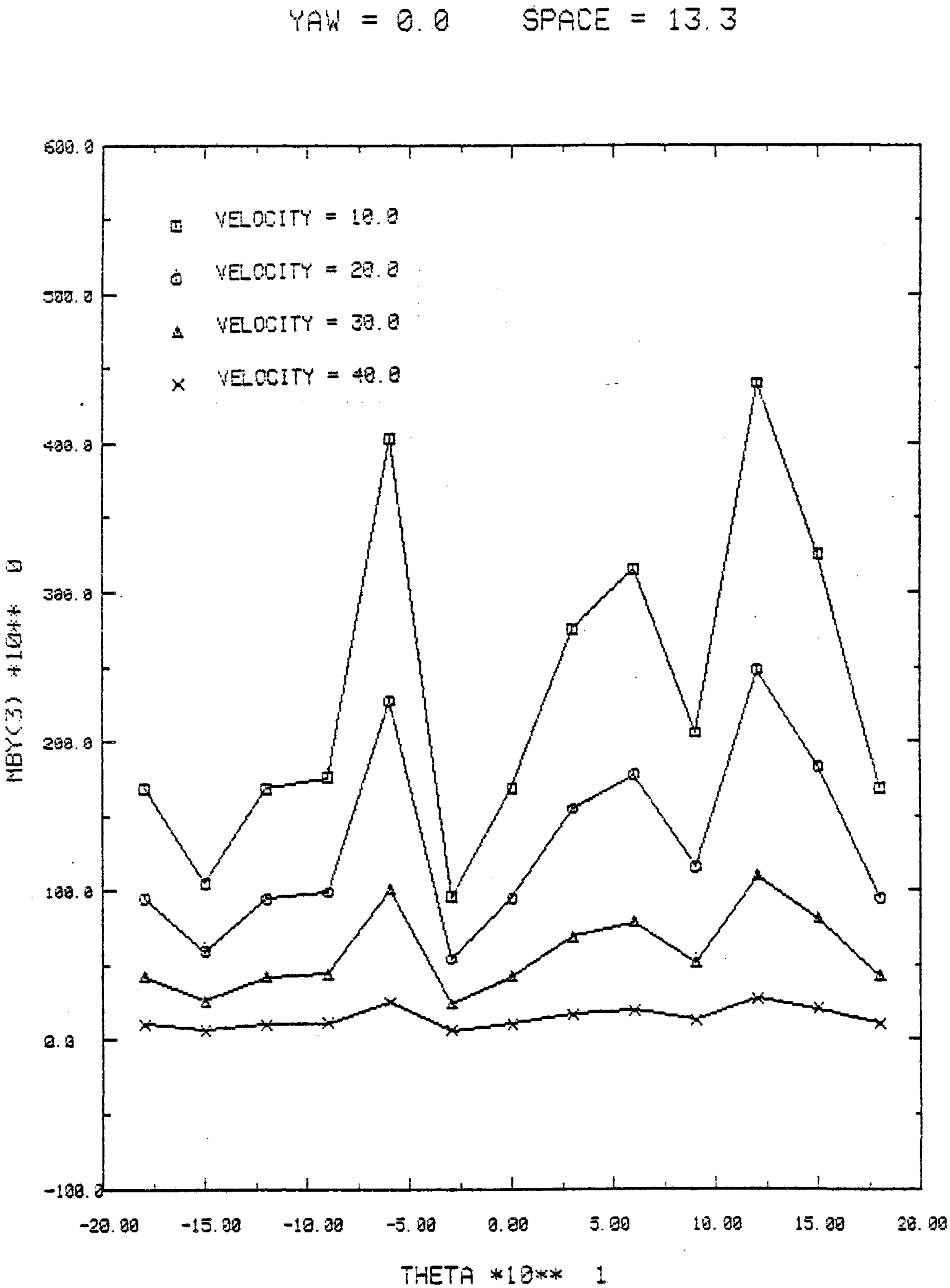


FIGURE 11. MBY(3) VERSUS THETA FOR YAW = 0, SPACE = 13.3, LENGTH = 120 FT

In addition to the above discussion for the reaction at the base of the pylons at low wind speeds, the critical design condition is the maximum wind speed expected. This design condition is the load that the truss structure must be modified to withstand. The three reactions FV(4), MBY(4), and MBY(3) are plotted versus wind velocity for three collector row spacings (13.3 ft, 20 ft and 40 ft) in Figures 12, 13, and 14, respectively. All three of these plots are for zero yaw and the stow position of $\theta = -90^{\circ}$. From Figure 12 it can be seen that for a spacing of 13.3 ft the net vertical load is zero at a wind speed of about 50 mph, i.e., the lifting force at 50 mph is equal to the weight of the collectors. It's interesting to note that the maximum measured wind speed at this location is 49 mph. The building codes specify a design wind speed of 80 mph which constitutes a safety factor of 1.6 for wind speed which in turn constitutes a load safety factor of about 2.5. This plot also shows the effect of an increase in load with row spacing. At 80 mph the vertical load for a 13.3-ft spacing is -769 lb, for a 20-ft spacing is -1563 lb, and for a 40-ft spacing is -3772 lb. Increasing the spacing from 13.3 ft to 20 ft increases the vertical load by a factor of five. Great care must, therefore, be taken when selecting collector row spacing for any roof-mounted collector systems.

An even more critical parameter for roof mounting is the turning moments about the Y'-axis at the center drive pylon. This parameter is plotted versus wind velocity in Figure 13. The effect of row spacing is not as dramatic an effect for this turning moment as it is for the lifting force. In fact, no effect of spacing was shown in the wind tunnel tests for pitching moment. The effect shown in Figure 13 is a result of the blockage effect for the drag load. It should be noted that since the drag load causes a positive moment and the pitching moment causes a negative moment for the stow position of -90°, an increase in row spacing actually decreases the net moment at the base of the drive pylon. At 80 mph the resultant turning moment on the drive pylon is -35095 ft-lb for a 13.3-ft spacing, -32085 ft-lb for a 20-ft spacing, and -23100 ft-lb for a 40-ft spacing. So for this parameter the effect of increasing the spacing from 13.3 ft to 20 ft decreases the moment by 9%, and the effect of increasing the spacing from 13.3 ft to 40 ft decreases the moment by 34%. The effect of increasing drag with an increase in spacing is shown in Figure 14. At 80 mph the effect of increasing row spacing from 13.3 ft to 20 ft increases the turning moment on the third pylon by a factor of 5.3 and for an increase in spacing from 13.3 ft to 40 ft by a factor of 18. It is, therefore, important to take extreme care in the layout of collector arrays for roof mounting. The trade-off between wind blockage and sunlight blockage is important in the selection of collector row spacing. If the spacing is too close the thermal performance suffers. If the spacing is too far, the cost of roof modifications is too high. The choices are obviously finite since modification costs are lower if collector pylons are mounted directly on a structural member. In the case under study the structural members are spaced 6-2/3 ft apart so that there are only five different choices between 13.3 ft and 40 ft.

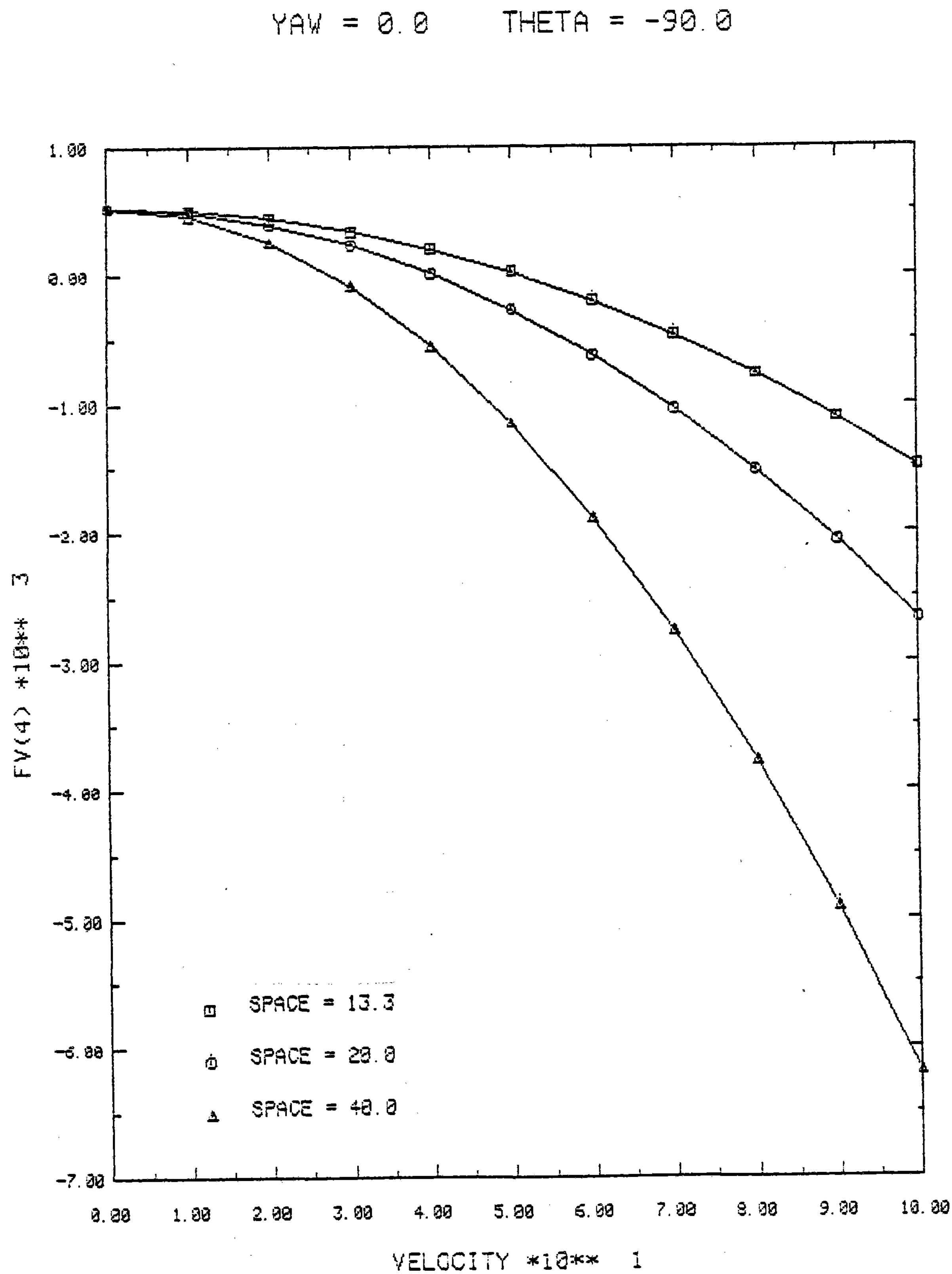


FIGURE 12. FV(4) VERSUS VELOCITY FOR YAW = 0, THETA = -90°, AND LENGTH = 120 FT

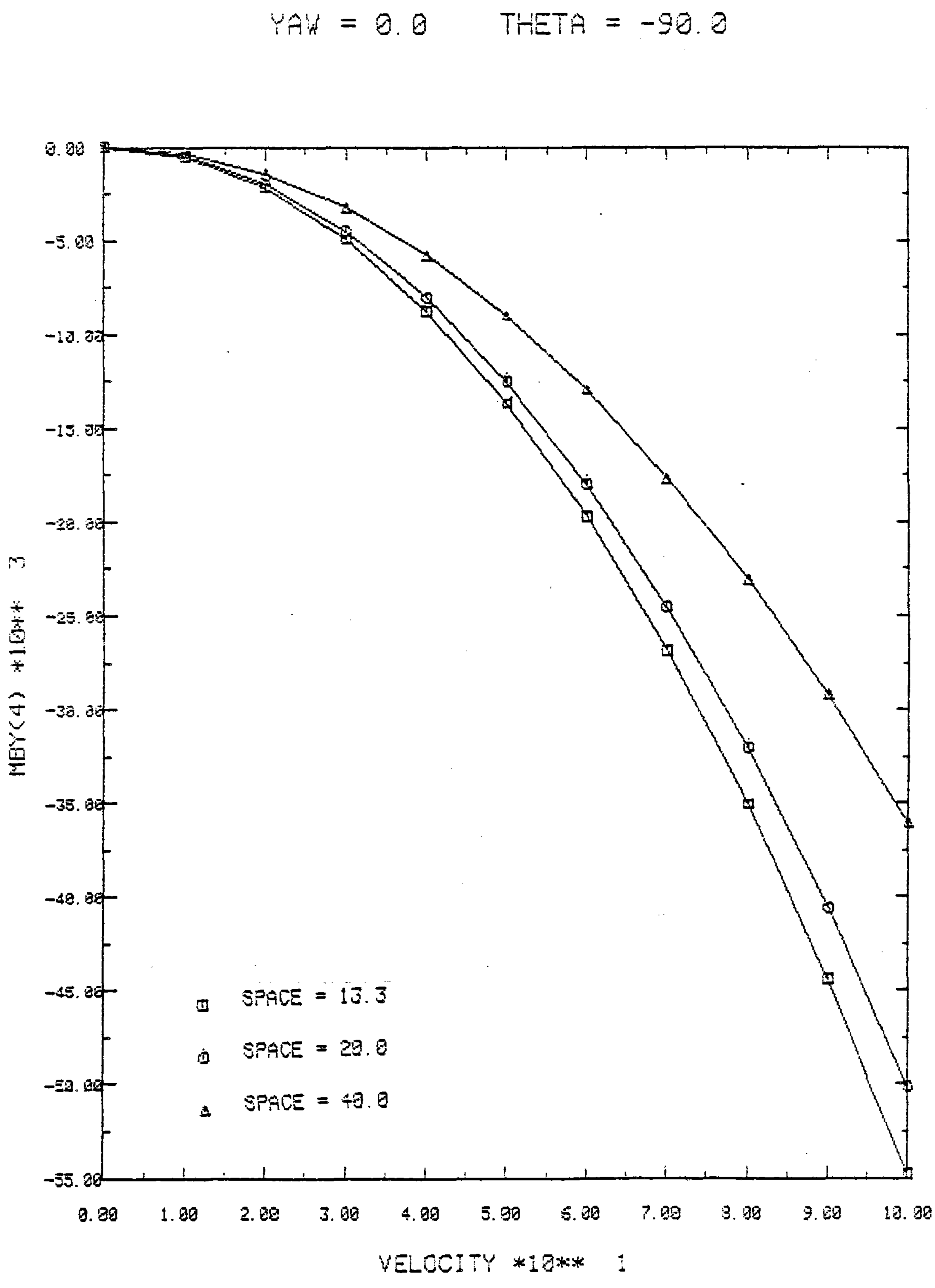


FIGURE 13. MBY(4) VERSUS VELOCITY FOR YAW = 0, THETA = -90° AND LENGTH = 120 FT

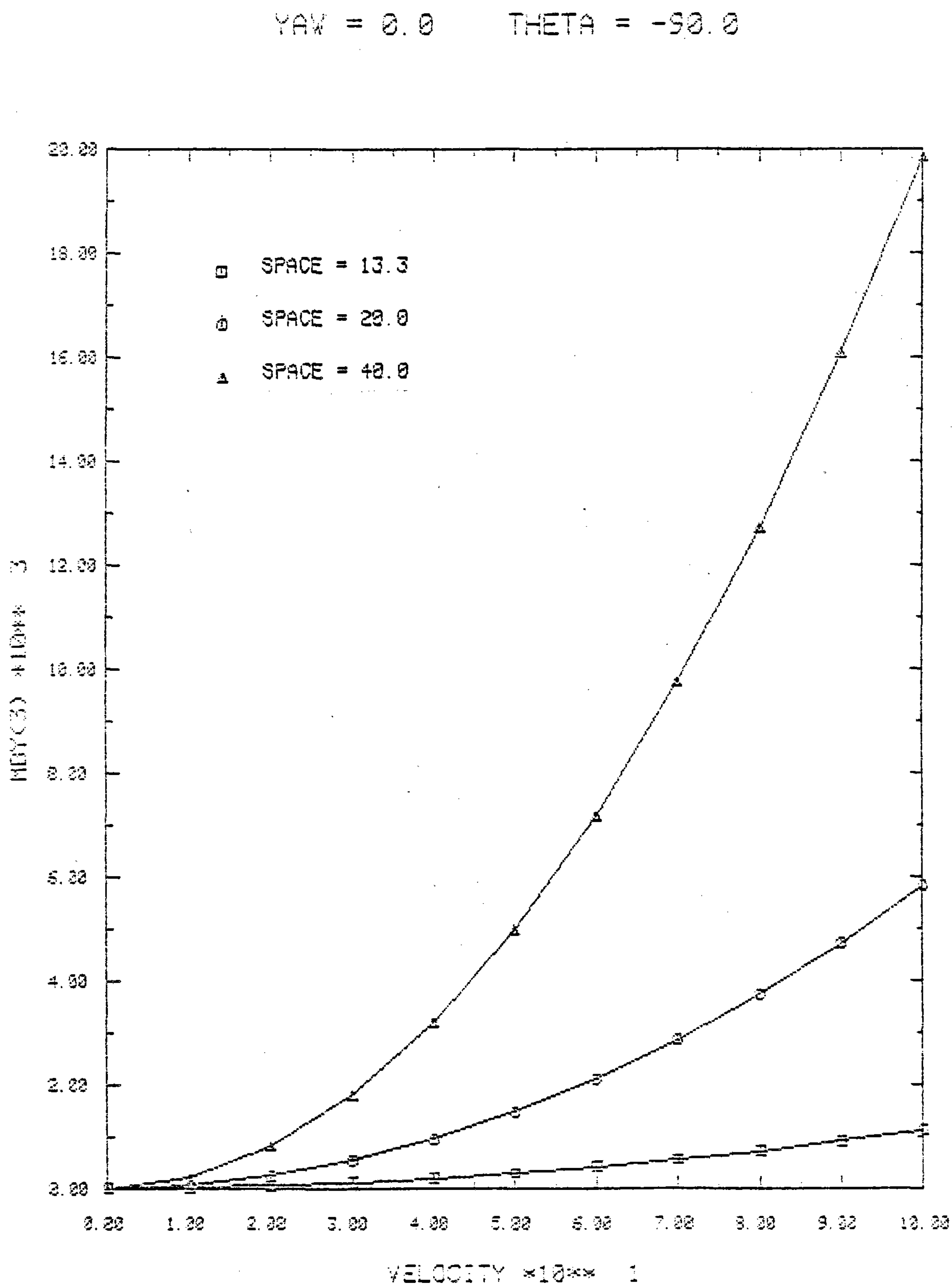


FIGURE 14. MBY(3) VERSUS VELOCITY FOR YAW = 0, THETA = -90°, AND LENGTH = 120 FT

Another parameter investigated during this study was the yaw angle. It was concluded that this angle had minimal effect on the structural loads and in all cases except one, the loads and moments decreased with an increase in yaw. A yaw angle of zero, therefore, was used to provide the worst case condition. The one case that did not provide the worst case condition was the turning moment about the X'-axis. This effect is shown in Figure 15. For design purposes, this moment is still only 20% of the moment about the Y'-axis even at a yaw angle of 75°. The moment about the X'-axis used for structural design purposes will be that at a yaw angle of 75°.

D. Design Loads

As mentioned above, the design condition is an 80 mph wind speed with the collectors in the stow position of a -90° pitch angle. As will be discussed in the preliminary design section of this report, a number of design trade-offs were conducted. The design loads for four collector configurations under consideration are outlined in Table VIII. The loads in Table VIII will be used as input by the structural consultant to analyze the magnitude of the roof modifications. To summarize, FV is the vertical force, FH is the horizontal or shear force, MBY is the moment about the Y'-axis, and MBX is the moment about the X'-axis.

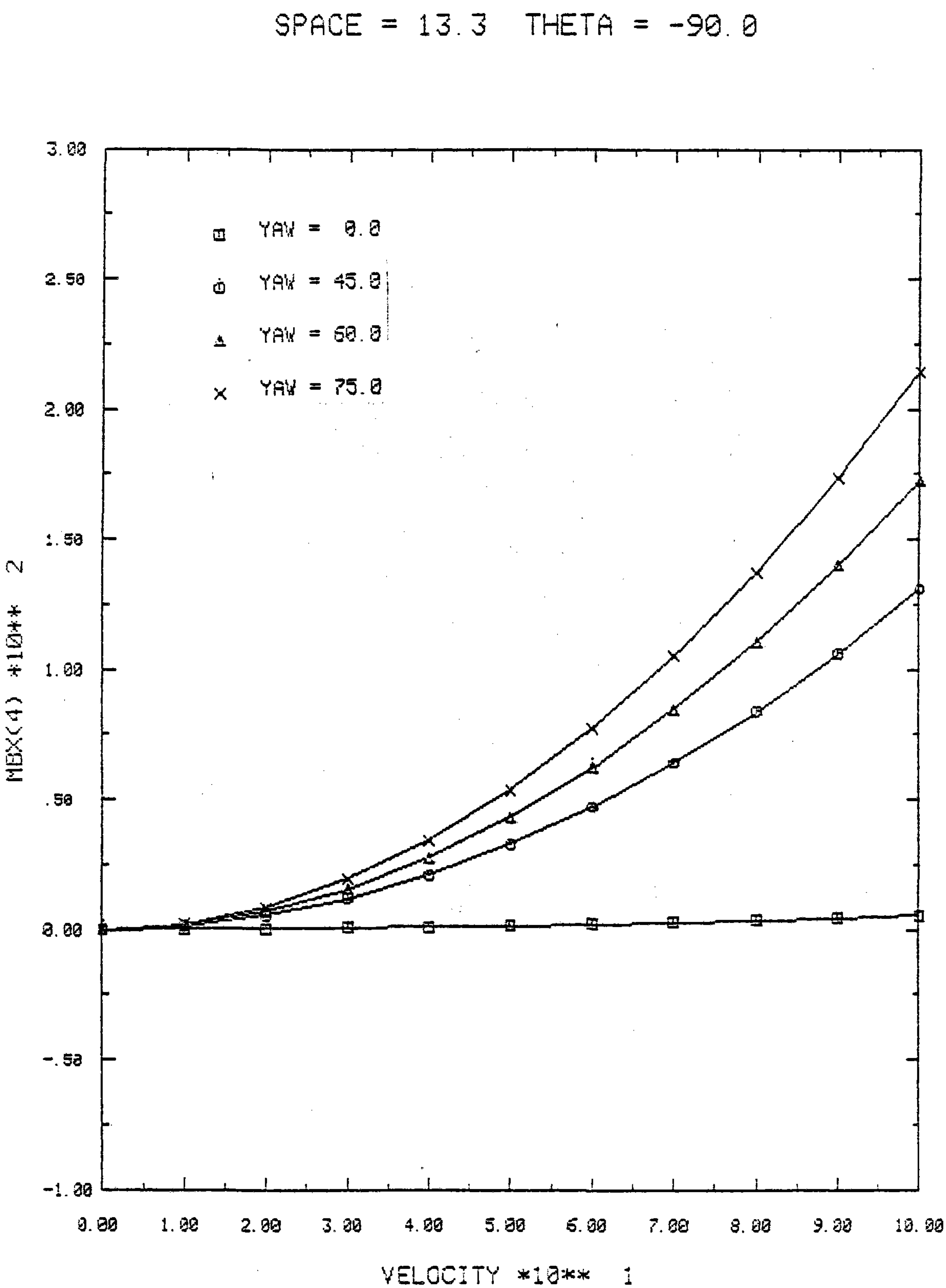


FIGURE 15. MBY(4) VERSUS VELOCITY FOR SPACE = 13.3 FT, THETA = -90°, AND LENGTH = 120 FT

TABLE VIII. SUMMARY OF DESIGN LOADS

	Configurations #1	#2	#3	#4	Yaw
Spacing, ft	13.3	13.3	13.3	20	
Row Length, ft	100	120	120	120	
Minimum	Manif.	Manif.	Roof Mod.	Light Blockage	
θ	-90	-90	-90	-90	
Velocity, mph	80	80	80	80	
FV(1)	-383	-383	-383	-759	0
FV(2)	-768	-768	-768	-1521	
FV(3)	-769	-769	-769	-1522	
FV(4)	-770	-769	-769	-1523	
FV(5)	-770	-770	-770	-1524	
FV(6)	-386	-770	-770	-1524	
FV(7)	-	-386	-386	-764	
FH(1)	80	80	80	422	0
FH(2)	160	160	160	844	
FH(3)	160	160	160	844	
FH(4)	160	160	160	844	
FH(5)	160	160	160	844	
FH(6)	80	160	160	844	
FH(7)	-	80	80	422	
MBY(1)	351	351	351	1855	0
MBY(2)	703	703	703	3713	
MBY(3)	704	703	703	3713	
MBY(4)	-29129	-35095	-35095	-32085	
MBY(5)	704	704	704	3714	
MBY(6)	353	704	704	3715	
MBY(7)	-	353	353	1858	
MBX(1)	69	69	69	137	75
MBX(2)	137	137	137	228	
MBX(3)	137	137	137	228	
MBX(4)	137	137	137	228	
MBX(5)	137	137	137	228	
MBX(6)	69	137	137	228	
MBX(7)	-	69	69	137	

VI. SAFETY ANALYSIS

A. Introduction

The solar industrial process heat system designed during this project is basically a very safe and reliable system. The piping and pumping system is almost identical to the current process hot water system in the plant and as such does not increase safety problems in any way. Since the fluid is pressurized water with an overpressure of only 15 psig there are no fire or toxicity hazards. This open loop system in effect is just an extension of the current plant process piping system, and as such the conventional mechanical and electrical safety aspects of the design are incorporated into the solar system design. All of these aspects are considered in every facet of the mechanical and electrical system specifications. The design concept is to pump process hot water from the existing hot water return line through a 50,400 ft^2 concentrating solar collector array and return the solar heated water to the same plant process line downstream of the pump suction point. All mechanical and electrical systems are designed in accordance with applicable building codes, so that conventional safety requirements such as grounding, circuit breakers, and switches are considered and included into the system design. The only additional safety considerations are those imposed by the collectors themselves: the effect of operational aspects on the current process system, consideration for workers and visitors on the roof, and collector environmental effects.

B. Collector Array Safety

Since the collector system is in essence a heat source, care must be taken to prevent any overtemperature conditions which would lead to excessive pressures. This condition could occur if the collector were focused with no flow. This stagnation condition would lead to boiling of the water in the collector tubes and a high enough thermal gradient in the tubes to warp the receiver tubes and plate out the selective surface. Another potential problem would be excessively high winds which could damage the collector drive system if the collectors were in the tracking mode. This damage could lead to a condition of focused sunlight under uncontrolled conditions or a condition of the reflector module being whipped about uncontrollably by the wind and rupturing the flexible hoses. To prevent these hazardous conditions the collector package is equipped with a hazard-stow relay system, which will drive the collector system to the stowed and locked position, i.e., a position with the collectors facing straight down so no focused sunlight is received by the collector thereby eliminating the energy input required to sustain a high temperature and high pressure. This position also puts the collectors in a hydraulic lock condition to prevent wind damage. The hazard-stow relay is activated should any of the field contact closure devices cause the circuit to the relay coil to lose power. The field contact closure devices are for loss of AC power (a battery backup and hydraulic accumulator are provided), high winds, insufficient light level (nightfall or stormy weather as well as freezing by radiation to a clear night sky), overtemperature or freezing fluid conditions, and loss of flow in the field. The system is also provided with system pressure relieve for each collector row.

C. Operational Hazards

The main operational hazard would be a break in either the manifold piping or collector absorber tubes. This condition would pump the plant process water on the building rooftop, thereby running the entire plant process water supply dry. To prevent this from occurring, a high flow limit switch will be incorporated so that if a line breaks the pump head will decrease, the flow capacity will increase. This would lead to an excessive flow rate which would trip the limit switch. The signal from this switch would defocus the collectors, turn off the system pump, and stow the collectors.

D. Work and Visitor Safety

To minimize the potential of workers or visitors from tripping over a large array of manifold piping, all of the manifold piping will be installed in the truss structure below the roof line, and penetrating the roof at the inlet and exit of each row. An additional safety precaution is the collector mounting locations that provide a 20 ft clear area between the collectors and the edge of the building for maintenance personnel. For visitors, a controlled access walkway is provided, that is located far enough away from any active collector components to prevent visitors from coming in physical contact with those components and to prevent any reflected light from injuring these visitors.

E. Collector Environment Effects

The only potential effect that the collector system can have on the surrounding human environment would be the possibility of reflected light hampering air traffic, since the plant site is located in the air traffic control zone for the Oakland International Airport. The collector system is composed of 60 rows of parabolic trough concentrating collectors. As such, 50,400 ft^2 of reflective mirrors are incorporated to focus sunlight onto 7500 linear ft of black plated steel pipe. The geometry of this reflection configuration yields a focal length of less than 2 ft so that any stray light would be less diffuse than that reflected by a flat glass window used in decorative glass office buildings. In addition to the geometry of the collectors, the geometry of the location also minimizes any potential effects. The collector field is located south of the airport so that approaching aircraft from the south would have the sun behind them so that no reflected light would impinge on these aircraft. Departing traffic to the north and south will be "climbing out" and as such any reflected light would not pose a problem to the pilot, because the light will not be in their forward field of vision. Air traffic approaching from the north are the only aircraft that potentially could be affected by reflected light. The comparison of the focal length with the actual distance that the aircraft would be from the collector field assures that no adverse effect will be experienced by the pilots in these aircraft.

In conclusion, the system considered in this report has been designed with great concern for the safety operation of this process heat system. The basic design does not have any major safety problems.

VII. ENVIRONMENTAL IMPACT ASSESSMENT

A. Description of the Proposed Action

The proposed action is the construction of a solar process heat system for Caterpillar Tractor Co.'s San Leandro plant located in San Leandro, California. The design concept is to pump plant process hot water from the system return line through a concentrating collector field of about 50,000 ft^2 and inject this solar heated water back into the system return line thereby preheating the return water to the current hot water generators. Since the potential magnitude of the environmental impact for this simple system will be extremely small, the depth and scope of this assessment will also be small.

B. Description of the Existing Environment

1. Climatological Summary at the Industrial Plant Site

The San Leandro plant is located in northwest San Leandro. This climate at this site has three outstanding features: mild year-round temperatures; low overcast, clearing by noon with almost no rain during the summer; and copious rains during the winter. Located on the east shore of San Francisco Bay, San Leandro enjoys a climate more equable than would be expected if only latitude were considered. Because of the prevailing westerly winds from the Pacific, where temperature varies very little between winter and summer, winters are mild and summers are cool. On an average of about 4 days a year, when northeasterly winds have overcome the prevailing westerly wind, daytime temperatures may reach into the nineties and on rare occasions (6 times since 1928) temperatures of 100° or higher have been recorded. Although during the winter about 6 days with minimum temperatures of 32° or below can be expected, some flowers are usually in bloom, and hardy shrubs seldom are damaged. The average date of the last freeze in the spring is February 3, but freezing temperatures have been reported as late as April 6. The average date of the first freeze in the fall is December 12, although temperatures of 32° or lower have been observed as early as November 4.

Since 1928 the total annual rainfall has ranged from a low of 8.34 inches in 1929 to a high of 29.54 inches in 1941. About 90% of the annual total rainfall is received in the six months, November through April. During the 100-day period, June 15 - September 22, the normal rainfall is only 0.07 inch. In spite of the almost rainless summers, however, cooling sea breezes, morning overcast and rather high relative humidity prevent any semblance of a desert climate.

Separating San Leandro both geographically and climatically from its neighboring communities to the north and east, is a range of hills 700 to 1900 feet in height, roughly paralleling the Bay shore and lying about 4 miles inland. East of these hills, summers are normally free of fog, have low humidities, and afternoon temperatures 15° to 25° higher than San Leandro. In winter, local variations in temperature are not so apparent, with the entire East Bay area registering daily high and low temperatures comparable to those of San Leandro.

The broad valleys of Contra Costa County and southern Alameda County are subject to nighttime and early morning radiation-type fogs in the winter, particularly after a period of rain when skies are clear and the air damp and still. These fogs occur with a frequency somewhat greater than San Leandro's average of 18 days per year, and the persistency of the fogs is a bit greater, with little or no clearing on some days.

2. Land Use at the Industrial Plant Site

The industrial site itself is zoned for heavy industry with similar heavy industry located to the east. To the south and to the north, single family residential land use prevails. Since the collector field will be located on the second story roof of the plant, this installation will have no effect on land use in the area.

C. Potential Environmental Impact

1. Air and Water Pollution

Since the heat transfer fluid is pure water, there will be no adverse effect on either the existing air or water table. The water being pumped through the collectors is not the water used for washing parts. The water with detergents for this function is isolated from the collector system by heat exchangers in each part's washer. The discharge of this wash water is covered under the plant's current NPDES permit. The process water used in the collector system is the same water used in the current process hot water and is, therefore, also covered by the plant's current NPDES permit. In summary, there are no new fluids or fluid systems that are not an extension of the current plant system so that no new permits are required. The system will be equipped with a safety system to shut down the collector pumping system in the event of a break in any collector array piping, so that the quantity of water that can be lost due to system failure is so small that no significant impact would be imposed on the surrounding industrial environment. The plant is located in a heavily industrialized setting with periods of poor air quality. There is no aspect of this project that would adversely affect the air quality. In fact, the energy saved by the solar system would decrease the amount of fossil fuel burned by the plant boilers thereby improving the air quality due to the elimination of the products of combustion for this fuel.

2. Water Usage

No significant water usage will be required after initial charging of the system. The small amount needed will be for monthly or bimonthly washing of the collectors. The estimated water usage is about 1000 gallons of water per month.

3. Noise Impact

It is possible that noise generated as a result of construction activities will increase noise levels above existing work limits. The predominate industrial activities at the site, however, generate a relatively high dBA level under present working conditions; it would be unlikely, therefore, that the intermittent noise, within a generally narrow time frame generated through standard construction activities, would have a significant adverse impact.

4. Energy Impact

The proposed action will indeed have a significant impact on the energy usage on the industrial plant. This impact and the economical consequences of this impact are the major reasons for initiation of this proposed action. This system is estimated to provide about 60% of the plant process hot water needs during ideal weather conditions. The energy impact will obviously be a positive contribution. The magnitude of the energy saved is estimated to be 12 billion BTU during an average weather year. During nonaverage year this value could vary by as much as ±10%.

5. Geological Impact

The solar process system will have no affect on the surrounding geography, but the location of the plant site in a severe seismic zone could have an affect on the system. This potential effect was considered in the structural design to minimize damage due to earthquakes.

6. Land Usage Impact

If the solar collector field were mounted on the ground, this land would need to be purchased from adjacent industrial locations. The size of the land required would probably be about three acres. Since the collector field will be roof-mounted, no long range impact on land usage will be felt, and the surrounding valuable urban land can be used for more productive purposes.

7. Socio-Economic Impact

The proposed action will not cause any adverse sociological or economic impacts. The only potential effect would be positive and that would result from the increase in jobs and financial interaction with the local construction community. This effect, however, is expected to be small since the absolute magnitude of the cost of construction is small in comparison to the local construction economy.

8. Visual Impact

The only potential visual effect that the solar reflector system could have on the surroundings would be possible reflection that could hamper air traffic, since the plant site is located in the air traffic control zone for the Oakland International Airport. The collector system is composed of 60 rows of parabolic trough concentrating collectors. As such, 50,400 ft^2 of reflective mirrors are incorporated to focus sunlight onto 7500 linear ft of black plated steel pipe. The geometry of this reflection configuration yields a focal length of less than 2 ft so that any stray light would be less diffuse than that reflected by a flat glass window used in decorative glass office buildings. In addition to the geometry of the collectors, the geometry of the locations also minimizes any potential effects. The collector field is located south of the airport so that approaching aircraft from the south would have the sun behind them so that no reflected light would impinge on these aircraft. Departing traffic to the north and south will be "climbing out" and as such any reflected light would not pose a problem to the pilot, because the light will not be in their forward field of vision. Air traffic approaching from the north are the only aircraft that potentially could be affected by reflected light. The comparison of the focal length with the actual distance that the aircraft would be from the collector field assures that no adverse effect will be experienced by the pilots in these aircraft.

VIII. DATA COLLECTION AND EVALUATION PLAN

To evaluate the performance of this solar collector installation requires the measurement, collection and analysis of meteorological and process parameters. This data collection and evaluation will consist of three parts, as follows:

- Parameter Selection
- Measurement Accuracies
- Evaluation Plan

A. Parameter Selection

The selection of parameters for the performance evaluation is based on a set of objectives established in the "Data Acquisition and Analysis Guidelines for IPH Demonstration Projects" by Kutsler and Kearney from SERI. These objectives are as follows:

- Determine the energy delivered to the process by solar collector system on a monthly and an annual basis.
- Determine parasitic energy used by the solar collector tracking and pumping system on a monthly and an annual basis.
- Determine the percent of solar energy to other fuel sources on a monthly and annual basis.
- Determine collector array efficiency on a "instantaneous", daily, weekly, and annual basis.
- Determine significant losses (piping runs, etc.).
- Determine changes in collector system operational characteristics with weather exposure.
- Determine long-term reliability in terms of materials, components, and system performance.

To achieve the objectives, a set of parameters must be measured and used to determine the following:

- Short-wave solar radiation available at the collector field.
- Thermal energy collected by the collector field.
- Solar-thermal energy transferred to the process.
- Thermal energy losses from the system.
- Non-solar thermal energy transferred to the process.

- Parasitic energy required for collector tracking and pumping.
- Environmental conditions affecting the thermal loss characteristic of the collector field.

1. Solar Radiation

Short-wave solar radiation measurements consist of three categories: direct beam, diffuse horizontal, and total horizontal. The direct beam component is the focusable component of energy included within a 1/2° cone about the sun's center. When passing through a turbid atmosphere, with large aerosols, a significant amount of energy is translated into a cone of about $\pm 5°$. This energy is designated as the circumsolar component. This circumsolar component has the same general angular time variations as the direct component and results from forward scattering of the sun's rays. The diffuse component ("sky radiation") results from atmospheric scattering. This component requires a measurement with a stationary, horizontal, absorbing surface. Radiation which is available to the collectors is limited to direct, circumsolar, and a portion of the diffuse. The available radiation is limited by the collector acceptance angle. Thus, to measure the total radiation seen by the collector, three pyranometers will be mounted to track with a collector row. One will provide total radiation as a function of collector angular position, and the other two will have modified apertures. One will have a shadow band to block radiation in the collector aperture; thus, the radiation at the collector is the difference between the total and the shadowed measurements. The second modified pyranometer will have a "shadow" type band assembly to simulate the collector aperture to yield a direct measurement of radiation available to the collector. This method provides redundancy in measurements.

2. Thermal Energy

To determine the thermal performance of the solar collector system, temperature and volumetric flow rates will be measured. These measurements will allow the determination of the solar energy transferred to the process, and thermal losses from the solar collector system, piping, and non-solar thermal energy transferred to the process. The temperature and flow measurements required to categorize the thermal performance are as follows:

TE100, TE101	- Collector Bank Inlet Temperatures
TE102, TE103	- Collector Bank Outlet Temperatures
TE104, TE105	- Collector Row Inlet Temperatures
TE106, TE107	- Collector Row Outlet Temperatures
TD100	- Temperature Differential Across a Collector
TE200	- Non-Solar Outlet Temperature
TE202	- Non-Solar Inlet Temperature
FE100, FE101	- Collector Bank Inlet Flow Rates
FE102, FE103	- Collector Bank Outlet Flow Rates
FE200	- Flow Rate from Non-Solar Supply

With these measured quantities, the thermal energy transferred can be calculated using the following equation:

$$Q = m \, C_p \, (T_{f,o} - T_{f,i}) \tag{31}$$

The thermal energy from the solar collectors, non-solar, and thermal pipe losses require the calculation of mass flow rate, m, by multiplying the volume flow rate, w, by the density, ρ, at the average fluid temperature. This result is then multiplied by the fluid specific heat (C_p) at the average fluid temperature and then multiplying by the temperature differential. Thermal losses are given by comparison of single row performance and collector bank performance after flow balancing is verified. Non-solar supplied is derived in a similar fashion as the collector performance. The use of multiple flow meters in each loop provides redundancy in the measurements. Each temperature location will contain dual RTD sensors to provide redundancy in the event of a sensor failure. A set of pressures across the collector banks will also be measured. These sensors provide information on abnormal system conditions (i.e., ruptured collector tube).

3. <u>Parasitic Losses</u>

Parasitic losses result from the energy required to power fluid transfer pump motors and the tracking system hydraulic pump drive motors. The electrical power will be measured by an A.C. wattmeter transducer.

4. <u>Environmental Conditions</u>

Several environmental conditions other than solar radiation affect the operation of the collector field. The parameters are as follows:

- Wind Speed
- Wind Direction
- Relative Humidity
- Rain Fall
- Ambient Temperature

Wind speed and direction not only affect the convective loss from the absorber tube, but also tracking accuracy of the reflector. Changes in relative humidity cause changes in direct beam radiation, and reflective surface conditions. Although the collectors are stowed for most rainfall conditions, this parameter will provide some information on collector operational changes and washing cycles due to rainfall. Ambient air temperature is a standard measurement and also provides information on losses from the collector tube, as well as external piping.

B. Measurement Accuracies

The topic of measurement accuracies is expanded to also include reliability and calibration. General guidelines have been published for the installation of instrumentation in solar performance evaluations. Both ASHRAE Standard 93-77 (ANSI B198.1-1977) entitled "Methods of Testing to Determine the Thermal Performance of Solar Collectors" and "Instrumentation Installation Guidelines" (DOE Contract EG-77-C-01-4049) were used to establish measurement accuracies, calibration intervals and reliability. Measurements which are used directly to evaluate the solar collector system performance and efficiency require special consideration; all other are general purpose measurements.

1. General Purpose Measurements

This group of measurements include process hot water pressure and meteorological measuremetns. This group of measurements will not require periodic calibration and redundant measurements will not be provided. Installation accuracy for these measurements are given as follows:

Pressure	±1%
Wind Speed	±1%
Wind Direction	±1%
Relative Humidity	±2%
Rainfall	±1%
Ambient Air (Dry Bulb)	±.5%

2. Performance Evaluation Parameters

Measurements for the performance evaluation include the following:

- Collector Bank Inlet Temperatures
- Collector Bank Outlet Temperatures
- Collector Row Inlet Temperatures
- Collector Row Outlet Temperatures
- Non-Solar Inlet Temperature
- Non-Solar Outlet Temperature
- Collector Bank Flow Rates
- Collector Row Flow Rates

- Non-Solar Flow Rates
- Solar Energy Measurements
- Electrical Power Measurements

Each of these measurements will be duplicated with a parallel measurement to enhance data integrity and allow checks for deteriorating performance. The measurement system will be calibrated at 6-month intervals under normal operation. Temperature and electrical power measuring instruments will be calibrated in place against a certified calibrated instrument. Flowmeters, and pyranometers, will be exchanged on a rotating basis and calibrated in a laboratory. Accuracy of the measurements is based on sensor accuracy, signal conditioning and data sampling rate. The sensor and signal conditioning errors are combined as instrument accuracy. Criterion provided by DOE requires that the energy balance method of performance evaluation requires calculations of ±6%. To assure acceptable accuracy of the derived quantities, an uncertainty analysis is performed to determine required measurement accuracy. The first step in this analysis is to investigate the sensitivity of the derived quantitites to the measured quantities. If instrumentation precision errors are assumed to be absolute limits, the accuracy of the derived quantities can be determined by expanding the functional relationships for this quantity in a Taylor series and negating the second order and larger terms. For example, to determine the error in deriving the thermal energy transferred to the collector fluid by the collector field,

$$Q_c = C_p W \rho \ (T_{f,o} - T_{f,i}) \tag{32}$$

$$\frac{\partial Q_c}{\partial C_p} = W \rho \ (T_{f,o} - T_{f,i}) \tag{33}$$

$$\frac{\partial Q_c}{\partial W} = C_p \rho \ (T_{f,o} - T_{f,i}) \tag{34}$$

$$\frac{\partial Q_c}{\partial_p} = C_p W \ (T_{f,o} - T_{f,i}) \tag{35}$$

$$\frac{\partial Q_c}{\partial \Delta T} = C_p W \rho \tag{36}$$

$$\Delta Q_c = \left| \frac{\partial Q_c}{\partial C_p} \Delta C_p \right| + \left| \frac{\partial Q_c}{W} \Delta W \right| + \left| \frac{\partial Q_c}{\partial \rho} \Delta \rho \right| + \left| \frac{\partial Q_c}{\partial T_{f,o}} \Delta T \right| \tag{37}$$

If, however, the errors are random and uncorrelated, then precision errors can be calculated by a statistical method where:

$$\Delta Q_c = \left[\left(\frac{\partial Q_c}{\partial C_p}\Delta C_p\right)^2 + \left(\frac{\partial Q_c}{\partial W}\Delta W\right)^2 + \left(\frac{\partial Q_c}{\partial \rho}\Delta \rho\right)^2 + \left(\frac{\partial Q_c}{\partial T_{f,o}}\Delta T\right)^2\right]^{1/2} \tag{38}$$

The error for either case is then expressed as

$$\text{Error} = \pm \frac{\Delta Q_c}{Q_c} \tag{39}$$

This application requires the temperature measurement to at least ±.1°F. Since the temperature differential $(T_{f,o}-T_{f,i})$ is calculated from two measurements, the derived accuracy is as follows:

$$\text{Accuracy} = \left[\sqrt{\sigma_1{}^2 + \sigma_2{}^2} \;/\; \Delta T\right] = .35\% \text{ for } \Delta T \quad 40°\text{F} \tag{40}$$

Three other parameters must be considered. Specific heat of the collector fluid (C_p), volumetric flow (W), and density (ρ) of the collector fluid. The value of C_p for pure water has a variation of only 0.3% over the collector temperature range; however, the collector is a mixture of water and other chemicals which will change the value of C_p slightly. This value will be determined from initial samples from the system and checked periodically. For this analysis its accuracy will be considered at 1%. Likewise, density is not a continuously measured parameter. A function table of density with respect to temperature will be used in the data evaluation. This relationship will be checked from initial samples, as well as samples at periodic intervals. An accuracy of ±1% is assumed. Thus, the only parameter left in the energy balance equation which influences the accuracy is flow measurement. The required measured accuracy of the flow measurement to obtain a 6% accuracy in the thermal equation at minimum operating conditions is 3.6% for random and uncorrelated parameters. The more conservative absolute approach requires an accuracy of ±.5%. To insure the best data collection performance, the ±.5% flow accuracy will be used for design.

Since the measured variables are samples at periodic intervals, errors result for sampling intervals which are not at least 2.5 times the highest frequency in the signal. Practical stored data sampling rates are much lower than the frequencies of solar, flow and temperature parameter variations. The collector system will be designed to sample rapidly changing parameters at a fast rate and calculate the mean value over the data storage interval. This removes aliasing problems and improves data integrity by removing noise. Error from sampling for these rapidly varying signals is a function of the number of samples, N, and ratio of the varying to steady signal component, α:

$$\sigma < \frac{\alpha}{\sqrt{N}\,(1-\alpha)} \tag{41}$$

By taking large numbers of samples and statistically producing the mean of the waveform, the error is reduced to:

$$1/\sqrt{N} \tag{42}$$

Thus, using statistical analysis methods, the hourly performance evaluation will have 22 times the error of a yearly analysis based on 20 samples per hour rate.

C. Data Evaluation

The objective of data evaluation is to provide performance information on the solar collector system and then relate the information to overall process performance. Solar data will be evaluated both in real-time (on-site) and in batch mode.

1. Real-Time

To provide real-time, on-site, data evaluation requires the data collection system to support analytical software, rapid data storage and retrieval, remote communication, local keyboard entry, CRT display, and hard copy printing. Thus the system will provide, on request, the immediate values of measured parameters (temperature, flow, etc.) and calculated thermal energy. The immediate values will be processed to provide hourly performance values. The hourly values will be stored and used to provide a daily summary printout, as well as a monthly summary report. The hourly performance will also be accrued for yearly evaluations. The remote communication channel allows interrogation of immediate values, as well as stored data base. This also provides a mode for remote reprogramming if required to enhance the system.

Analytical software will also provide data reliability evaluation. Since redundant measurements are collected, the comparison of equivalent parameters provides information used to flag problems in a measurement. A comparison of measured parameters to set allowable operating limits will provide alarm notification.

2. Batch Mode

The data collection system will provide storage of all measured parameters including sample time on 9-track magnetic tape. The data will be stored in ASCII format with each datum 8 bytes in a record length of 80 bytes and with 16 records per block. Thus, the tape will be in ANSI labeled format with a block size of 1280 and recorded at 800 BPI. For a sampling rate slower than 2 minutes, the tape will be removed on a monthly basis and shipped to SwRI. Data from the tape will be immediately reduced on a PDP11/70 to hourly performance values and these values compared to values generated by the on-site system. Further analysis of individual parameters will result if discrepancies are found. This provides a monthly check of tape recorded data integrity. The monthly tapes will be used in a yearly performance evaluation of the system using the energy balance method.

IX. PRELIMINARY DESIGN

The Preliminary Design as defined in this context includes all design and analysis that precede the Detail Design. The Detail Design includes the generation of the detail design drawings and the system specifications. With these two definitions in mind, the objective of the Preliminary Design is to select the most cost-effective collector design, select the optimum system configuration, select the optimum array configuration, and optimum insulation thickness.

A. Solar Collector Selection

1. Collector Alternatives

The current state-of-the-art in high-temperature solar collectors that have been independently tested and are in the production stage of development numbers four manufacturers. These manufacturers are:

- o Acurex Corporation
- o Jacobs-Del Solar System, Inc.
- o Solar Kinetics, Inc.
- o Suntec Systems, Inc.

All of these manufacturers have had independent thermal performance tests conducted at the Sandia Mid-Temperature Collector Module Test Facility. It is interesting to note that most of these manufacturers are constantly modifying these units to improve the performance, reliability, maintainability, ease of fabrication, or ease of installation. It is therefore, difficult to have exact test data on the most up-to-date version of each collector. Great care, however, was taken so when the latest version was recommended over the specific model tested, that this new unit was indeed more efficient so that the test data was conservative. A brief description of each of the collectors available is listed below.

a. Acurex Corporation Model 3001

The Acurex Model 3001 is a reflecting parabolic trough collector with a 6-ft wide aperture, a concentration ratio of 58, and a rim angle of 90°. This unit is constructed in 10-ft modules with vertical steel columns provided between modules to support the system weight of 5.9 lb/ft^2. Eight of these modules are normally included in a single row with a single drive system in the center of the row. The drive system consists of a fractional horsepower gear motor which transmits power through an enclosed gear box. Input to the motor is controlled by a shadow band tracker with two silicon photo-cells. When the vertical axis of a collector is aimed at the sun, the output from the two cells is balanced and the motor deactivated.

The reflective surface of the parabolic trough is fabricated from ALZAK with a reflectance of 0.75. In addition to the ALZAK, the manufacturer is beginning to quote units with both glass and FEK, but test results have not been made available at this time. Once the sunlight is reflected from the surface, it passes through a Pyrex glass jacket and strikes the receiver tube. The receiver is constructed of a 1-1/4 inch mild steel pipe with a black chrome selective surface. The absorptance of this surface is 0.94, and the emittance is 0.18.

The principal advantage of this unit is that the reflective surface of this unit is a relatively stable surface with very small degradation due to exposure. This reflective surface is also very hail resistant because of its 40-mil aluminum skin. The disadvantages of this unit are: low mirror reflectance, receiver tube breakage problems, rusting of the reflective casing, low system performance, leakage of the flexible hose connection, and high purchase and installation cost. As will be shown later in this document, the cost-effectiveness of this particular unit is less than some of the other candidate collectors, because of its low performance and a higher cost.

b. Jacobs-Del 24-in. Concentrating Collector

The Del Collector is a parabolic trough concentrator composed of glass mirror segments. Each segment is a 2-ft long piece of sagged glass formed to the appropriate parabolic shape and back silvered. The silvering is protected from the weather by an inert, nonporous coating on the back side and by the glass on the reflecting side. These mirrors, which have a reflectance of 0.9, are fitted into a parabolic frame with an aperture of 2 ft and a rim angle of 110°. The parabola is composed of four mirror segments with some optical distortion at the edge of each mirror, or eight 1-in. distortion bands. These bands decrease the thermal performance from the theoretically predicted values.

The reflector concentrates the sunlight onto a stationary receiver tube positioned at the focal point and center of rotation of the parabola, which is also the center of gravity of the unit. The fixed 1/2-in. diameter receiver is coated with a selective coating of black chrome which exhibits an absorptance of 0.94 and an emittance of 0.18. This hard-mounted receiver is completely fixed so that no flexible fluid connections are required. Thermal losses from this tube are decreased by a 1.5-in. diameter Pyrex glass tube with a transmittance of 0.9.

The drive system for this unit is a photoelectric sensor which controls a reversible motor and an enclosed worm gear assembly. This control unit provides stow as well as defocus features to provide a complete hazard avoidance system.

The advantages of this collector are its stationary receiver, its glass reflector, which provides high reflectance and long life, and low wind loads. The disadvantages are a low thermal performance due to low concentration ratio, high unit weight, high installation costs, and high purchase price.

c. Solar Kinetics T-700 Collector

The Solar Kinetics T-700 is a large aperture (7 ft) parabolic trough concentrating solar collector constructed of a rigid monocoque aluminum assembly which provides an excellent strength to weight ratio. The rim angle of this unit is 90° with a concentration ratio of 52. One of the unique features of this collector is the no-lash hydraulic tracking system. This system provides accuracy and durability with two tracking speeds, one for daily tracking of the sun and one for hazard stow operation. The hydraulic accumulator provides the capability to stow the collector in the event of a loss of power.

The parabolic reflector is a precisely constructed mirror surface covered with metalized acrylic film which combines weather resistance and high reflectivity. This film is FEK-244, manufactured by the 3M Corporation, with a reflectance of 0.84, a proven life of at least seven years, and a predicted life of over 10 years. The surface reflects the sun's rays onto a 1.63-in. diameter steel tube coated with selective black chrome and a Pyrex glass cover with an O-ring seal for dust and dirt protection. The absorptance/emittance ratio of this coating is 0.94/0.18. After the heat transfer fluid passes through this receiver tube, it is conveyed to the stationary plumbing via an insulated stainless steel flexible hose which allows rotation of the collector without any flow restriction. The reflector rotation is made possible by self-aligning sealed ball bearings which absorb structural loads and misalignment from shifting of the building support without any binding.

As with all of the other collector manufacturers, Solar Kinetics is investigating the use of a glass mirror reflector. The manufacturers' current projections are that a glass mirror will be available as an option when the time comes for placing an order on this project. The improvement in performance will be an increase in reflectance from 0.84 to 0.92, but the mirror area will be 98% of the current film area, so that the overall increase in collector intercept factor will be from 0.66 to 0.71. Another potentially new development for this manufacturer will be an all steel unit, which will allow a significant cost reduction from the current handmade aluminum collector. This steel unit would be mass produced, but a large investment in tooling cost will be required. There is some question as to when this unit may be available. Current projections are that it will not be available for this project.

The advantages of the T-700 are the hydraulic tracking system, the O-ring receiver cover seal, the rigid reflector assembly, the excellent overall quality, the high thermal performance, and the low installation costs. The overall system was designed with low maintenance and minimal field installation requirements in mind. The only known disadvantage to the selection of this unit is the unknown durability of the acrylic reflective film.

d. Suntec Model 1655 Collector

The Model 1655 parabolic trough tracking solar collector has the largest aperture of any other candidate collectors considered for this survey. This aperture is 9.75 ft with a rim angle of 72 and a concentration ratio of 72. Reflector panels of this unit are constructed from 3/8-in. aluminum honeycomb assemblies with 1/2-in. aluminum channel protecting the edges. The reflective surface is also FEK-244, with a reflectance of 0.84. The reflector support structure is constructed from welded steel tubing that, in combination with the honeycomb reflective backing, provides excellent rigidity against wind buffeting. The tracking system for this assembly is provided by Suntec. The sensing head consists of two phototransistors located in the focus of the reflected beam. The output from these sensors causes an imbalance in the bridge circuit by shading one of the transistors and is restored to balance when an electromechanical drive mechanism advances the position of the collectors so that the vertical axis of the collector is pointed directly at the sun. The drive mechanism is an electric stepping motor that drives the collector via a chain and sprocket assembly. The energy impinging on the reflector is collected by a black chrome coated receiver pipe with spiral internal grooves and an internal plug. The cover for this tube is a half-cylinder of Pyrex glass with a back cover of double-layer metal shield coated with a reflective inner surface of ALZAK. The advantages of this unit are the high thermal performance, low weight, and excellent reflector rigidity. The disadvantages are high wind loads, potential for hail damage, degradation of plastic film, and relatively high field installation costs.

A summary of the physical and performance characteristics of these units is shown in Table IX. The performance characteristics are given in the form of the absorptance coefficient and the loss coefficient, which are indicated in the following equation:

$$\eta = F(\overline{\rho\tau\alpha})_e - U_\ell \, \Delta T/I \tag{43}$$

where:

η = efficiency

$F(\overline{\rho\tau\alpha})_e$ = optical absorptance coefficient

U_ℓ = thermal loss coefficient

ΔT = temperature difference between the average fluid temperature and the surrounding air temperature

I = direct normal solar radiation.

Some of the collector data is best correlated by a higher order fit such as:

$$\eta = F(\overline{\rho\tau\alpha})_e - U_{\ell 1}(\Delta T/I) - U_{\ell 2}(\Delta T/I)^2 \tag{44}$$

Of the above units, Acurex performance tests have just recently been completed so that this data reflects the latest collector modification. The Del unit has not undergone any modification since its performance test but the manufacturer is considering adding an evacuated absorber tube. The Suntec collector which was manufactured by Hexcel has undergone some manufacturing modification, but the items effecting the thermal performance have not changed. The Solar Kinetics unit has just undergone thermal performance testing and therefore reflects the latest design. Table X shows the monthly and yearly performance of all four units.

TABLE IX. PHYSICAL AND PERFORMANCE CHARACTERISTICS OF THE CANDIDATE COLLECTORS

	ACUREX	DEL	SOLAR KINETICS	SUNTEC
MIRROR WIDTH	6 FT	2 FT	7 FT	9 FT
MIRROR LENGTH	10 FT	8 FT	20 FT	20 FT
RIM ANGLE	90	110	90	72
REFLECTANCE	0.75	0.90	0.84	0.84
SYSTEM WEIGHT	5.9 LB/FT^2	7 LB/FT^2	3.7 LB/FT^2	3.5 LB/FT^2
RECEIVER WIDTH	1.25 IN.	0.5 IN.	1.63 IN.	1.5 IN.
RECEIVER ABSORPTANCE	0.94	0.94	0.94	0.94
RECEIVER EMITTANCE	0.18	0.18	0.18	0.18
DRIVE MECHANISM	WORM AND WORM GEAR	WORM AND WORM GEAR	HYDRAULIC	CHAIN AND SPROCKET
TRACKING SYSTEM	ACUREX	DELAVAN	DELAVAN	SUNTEC
CONCENTRATION RATIO	58	48	52	72
ABSORPTANCE COEFFICIENT	0.55	0.614	0.66	0.6781
LOSS COEFFICIENT:				
1ST ORDER	0.093	0.059	0.04106	0.093
2ND ORDER	0	0.137	0.03990	0

TABLE X. COLLECTOR COMPARISON SUMMARY, KBtu/ft^2

Month	Acurex	Del	Solar Kinetics	Suntec
Jan	12.5	13.6	16.0	15.8
Feb	5.0	5.4	6.4	6.3
Mar	11.7	12.7	15.0	14.9
April	22.7	24.6	28.9	28.6
May	27.7	29.2	35.3	35.1
June	28.7	31.1	36.6	36.3
July	27.3	29.6	34.9	34.7
Aug	23.4	25.3	29.8	29.6
Sept	13.2	14.2	16.8	16.7
Oct	8.0	8.6	10.2	10.1
Nov	5.2	5.6	6.6	6.5
Dec	2.5	2.7	3.2	3.2
Yearly	187.9	203.3	239.8	237.8

In selecting the most cost-effective collector, the other major consideration besides performance is the cost of the units. This cost must include both purchase price and installation cost. Table XI shows the current collector cost estimates for purchasing and installing these units projected to October 1980.

To estimate the most cost-effective collector design, the information for cost and performance outlined above was combined to obtain the $/MMBtu/yr for each unit. As shown in Table XII, the Solar Kinetics T-700 is indeed the most cost-effective unit. The Solar Kinetics collector is, therefore, proposed for this application. A detailed discussion of this unit is included in the next section of the report.

TABLE XI. COLLECTOR COST ESTIMATE FOR ITEMS AFFECTED BY COLLECTOR SELECTION ONLY

	Dollars per Square Foot						50,000 FT^2
	Purchase	Instal.	Piping	Elec.	Roof Mod.	Total	Total
Acurex	23.00	4.80	5.62	4.02	8.94	46.38	$2.319 MM
Del	30.80	7.00	8.89	9.51	21.14	77.34	3.867 MM
Solar Kinetics	22.60	3.00	4.82	3.44	7.64	41.50	2.075 MM
Suntec	25.85	5.42	3.75	2.95	6.56	44.53	2.227 MM

TABLE XII. COLLECTOR SELECTION PARAMETER FOR 50,000 FT^2

	Installed Cost	Collected Energy, 10^6 Btu/yr	$/MMBtu/yr
Acurex	2.319	9,395	247
Del	3.867	10,165	380
Solar Kinetics T-700	2.075	11,990	173
Suntec	2.227	11,890	187

2. Collector Selected: Solar Kinetics T-700

The Solar Kinetics T-700 has been chosen as the most cost-effective concentrating solar collector for the present application as outlined above. This collector unit as shown in Figure 16 is a parabolic trough collector manufactured in 20-ft long modules. These modules are connected together to form rows of 100 or 120 feet. Each row tracks the sun about an axis just below the vertex of the parabolic trough. The tracking actuator is located at the center support pylon and mirror modules are connected through the use of flanges and shafts mounted to self-aligning pillow block ball bearings. The mirror module is constructed using the well-developed and tested Solar Kinetics "monocoque-stressed skin" technique. This form of fabrication provides an excellent strength to weight ratio and the parabolic shape provides excellent torsional rigidity.

The 1-5/8-in. carbon steel receiver tube is plated with black chrome and covered by a Pyrex (7740) glass tube. The entire assembly is mounted to the receiver tube stand through a unique, fully adjustable clamp.

The receiver tube is fully floating with linear as well as rotational freedom. Each end is terminated with an expansion bellows which is connected to a flexible insulated hose. The hose assembly is connected to the pylon support at each end of the row where it connects to the manifold plumbing. The air annulus in each receiver assembly is plumbed together and an outlet fitting is provided at the center to allow air expansion through a dessicator. The reflective surface is an aluminized second surface acrylic sandwich bonded to the mirror sheet metal surface. This film has demonstrated up to 84% specular reflectivity and excellent weather resistance for seven years. Solar tracking is effected through the use of a solid state electronic differential shadow bar device. The tracking actuator developed at Solar Kinetics is a hydraulic drive system and is unique in that it eliminates backlash in the tracking system. Backlash becomes a serious problem with most mechanical trackers since continued wind buffeting wears gears and mechanical drives. When sunrise provides sufficient insolation for system startup, a light switch located at the central control panel provides power to the electronic trackers and each row will track from its inverted "stow" position. Tracking continues until the shadow cast from the shadow bar on the tracker is equal on both of the light-sensitive transistors. As the sun moves, the tracker maintains this shadow "dead-band" and accurate tracking is accomplished. A hazards-stow relay is provided which will drive the row to the "stow" position should any of the field contact closure devices cause the circuit to the hazard relay coil to lose power. Loss of AC power, nightfall, overtemperature fluid condition, high winds, rain, or insufficient flow will cause the collector to defocus by eliminating the automatic tracker and providing a direct stow signal to the drive pylon. A list of physical specifications is given in Table XIII.

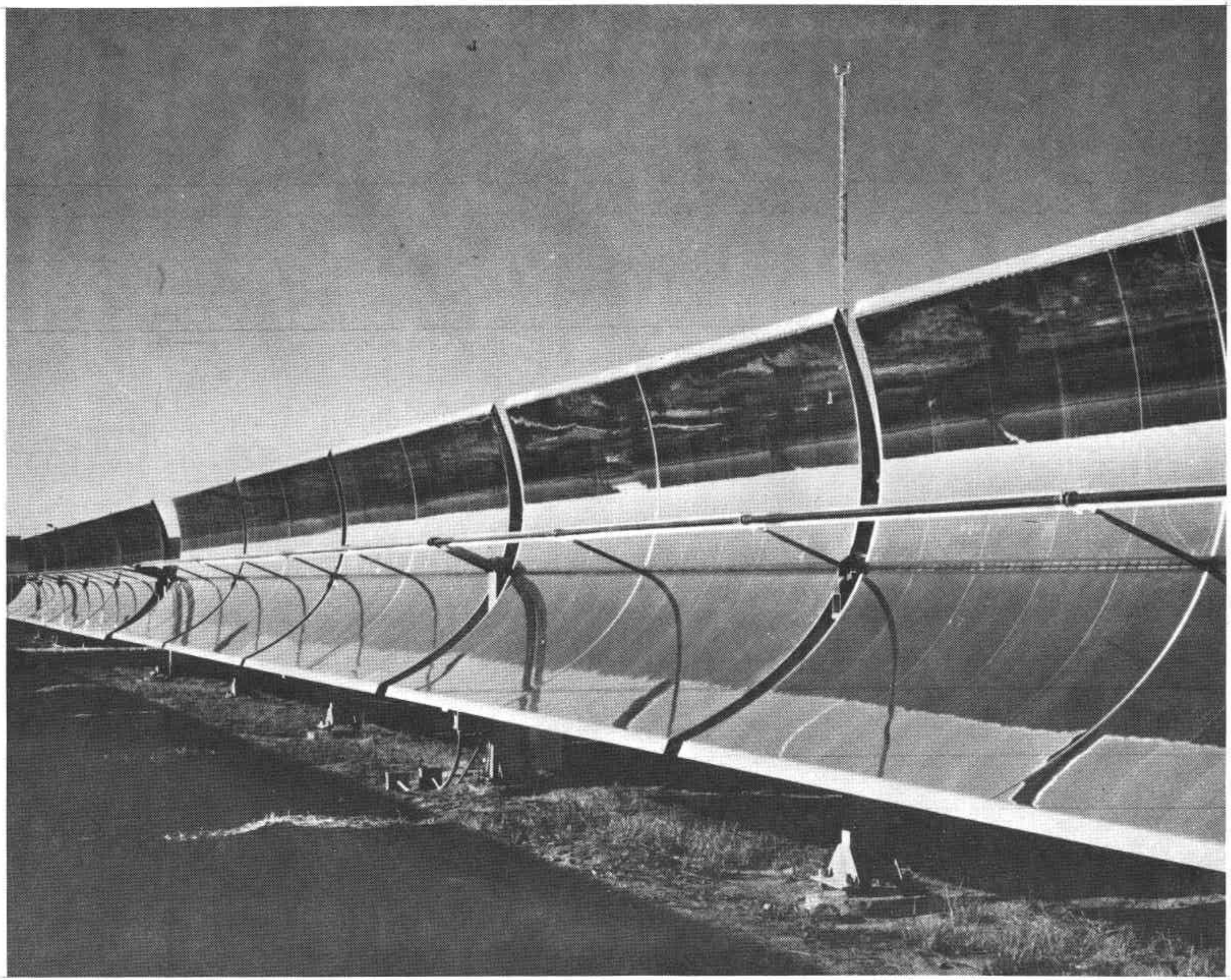


FIGURE 16. SOLAR KINETICS T-700 COLLECTORS

TABLE XIII. T-700 PHYSICAL SPECIFICATIONS

Module Width	-	89 in.
Module Length	-	20 ft
Mirror Width	-	84.5 in.
Solar Area ft^2	-	140
Mirror Reflectance	-	.84
Mirror Shape	-	90^o Parabolic
Maximum Height (vertical)	-	102 in.
Mirror Orientation	-	N/S
Maximum Tracking	-	260^o
Stow Angle	-	-78^o (from horizontal)
Rotation Axis Height	-	53 in.
System Weight	-	4.0 lb/ft^2
End Pylon Static Load	-	280 lb
Center Pylon Static Load	-	560 lb
Pylon Base Mount Bolts	-	4 ea., 1-in. at 12-in. c-c
Pylon Spacing c-c	-	246 in.
Row Spacing c-c	-	13 ft-4 in. or 20 ft
Maximum Row Length	-	120 ft
Receiver Tube	-	1-5/8-in. Carbon Steel
Selective Surface	-	Black Chrome
Absorbtivity	-	0.94
Emissivity (400^oF)	-	0.18
Receiver Cover	-	Pyrex Glass (7740)
Cover Transmissivity	-	0.91
Annulus Size	-	0.25 in.
Annulus Medium	-	Dry Air
Pumping Loss (T-66)	-	4 psi/100 ft at 5 gpm
Plumbing Connections	-	1-in. Std. Pipe
Maximum Operating Temperature	-	500^oF
Maximum Operating Pressure	-	250 psi

B. System Configuration

The basic system design concept is to heat a portion of the plant process hot water with solar energy during the periods that this energy is available and use the current fossil fuel powered "boilers" when the sun is not shining. Since the plant can accept 100% of the solar heated water at all times no storage system is needed. If the current proposed collector field is expanded in the future the need for storage could change.

The System configuration can take one of two basic forms. The first is an open loop system and the second is a closed loop system. The open loop system is a relatively simple configuration with only three options, as shown in Figure 17. These options are the location of the hot water injection point and the use of a collector loop boost pump. The water will obviously be supplied from the plant return line (lowest temperature line). The solar heated water can be injected into the process via either the return line or the hot water supply line. For the case of an injection point in the supply line a pump is required, but for the case of injection in the return line a pump can be used or may not be required. The relative advantages and disadvantages of these options will be discussed later in this chapter.

The closed loop system is somewhat more complex with a large number of design options. These options are summarized in Figure 18 and are the choice of the collector loop transfer fluid, the solar heated process water injection point, and the use of a second supply pump in the process line. The combination of all these potential configurations leads to twelve different closed loop design options in addition to the three open loop design options mentioned above. To determine which of these options is preferred, the analysis will be conducted in the following sequence: 1) decision as to the number of supply pumps for the closed loop system, 2) selection of the collector loop heat transfer fluid for the closed loop system, 3) determination of the optimum location for the hot water injection point, and 4) selection between a closed loop versus an open loop system. This sequence will be followed in numerical order so that the preferred closed loop system will be selected and then compared with the preferred open loop system.

The first question to be addressed is the use of a second supply pump on the process side of the heat exchanger in the closed loop system. This pump will be required if the solar heated water will be injected into the process hot water supply line, but may not be necessary if this water is to be returned to the process return line. The obvious reason for this is that the hot water supply (HHWS) line is at a higher pressure than the hot water return (HHWR) line, so a pump will be required to overcome this pressure difference. For the HHWR injection point, the use of the additional boost pump can be eliminated if there is any excess head available from the current process pump in order to force the fluid through an additional heat exchanger. The head required for this heat exchanger can be reduced by providing an abundant heat transfer-surface area which will increase the cost of the heat exchanger. For the purposes of this initial investigation it is felt that this additional pump can be eliminated.

OPEN LOOP SYSTEM CONFIGURATION

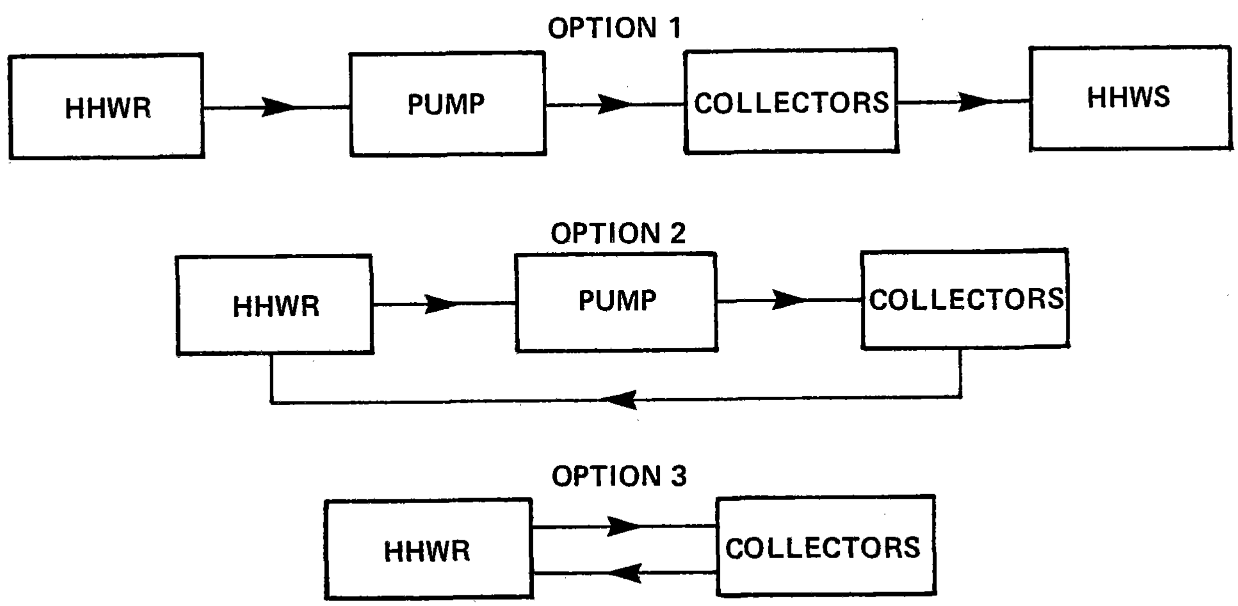


FIGURE 17.

CLOSED LOOP SYSTEM CONFIGURATION

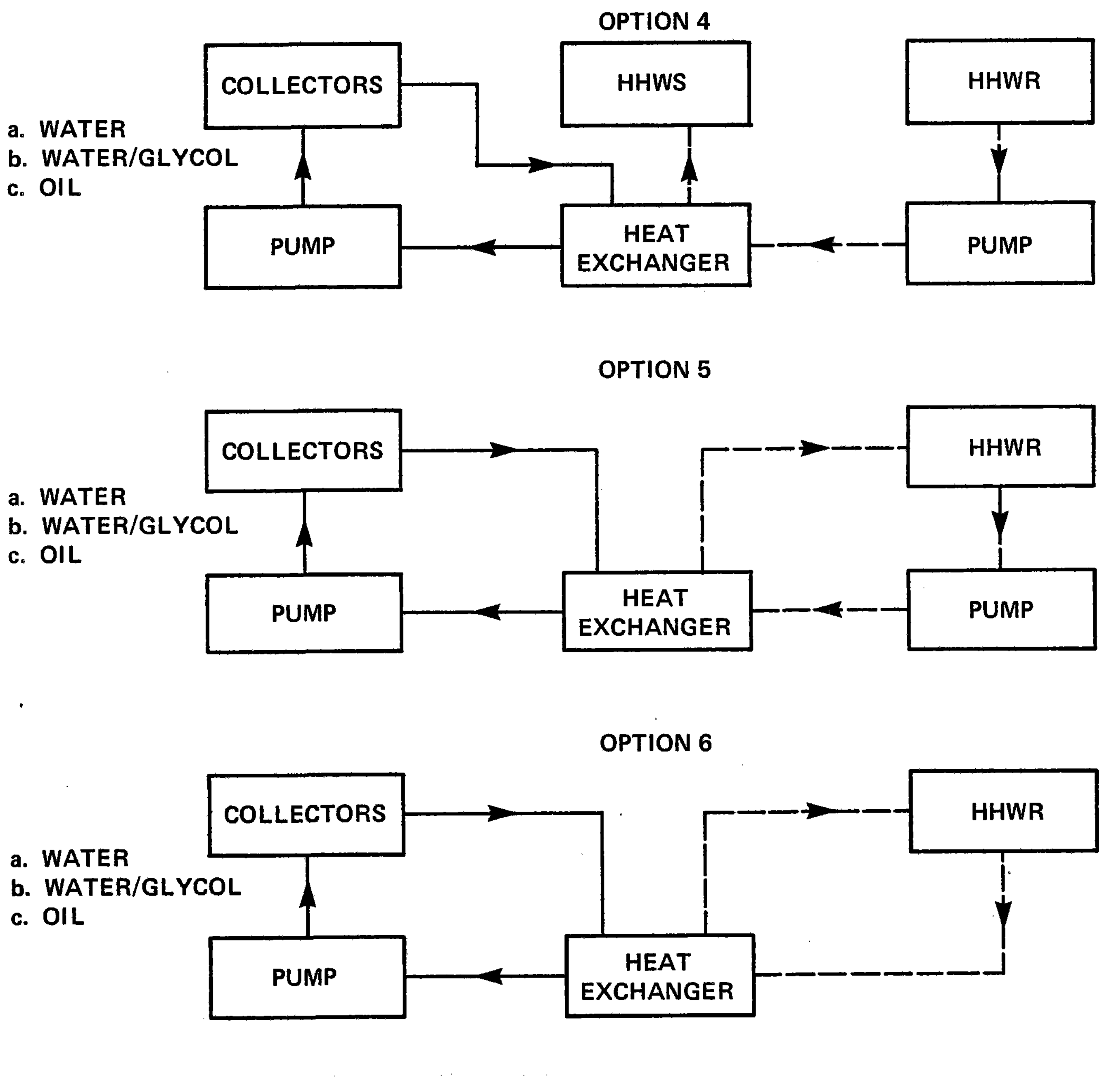


FIGURE 18.

The next question to be addressed is the selection of the most advantageous location for the hot fluid injection point. The choices are the HHWS line or the HHWR line. The HHWS injection point system would be a constant ΔT system with a variable flow. The HHWR injection point system would be a constant flow system with a variable ΔT. This latter system has the advantages of a lower average collector temperature at any condition below the peak operating condition and therefore a more efficient collector system. It, also, has a simpler and therefore less expensive control system. The HHWS injection point system has the disadvantage of having to match the process pressure difference and temperature difference. For the above reasons, it is felt that the HHWR injection point system would be more efficient and less expensive so it has been chosen as the preferred system.

The last question for the closed loop system is the selection of the collector loop heat transfer fluid. The choices are pressurized water, heat transfer oil, and glycol/water mixture. The maintenance cost of both the heat transfer oil and glycol/water systems is more expensive than the pressurized water at the required temperature and pressure for this application. The oil and glycol system would not have any potential problems for freezing. The glycol system would require more maintenance than the oil since the glycol would need to be changed periodically due to a gradual increase in acidity. Oil systems require extreme care to prevent leakage, injection of oxygen, and fire hazards. This added cost of maintenance may be warranted if the operating temperature was much higher or the climate of the installation exhibited an extreme freeze problem. The preferred closed loop system is, therefore, a pressurized water system with only a single pump in the collector loop where the process water is returned to the HHWR line. This system will then be used for comparison with an open loop system.

The open loop system options are similar to the closed loop system options. The solar heated water should be returned to the HHWR line for the reasons outlined above. The only question to be answered, therefore, is the need for a boost pump. If enough head reserve is available from the four present process circulation pumps then an additional pump may not be required. One disadvantage of the option without a boost pump is that less control would be available for non-optimum operating conditions. Another potential problem would be that the added head requirement of the collector field may lower the suction pressure below the required NPSH. This problem could be resolved by increasing the overpressure on the expansion tank. For the purposes of this preliminary investigation the recommended open loop system will include a boost pump. This pump will be a low head, low horsepower pump and should, therefore, not be a high cost item.

The final open loop system is a system with a boost pump that injects a constant flow rate of hot water into the HHWR line. This system will now be compared with the closed loop pressurized water system with a single collector loop pump where the heated water is injected into the HHWR line. In comparing these two systems, both have pressurized water flowing through the collector. Both systems will have a sensor to indicate a freeze condition so the circulation pump will be temporarily turned on for the rare occasions when freezing may occur. The main differences are that the closed loop system will operate at a higher temperature to overcome the temperature drop across the heat exchanger and therefore operate at a lower thermal efficiency. The closed loop system will also be more expensive from a first cost and maintenance basis because the addition of the heat exchanger and the need for controlling the chemistry of the collector loop water. The recommended configuration is, therefore, the open loop system because it will be more efficient and less costly than the closed loop system. A schematic of the recommended configuration is shown in Figure 19.

C. Collector Array Configuration

In addition to the above system configurations, there are four basic collector array configurations. The first configuration locates all of the collectors south of the roof mounted process cooling towers. This configuration consists of three banks of 24 rows which are 100 ft long each. The collector row spacing is 13.3 ft where the rows are located on every other purlin. To minimize the manifolding of this system, the absorber tube turbulator ribbon in each collector tube can be eliminated if the three rows are piped in series. The configuration can, therefore, be considered as a single bank of 24 rows each with 300 ft long rows. This configuration is shown in the collector arrangement concept layout in Figure 20.

The second configuration is similar to the first configuration except that the collector row length is 120 ft. This is the maximum recommended row length for a single drive pylon, and as such minimizes the tracking hardware per square foot of collector. The cost per ft^2 of collector is also minimized. This configuration consists of two banks of 24 rows each located south of the cooling tower plus two banks of 6 rows each located west of the cooling towers. A layout of this configuration is shown in Figure 21. As can be seen from this illustration, this configuration is a closely pacted array to minimize the piping manifolds for this row length. The layout is not as compact as configuration No. 1 but is a compromise between the lower collector cost due to the longer rows and the higher manifolding cost due to the need to spread the field out to accommodate the longer rows.

The third configuration is similar to the second configuration except the drive pylons are located at the intersection of the purlins and the east/west truss members. The intent of this configuration is to minimize the cost of roof modification, but results in the increase in required manifolding. This layout is shown in Figure 22 with the same number of rows, same spacing, and same row length as configuration No. 2.

The fourth configuration is similar to the third configuration except that the row spacing has been increased to 20 ft to minimize optical blockage between collectors. The wind loads will be increased however and the manifold cost will be increased. This configuration is shown in Figure 23.

A performance analysis was conducted for each configuration with the results summarized in Table XIV. A cost estimate was also conducted with the results shown in Table XV. The two sets of data were then combined to generate a cost-effectiveness factor of \$/MMBtu/yr. These data are given in Table XVI. As can be seen from this table, the most cost-effective option is Configuration No. 3; therefore, this is the configuration developed during the Detail Design phase of the project.

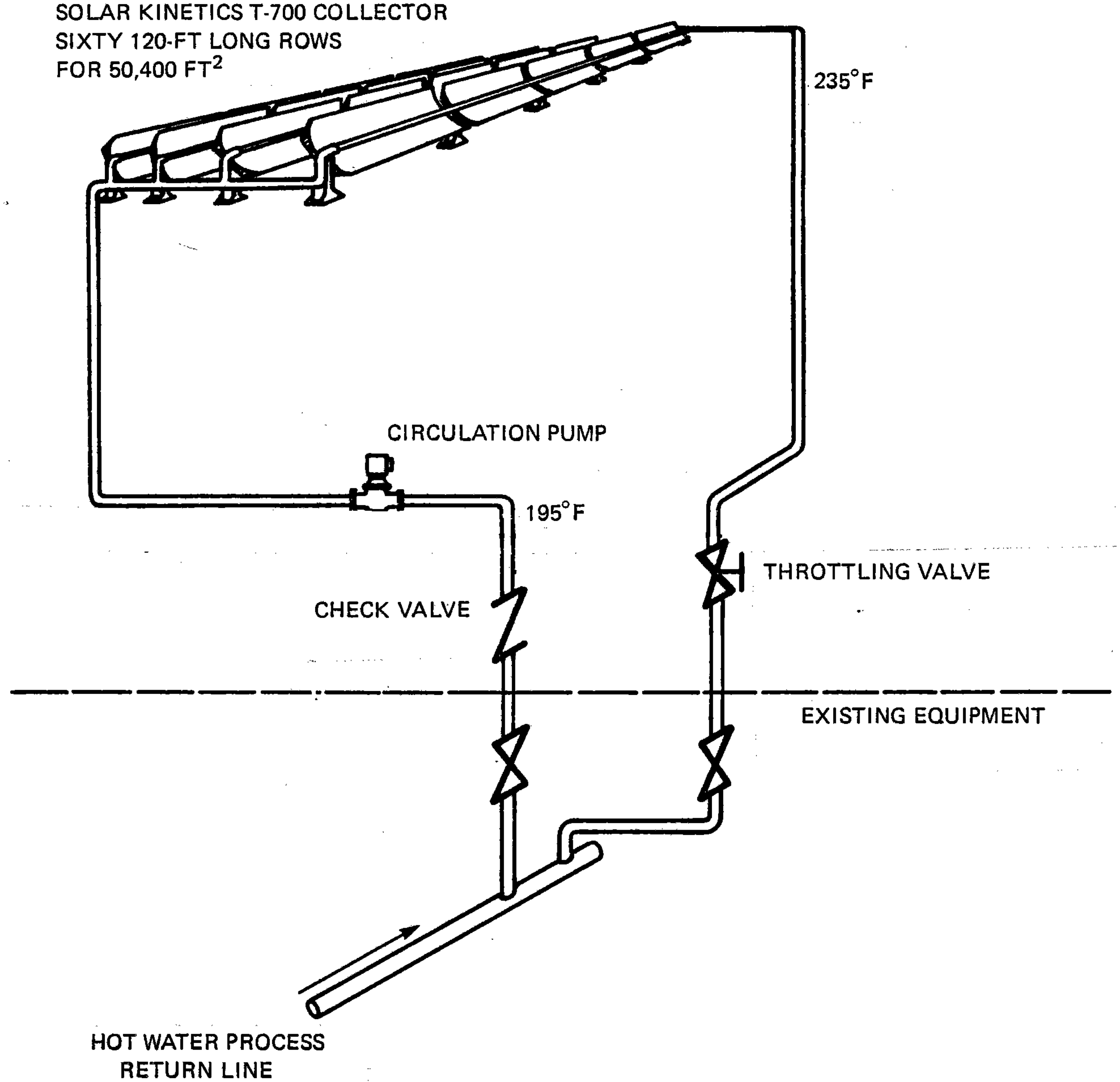


FIGURE 19. SYSTEM SCHEMATIC FOR A LARGE-SCALE INDUSTRIAL PROCESS HEAT SYSTEM FOR CATERPILLAR TRACTOR COMPANY'S SAN LEANDRO PLANT

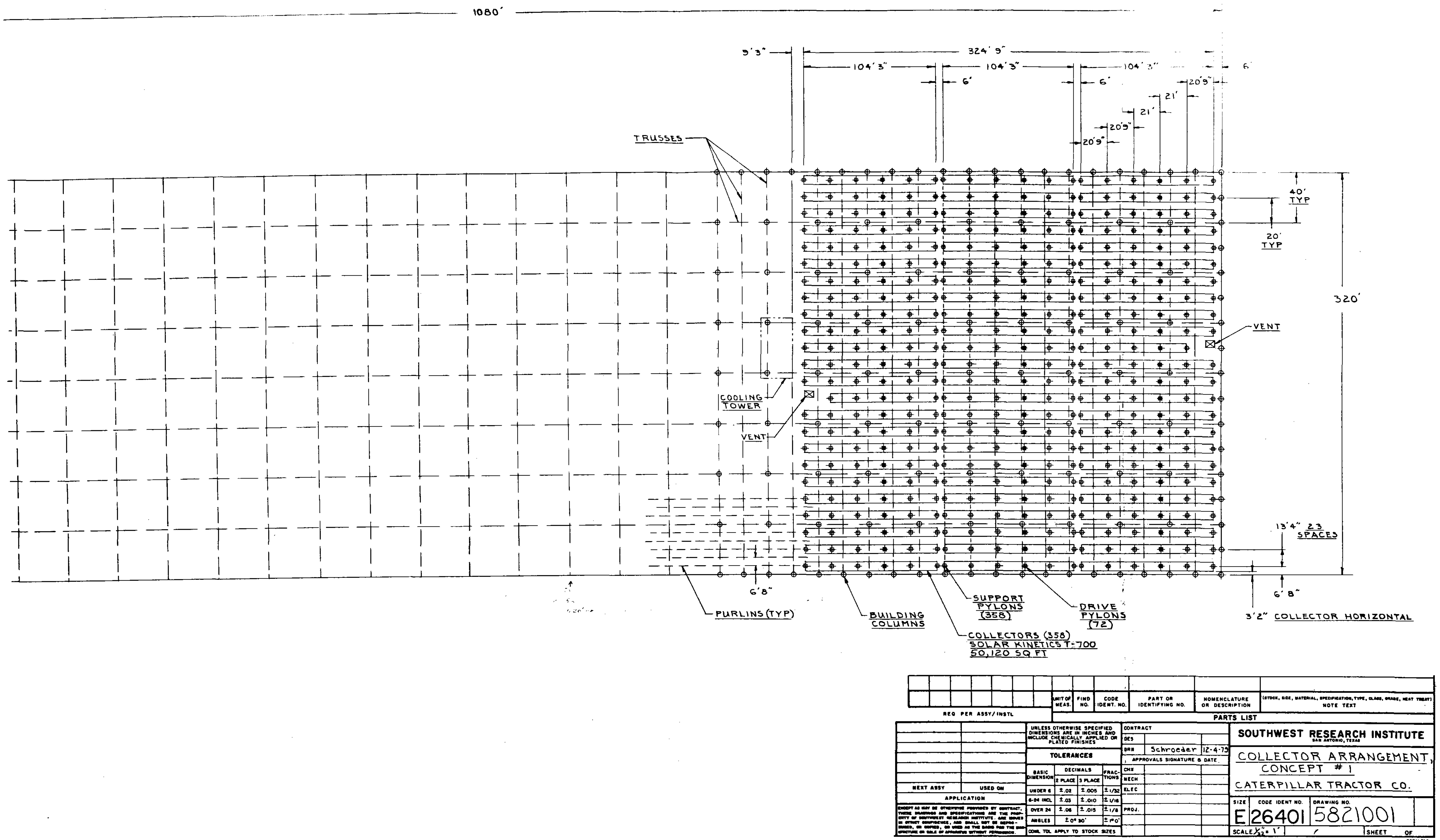


FIGURE 20. MINIMUM ROOF AREA CONFIGURATION

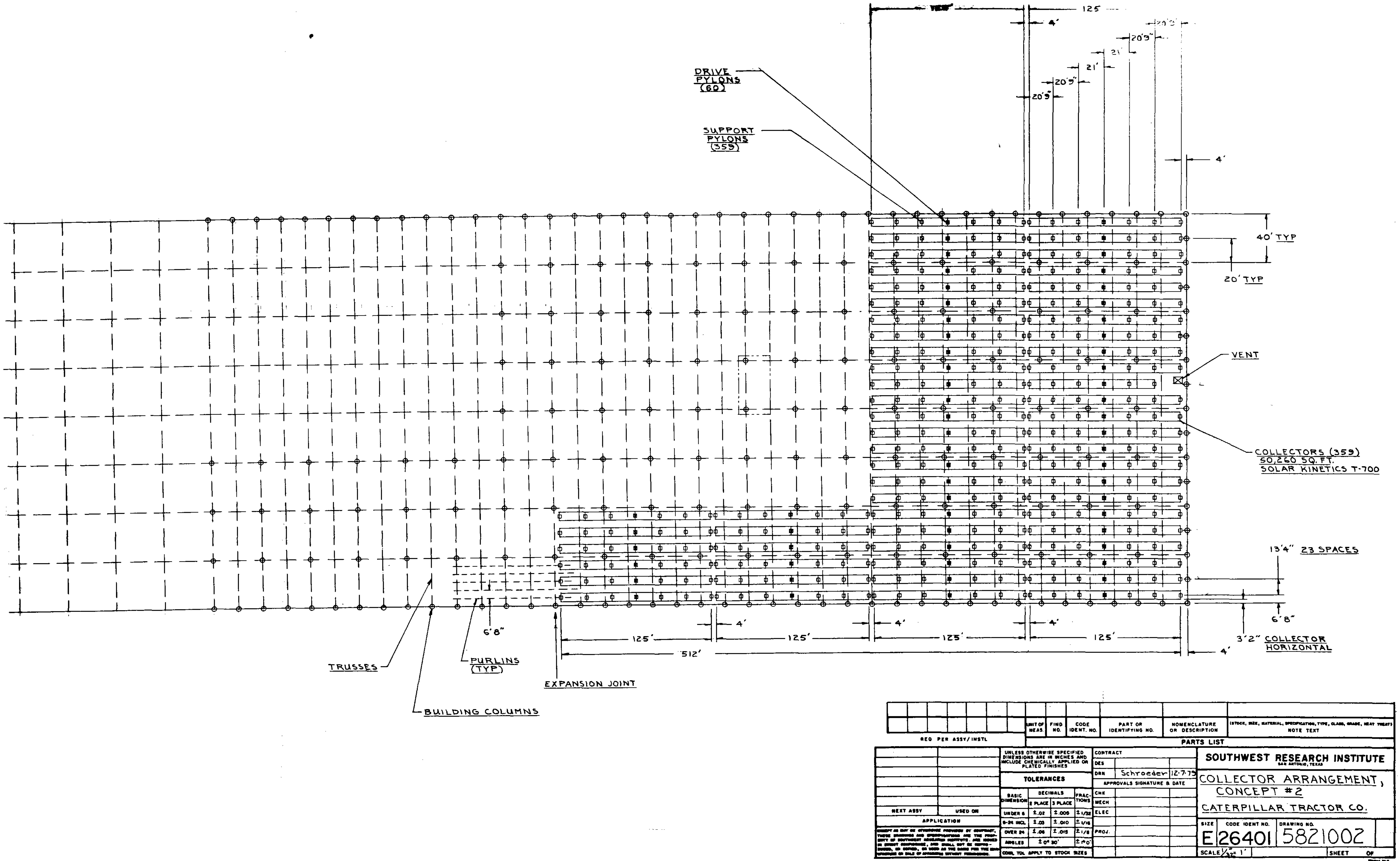


FIGURE 21. MINIMUM MANIFOLDING CONFIGURATION FOR MAXIMUM ROW LENGTH

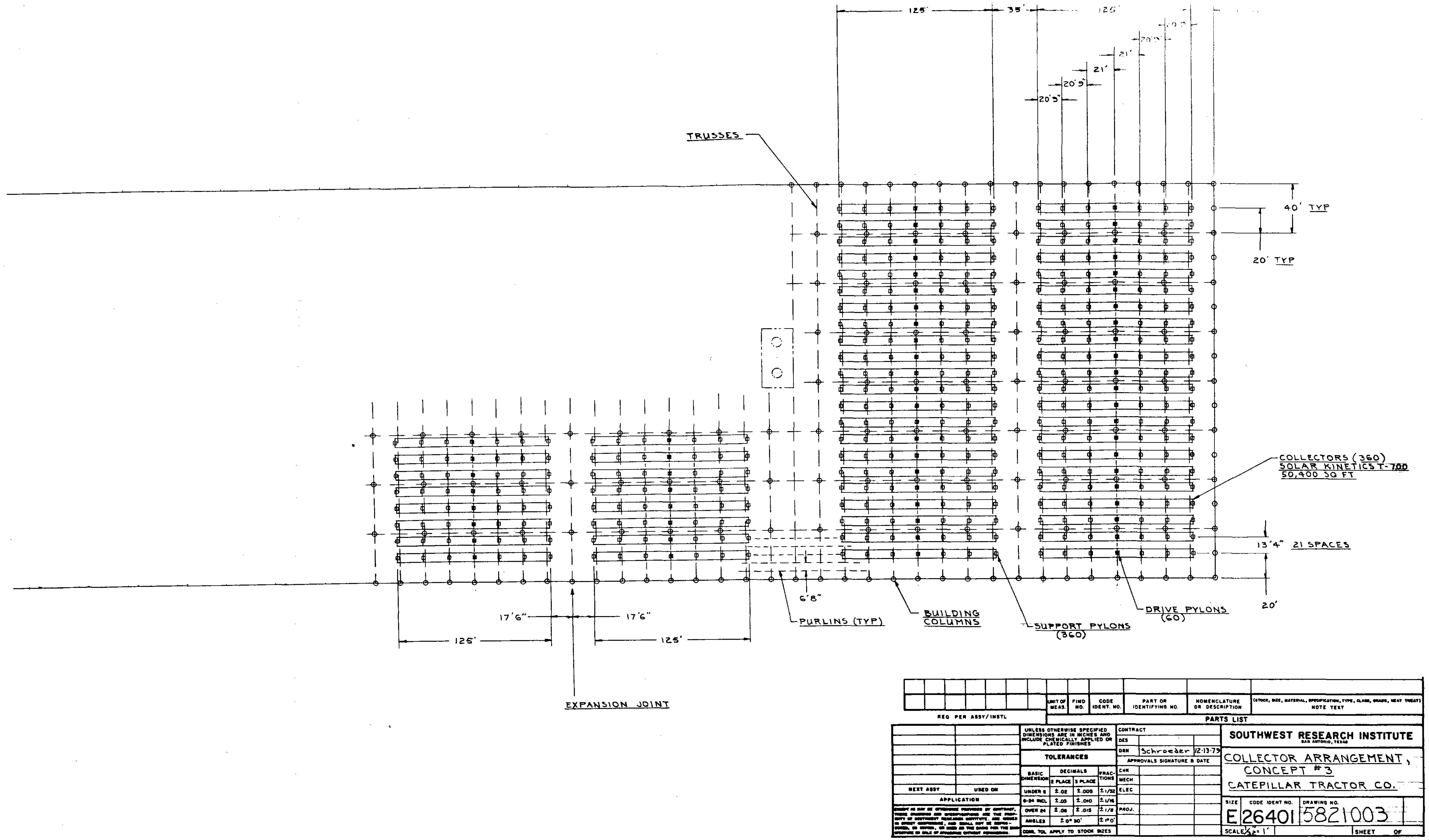


FIGURE 22. MINIMUM ROOF MODIFICATION CONFIGURATION

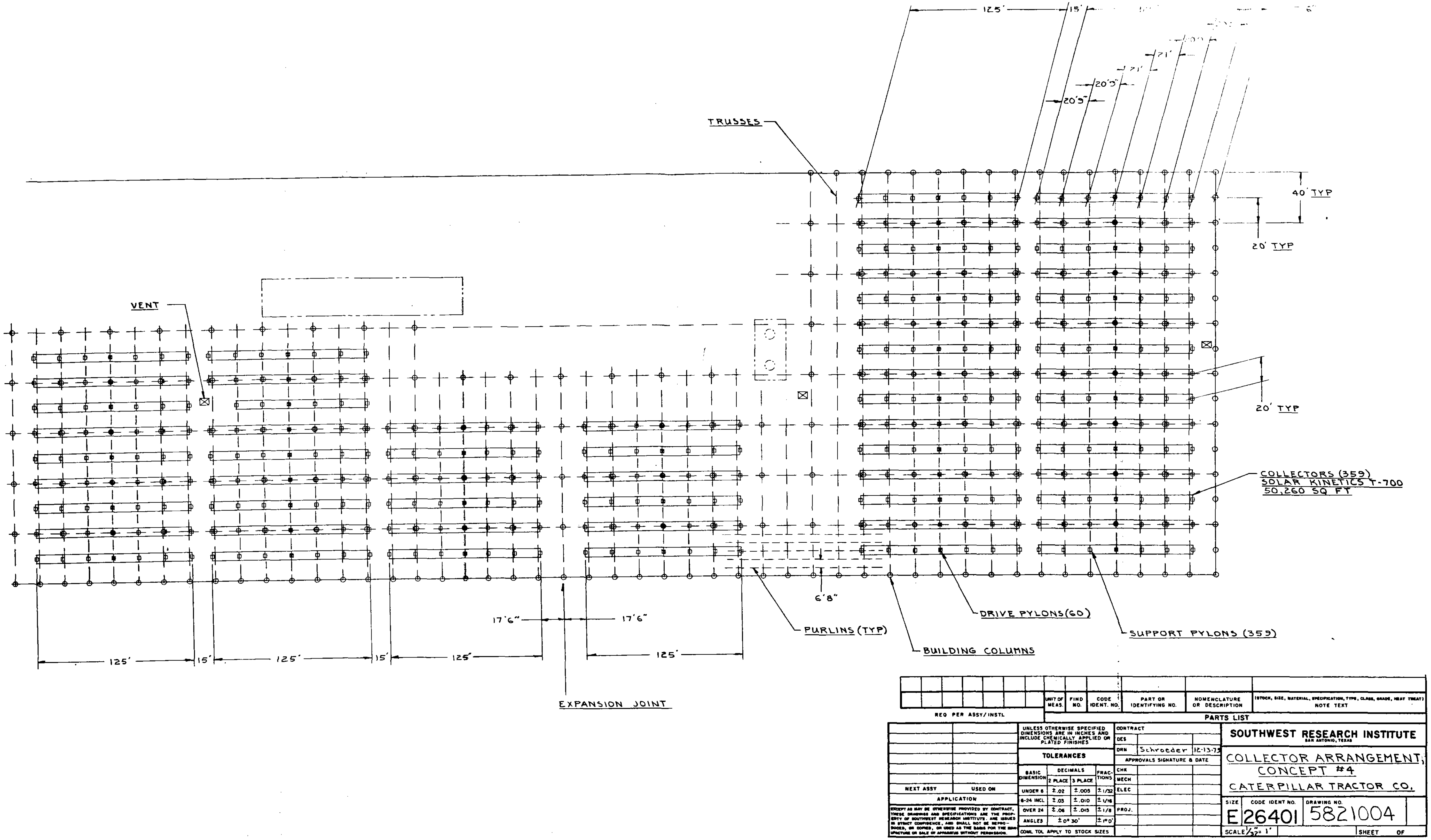


FIGURE 23. MINIMUM LIGHT BLOCKAGE CONFIGURATION

TABLE XIV. COLLECTOR PERFORMANCE SUMMARY FOR EACH OF THE COLLECTOR ARRAY CONFIGURATIONS, KBTU/FT^2

MONTH	ARRAY CONFIGURATION			
	#1	#2	#3	#4
JAN	15.9	16.0	16.0	17.3
FEB	6.4	6.4	6.4	7.0
MAR	14.9	15.0	15.0	16.1
APR	28.7	28.8	28.9	31.0
MAY	35.1	35.2	35.3	37.8
JUN	36.4	36.5	36.6	39.1
JUL	34.9	34.9	34.9	37.3
AUG	29.6	29.7	29.8	31.7
SEPT	16.7	16.8	16.8	18.1
OCT	10.1	10.2	10.3	11.0
NOV	6.5	6.6	6.6	7.2
DEC	3.2	3.2	3.2	3.5
YEARLY	238.2	239.1	239.8	257.4

TABLE XV. COST ESTIMATE SUMMARY FOR THE COLLECTOR ARRAY CONFIGURATION SELECTION

Configuration	Collector	Installation	Piping	Electrical	Structural	Total
1	22.60	3.00	4.34	3.09	7.89	40.92
2	22.60	3.00	4.80	3.43	7.42	41.25
3	22.60	3.00	4.82	3.44	7.04	40.90
4	22.60	3.00	6.00	4.28	8.47	44.35

TABLE XVI. COST-EFFECTIVENESS FACTORS FOR THE COLLECTOR ARRAY CONFIGURATION SELECTION

Configuration	Total Cost	Energy Collected, 10^6 Btu/yr	$/MMBtu/yr
1	$2.051 MM	11,939	172
2	$2.073 MM	12,017	173
3	$2.061 MM	12,086	171
4	$2.229 MM	12,937	172

D. Optimum Insulation Thickness

The starting point for determining the most cost-effective insulation thickness was the value provided by the industrial partner as a part of their Standard Guide Specifications. These thicknesses were determined by utilizing the computer program ECON-I with the following assumptions:

1) Average yearly ambient temperature - 75°F
2) Depreciation period for heat-producing plant - 33 years
3) Depreciation period for insulation - 33 years
4) Capital investment in heat producing plant - $90.00/Lb.Steam/Hr.
5) Total production cost of steam - $3.75/1000 Lbs. Steam
6) Installed cost of 1" of calcium silicate insulation on a flat surface - $9.25/sq.ft.
7) Installed cost of 1" of Fiberglas insulation on a flat surface - $6.80/sq.ft.
8) Installed cost of 1-1/2" of calcium silicate insulation on a 2-1/2" pipe - $4.90/lin.ft.
9) Installed cost of 1" of Fiberglas insulation on a 1-1/2" pipe - $2.80/lin.ft.

The results of the program gave the following insulation thicknesses:

Pipe Size	Insulation Thickness
1" - 1-1/2"	1"
2" - 4"	2"
6"	2-1/2"

To determine the energy losses from the piping system, a thermal analysis was conducted. The result of that analysis was that 24 MMBtu/yr or 0.2% of the energy collected was lost through the pipe insulation. These insulation thicknesses are about the maximum sizes that can be used with standard piping support hardware, such as alignment guides. If larger thicknesses are required, special arrangements must be made for the piping support hardward. Due to the small thermal pipe losses in comparison to the total collected, it is not recommended that the pipe insulation thickness given above be increased. In comparing current costs of fuel and installation, it may be suggested that ECON-I be rerun with current figures, but the life of the solar collection system is much shorter than the 33 year life used. With all of this considered, the standard values given above will be specified for this system.

X. DETAILED DESIGN

The Detailed Design phase of this program consists of developing the preliminary design into contract documents and providing all the details necessary to generate the Final Design Drawings and System Specifications. The Final Design Drawings are included in Appendix A with the following number sequence:

H200 to H206	-	Collector System Design
H220 to H227	-	Mechanical System Design
E240 to E244	-	Electrical Design
CI260 to CI270	-	Control and Instrumentation Design
S280 to S285	-	Structural Design.

The System Specifications are included in Appendix B with the numbering sequence shown in the index to that Appendix. Since the combination of these drawings and specifications accurately describe this system design, only a brief discussion of start-up and operation will be given here. For design details the reader is referred to the two appendices indicated above.

A. Initial System Start-Up

The start-up sequence can best be described by referring to the mechanical (H220 to H227) and the piping and instrumentation (CI270) drawings. Items such as leakage testing, cleaning of pipe, inspection, start-up and tests are included in the specifications and will not be repeated here. The first step in the start-up sequence is to open the isolation valve (Dwg. H223) between the HHWR line and the pumps. The plant operating pressure will fill the line up to the pumps, venting the air via the air vent in the pump suction line. The next step will be to verify that all upstream shut-off valves (Dwg. H222) for the collectors are closed and the downstream valves are open. The ball valve (Dwg. H226) leading to the south field is open and the ball valve leading to the north field is closed. After all of the tests and inspection for the pump are performed per the mechanical and electrical specifications, the pump is turned on and all the air between the pump and the collectors is evacuated via the air vent located in the deadend of the inlet manifold. The isolation valve between the exit manifold and the plant HHWR line is opened with the next step being to open the isolation valves on each of the inlet sections of the collector rows one at a time, the idea being to flush the air from each receiver tube individually. Since the exit manifold is sloped up to the deadend, which has an air vent, the air from each receiver will flow "uphill" to the air vent and the water will flow "downhill" to the plant return line. After each row is cleaned, the inlet isolation valve is closed; this will provide a high velocity through each row. Once all of the rows in the south bank are cleared, then the north bank isolation valve is opened, the south bank valve is closed, and the same process is followed for the north field as was followed for the south field.

The last step is to open the isolation valves to both fields and all the collector rows. The total flow to both fields will be stabilized with the temperature regulator manually opened before balancing begins.

B. System Balancing

Once the flow in the entire field is stabilized, the ball valves to each field will be adjusted to give the proper ratio of flow between the two fields (refer to Dwg. CI270). The flow rate to each field should be as high as possible with the proper ratio. The measured flow rate will, therefore, be higher than that indicated for final operation. The next step in balancing is to adjust the circuit settler valves for each collector row to the flow indicated on the drawing (note this process will be conducted with the collectors in the stow position). Once all of the collector row flow rates are set, the total flow to each bank should be checked. The total system should now be balanced for the cold condition. The next step is to focus the collectors and allow adequate time for the temperature rise in the system to stabilize. A hand-held digital thermometer should be used in the thermowells provided at the exit of each collector row. Final adjustment of the circuit settlers should be made to provide a constant temperature output for all rows under clear sky conditions. This step should only be a check because the cold condition flow balancing should provide a constant outlet temperature. Once the balancing has been accomplished, the system should be shut-down and allowed to undergo the standard automatic start-up.

C. System Operation Sequence

The Solar Process Heat System will only operate if the plant process hot water system is operating. If this process hot water system is operating, then the collector system central controller takes over when the central direct normal light switch indicates minimum present direct normal levels (adjustable) for a minimum period of 15 minutes. The central controller issues a "track ready" command, if the wind speed is below 40 mph and there is no rainfall, to start the system flow pumps. After a 5-minute delay to allow fluid flow to be established, the collectors are directed out of the stow position which takes about 30 seconds for sunrise. As each collector row approaches the sun and falls within 20° of focus, one of the light sensors will switch the row to automatic track. This signal is maintained as long as the minimum light level is met and the receiver tube temperature is below the critical value. The temperature regulating valve on each bank will open when its temperature sensor indicates a temperature in excess of the HHWR line. Prior to the opening of the regulator, a 10% by-pass is provided for cold start-up. If direct normal radiation minimums are not met and the outlet temperature falls below the HHWR line temperature, the temperature regulator closes and the flow drops to the 10% level. In the event that this continues for a preset period (adjustable up to 45 minutes), the central collector controller will stow the collectors and shut off the pump. The collectors will remain in this position until the original automatic scenario is reinitialized.

The only exception to the above operating scenario is when the field temperature switch senses a freeze condition and the above automatic sequence is overridden. When this occurs the flow pump turns on and the 10% by-pass flow is pumped through the collectors until the outlet temperature for each bank is raised above a preset value. In this way, the pumps will cycle on and off throughout the freeze condition to prevent damage to the system. The number of times that this occurs is only 1 day during an average year.

In addition to standard operations, the collector system is also provided with the following safety features:

- Loss of power to each drive pylon (60 each)
- Overtemperature at each row (60 each)
- Fluid overtemperature at each bank (2 each)
- Freeze sensor at each bank (2 each)
- Fluid overpressure at each bank (2 each)
- Loss of flow at each bank (2 each)
- Loss of power to the field (1 each)
- Rain switch (1 each)
- High wind (1 each)
- Low light level (1 each)

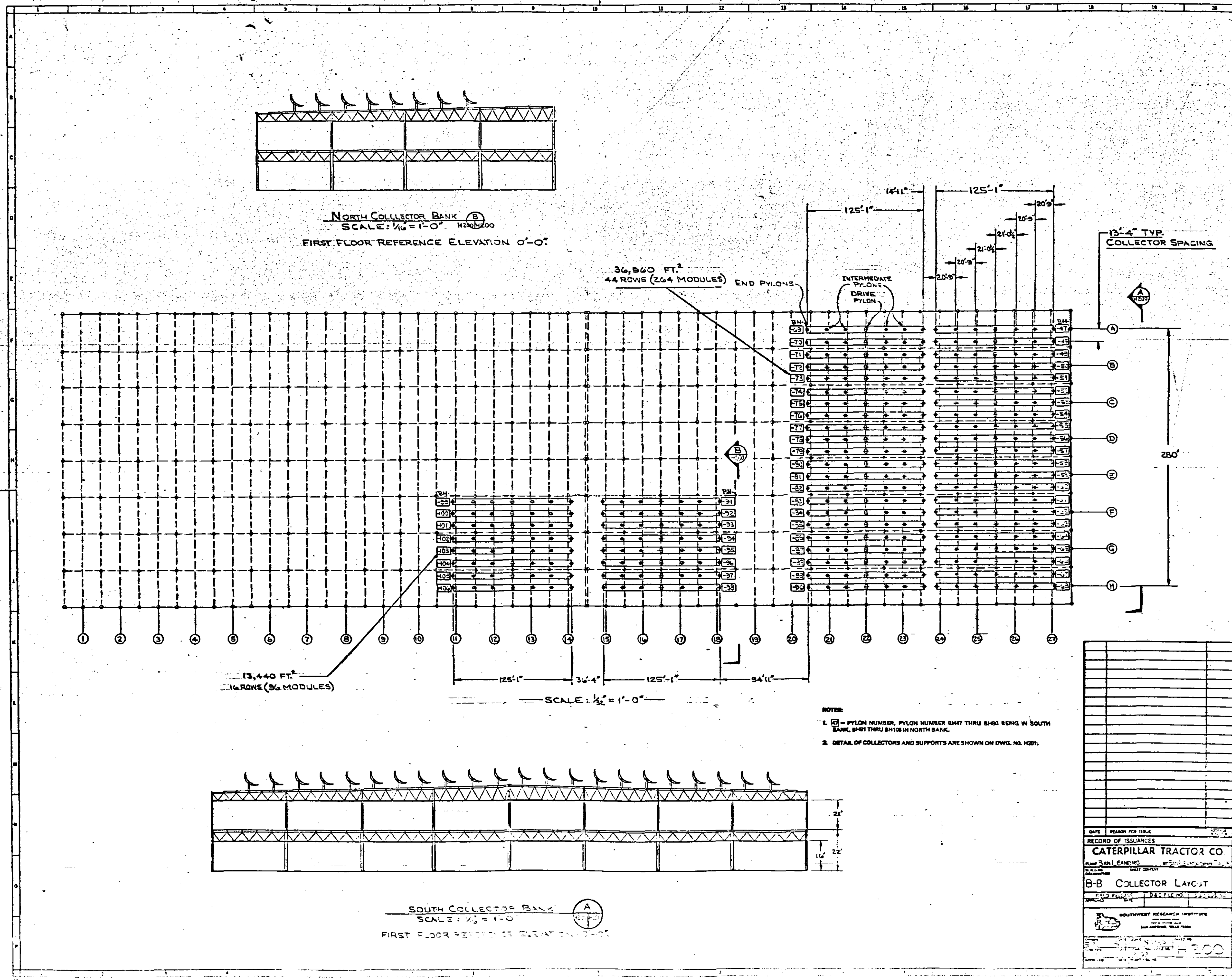
XI. CONCLUSIONS

The result of this program is a complete set of contract documents for a large-scale solar industrial process heat system to be installed at Caterpillar Tractor Co.'s San Leandro, California plant. This system has been designed in accordance with all local building codes and consistent with CTCo.'s Standard Design Procedures. The final design provides a relatively high thermal performance, cost-effective, safe, and environmental compatible solar process heat system. While the contents of this report completely fulfill the objectives of the Phase I Design Contract, this document is only the starting point for implementing this design. The analysis in this report will be used by CTCo. in their decision-making process to determine the level of investment that can be justified during the construction and operation phases of this program. The basic approach will be to use the economic analysis and a yet to be determined acceptable rate of return on investment to determine their percent contribution. This data will then be incorporated into an investment proposal and presented to CTCo. management for approval. Once this has been accomplished, then negotiation can begin between SwRI, CTCo. and DOE. After these negotiations have been completed, the contract documents will be sent out for final bid. The acceptance of the most advantageous bid and the successful negotiation of the construction contract will indicate the actual start of construction. The estimated start date is in early 1981 with construction completed in mid-1982. Following this construction phase, a three-year operational and analysis phase will begin to demonstrate that industrial applications of solar energy can not only help in our country's fight for energy independence, but can also be integrated into the standard construction practices of our nation's major manufacturing industries.

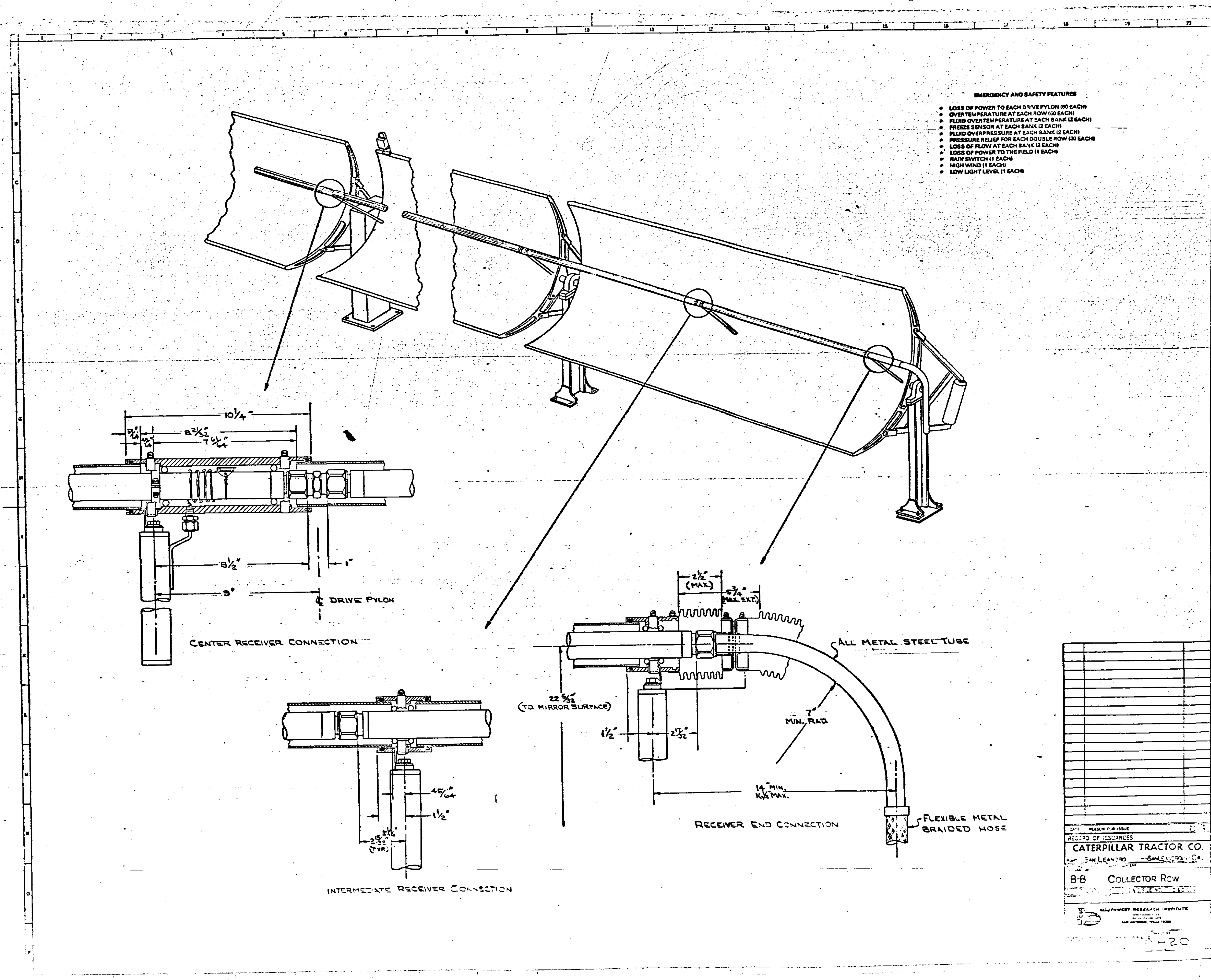
APPENDIX A

FINAL DESIGN DRAWINGS

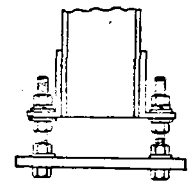
Drawing No.	Title
H200	Collector Layout
H201	Collector Row
H202	Support Pylons
H203	Mirror Module
H204	Receiver Tube Assembly
H205	Glass Cover Assembly
H206	Flex Hose Assembly
H220	Collector Piping Schematic
H221	Second Floor Piping Plan
H222	Second Floor Piping Sections
H223	First Floor Piping
H224	Collector Piping - Roof
H225	Solar HHW Pumps
H226	Pump Outlet Piping & Floor Meter Details
H227	Piping Support Details
E240	Power Distribution Floor Plan
E241	Power Distribution Sections
E242	Power Distribution Details
E243	Power to Motor Controls
E244	Power Cabinet
CI260	Symbols and Definitions
CI261	Solar Collector Control Floor Plan
CI262	Data Acquisition Sensor Element Location
CI263	Sensor Element Cable Termination Diagram
CI264	Remote Data Acquisition Cable Termination
CI265	Cabinet Junction and Control Enclosure Detail
CI266	Alarm Cable Termination
CI267	Cable & Sensor Element Specification List
CI268	Solar Central Control to Row Control
CI270	Piping and Instrumentation Diagram
S280	Roof Truss Structural Reinforcement Plan (South Field)
S281	Roof Truss Structural Reinforcement Plan (North Field)
S282	Truss Reinforcement Details
S283	Structural Details
S284	Structural Details
S285	Platform and Walkway Details



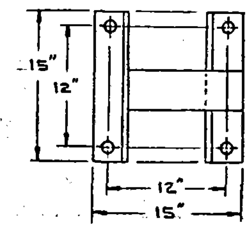
NORTH COLLLECTOR BANK
SCALE: 1/16" = 1'-0"
FIRST FLOOR REFERENCE ELEVATION 0'-0"
36,960 FT.²
44 ROWS (264 MODULES)
END PYLONS
INTERMEDIATE PYLONS
DRIVE PYLON
125'-1"
14'-11"
20'-9"
21'-0½"
13'-4" TYP. COLLECTOR SPACING
280'
13,440 FT.²
16 ROWS (96 MODULES)
125'-1"
36'-4"
94'-11"
SCALE: 1/32" = 1'-0"
SOUTH COLLECTOR BANK
SCALE: 1/16" = 1'-0"
NOTES:
1. 47 = PYLON NUMBER, PYLON NUMBER BH47 THRU BH90 BEING IN SOUTH BANK, BH91 THRU BH108 IN NORTH BANK.
2. DETAIL OF COLLECTORS AND SUPPORTS ARE SHOWN ON DWG. NO. H201.
DATE
REASON FOR ISSUE
RECORD OF ISSUANCES
CATERPILLAR TRACTOR CO.
SAN LEANDRO
SHEET CONTENT
B-B COLLECTOR LAYOUT
D&C FILE NO.
SOUTHWEST RESEARCH INSTITUTE
SAN ANTONIO, TEXAS
SHEET NO.
H200



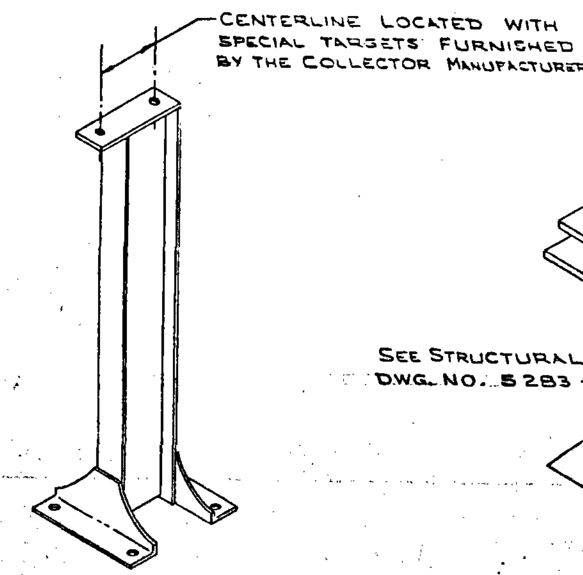
EMERGENCY AND SAFETY FEATURES
LOSS OF POWER TO EACH DRIVE PYLON (60 EACH)
OVERTEMPERATURE AT EACH ROW (60 EACH)
FLUID OVERTEMPERATURE AT EACH BANK (2 EACH)
FREEZE SENSOR AT EACH BANK (2 EACH)
FLUID OVERPRESSURE AT EACH BANK (2 EACH)
PRESSURE RELIEF FOR EACH DOUBLE ROW (30 EACH)
LOSS OF FLOW AT EACH BANK (2 EACH)
LOSS OF POWER TO THE FIELD (1 EACH)
RAIN SWITCH (1 EACH)
HIGH WIND (1 EACH)
LOW LIGHT LEVEL (1 EACH)
10¼"
8 21/32"
7 61/64"
8½"
1"
9"
℄ DRIVE PYLON
CENTER RECEIVER CONNECTION
45/64"
1½"
2 15/32 ±1/16 (TYP)
INTERMEDIATE RECEIVER CONNECTION
2½" (MAX.)
5¾" (MAX. EXT.)
ALL METAL STEEL TUBE
22 5/32" (TO MIRROR SURFACE)
1½"
2 17/32"
7" MIN. RAD
14" MIN. 16½" MAX.
FLEXIBLE METAL BRAIDED HOSE
RECEIVER END CONNECTION
DATE REASON FOR ISSUE
RECORD OF ISSUANCES
CATERPILLAR TRACTOR CO.
SAN LEANDRO
B-B COLLECTOR ROW
SOUTHWEST RESEARCH INSTITUTE
SAN ANTONIO, TEXAS
-20



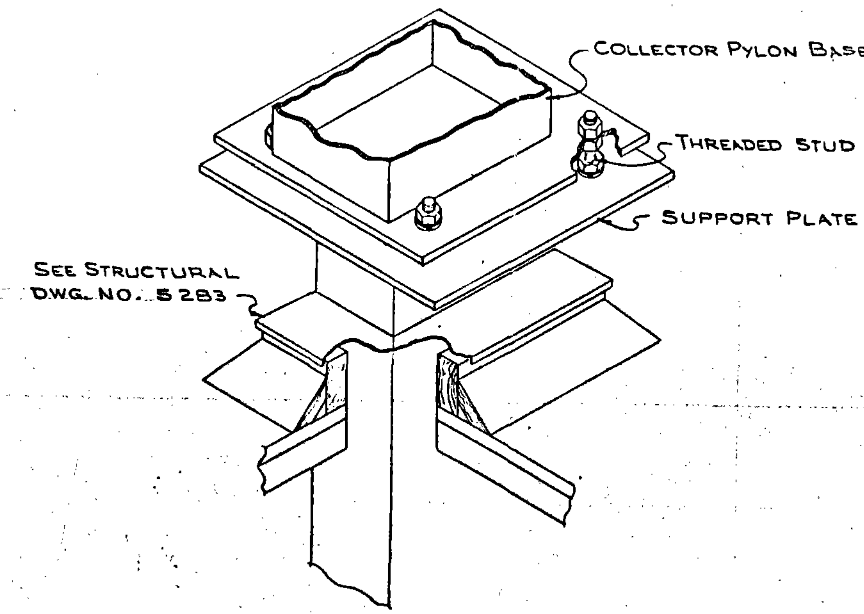
PYLON CONNECTION DETAIL



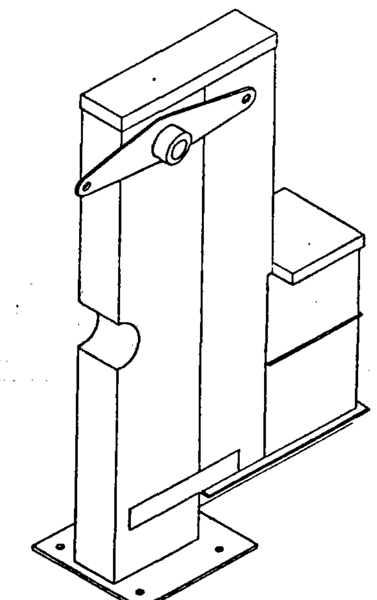
PYLON BASE DIMENSIONS
FOR ALL INTERMEDIATE
AND END PYLONS



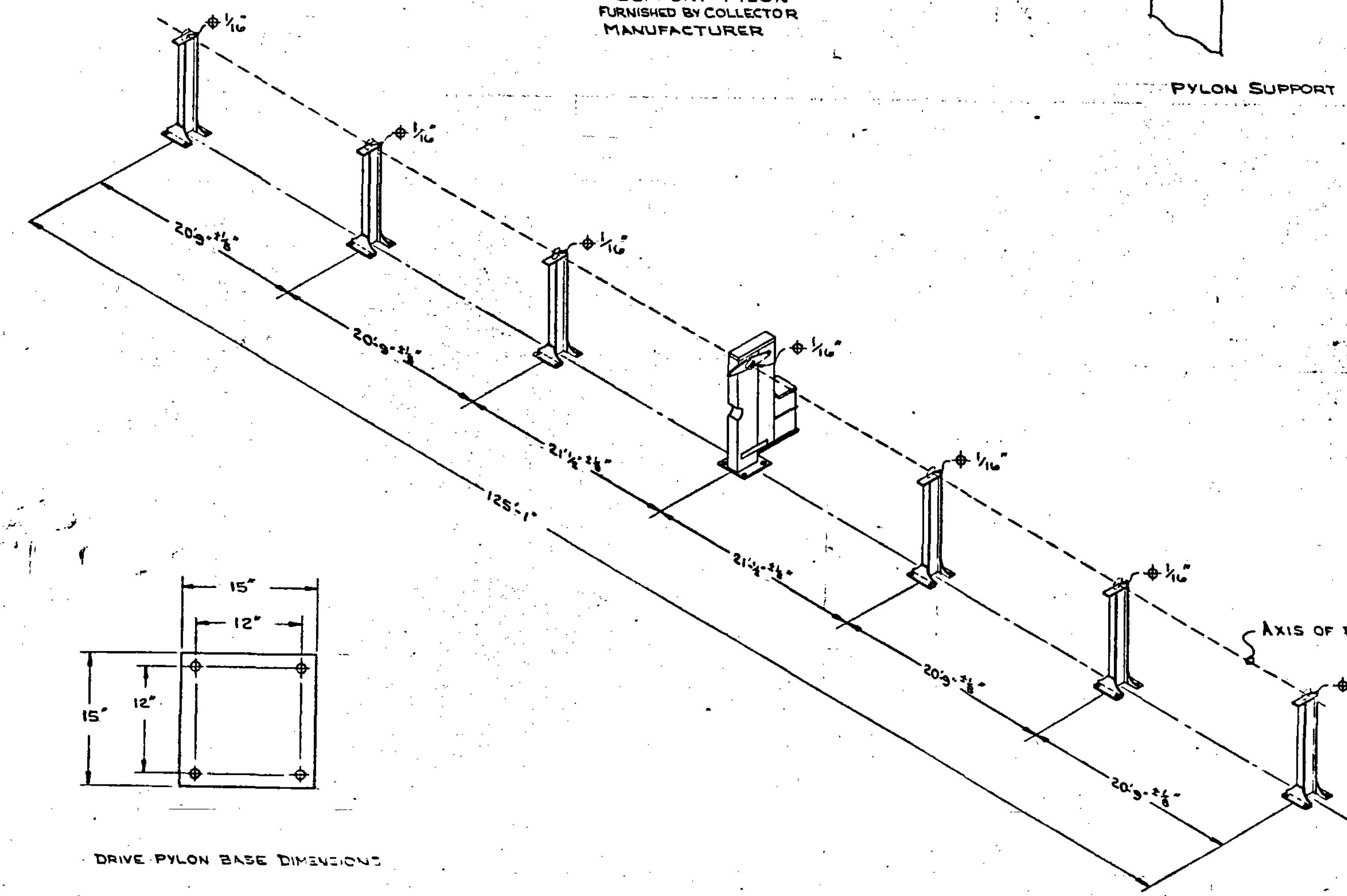
SUPPORT PYLON
FURNISHED BY COLLECTOR MANUFACTURER



PYLON SUPPORT DETAIL



DRIVE PYLON
FURNISHED BY COLLECTOR MANUFACTURER



⊕ 1/16" ALL CENTERLINES OF EACH PYLON MUST BE ALIGNED TO WITHIN ±1/16" IN BOTH THE VERTICAL AND HORIZONTAL DIRECTIONS TO THE CENTERLINE OF THE DRIVE PYLON.

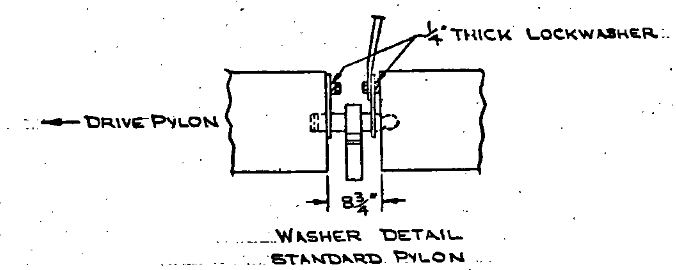
DRIVE PYLON BASE DIMENSIONS

INSTALLATION AND ALIGNMENT OF SUPPORT AND DRIVE PYLONS

1. ROOF TOP MOUNTING PLATES SHALL BE PREPARED TO ACCEPT THE PYLON BOLT PATTERN AND SPACING PER STRUCTURAL DRAWINGS. THE DOUBLE NUT TECHNIQUE IS USED TO FASTEN THE BOTTOM OF THE PYLONS AND ALLOW FOR ADJUSTMENT AND ALIGNMENT.
2. PYLONS SHALL BE INSTALLED AND ALIGNED WITH A LASER TRANSIT. CARE SHOULD BE TAKEN TO OBTAIN A TRUE LINE OF SIGHT THROUGH THE CENTER OF THE AXIS OF ROTATION TO WITHIN ± 1/16".
3. DRIVE PYLONS SHALL BE IN THE STOW POSITION AND FILLED WITH HYDRAULIC FLUID TO PREVENT ROTATION.
4. MIRROR MODULES CANNOT BE INSTALLED UNTIL PYLONS ARE ALIGNED AND TIGHTENED TO THE SUPPORT PLATES AS INDICATED ABOVE.

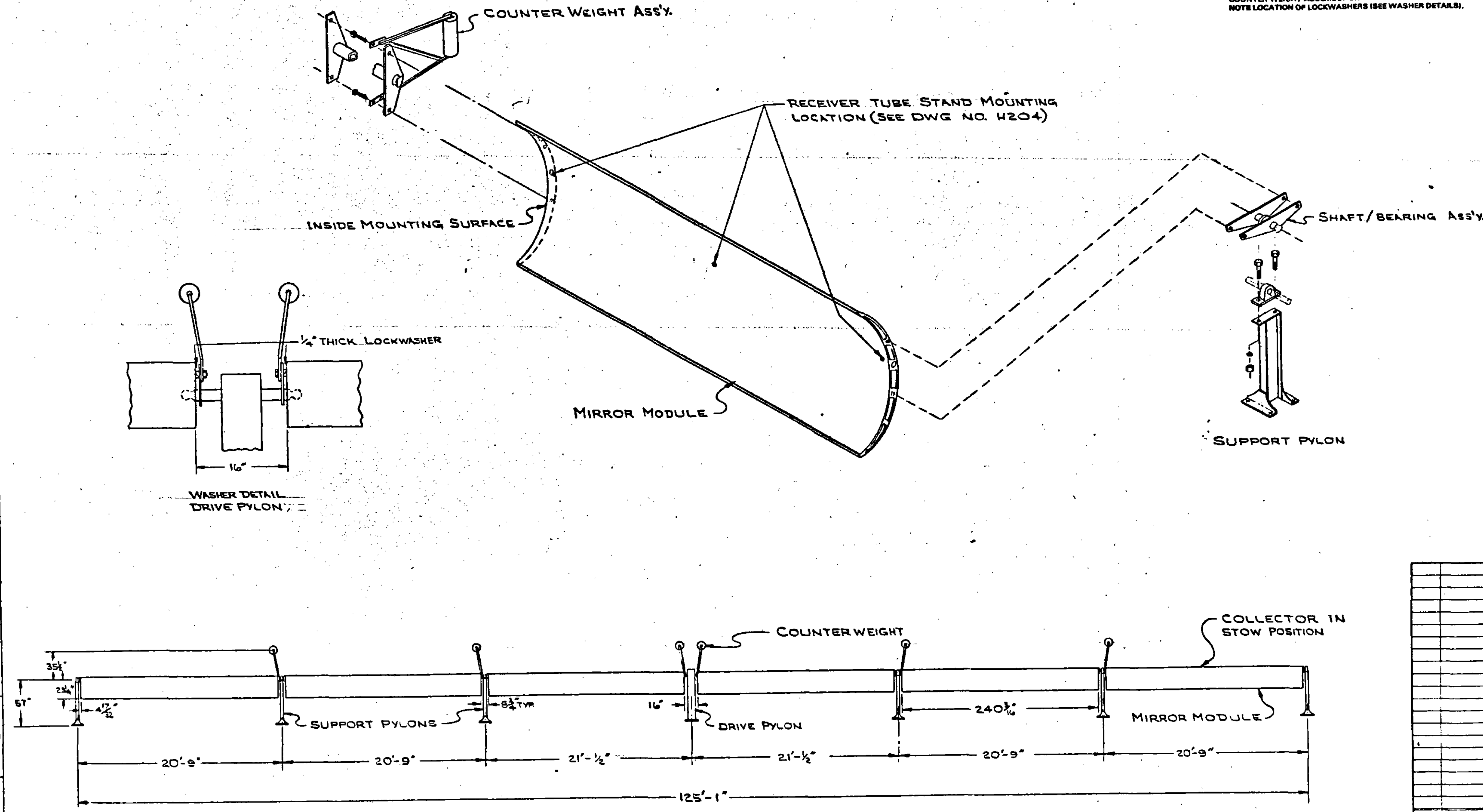
DATE	REASON FOR ISSUE
RECORD OF ISSUANCES	

CATERPILLAR TRACTOR CO
PLANT SAN LEANDRO
B-B SUPPORT PYLONS
FIELD RELEASE
SOUTHWEST RESEARCH INSTITUTE
SAN ANTONIO, TEXAS
EZ
H202



FASTENING AND ALIGNMENT OF MIRROR MODULE

1. MOUNT SHAFT/BEARING ASSEMBLY TO OUTSIDE END OF EACH MODULE.
2. INSTALL MIRROR MODULE BY PLACING THE INSIDE MOUNTING SURFACE OF THE MODULE ON THE OUTSIDE SHAFT OF THE INNER SHAFT/BEARING ASS'Y. (STARTING AT THE DRIVE PYLON AND WORKING OUT.)
3. BOLT OUTSIDE SHAFT/BEARING ASS'Y. TO THE SUPPORT PYLON.
4. BOLT INSIDE SHAFT/BEARING ASS'Y. TO THE MIRROR MODULE INCLUDING COUNTER WEIGHT ASSEMBLY ON THE INNER SIDE OF THE MIRROR MODULE. NOTE LOCATION OF LOCKWASHERS (SEE WASHER DETAILS).



DATE	REASON FOR ISSUE

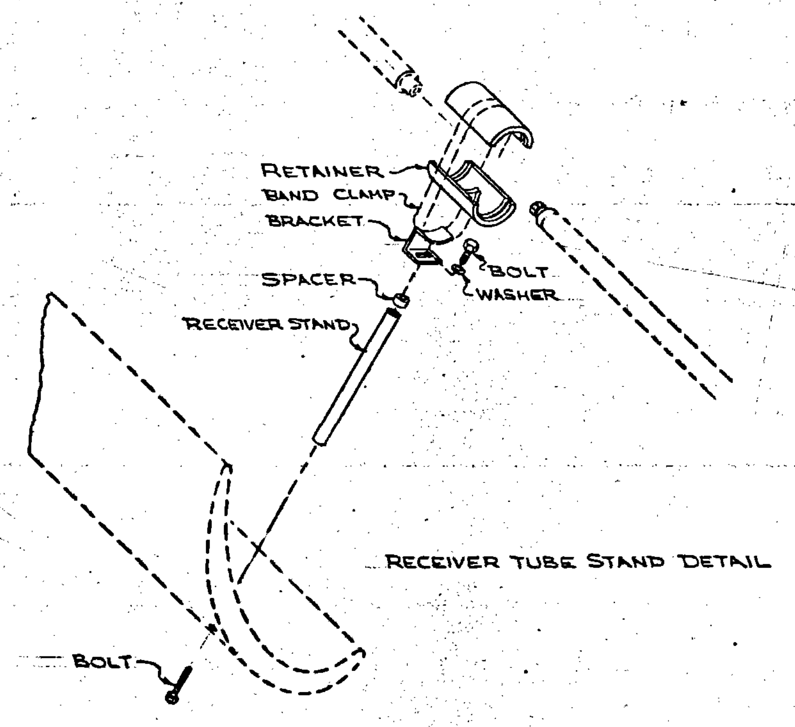
RECORD OF ISSUANCES

CATERPILLAR TRACTOR CO.

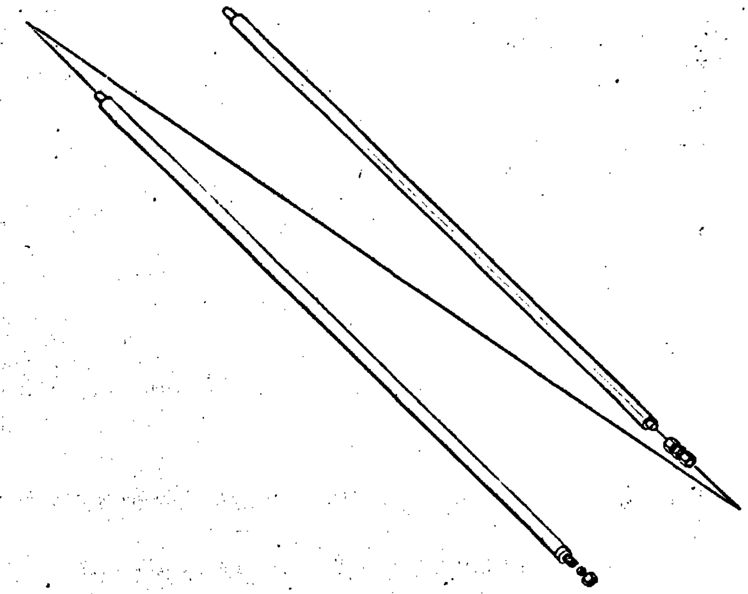
B-B

SOUTHWEST RESEARCH INSTITUTE

H203



RECEIVER TUBE STAND DETAIL



RECEIVER TUBE DETAIL

INSTALLATION OF COLLECTOR RECEIVER TUBES

1. RECEIVER TUBE STANDS ARE BOLTED IN PLACE USING ONE 1/2-13x6-1/2 BOLT PER STAND, THROUGH THE MIRROR MODULE. NOTE THAT MIRROR MODULE "C" HAS THREE RECEIVER TUBE STANDS. ALL OTHER MIRROR MODULES HAVE TWO STANDS. THE STAND AT THE DRIVE PYLON USES A 5/8-11x13-1/2 STUDMOUNT.

2. RECEIVER BRACKETS ARE BOLTED TO THE STANDS USING 1/2-13x1 BOLT. A 1/4" THICK ALUMINUM SPACER MUST BE INSERTED BETWEEN THE BRACKET AND RECEIVER TUBE STAND TO ESTABLISH PROPER RECEIVER TUBE HEIGHT. THESE BRACKETS SHOULD BE CENTERED BETWEEN THE COLLECTOR EDGES. A SLOTTED HOLE ALLOWS THIS ADJUSTMENT. IT IS IMPORTANT TO ALIGN THE SADDLE PORTION OF THE BRACKET WITH THE COLLECTOR CENTERLINE USING THE PATTERN SUPPLIED BY THE MANUFACTURER TO LOCATE THE RECEIVER CENTERLINE AT THE FOCAL LENGTH (22.157" FROM THE MIRROR SURFACE).

3. EACH RECEIVER TUBE SHOULD BE CAREFULLY CLEANED BEFORE INSTALLATION.

   a. CLEAN THE SURFACE WITH A LINT-FREE CLOTH, USING WINDEX GLASS CLEANER. THIS DETERGENT MUST BE WIPED OFF BEFORE THE SURFACE DRIES. THIS CLEANING REMOVES ADHERED DIRT AND WATER SOLUBLE CONTAMINANTS. THE WINDEX MUST NOT BE ALLOWED TO DRY ON THE TUBE.

   b. THOROUGHLY WIPE TUBE WITH A CLEAN, LINT-FREE TOWEL SOAKED WITH 1,1,1 TRICHLOROETHANE. THIS SOLVENT REMOVES ANY OILY SURFACE CONTAMINANTS.

   c. AFTER CLEANING, THE TUBES MUST NOT BE HANDLED OR TOUCHED WITH THE BARE HAND. ONLY CLEAN, OIL-FREE RAGS OR GLOVES SHOULD BE USED. SKIN OILS AND OTHER SUBSTANCES CAUSE SERIOUS DEGRADATION OF THE SELECTIVE SURFACE.

4. BEGINNING AT MIRROR MODULE "C", POSITION THE RECEIVER TUBE AT THE RECEIVER BRACKET. PLACE THE TWO HALVES OF THE RETAINER OVER THE TUBE AND SECURE THE ASSEMBLY TO THE BRACKET WITH A BAND CLAMP. REPEAT THIS FOR THE OTHER TWO STANDS.

5. THE PYREX GLASS COVER IS INSTALLED NEXT PER DWG. H205.

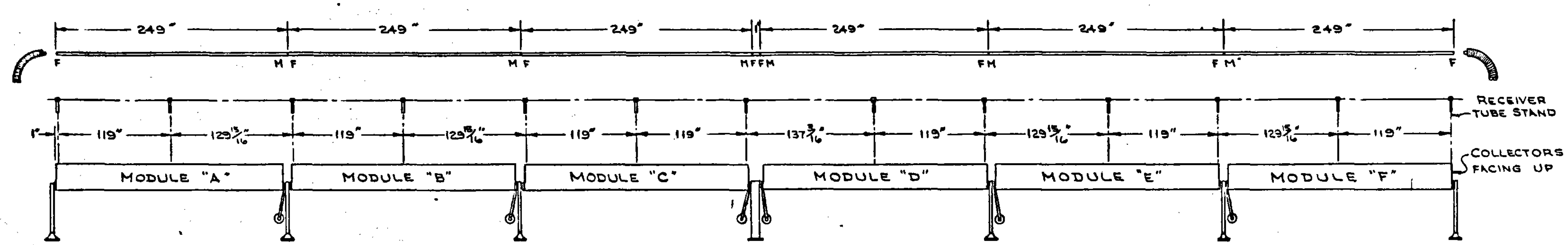
6. WORKING OUTWARD FROM THE CENTER, THE NEXT RECEIVER TUBE IS CONNECTED TO ITS PREDECESSOR. INSERT THE MALE FITTING INTO THE FEMALE END OF THE ORIGINAL TUBE. WRENCH THE NUT DOWN EASILY UNTIL A SUDDEN INCREASE IN TORQUE IS EVIDENT. FROM THIS POINT, TURN THE NUT AN ADDITIONAL 1/6 TURN (1 WRENCH FLAT) TO SPRING THE FERRULE INTO PLACE TO SEAL AGAINST THE TUBE AND FITTING BODY.

7. INSTALL ADDITIONAL PYREX COVERS PER DWG. H205.

8. CONTINUE TO BUILD THE RECEIVER UNTIL ONE HALF OF THE ROW IS COMPLETE. INSTALL THE CENTER UNION FITTING.

9. INSTALL THE RECEIVERS ON THE SECOND HALF OF THE ROW, AGAIN WORKING CENTER TO END. TAKE CARE TO MAINTAIN THE CLEANLINESS OF THE TUBES.

10. INSTALL FLEX HOSE ASSEMBLIES PER DWG. H206.



DATE

RECORD OF ISS

CATERPILLAR TRACTOR CO

SAN LEANDRO SAN FRANCISCO CA

B B RECEIVER TUBE ASSEMBLY

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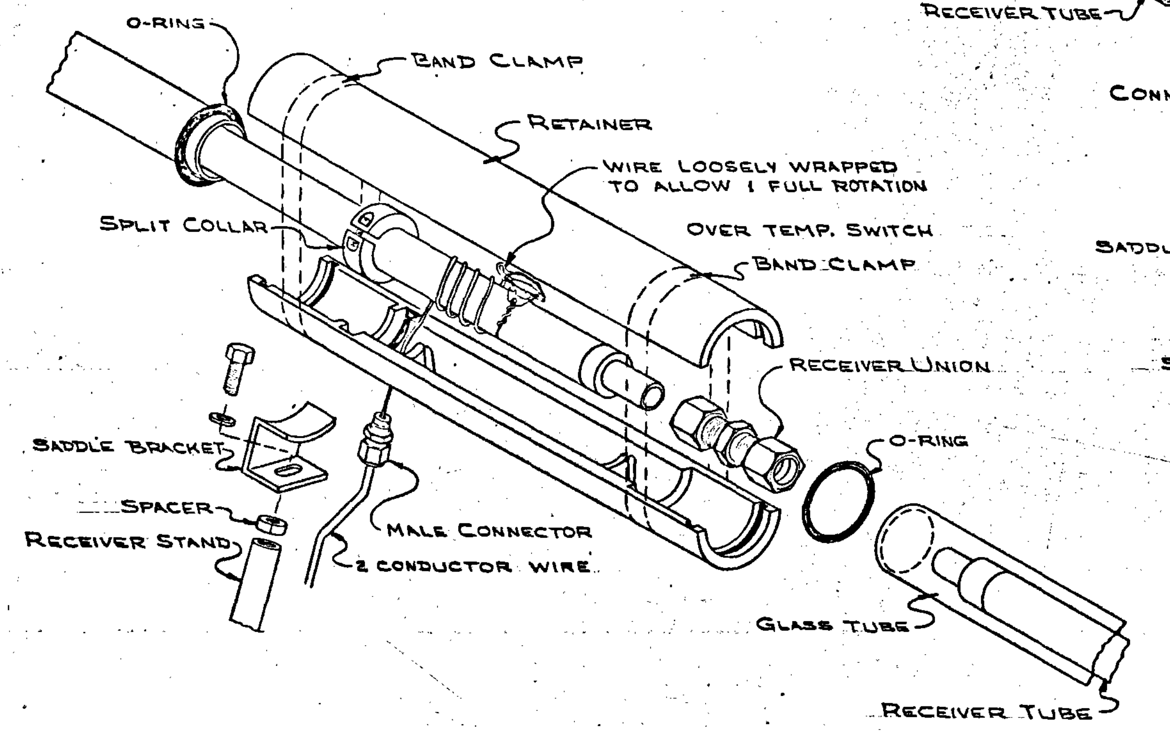
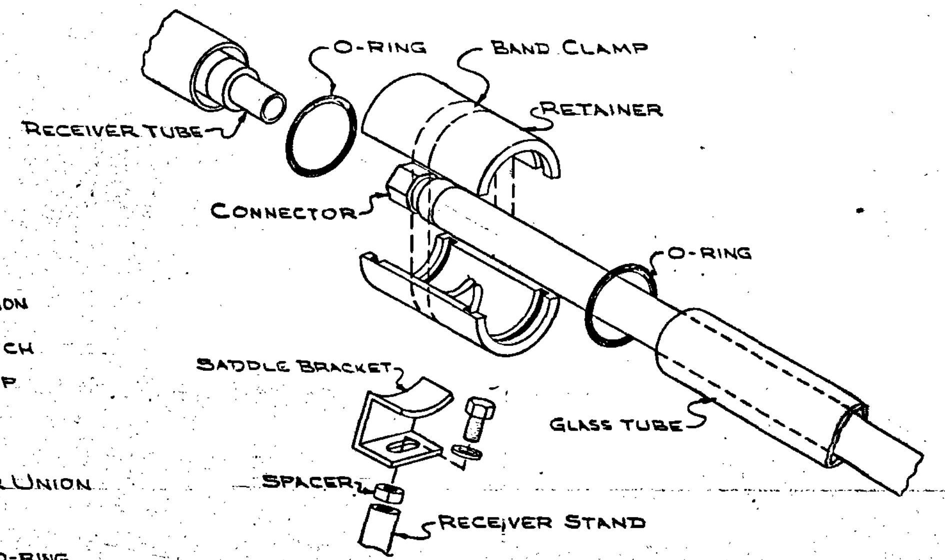
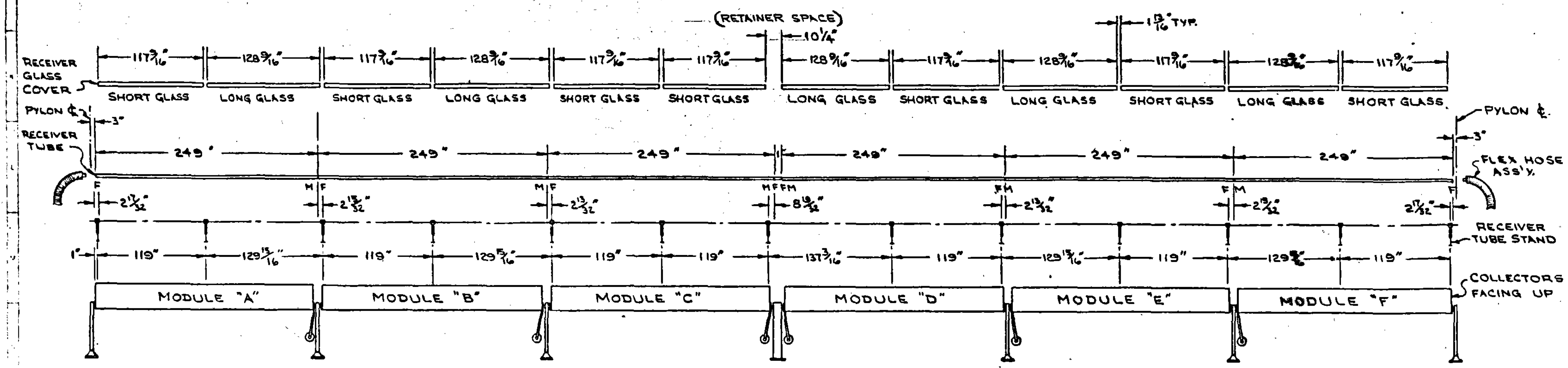
INSTALLATION OF GLASS RECEIVER COVER ASSEMBLY

1. INSTALL RECEIVER FOR MODULE "C" PER DWG. H204.
2. THE PYREX GLASS COVER IS INSTALLED AS FOLLOWS. POSITION AN O-RING AROUND THE OUTSIDE, 3/8" FROM EACH END OF THE PYREX TUBE. REMOVE THE CLAMP ASSEMBLY INSTALLED PER DWG. H204 AT ONE END OF THE RECEIVER. GUIDE THE GLASS COVER OVER THE FREE END OF THE RECEIVER TUBE, SLIDING IT IN PLACE ON THE RECEIVER. A CLEAN RAG SHOULD BE *USED TO CUSHION THE END OF THE GLASS COVER DURING THIS PROCESS.* LOOSEN THE CENTER RETAINER AND SLIDE THE BAND CLAMP TO ONE SIDE AND SPREAD THE RETAINER ENOUGH TO POSITION THE GLASS COVER INSIDE, WITH THE O-RING IN ITS GROOVE. REASSEMBLE THE RETAINER AND BAND CLAMP OVER THE GLASS COVER WHILE CENTERING THE GLASS TUBE. IN SIMILAR FASHION, REASSEMBLE THE END RETAINER.
3. INSTALL THE SECOND PYREX COVER FROM THE OPPOSITE END OF THE RECEIVER TUBE, USING THE SAME PROCEDURE. INSURE THAT THE GLASS HAS AT LEAST 1/16" END CLEARANCE INSIDE THE RETAINER ASSEMBLY.
4. INSTALL THE NEXT RECEIVER PER DWG. H204.
5. WORKING AS BEFORE, SLIDE THE PYREX COVER INTO PLACE. NOTE THAT NOW THE COVER MUST BE GUIDED OVER THE WHOLE LENGTH OF THE TUBE, SINCE ONLY ONE END IS FREE. THE RECEIVER SHOULD NOT BE ALLOWED TO SAG BETWEEN SUPPORTS—THIS CAN CAUSE GLASS BREAKAGE.
6. CONTINUE TO BUILD THE RECEIVER/COVER ASSEMBLY BY COMBINING THE INSTRUCTIONS INCLUDED HERE WITH THOSE ON DWG. H204 UNTIL ONE HALF OF THE ROW IS COMPLETE.
7. INSTALL THE CENTER UNION FITTING PER DWG. H204.
8. INSTALL THE RECEIVER/COVER ASSEMBLY ON THE SECOND HALF OF THE ROW, AGAIN WORKING CENTER TO END.
9. INSTALL FLEX HOSE ASSEMBLY PER DWG. H208.





NOTE
PREVENT DUST ACCUMULATION INSIDE OF GLASS TUBES



SCALE: 1/4" = 1'-0"

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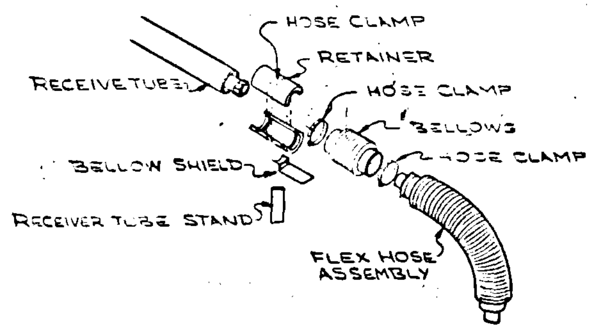
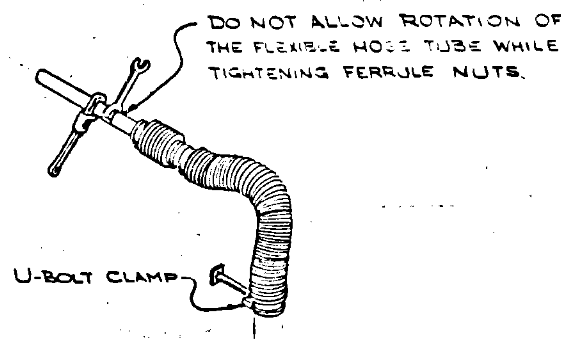
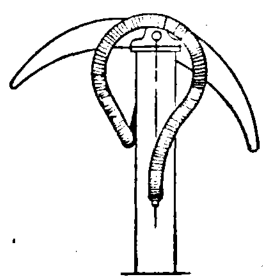
B-B GLASS COVER ASSEMBLY
SOUTHWEST RESEARCH INSTITUTE



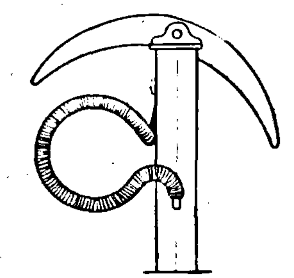
FLEX HOSE ASS'Y.



FLEX HOSE INSTALLATION DETAIL



CORRECT HOSE POSITION



INCORRECT HOSE POSITION

FLEX HOSE POSITION DETAIL

INSTALLATION OF FLEX HOSE ASSEMBLY

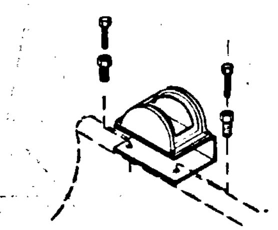
1. AFTER THE RECEIVER ASSEMBLY IS COMPLETE, ATTACH THE FLEX HOSE ASSEMBLIES. INSERT THE TUBE END INTO THE RECEIVER TUBE FEMALE FITTING. USE THE SAME TIGHTENING PROCEDURE AS THE RECEIVER TUBE CONNECTIONS (FITTINGS ARE THE SAME). THE RECEIVER MAY BE MOVED OFF CENTER TO OBTAIN ADDITIONAL WORKING ROOM DURING THIS OPERATION. GRIP THE FITTING BOSS ON THE RECEIVER TUBE WITH A PIPE WRENCH TO PREVENT ROTATION WHILE THE FERRULE NUT IS TIGHTENED WITH AN OPEN END WRENCH (SEE FLEX HOSE INSTALLATION DETAIL). NEXT, CLAMP THE BOTTOM END OF THE FLEX HOSE IN THE HOSE BRACKET AND SECURELY TIGHTEN THE U-BOLT CLAMP. THE CONNECTION MAY NOW BE MADE TO THE FLUID MANIFOLD. CARE MUST BE EXERCISED DURING FLEX HOSE INSTALLATION TO PREVENT ANY ROTATION OF THE FLEXIBLE TUBE AS THE FERRULE NUT IS TIGHTENED. ANY TORQUE ON THIS HOSE MAY CAUSE PREMATURE HOSE FAILURE.

2. LOOSEN THE RECEIVER BRACKET BOLT AT EACH END OF THE COLLECTOR ROW AND INSTALL THE BELLOWS SHIELD. (SEE FLEX HOSE ASS'Y DETAIL.) THIS SHIELD PREVENTS HIGH INTENSITY SUNLIGHT FROM CONTACTING THE SILICONE BELLOWS.

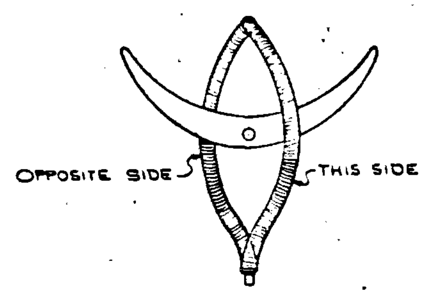
3. CENTER THE RECEIVER END TO END AND, AT THE CENTER OF THE ROW, INSTALL THE OVERTEMPERATURE SWITCH (SEE OVERTEMPERATURE SWITCH DETAIL). ROUTE THE WIRING DOWN THE SIDE OF THE DRIVE PYLON AND INTO THE CONTROL BOX. THE WIRE IS CLIPPED TO THE DRIVE PYLON COVER SCREWS. SUFFICIENT SLACK SHOULD BE AVAILABLE TO ALLOW COLLECTOR ROTATION. INSTALL THE RECEIVER LOCATING RING AND REPLACE THE TOP HALF OF THE CENTRAL RECEIVER O-RING RETAINER WITH TWO CLAMPS.

4. CORRECT RECEIVER INSTALLATION SHOULD BE CHECKED BEFORE THE FLUID SYSTEM IS FILLED OR PRESSURIZED. BEFORE BEGINNING THIS CHECKOUT, INSURE THAT THERE ARE NO OBSTRUCTIONS TO COLLECTOR MIRROR ROTATION, AND THE FLEX HOSE POSITION IS CORRECT (SEE FLEX HOSE POSITION DETAIL).
   a. THE RECEIVER TUBE SHOULD BE FREE TO ROTATE IN THE RETAINERS—CHECK THIS BY OSCILLATING THE FLEX HOSE A SMALL AMOUNT SIDE TO SIDE.
   b. USING THE MANUAL CONTROL SWITCH, ROTATE THE COLLECTOR OUT OF STOW UNTIL IT IS FACING THE HORIZON (APPROXIMATELY 90°).
   c. MOVING ABOUT 15° AT A TIME, ROTATE THE COLLECTOR UPWARD. AT EACH INTERVAL, CHECK THAT THE RECEIVER IS FREE TO ROTATE AS ABOVE (a).
   CHECK THAT THE FLEX HOSE IS NOT IN ANY BIND OR STRAIN. IF THE FLEX HOSE IS INCORRECTLY MOUNTED AT THE LOWER END, THE RECEIVER MAY BE BENT AT THE HIGHEST ROTATIONAL POSITION, OR THE FLEX HOSE DAMAGED.
   SIGHT DOWN THE ROW FROM ONE END AND CHECK THE RELATIVE POSITION OF THE TWO FLEX HOSES. THE HOSES SHOULD BE PARALLEL TO EACH OTHER (SEE FLEX HOSE ALIGNMENT DETAIL). IF THEY ARE NOT, CORRECT THIS BY LOOSENING THE FLEX HOSE/RECEIVER FITTING AND ROTATING THE FLEX HOSE SLIGHTLY, THEN RETIGHTEN THE FITTING.
   d. CONTINUE ROTATION UNTIL THE COLLECTORS ARE AIMED AT THE OPPOSITE HORIZON.

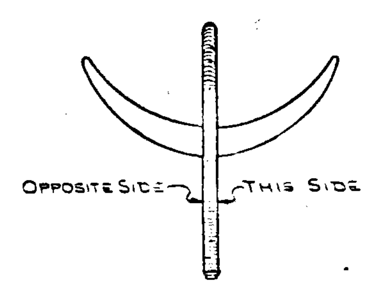
5. INSTALL THE TRACKING SENSOR (SEE TRACKING SENSOR DETAIL). ROUTE THE WIRING DOWN THE MIRROR MODULE TO DRIVE PYLON AND ON TO THE CONTROL BOX. THE SENSOR SHALL BE ALIGNED USING THE ADJUSTMENT SCREW PROVIDED.



TRACKING SENSOR DETAIL

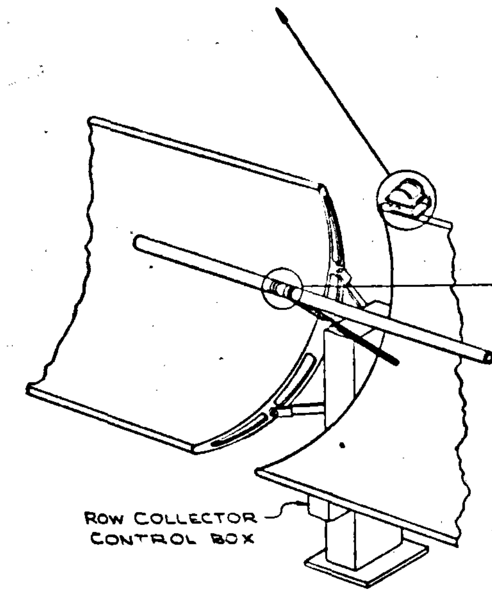


INCORRECT - HOSE MISALIGNED

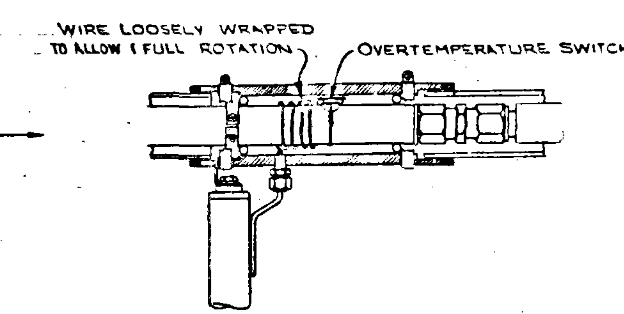


CORRECT - HOSE ALIGNED

FLEX HOSE ALIGNMENT DETAIL



SENSOR LOCATION DETAIL



OVERTEMPERTURE SWITCH DETAIL

DATE | REASON FOR ISSUE

RECORD OF ISSUANCES

CATERPILLAR TRACTOR CO.

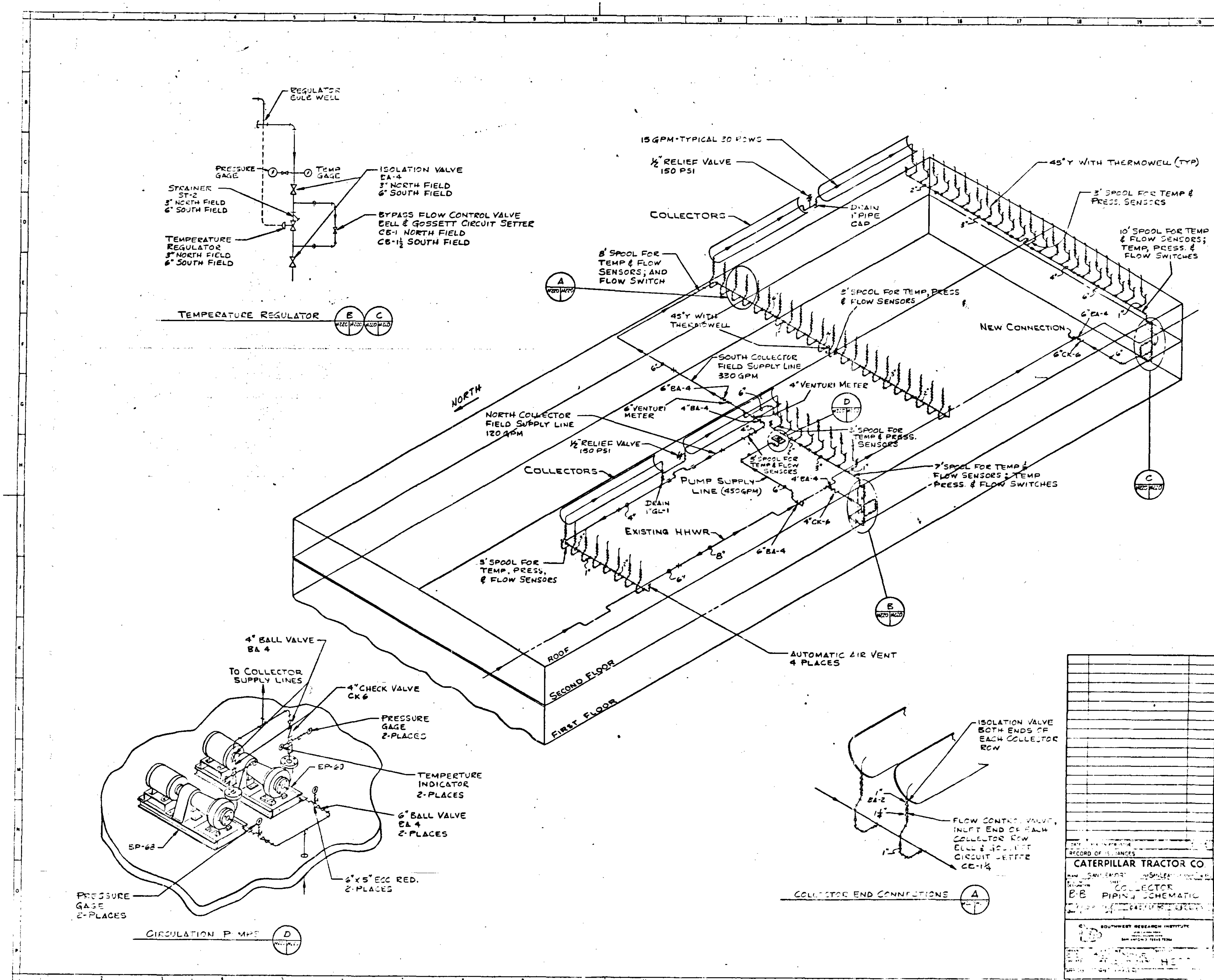
SAN LEANDRO | SAN LEANDRO | CA.

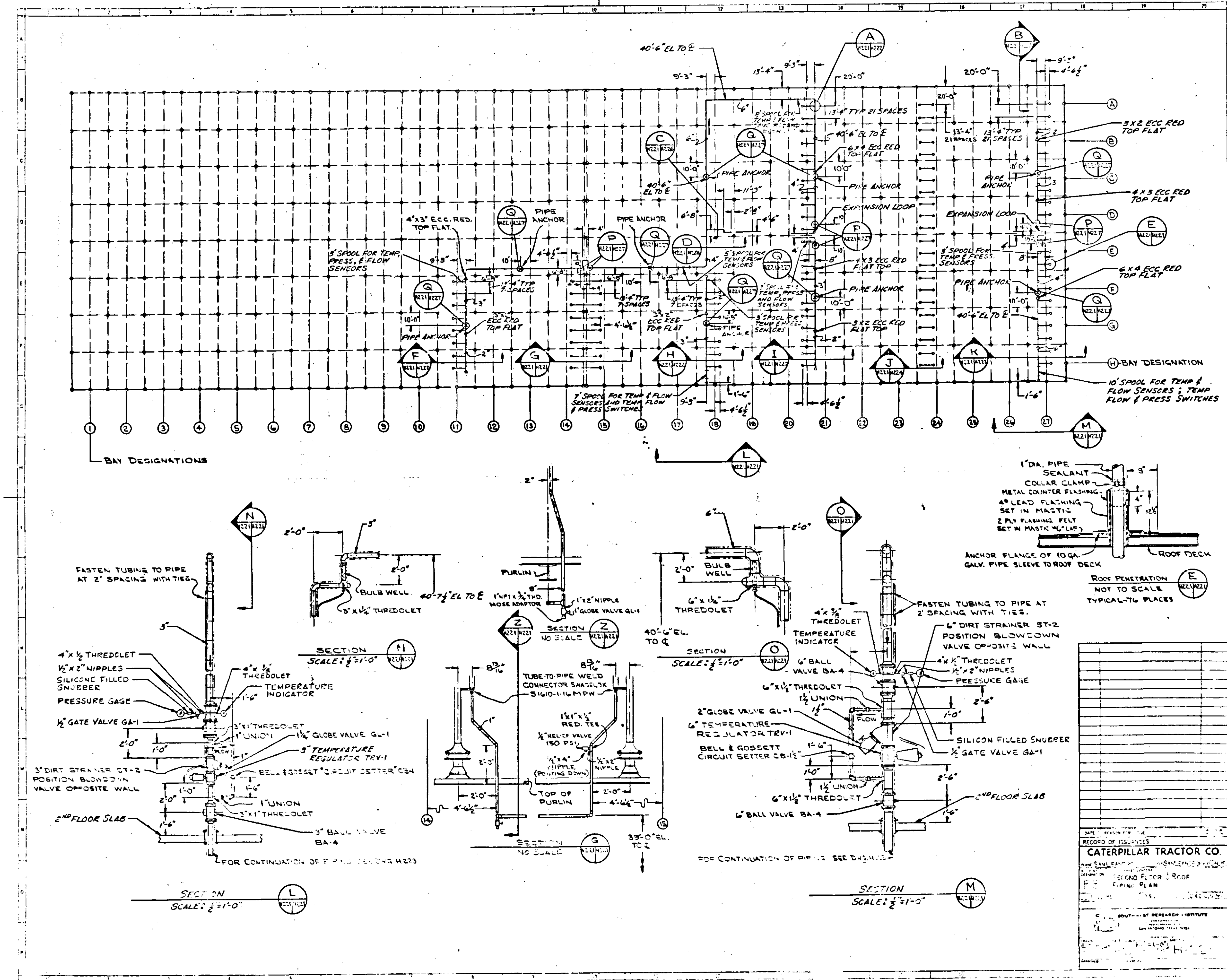
B-B FLEX HOSE ASSEMBLY

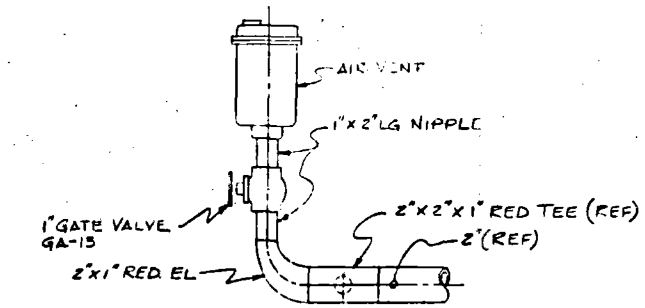
SOUTHWEST RESEARCH INSTITUTE

SAN ANTONIO TEXAS

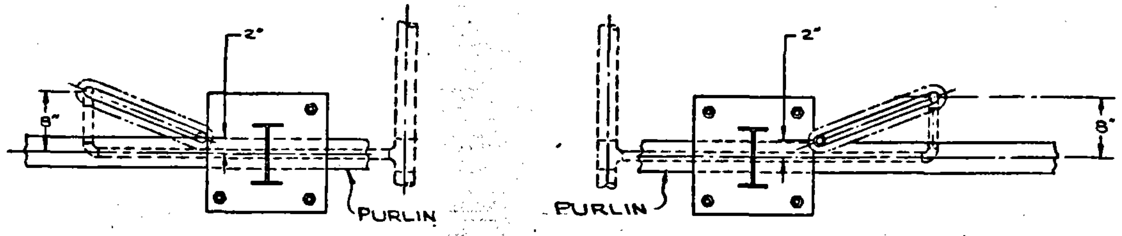
H-20

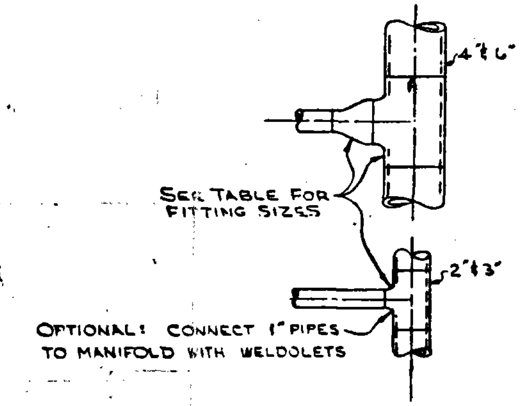

REGULATOR BULB WELL
PRESSURE GAGE
TEMP GAGE
ISOLATION VALVE
EA-4
3" NORTH FIELD
6" SOUTH FIELD
STRAINER
ST-2
3" NORTH FIELD
6" SOUTH FIELD
BYPASS FLOW CONTROL VALVE
BELL & GOSSETT CIRCUIT SETTER
CB-1 NORTH FIELD
CB-1½ SOUTH FIELD
TEMPERATURE
REGULATOR
3" NORTH FIELD
6" SOUTH FIELD
TEMPERATURE REGULATOR
B
C
15 GPM - TYPICAL 30 ROWS
½" RELIEF VALVE
150 PSI
45° Y WITH THERMOWELL (TYP)
3' SPOOL FOR TEMP & PRESS. SENSORS
DRAIN
1" PIPE
CAP
COLLECTORS
10' SPOOL FOR TEMP & FLOW SENSORS; TEMP, PRESS. & FLOW SWITCHES
8' SPOOL FOR
TEMP & FLOW
SENSORS; AND
FLOW SWITCH
A
3' SPOOL FOR TEMP, PRESS
& FLOW SENSORS
45° Y WITH
THERMOWELL
NEW CONNECTION
6" BA-4
6" CK-6
SOUTH COLLECTOR
FIELD SUPPLY LINE
330 GPM
6" BA-4
4" VENTURI METER
D
NORTH
NORTH COLLECTOR
FIELD SUPPLY LINE
120 GPM
6" VENTURI
METER
4" BA-4
3' SPOOL FOR
TEMP & PRESS.
SENSORS
½" RELIEF VALVE
150 PSI
5' SPOOL FOR
TEMP & FLOW
SENSORS
COLLECTORS
PUMP SUPPLY
LINE (450 GPM)
4" BA-4
7' SPOOL FOR TEMP &
FLOW SENSORS; TEMP
PRESS. & FLOW SWITCHES
DRAIN
1" GL-1
4" CK-6
EXISTING HHWR
6" BA-4
5' SPOOL FOR
TEMP, PRESS,
& FLOW SENSORS
ROOF
SECOND FLOOR
FIRST FLOOR
AUTOMATIC AIR VENT
4 PLACES
4" BALL VALVE
BA 4
TO COLLECTOR
SUPPLY LINES
4" CHECK VALVE
CK 6
PRESSURE
GAGE
2-PLACES
EP-23
TEMPERTURE
INDICATOR
2-PLACES
6" BALL VALVE
BA 4
2-PLACES
SP-63
6" x 5" ECC RED.
2-PLACES
PRESSURE
GAGE
2-PLACES
CIRCULATION PUMPS
D
ISOLATION VALVE
BOTH ENDS OF
EACH COLLECTOR
ROW
BA-2
FLOW CONTROL VALVE,
INLET END OF EACH
COLLECTOR ROW
BELL & GOSSETT
CIRCUIT SETTER
CB-1¼
COLLECTOR END CONNECTIONS
A
RECORD OF ISSUANCES
CATERPILLAR TRACTOR CO.
COLLECTOR
PIPING SCHEMATIC
B-B
SOUTHWEST RESEARCH INSTITUTE


40'-6" EL TO ℄
13'-4" TYP 21 SPACES
40'-6" EL TO ℄
6x4 ECC RED TOP FLAT
PIPE ANCHOR
EXPANSION LOOP
4"x3" ECC. RED. TOP FLAT
PIPE ANCHOR
3" SPOOL FOR TEMP, PRESS, & FLOW SENSORS
13'-4" TYP 7 SPACES
3x2 ECC RED TOP FLAT
4x3 ECC RED TOP FLAT
6x4 ECC RED TOP FLAT
3x2 ECC RED FLAT TOP
4x3 ECC RED FLAT TOP
3" SPOOL FOR TEMP & PRESS. SENSORS
3" SPOOL FOR TEMP, PRESS AND FLOW SENSORS
7' SPOOL FOR TEMP & FLOW SENSORS AND TEMP, FLOW & PRESS SWITCHES
10' SPOOL FOR TEMP & FLOW SENSORS ; TEMP FLOW & PRESS SWITCHES
BAY DESIGNATION
BAY DESIGNATIONS
FASTEN TUBING TO PIPE AT 2' SPACING WITH TIES
4"x ½ THREDOLET
½"x2" NIPPLES
SILICONE FILLED SNUBBER
PRESSURE GAGE
½" GATE VALVE GA-1
4"x ⅜ THREDOLET
TEMPERATURE INDICATOR
3"x1" THREDOLET
1" UNION
1¼ GLOBE VALVE GL-1
3" TEMPERATURE REGULATOR TRV-1
3" DIRT STRAINER ST-2 POSITION BLOWDOWN VALVE OPPOSITE WALL
BELL & GOSSETT "CIRCUIT SETTER" CB-1
1" UNION
3"x1" THREDOLET
2ND FLOOR SLAB
3" BALL VALVE BA-4
FOR CONTINUATION OF PIPING SEE DWG H223
SECTION L
SCALE: ½"=1'-0"
BULB WELL
3"x1¼" THREDOLET
40'-7½" EL TO ℄
SECTION N
SCALE: ½"=1'-0"
PURLIN
1"NPT x ¾ THD. HOSE ADAPTOR
1"x2" NIPPLE
1" GLOBE VALVE GL-1
SECTION Z
NO SCALE
TUBE-TO-PIPE WELD CONNECTOR SWAGELOK S1610-1-16MPW
1"x1"x½" RED. TEE
½" RELIEF VALVE 150 PSI
½"x4" NIPPLE (POINTING DOWN)
½"x2" NIPPLE
TOP OF PURLIN
SECTION G
NO SCALE
39'-0" EL. TO ℄
BULB WELL
6"x1¼" THREDOLET
40'-6" EL. TO ℄
SECTION O
SCALE: ½"=1'-0"
FASTEN TUBING TO PIPE AT 2' SPACING WITH TIES.
4"x⅜ THREDOLET
TEMPERATURE INDICATOR
6" DIRT STRAINER ST-2 POSITION BLOWDOWN VALVE OPPOSITE WALL
6" BALL VALVE BA-4
4"x½" THREDOLET
½"x2" NIPPLES
PRESSURE GAGE
6"x1½ THREDOLET
1½ UNION
2" GLOBE VALVE GL-1
6" TEMPERATURE REGULATOR TRV-1
BELL & GOSSETT CIRCUIT SETTER CB-1½"
FLOW
SILICON FILLED SNUBBER
½ GATE VALVE GA-1
1½" UNION
6"x1½ THREDOLET
6" BALL VALVE BA-4
2ND FLOOR SLAB
FOR CONTINUATION OF PIPING SEE DWG H223
SECTION M
SCALE: ½"=1'-0"
1" DIA. PIPE
SEALANT
COLLAR CLAMP
METAL COUNTER FLASHING
4# LEAD FLASHING SET IN MASTIC
2 PLY FLASHING FELT SET IN MASTIC
ANCHOR FLANGE OF 10 GA. GALV. PIPE SLEEVE TO ROOF DECK
ROOF DECK
ROOF PENETRATION E
NOT TO SCALE
TYPICAL-76 PLACES
RECORD OF ISSUANCES
CATERPILLAR TRACTOR CO.
SECOND FLOOR & ROOF PIPING PLAN
SOUTHWEST RESEARCH INSTITUTE

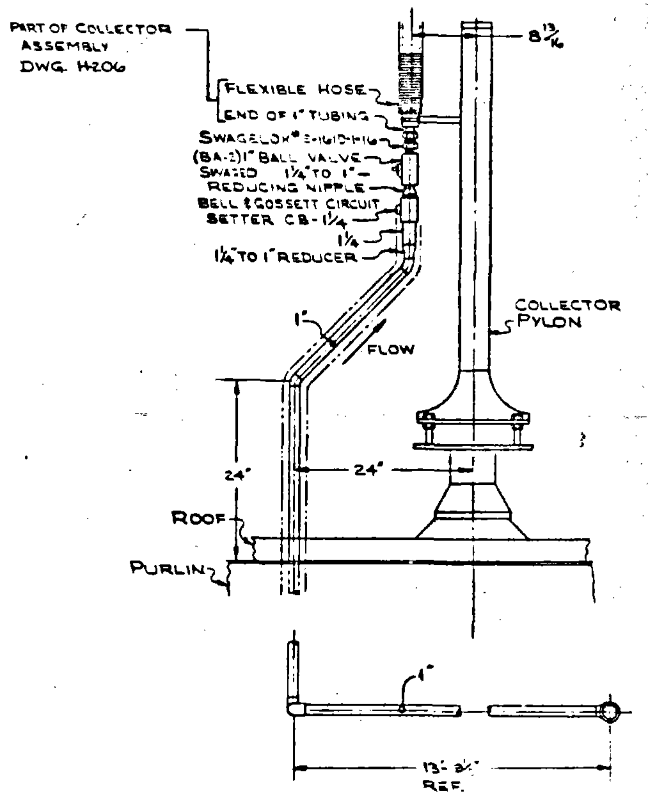


AUTOMATIC AIR VENT (B)
SCALE: 1/4" = 1"
TYPICAL 4 PLACES

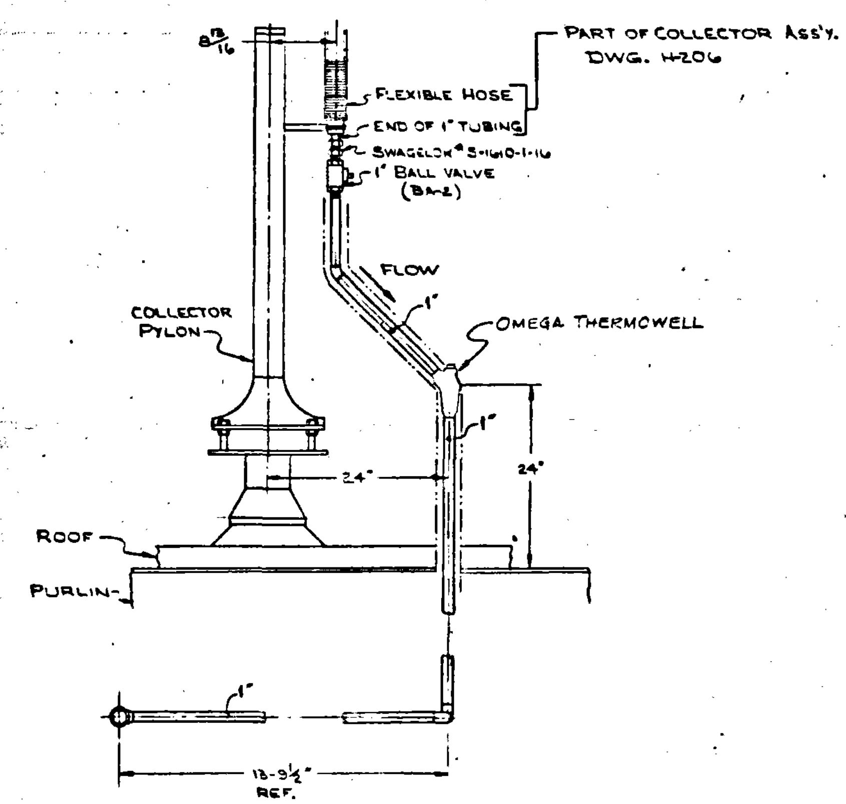




BRANCH PIPING DETAIL (A)
SCALE: 1/4" = 1"



SECTION (F) (J)
SCALE: 1/3" = 1'



SECTION (H) (K)
SCALE

FOR COLLECTOR LOCATION SEE DWG # H-200

COLL. NO.	REDUCING TEE	REDUCER
BH47	2 x 2 x 1	
BH48	2 x 2 x 1	
BH49	2 x 2 x 1	
BH50	3 x 3 x 1	
BH51	3 x 3 x 1	
BH52	3 x 3 x 1	
BH53	3 x 3 x 1	
BH54	3 x 3 x 1	
BH55	4 x 4 x 2	2 x 1
BH56	4 x 4 x 2	2 x 1
BH57	4 x 4 x 2	2 x 1
BH58	4 x 4 x 2	2 x 1
BH59	4 x 4 x 2	2 x 1
BH60	4 x 4 x 2	2 x 1
BH61	4 x 4 x 2	2 x 1
BH62	4 x 4 x 2	2 x 1
BH63	6 x 6 x 2	2 x 1
BH64	6 x 6 x 2	2 x 1
BH65	6 x 6 x 2	2 x 1
BH66	6 x 6 x 2	2 x 1
BH67	6 x 6 x 2	2 x 1
BH68	6 x 6 x 2	2 x 1
BH69	6 x 6 x 2	2 x 1
BH70	6 x 6 x 2	2 x 1
BH71	6 x 6 x 2	2 x 1
BH72	6 x 6 x 2	2 x 1
BH73	6 x 6 x 2	2 x 1
BH74	6 x 6 x 2	2 x 1
BH75	4 x 4 x 2	2 x 1
BH76	4 x 4 x 2	2 x 1
BH77	4 x 4 x 2	2 x 1
BH78	4 x 4 x 2	2 x 1
BH79	4 x 4 x 2	2 x 1
BH80	4 x 4 x 2	2 x 1
BH81	4 x 4 x 2	2 x 1
BH82	4 x 4 x 2	2 x 1
BH83	3 x 3 x 1	
BH84	3 x 3 x 1	
BH85	3 x 3 x 1	
BH86	3 x 3 x 1	
BH87	3 x 3 x 1	
BH88	2 x 2 x 1	
BH89	2 x 2 x [illegible]	
BH90	2 x 2 x 1	
BH91	3 x 3 x 1	
BH92	3 x 3 x 1	
BH93	3 x 3 x 1	
BH94	3 x 3 x 1	
BH95	3 x 3 x 1	
BH96	2 x 2 x 1	
BH97	2 x 2 x 1	
BH98	2 x 2 x 1	
BH99	2 x 2 x 1	
BH100	2 x 2 x 1	
BH101	2 x 2 x 1	
BH102	2 x 2 [illegible]	
BH103	3 x 3 [illegible]	
BH104	3 x 3 x 1	
BH105	3 x 3 x 1	
BH106	3 x 3 x 1	

RECORD OF ISSUANCES

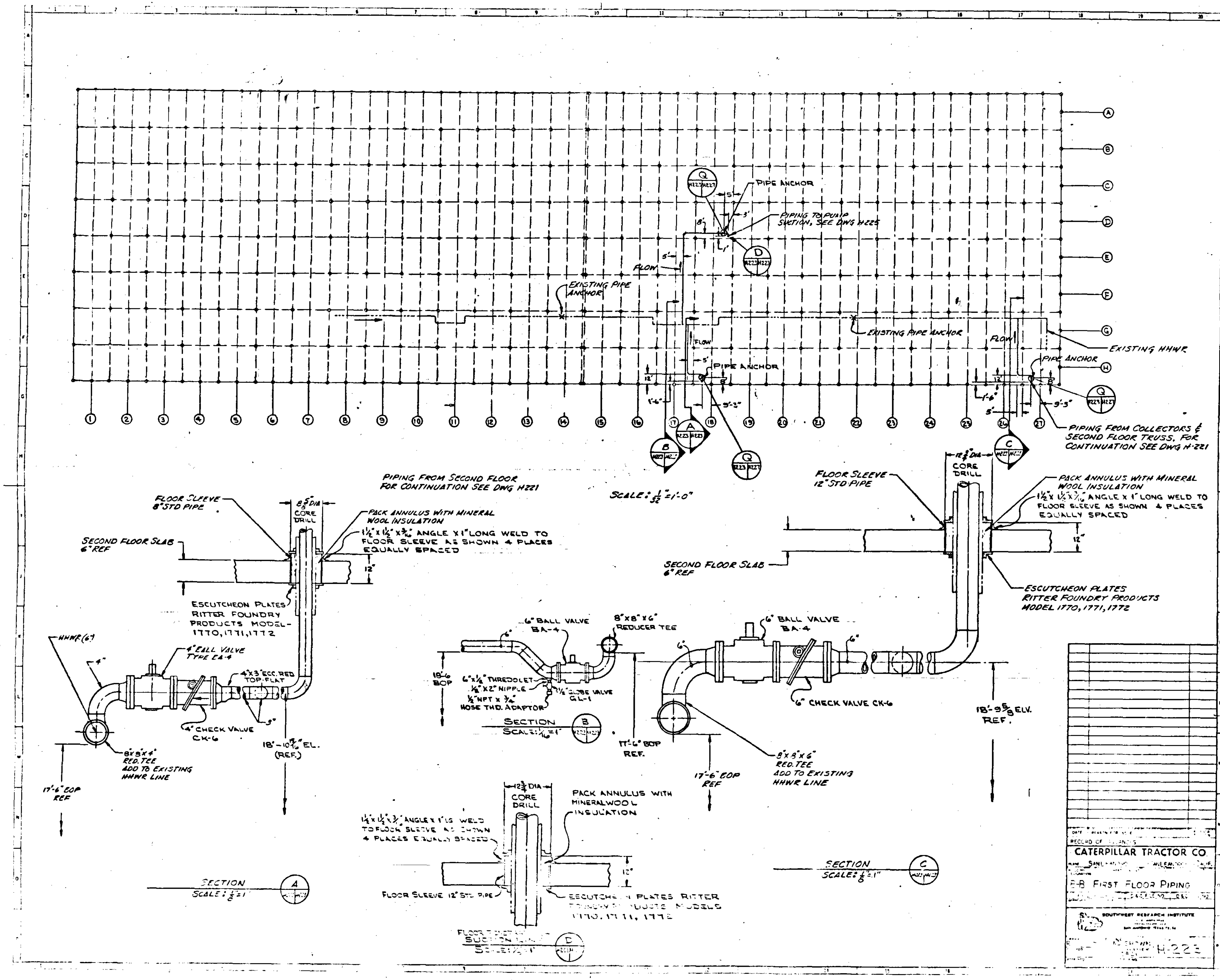
CATERPILLAR TRACTOR CO.

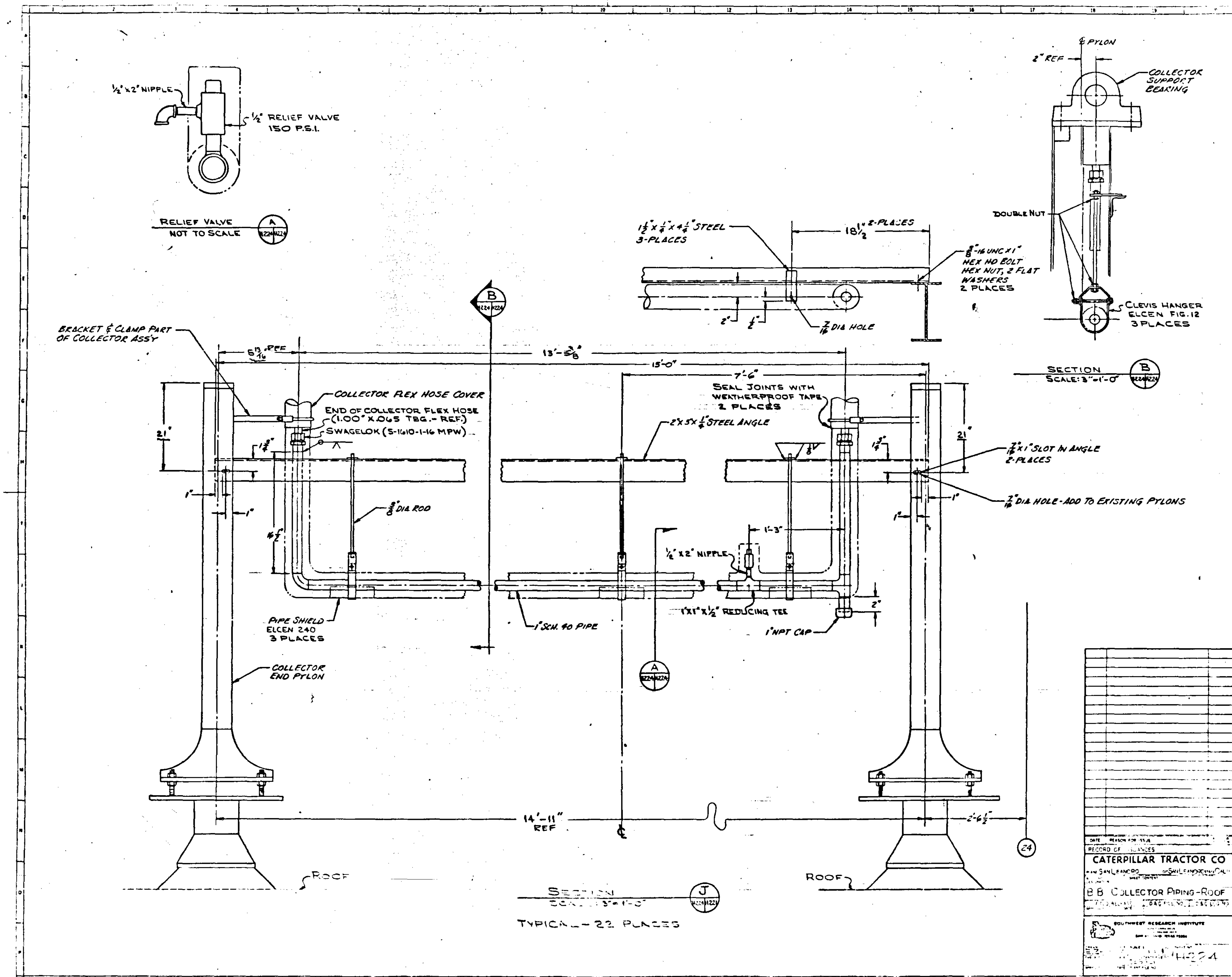
SAN LEANDRO

B.B. SECOND FLOOR PIPING SECTIONS

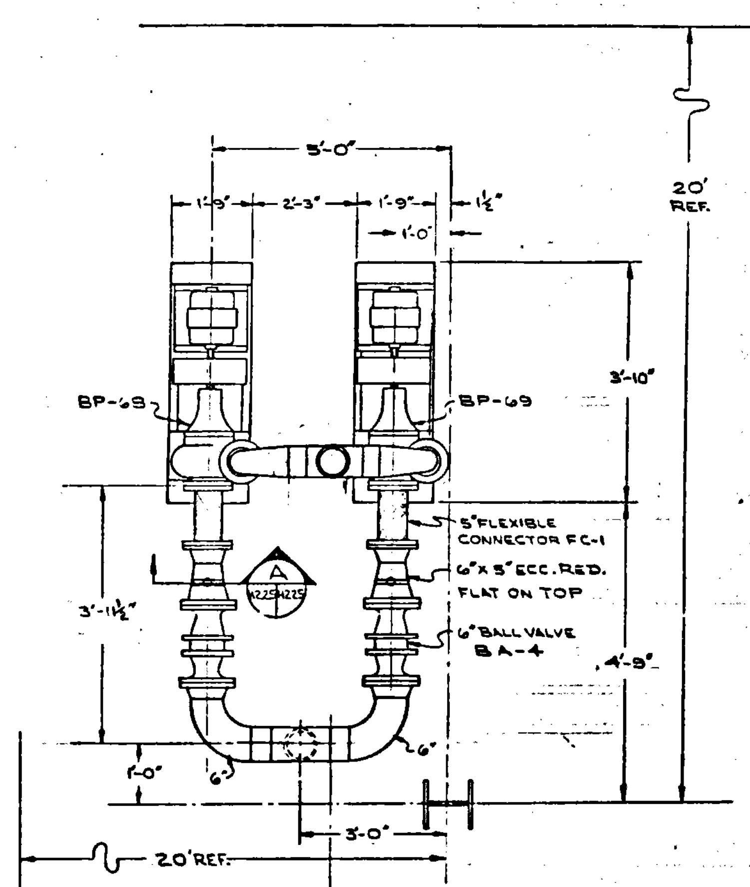
SOUTHWEST RESEARCH INSTITUTE

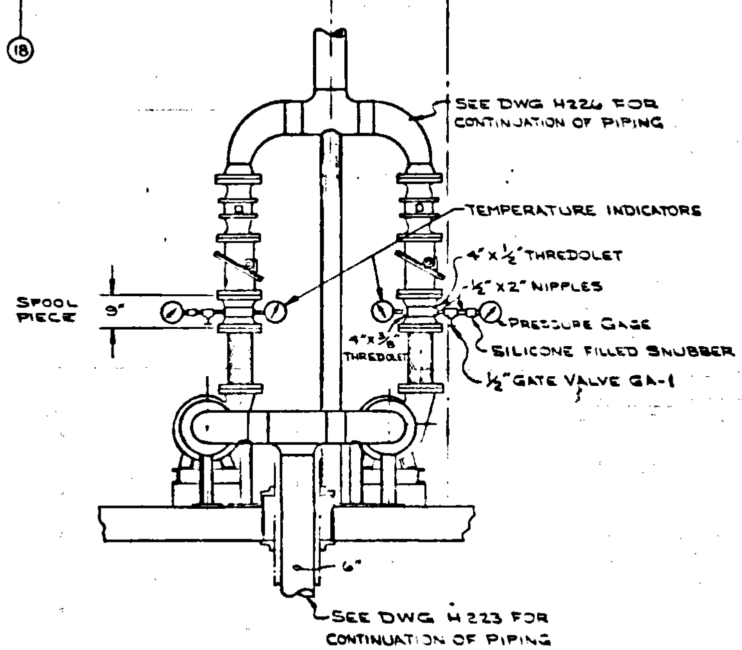
H-222

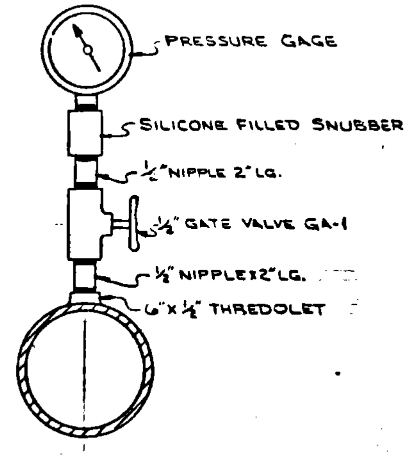

PIPE ANCHOR
PIPING TO PUMP SECTION, SEE DWG H225
FLOW
EXISTING PIPE ANCHOR
EXISTING PIPE ANCHOR
EXISTING HHWR
PIPE ANCHOR
PIPING FROM COLLECTORS & SECOND FLOOR TRUSS, FOR CONTINUATION SEE DWG H-221
SCALE: 1/32" = 1'-0"
PIPING FROM SECOND FLOOR FOR CONTINUATION SEE DWG H221
FLOOR SLEEVE 8" STD PIPE
8 5/8" DIA CORE DRILL
PACK ANNULUS WITH MINERAL WOOL INSULATION
1 1/2" x 1 1/2" x 3/16" ANGLE x 1" LONG WELD TO FLOOR SLEEVE AS SHOWN 4 PLACES EQUALLY SPACED
SECOND FLOOR SLAB 6" REF
ESCUTCHEON PLATES RITTER FOUNDRY PRODUCTS MODEL-1770, 1771, 1772
HHWR (6")
4" BALL VALVE TYPE BA-4
4"x3" ECC. RED TOP-FLAT
4" CHECK VALVE CK-6
8"x8"x4" RED. TEE ADD TO EXISTING HHWR LINE
18'-10 1/16" EL. (REF.)
17'-6" BOP REF
SECTION SCALE: 1/2" = 1'
6" BALL VALVE BA-4
8"x8"x6" REDUCER TEE
6"x1/2" THREDOLET
1/2" x 2" NIPPLE
1/2" NPT x 3/4" HOSE THD. ADAPTOR
1/2" GLOBE VALVE GL-1
18'-6" BOP
SECTION SCALE: 1/16" = 1'
17'-6" BOP REF.
FLOOR SLEEVE 12" STD PIPE
12 3/4" DIA CORE DRILL
PACK ANNULUS WITH MINERAL WOOL INSULATION
1 1/2" x 1 1/2" x 3/16" ANGLE x 1" LONG WELD TO FLOOR SLEEVE AS SHOWN 4 PLACES EQUALLY SPACED
SECOND FLOOR SLAB 6" REF
ESCUTCHEON PLATES RITTER FOUNDRY PRODUCTS MODEL 1770, 1771, 1772
6" BALL VALVE BA-4
6" CHECK VALVE CK-6
8"x8"x6" RED. TEE ADD TO EXISTING HHWR LINE
17'-6" BOP REF
18'-9 5/8" ELV. REF.
12"
PACK ANNULUS WITH MINERAL WOOL INSULATION
FLOOR SLEEVE 12" STD PIPE
ESCUTCHEON PLATES RITTER FOUNDRY PRODUCTS MODELS 1770, 1771, 1772
SECTION SCALE: 1/8" = 1'
SECTION D
CATERPILLAR TRACTOR CO
B-B FIRST FLOOR PIPING
SOUTHWEST RESEARCH INSTITUTE
H-223



1/2" x 2" NIPPLE
1/2" RELIEF VALVE 150 P.S.I.
RELIEF VALVE
NOT TO SCALE
℄ PYLON
2" REF
COLLECTOR SUPPORT BEARING
DOUBLE NUT
CLEVIS HANGER ELCEN FIG. 12 3 PLACES
SECTION B
SCALE: 3" = 1'-0"
1 1/2" x 1/4" x 4 1/4" STEEL 3-PLACES
18 1/2" 2-PLACES
5/8"-16 UNC x 1" HEX HD BOLT HEX NUT, 2 FLAT WASHERS 2 PLACES
7/16 DIA HOLE
BRACKET & CLAMP PART OF COLLECTOR ASS'Y
6 13/16 REF
13'-3 3/8"
15'-0"
7'-6"
COLLECTOR FLEX HOSE COVER
END OF COLLECTOR FLEX HOSE (1.00" x .065 TBG. - REF.)
SWAGELOK (S-1610-1-16 MPW)
SEAL JOINTS WITH WEATHERPROOF TAPE 2 PLACES
2" x 5" x 1/4" STEEL ANGLE
7/16" x 1" SLOT IN ANGLE 2-PLACES
7/16" DIA HOLE - ADD TO EXISTING PYLONS
3/8" DIA ROD
1'-3"
1/2" x 2" NIPPLE
1" x 1" x 1/2" REDUCING TEE
1" NPT CAP
1" SCH. 40 PIPE
PIPE SHIELD ELCEN 240 3 PLACES
COLLECTOR END PYLON
14'-11" REF
2'-6 1/2"
ROOF
ROOF
SECTION J
SCALE: 3" = 1'-0"
TYPICAL - 22 PLACES
DATE REASON FOR ISSUE
RECORD OF ISSUANCES
CATERPILLAR TRACTOR CO
SAN LEANDRO SAN LEANDRO CALIF
B B COLLECTOR PIPING - ROOF
SOUTHWEST RESEARCH INSTITUTE
H224



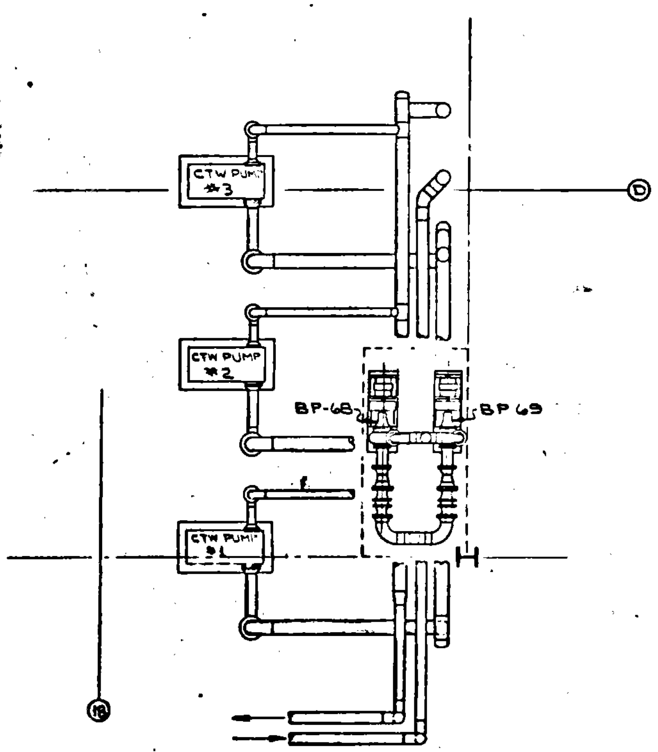




GAGE DETAIL

SCALE: ½" = 1"

(2 PLACES)

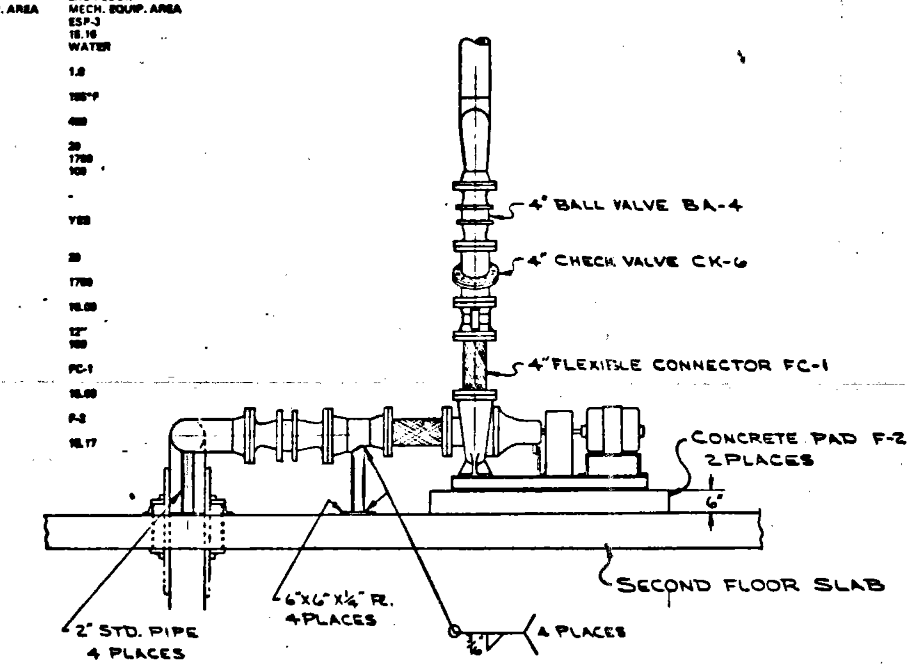


EQUIPMENT PLAN

NOT TO SCALE

PUMP SCHEDULE

UNIT NO.	BP68	BP69
BLDG. LOCATION	2ND FLOOR	2ND FLOOR
SYSTEM	MECH. EQUIP. AREA	MECH. EQUIP. AREA
SPEC. TYPE	ESP-3	ESP-3
SPEC. SECTION	15.16	15.16
FLUID TYPE	WATER	WATER
FLUID SP. GV.	1.0	1.0
FLUID TEMP °F	[illegible]	[illegible]
PUMP GPM	400	400
PUMP HP	20	20
PUMP RPM	[illegible]	[illegible]
TOTAL HEAD FT.	100	100
SEAL PACKING	-	-
SEAL MECHANICAL	YES	YES
MOTOR HP	20	20
MOTOR RPM	[illegible]	[illegible]
MOTOR SEE DIV.	[illegible]	[illegible]
FLEX CONN LENGTH	12"	12"
FLEX CONN OPERATION PRESS PSI	100	100
FLEX CONN SPEC TYPE	FC-1	FC-1
SPEC. SECTION	[illegible]	[illegible]
BASES SPEC TYPE	F-2	F-2
BASES SPEC SECTION	15.17	15.17



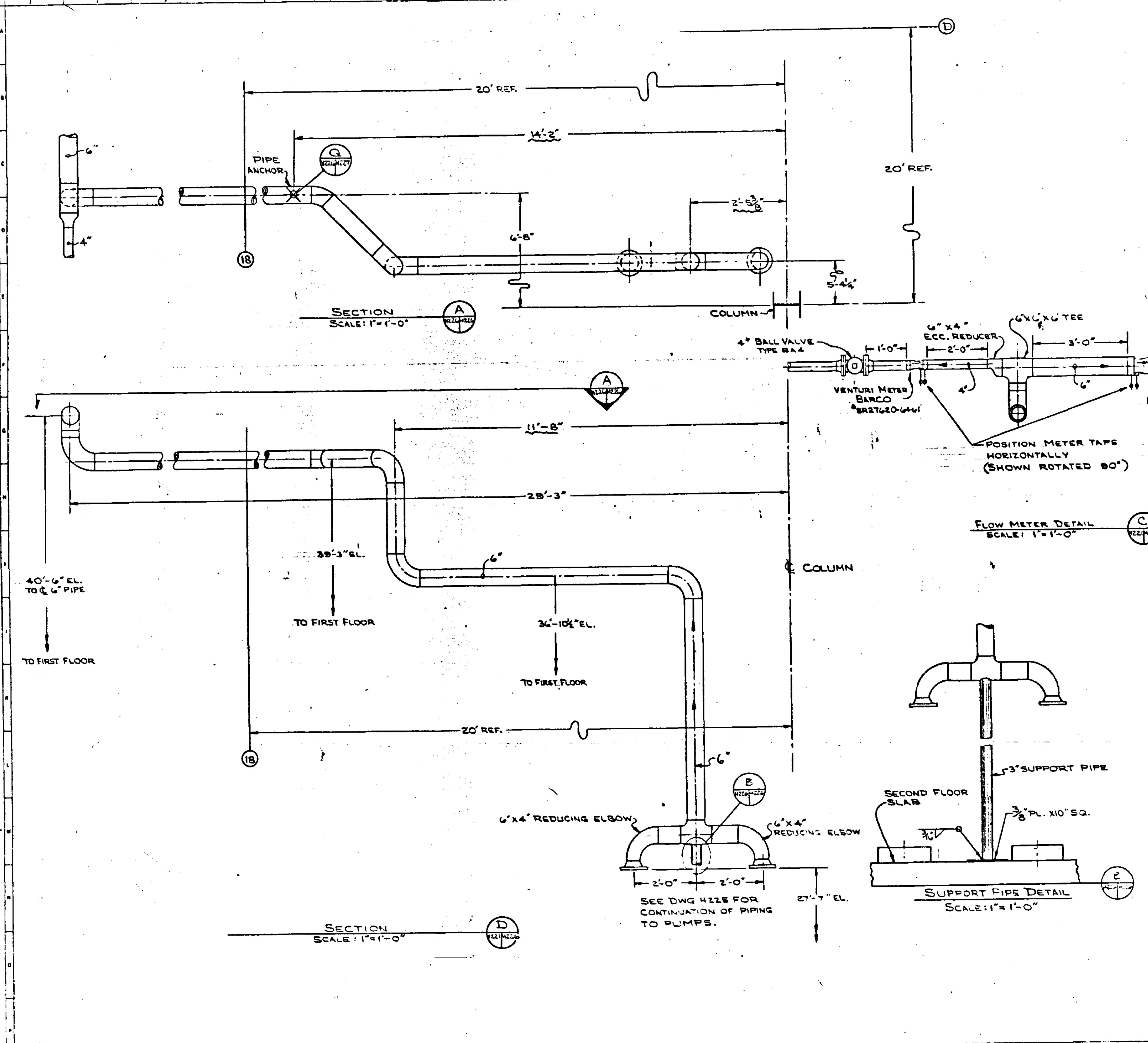
CATERPILLAR TRACTOR CO

SAN LEANDRO

B-B SOLAR HHW PUMPS

SOUTHWEST RESEARCH INSTITUTE

H-225



DATE	REASON FOR ISSUE
RECORD OF ISSUANCES	

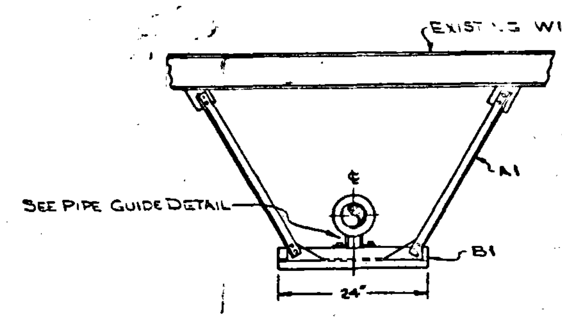
CATERPILLAR TRACTOR CO.

SAN LEANDRO — SAN LEANDRO, CALIF.

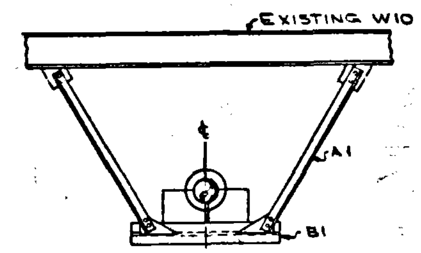
B-B PUMP OUTLET PIPING & FLOW METER DETAILS

SOUTHWEST RESEARCH INSTITUTE
SAN ANTONIO, TEXAS

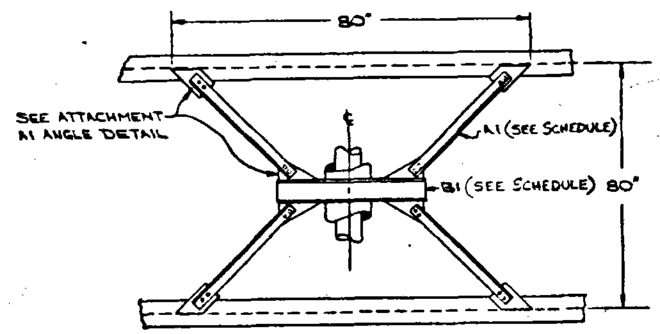
SCALE: 1"=1'-0" SHEET NO. H-226



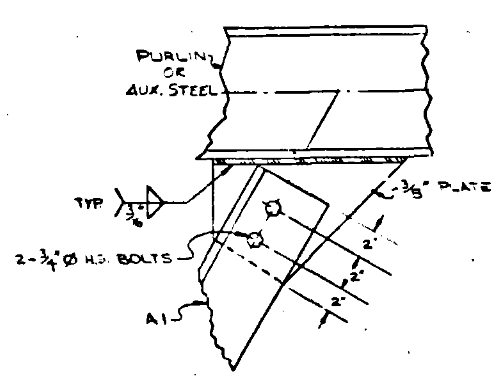
PIPE GUIDE SUPPORT DETAIL (P) H221 H227



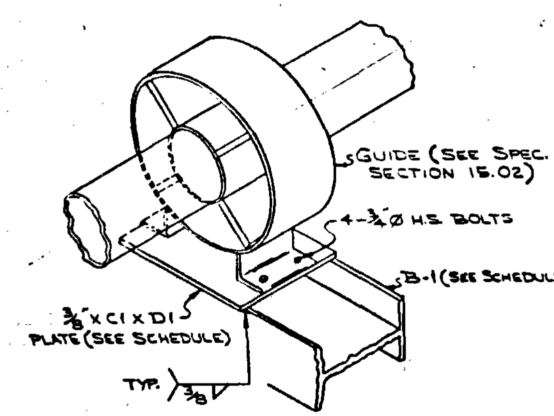
PIPE ANCHOR SUPPORT DETAIL (Q) H221 H227



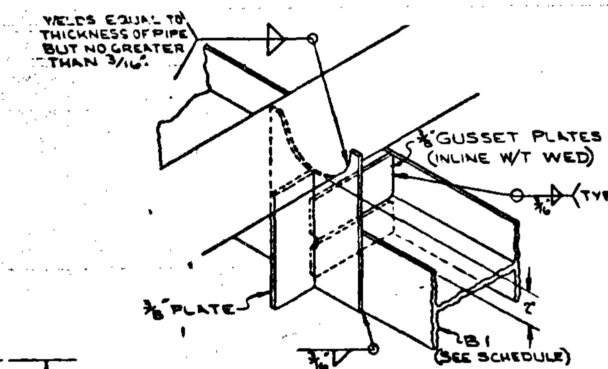
GUIDE ANCHOR/SUPPORT DETAIL (R) H227 H227



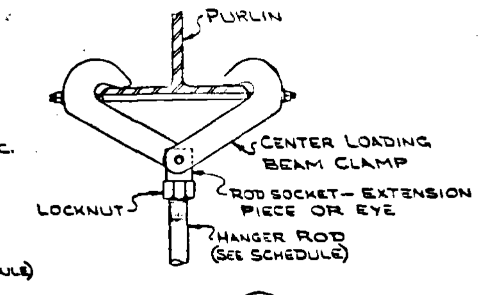
ATTACHMENT A1 ANGLE DETAIL (S) H227 H227



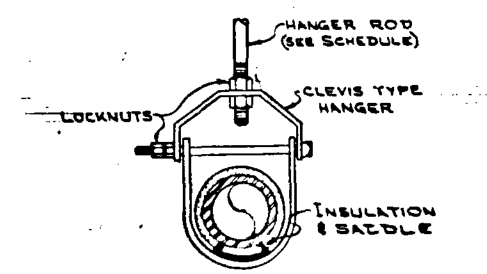
PIPE GUIDE DETAIL (T) H227 H227



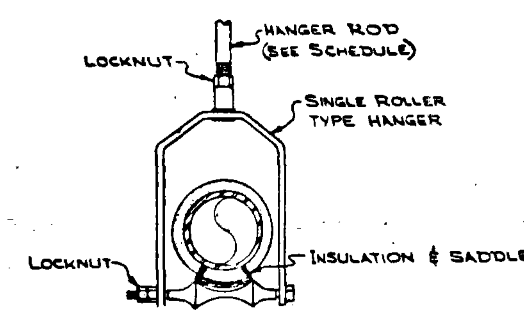
PIPE ANCHOR DETAIL (U) H227 H227



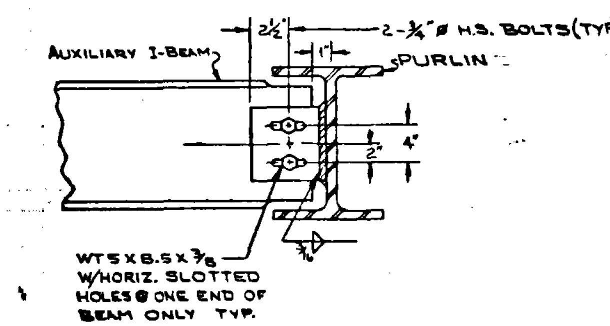
TYP. ATTACHMENT DETAIL (W) H227 H227



1"&2" HANGER DETAIL (X) H227 H227



3"–6" HANGER DETAIL (Y) H227 H227



CLIP DETAIL FOR PARALLEL PIPE RUN (V) H227 H227

GENERAL HANGER, ANCHOR, & GUIDE NOTES

1. FOR BUILDING FRAMING PLANS AND DETAILS SEE STRUCTURAL DRAWINGS.
2. UNLESS NOTED OTHERWISE THE FOLLOWING PROVISIONS SHALL GOVERN THE SPACING OF PIPE HANGER SUPPORTS:
   a. SEE SPECIFICATION 15.02 FOR SPACING AND SIZING OF HANGER SUPPORT SYSTEM FOR PIPES UP TO 6 INCHES.
   b. NO VERTICAL LOAD SHALL BE CARRIED BY THE PIPE ANCHOR OR GUIDE SYSTEMS.
   c. SUPPORTS SHALL NOT BE HUNG FROM THE TOP CHORD OF ANY CARRYING TRUSS.
   d. FOR ADDITIONAL SUPPORTS REQUIRED BY HEAVY FITTINGS, PIPE BENDS, ETC., SEE SPECIFICATION 15.02.
3. ALL STRUCTURAL STEEL FOR HANGING, GUIDING OR ANCHORING TO BE A.S.T.M. A-36.
4. FABRICATION AND ERECTION OF STRUCTURAL STEEL SHALL CONFORM WITH THE CURRENT A.I.S.C. SPECIFICATIONS.
5. ALL WELDING SHALL BE MINIMUM 3/16 INCH AND CONFORM WITH THE A.W.S. STRUCTURAL WELDING CODE D.1.1 USING E-70 ELECTRODES. NO FIELD WELDING IS ALLOWED UNLESS SHOWN ON CONTRACT DRAWINGS.
6. USE A.S.T.M. A-325 HIGH STRENGTH BOLTS FOR ANCHOR AND GUIDE CONNECTIONS.
7. PIPING SHALL BE HUNG AND ALIGNED BEFORE PLACING THE ANCHOR AND GUIDE FRAMING. HANGERS MUST BE LOCATED ON EACH SIDE OF GUIDE.

AUXILIARY STEEL SCHEDULE

PIPE SIZE	DIMENSIONS A1	DIMENSIONS B1
3"	3"x2"x¼" LLV	S4"x2⅝"
4"	3½"x2½"x⅜" LLV	S6"x3⅝"
6"	4"x3"x5/16" LLV	S3"x4"

HANGER ROD SCHEDULE

PIPE SIZE	ROD SIZE
2" AND UNDER	3/8"
3"	½"
4"	5/8"
6"	¾"

GUIDE PLATE SCHEDULE

PIPE SIZE	C1	D1
3"	4"	8"
4"	6"	10"
6"	8"	12"

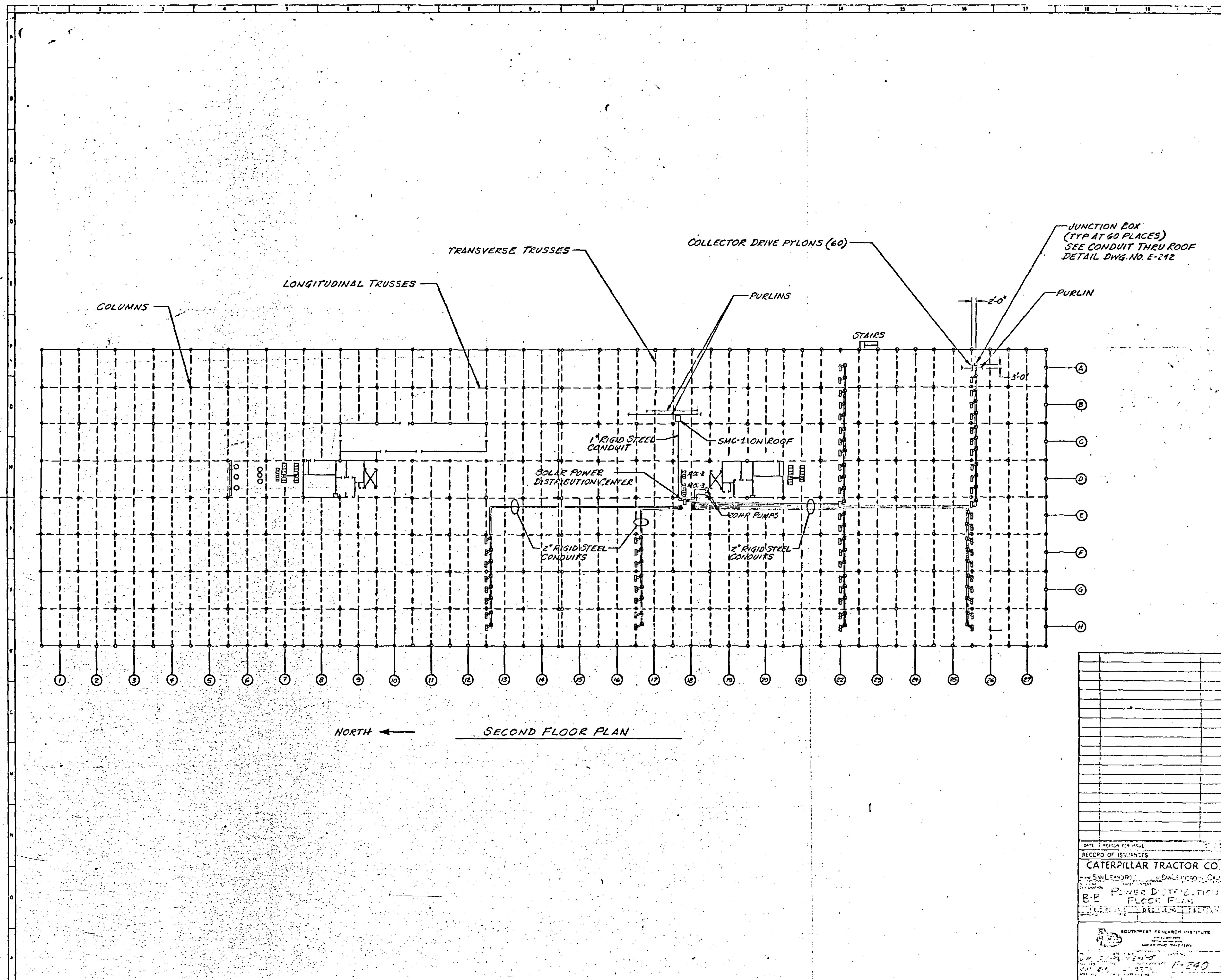
DATE | REASON FOR | NO.
RECORD OF REVISIONS

CATERPILLAR TRACTOR CO.
SAN LEANDRO SAN LEANDRO CA.

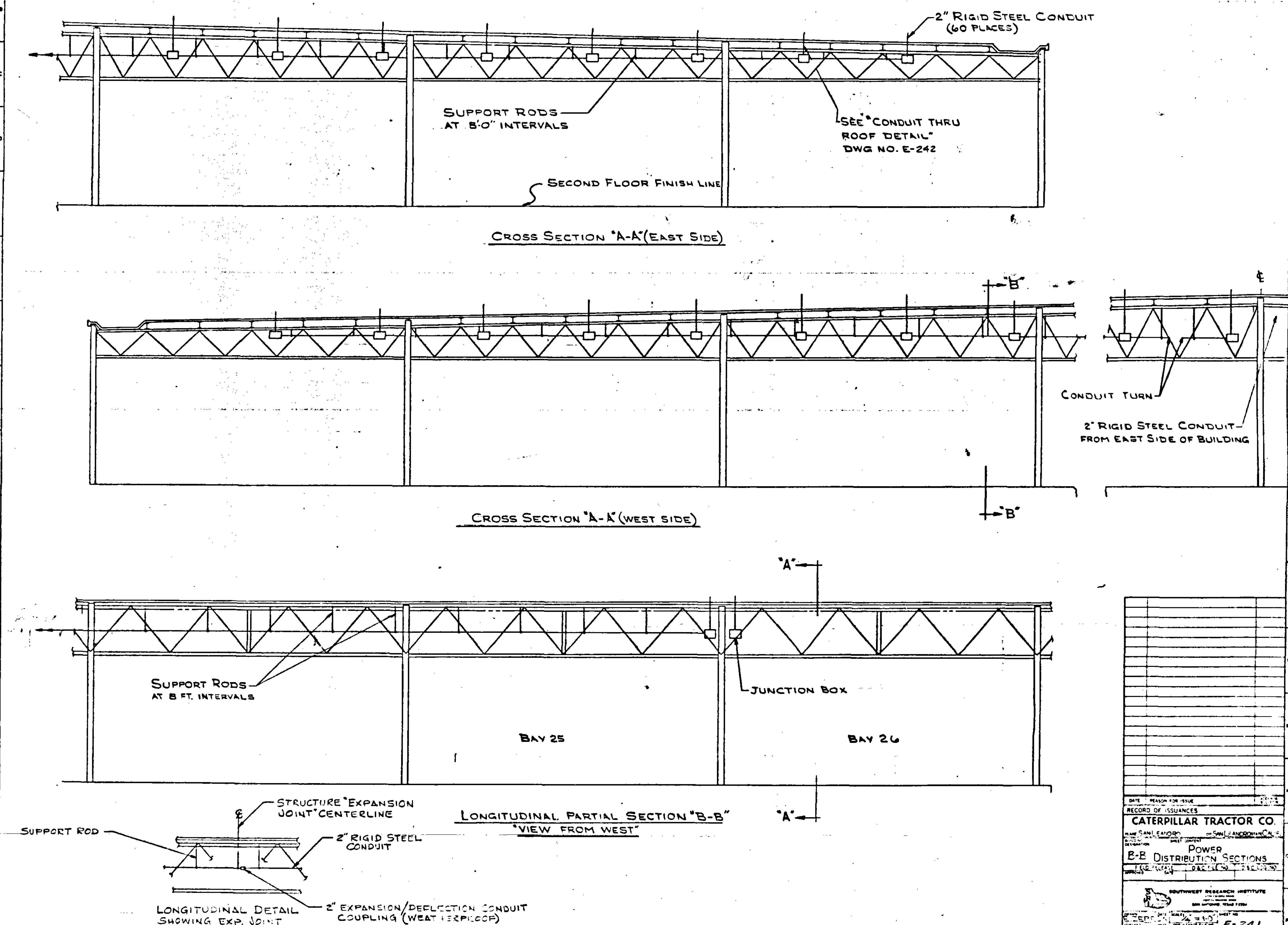
B-B PIPING SUPPORT DETAIL

SOUTHWEST RESEARCH INSTITUTE
SAN ANTONIO TEXAS

EZ 9/80 NOT TO SCALE
02-5821
H-227



COLUMNS
LONGITUDINAL TRUSSES
TRANSVERSE TRUSSES
COLLECTOR DRIVE PYLONS (60)
JUNCTION BOX (TYP AT 60 PLACES) SEE CONDUIT THRU ROOF DETAIL DWG. NO. E-242
PURLINS
PURLIN
2'-0"
3'-0"
STAIRS
1" RIGID STEEL CONDUIT
SMC-1 ON ROOF
SOLAR POWER DISTRIBUTION CENTER
20HP PUMPS
2" RIGID STEEL CONDUITS
2" RIGID STEEL CONDUITS
A
B
C
D
E
F
G
H
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27
NORTH
SECOND FLOOR PLAN
DATE
RECORD OF ISSUANCES
CATERPILLAR TRACTOR CO.
SAN LEANDRO
CALIF.
B-E
POWER DISTRIBUTION FLOOR PLAN
SOUTHWEST RESEARCH INSTITUTE
E-240



Date	Reason for Issue

Record of Issuances

CATERPILLAR TRACTOR CO.

Plant San Leandro City San Leandro State Calif.

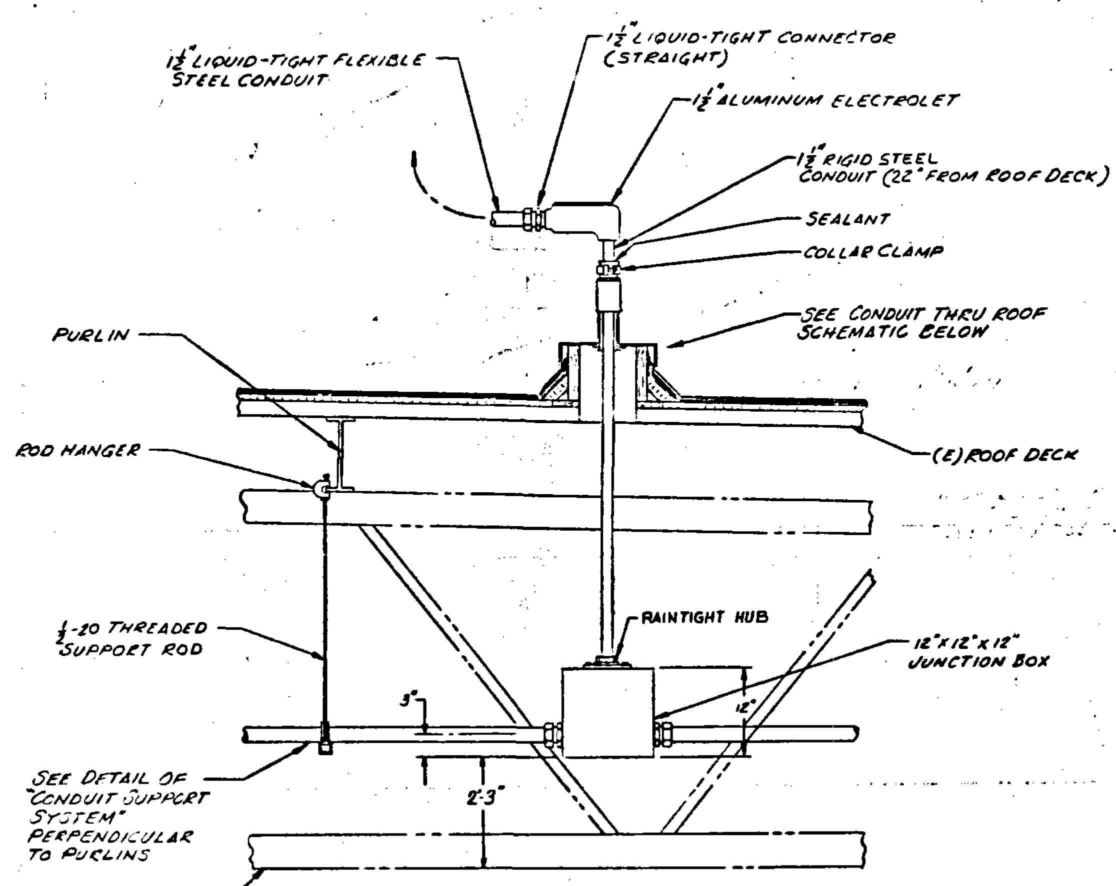
Building Designation B-B

Sheet Content: Power Distribution Sections

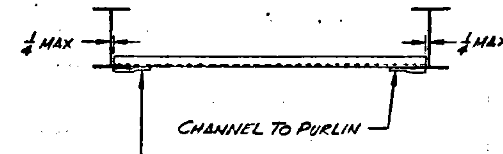
Southwest Research Institute, San Antonio, Texas

Scale 1/4" = 1'-0"

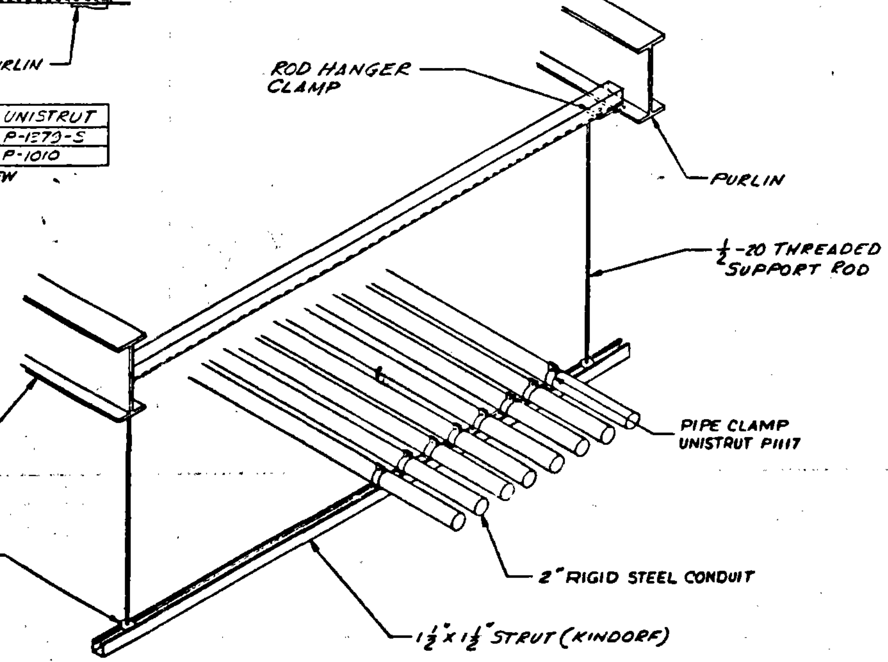
Sheet No. E-241



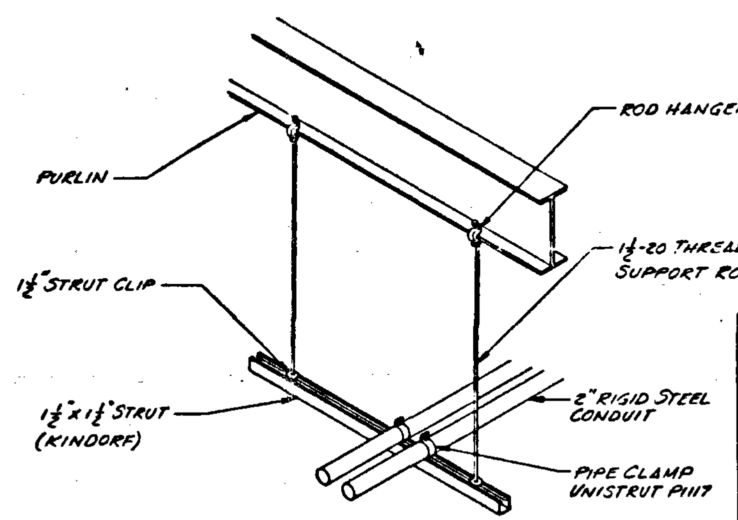
CONDUIT THRU ROOF
TYPICAL AT 60 PLACES
SCALE: 1½"=1'-0"



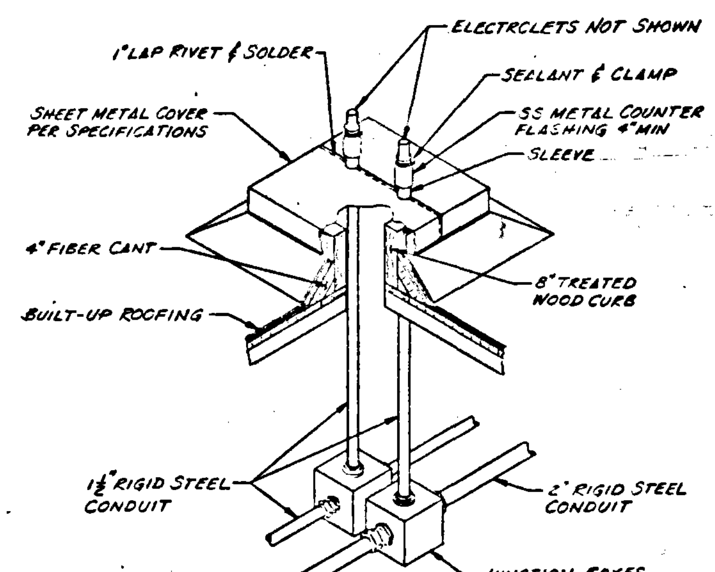
	B-LINE	UNISTRUT
CLAMP	B-211	P-1379-S
½" NUT	N-225	P-1010
½" HEX HD CAP SCREW		



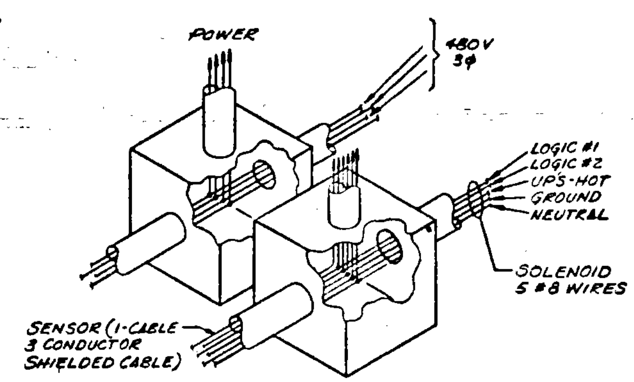
CONDUIT SUPPORT SYSTEM
(PARALLEL TO PURLINS)
SCALE: ½"=1'-0"



CONDUIT SUPPORT SYSTEM
(PERPENDICULAR TO PURLINS)
SCALE: ½"=1'-0"



CONDUIT THRU ROOF SCHEMATIC



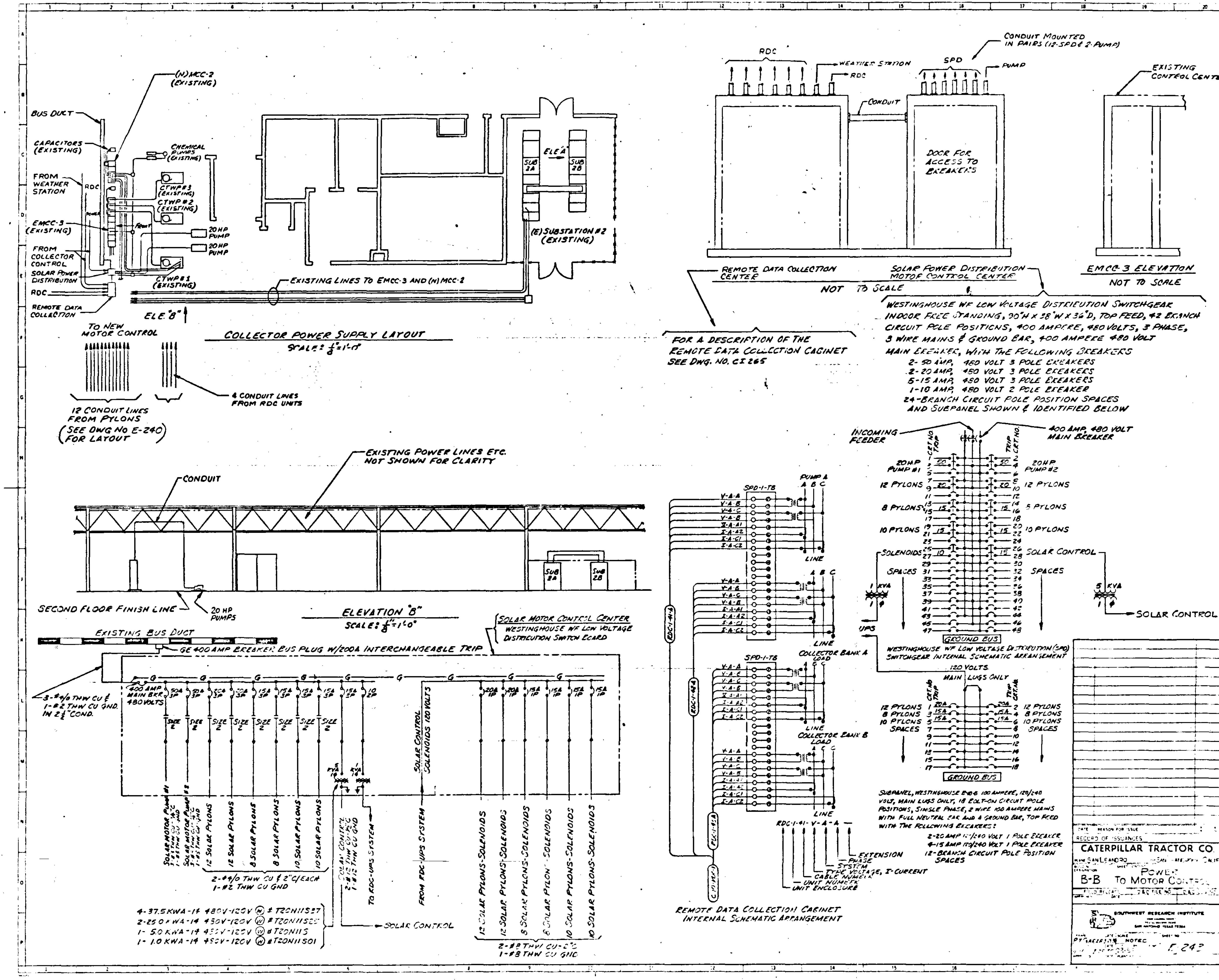
JUNCTION BOXES INTERNAL WIRING CONNECTION SCHEMATIC

CATERPILLAR TRACTOR CO
SAN LEANDRO — SAN LEANDRO CALIF.
B-B POWER DISTRIBUTION DETAILS

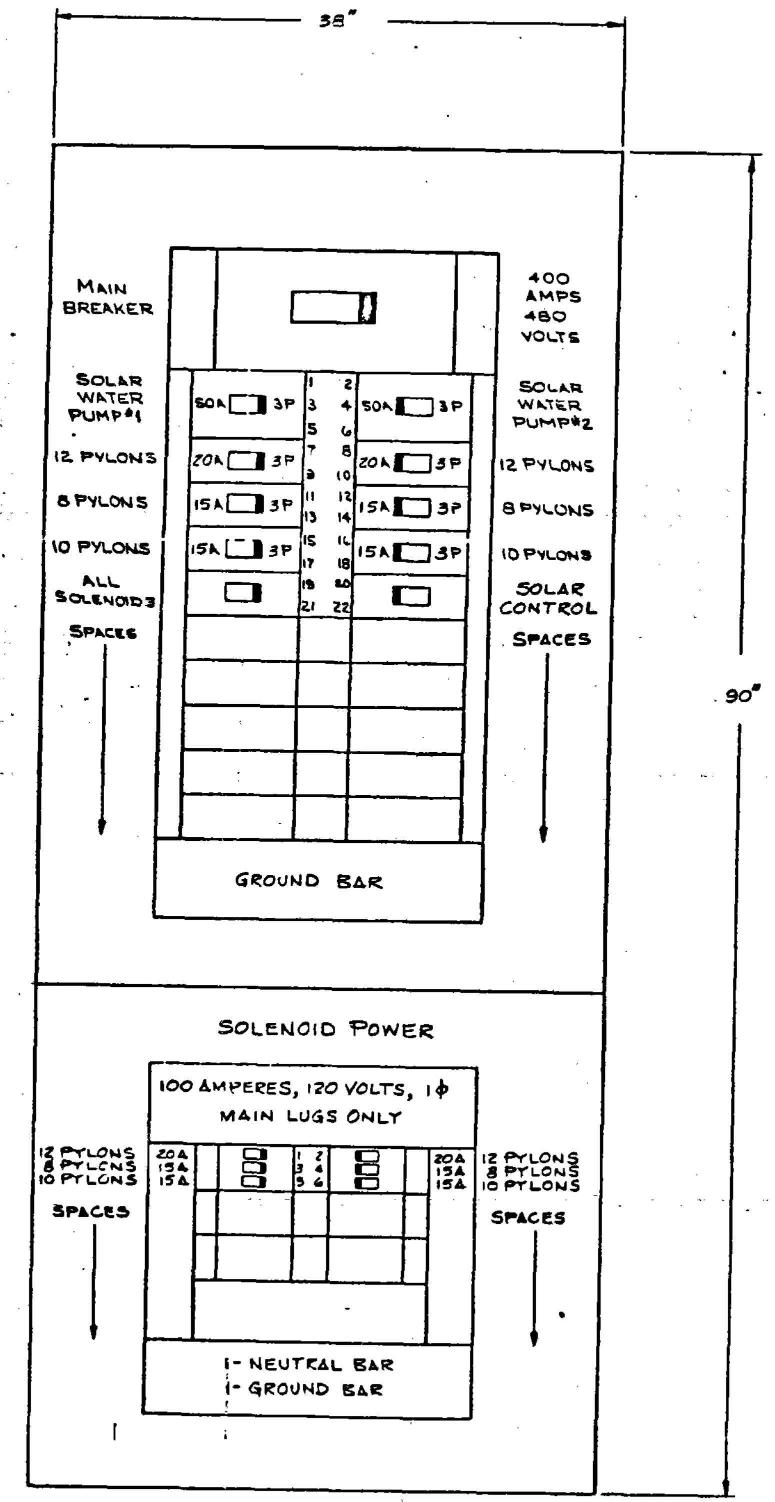
SOUTHWEST RESEARCH INSTITUTE

P GARZA — NOTED — 02-5321

E 242



COLLECTOR POWER SUPPLY LAYOUT
SCALE: 1/8"=1'-0"
(N) MCC-2 (EXISTING)
BUS DUCT
CAPACITORS (EXISTING)
CHEMICAL PUMPS (EXISTING)
FROM WEATHER STATION
RDC
CTWP #3 (EXISTING)
CTWP #2 (EXISTING)
EMCC-3 (EXISTING)
20 HP PUMP
20 HP PUMP
FROM COLLECTOR CONTROL
SOLAR POWER DISTRIBUTION
REMOTE DATA COLLECTION
CTWP #1 (EXISTING)
EXISTING LINES TO EMCC-3 AND (N) MCC-2
(E) SUBSTATION #2 (EXISTING)
ELE "A"
ELE "B"
SUB 2A
SUB 2B
TO NEW MOTOR CONTROL
12 CONDUIT LINES FROM PYLONS (SEE DWG NO E-240 FOR LAYOUT)
4 CONDUIT LINES FROM RDC UNITS
EXISTING POWER LINES ETC. NOT SHOWN FOR CLARITY
CONDUIT
SECOND FLOOR FINISH LINE
20 HP PUMPS
ELEVATION "B"
SCALE: 1/8"=1'-0"
EXISTING BUS DUCT
SOLAR MOTOR CONTROL CENTER
WESTINGHOUSE WF LOW VOLTAGE DISTRIBUTION SWITCH BOARD
GE 400 AMP BREAKER BUS PLUG W/200A INTERCHANGEABLE TRIP
3-#4/0 THW CU & 1-#2 THW CU GND. IN 2 1/2" COND.
400 AMP MAIN BKR 480 VOLTS
SOLAR MOTOR PUMP #1
SOLAR MOTOR PUMP #2
12 SOLAR PYLONS
8 SOLAR PYLONS
10 SOLAR PYLONS
SOLAR CONTROL
TO RDC-UPS SYSTEM
SOLAR CONTROL SOLENOIDS 120 VOLTS
FROM RDC-UPS SYSTEM
12 SOLAR PYLONS-SOLENOIDS
8 SOLAR PYLONS-SOLENOIDS
10 SOLAR PYLONS-SOLENOIDS
2-#4/0 THW CU & 2" C/EACH
1-#2 THW CU GND
2-#8 THW CU-2"C
1-#8 THW CU GND
4-37.5 KWA-1φ 480V-120V Ⓦ # T2ON11S37
2-25.0 KWA-1φ 480V-120V Ⓦ # T2ON11S25
1-5.0 KWA-1φ 480V-120V Ⓦ # T2ON11S
1-1.0 KWA-1φ 480V-120V Ⓦ # T2ON11S01
SOLAR CONTROL
RDC
WEATHER STATION
RDC
SPD
PUMP
CONDUIT MOUNTED IN PAIRS (12-SPD & 2-PUMP)
CONDUIT
DOOR FOR ACCESS TO BREAKERS
EXISTING CONTROL CENTER
REMOTE DATA COLLECTION CENTER
SOLAR POWER DISTRIBUTION MOTOR CONTROL CENTER
NOT TO SCALE
EMCC-3 ELEVATION
NOT TO SCALE
FOR A DESCRIPTION OF THE REMOTE DATA COLLECTION CABINET SEE DWG. NO. CI 265
WESTINGHOUSE WF LOW VOLTAGE DISTRIBUTION SWITCHGEAR INDOOR FREE STANDING, 90"H x 38"W x 36"D, TOP FEED, 42 BRANCH CIRCUIT POLE POSITIONS, 400 AMPERE, 480 VOLTS, 3 PHASE, 3 WIRE MAINS & GROUND BAR, 400 AMPERE 480 VOLT MAIN BREAKER, WITH THE FOLLOWING BREAKERS
2-50 AMP, 480 VOLT 3 POLE BREAKERS
2-20 AMP, 480 VOLT 3 POLE BREAKERS
5-15 AMP, 480 VOLT 3 POLE BREAKERS
1-10 AMP, 480 VOLT 2 POLE BREAKER
24-BRANCH CIRCUIT POLE POSITION SPACES AND SUBPANEL SHOWN & IDENTIFIED BELOW
INCOMING FEEDER
400 AMP, 480 VOLT MAIN BREAKER
20 HP PUMP #1
20 HP PUMP #2
12 PYLONS
8 PYLONS
10 PYLONS
SOLENOIDS
SOLAR CONTROL
SPACES
5 KVA
SOLAR CONTROL
UPS
GROUND BUS
WESTINGHOUSE WF LOW VOLTAGE DISTRIBUTION (SPD) SWITCHGEAR INTERNAL SCHEMATIC ARRANGEMENT
120 VOLTS
MAIN LUGS ONLY
GROUND BUS
SUBPANEL, WESTINGHOUSE EHB 100 AMPERE, 120/240 VOLT, MAIN LUGS ONLY, 18 BOLT-ON CIRCUIT POLE POSITIONS, SINGLE PHASE, 2 WIRE 100 AMPERE MAINS WITH FULL NEUTRAL BAR AND A GROUND BAR, TOP FEED WITH THE FOLLOWING BREAKERS:
2-20 AMP 120/240 VOLT 1 POLE BREAKER
4-15 AMP 120/240 VOLT 1 POLE BREAKER
12-BRANCH CIRCUIT POLE POSITION SPACES
SPD-1-TB
PUMP & A B C
LINE
COLLECTOR BANK A LOAD
COLLECTOR BANK B LOAD
RDC-1-41- V-A-A
EXTENSION
PHASE
SYSTEM
TYPE VOLTAGE, I-CURRENT
CABLE NUMBER
UNIT NUMBER
UNIT ENCLOSURE
REMOTE DATA COLLECTION CABINET INTERNAL SCHEMATIC ARRANGEMENT
DATE REASON FOR ISSUE
RECORD OF ISSUANCES
CATERPILLAR TRACTOR CO.
SAN LEANDRO
CALIF.
B-B
POWER TO MOTOR CONTROL
SOUTHWEST RESEARCH INSTITUTE
SAN ANTONIO TEXAS
MOTEC
E 243



CABINET FRONT VIEW

CATERPILLAR TRACTOR CO
SAN LEANDRO SAN LEANDRO · CALIF.

B-B POWER CABINET

SOUTHWEST RESEARCH INSTITUTE
SAN ANTONIO, TEXAS

EZ 4/80 1/16" = 1"
02-5821

E-244

CABINETS AND JUNCTION BOX NAMES

- SET-1-11 SENSOR ELEMENT TERMINATION
- RDC-1 REMOTE DATA COLLECTION CENTER
  - ISPS-SWRI-DATA COLLECTION AND PERFORMANCE EVALUATION SYSTEM (DCPES)
- SWS-1 SOLAR WEATHER STATION
  - ISPS-SWRI-WEATHER CENTER
- SCC-1-60 SOLAR COLLECTOR CONTROL CENTER
  - SOLAR KINETICS
- SPD-1 MOTOR AND POWER CABINETS
- PB-1-5 PULL BOX

CABLE NAMES

RDC-1-1-X-Y

- Y — WIRE CONNECTION: A1-ALARM SWITCH 1; A2-ALARM SWITCH 2; C-COMMON
- X — SIGNAL TYPE:
  - R - RESISTANCE 3 WIRE
  - DF - DIGITAL FREQUENCY
  - SG - 4 WIRE STRAIN GAGE
  - A - HIGH LEVEL ANALOG-AC
  - AM DC ANALOG MILLIVOLTS
  - NO NORMALLY OPEN CONTACT
  - P POTENTIOMETER
  - DC DIGITAL COUNT
- 1 — NUMBER OF CABLE
- 1 — UNIT
- RDC — CENTER

TERMINAL BLOCK NAMES

RDC-1-TB-17

- 17 — TERMINAL BLOCK NUMBER
- TB — TERMINAL BLOCK TYPE:
  - TB - SCREW TERMINATION REQUIRING CRIMP-ON LUGS
  - TS - INSERTION TYPE SCREW TERMINATION
  - TI - INSERTION CONNECTION AMP-229955-1
- 1 — UNIT
- RDC — CENTER NUMBER

CONDUIT NAMES

C-1-RDC-1-(PBX-CF-Y)

- (PBX-CF-Y) — OPTIONAL EXTENSION WHEN REQUIRED:
  - X - PULL BOX NUMBER
  - CF - CONDUIT TYPE
  - Y - EXTENSION CONDUIT
- 1 — CABINET NUMBER
- RDC — ORIGIONATING CABINET
- 1 — CONDUIT RUN NUMBER
- C — CONDUIT TYPE - C = RIGID STEEL CONDUIT; CF = SEALED BOX

TRANSDUCER NAMES

FE-100-DP

- DP — SIGNAL CONDITIONING REQUIRED *
- 100 — LOCATION NUMBER
- FE — BASIC TRANSDUCER TYPE

TRANSDUCER TYPES	SIGNAL CONDITIONING
FE - FLOW ELEMENT	* SEE-CABLE NAMES - SIGNAL TYPE
TE - TEMPERATURE ELEMENT	
PE - PRESSURE ELEMENT	
WV - WIND VELOCITY	
RF - RAIN FALL	
RH - RELATIVE HUMIDITY	
WD - WIND DIRECTION	
FS - FLOW SWITCH	
AVV - AIR VENT VALVE	
PRV - PRESSURE RELIEF VALVE	
ISV - ISOLATION VALVE	
TRV - TEMPERATURE REGULATED VALVE	
CSV - CIRCUIT SETTER VALVE W/FLOW INDICATOR	
DRV - DRAIN VALVE	
$\boxed{LS}$ - LIGHT SWITCH	
$\boxed{RS}$ - RAIN SWITCH	
- WIND SWITCH	
- TEMPERATURE SWITCH	
- FLOW SWITCH	
- PRESSURE SWITCH	
T - DIAL THERMOMETER	
P - PRESSURE GAGE	
F - VENTURI FLOWMETER WITH PRESSURE GAGE	
TT - TEMPERATURE TAP	

DATE | REASON FOR ISSUE

RECORD OF ISSUANCES

CATERPILLAR TRACTOR CO.

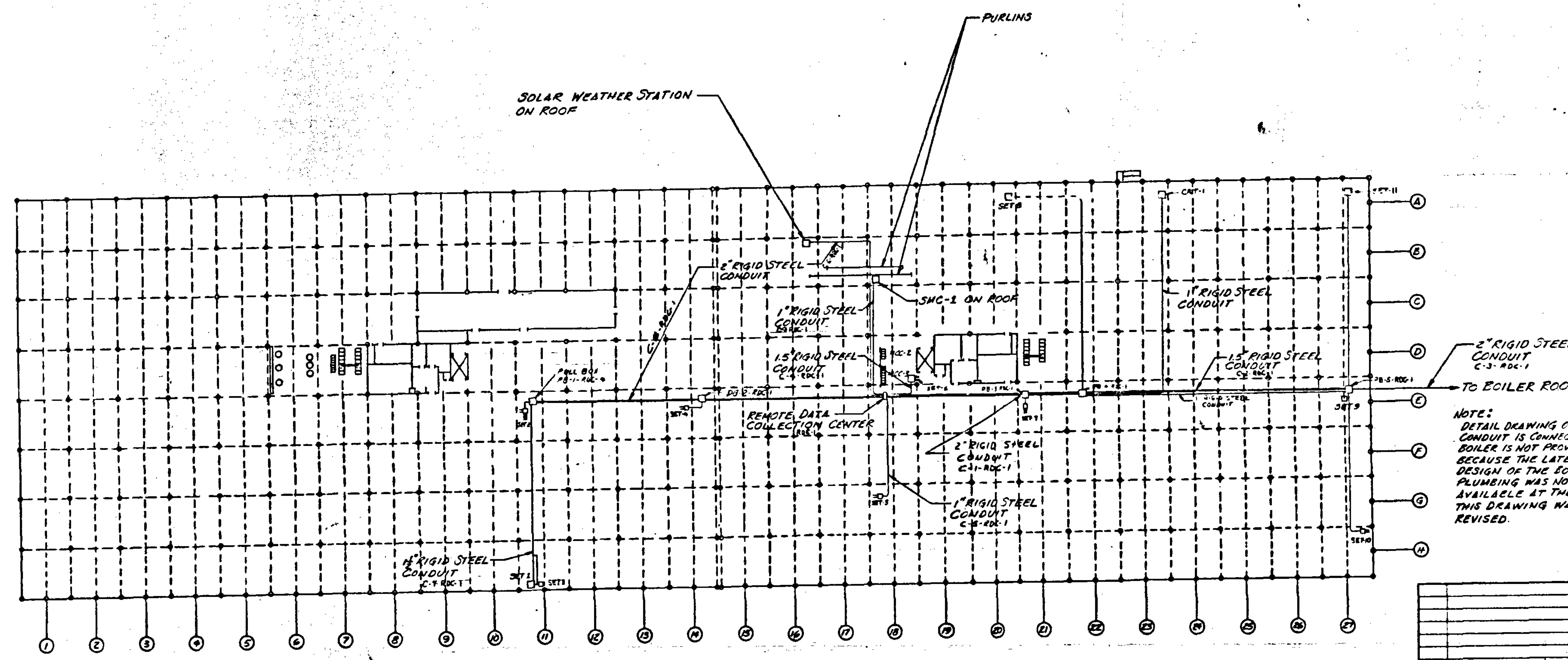
PLANT SAN LEANDRO CITY SAN LEANDRO STATE CALIF.

BUILDING DESIGNATION — SHEET CONTENT

B-B SYMBOLS & DEFINITIONS

SOUTHWEST RESEARCH INSTITUTE
SAN ANTONIO, TEXAS

DRAWN EZ — SHEET NO. CI-260



NORTH ←

SECOND FLOOR PLAN

NOTE:
DETAIL DRAWING OF HOW CONDUIT IS CONNECTED TO BOILER IS NOT PROVIDED BECAUSE THE LATEST DESIGN OF THE BOILER PLUMBING WAS NOT AVAILABLE AT THE TIME THIS DRAWING WAS BEING REVISED.

NOTE:
SEE DETAILS FOR PULL BOX AND SENSOR ELEMENT TERMINAL BOXES SET 4 ON DWG NO CI-265. SET LOCATIONS ARE SHOWN ON ISOMETRIC PIPING DWG NO. CI-262. SET WIRING IS SHOWN IN DETAILS ON DWG NO. CI-263.

DATE	REASON FOR ISSUE

RECORD OF ISSUANCES

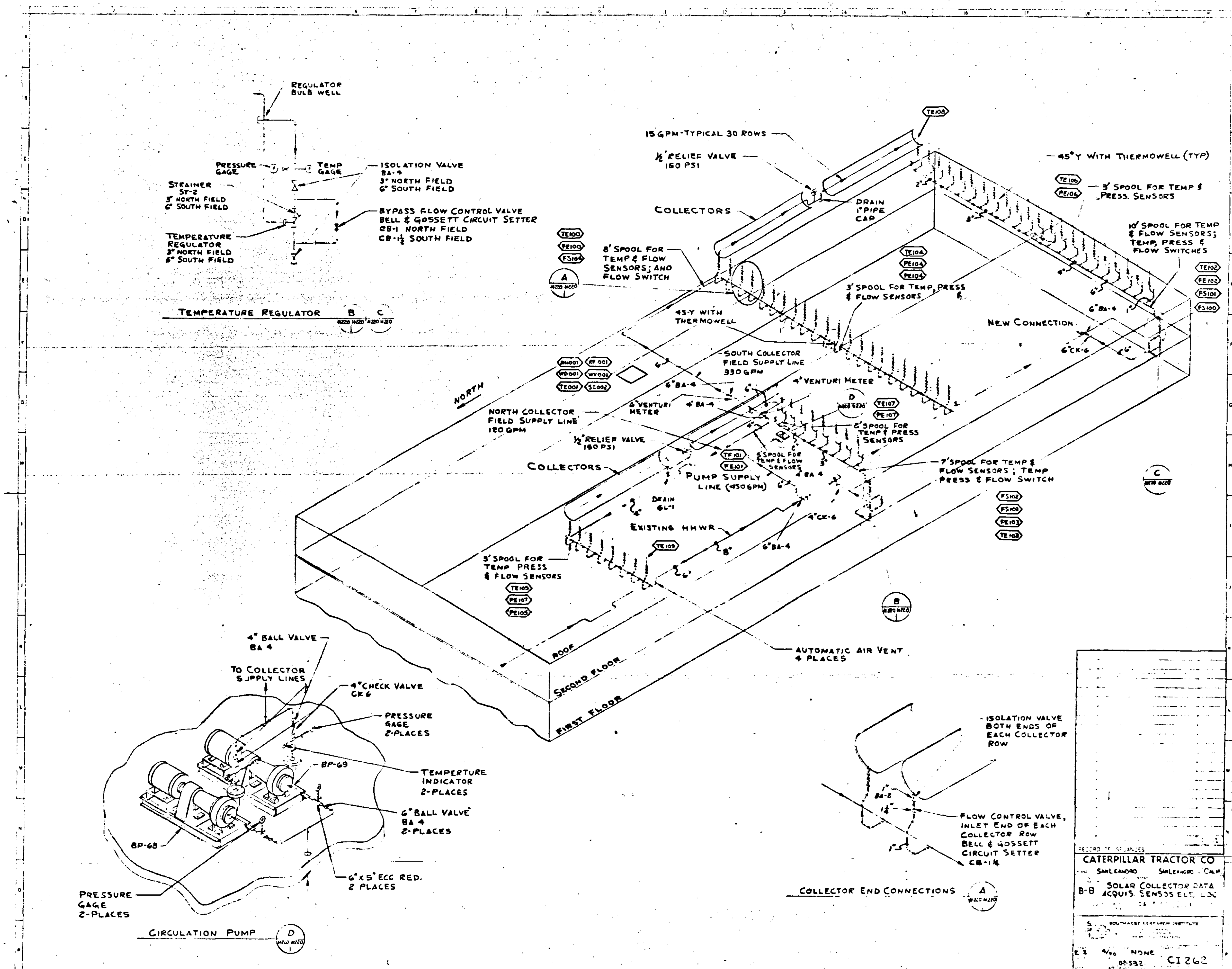
CATERPILLAR TRACTOR CO.

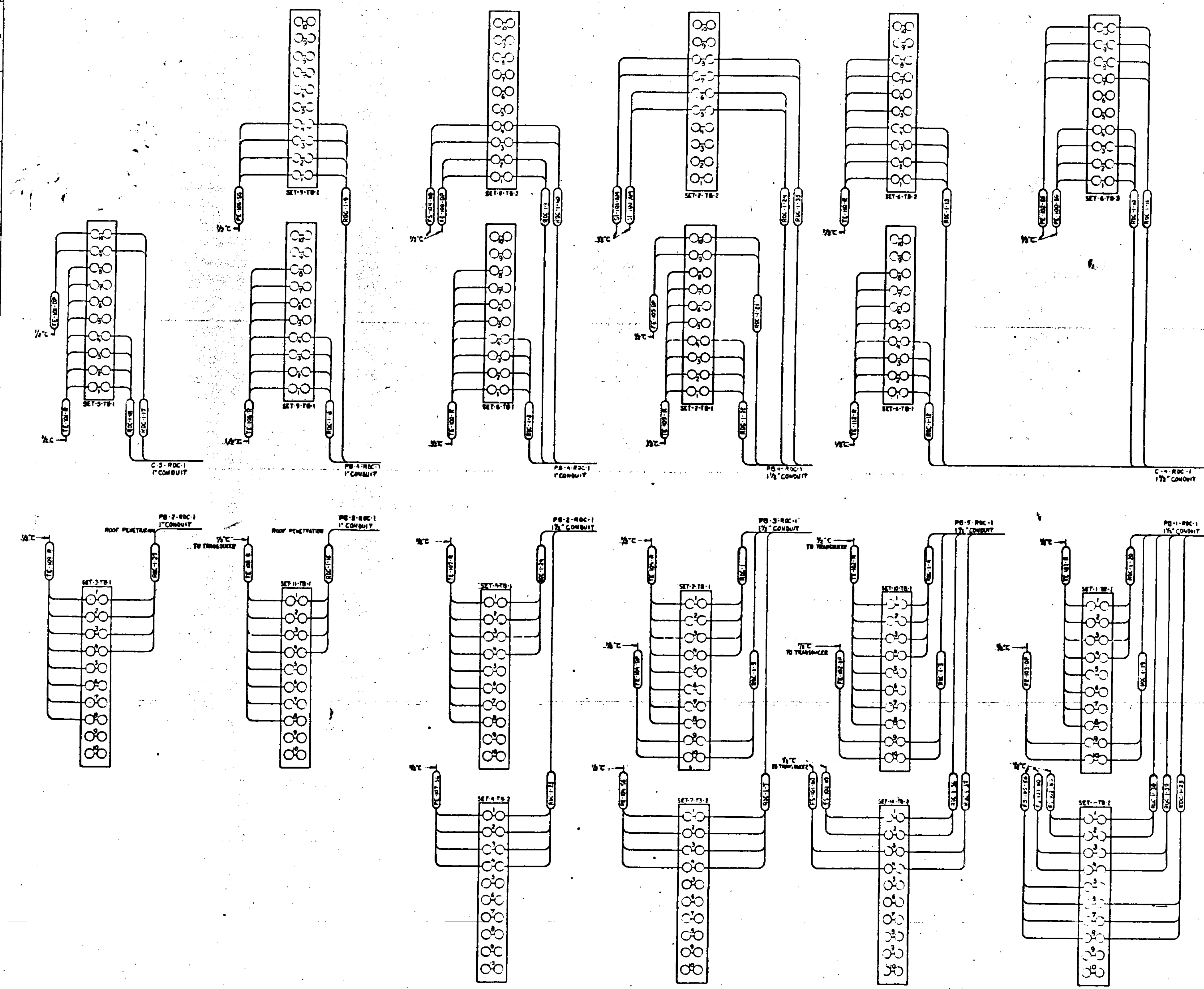
SAN LEANDRO — SAN LEANDRO, CALIF.

B-B SOLAR COLLECTOR CONTROL FLOOR PLAN

SOUTHWEST RESEARCH INSTITUTE
SAN ANTONIO, TEXAS

CI 261


REGULATOR BULB WELL
PRESSURE GAGE
TEMP GAGE
ISOLATION VALVE BA-4 3" NORTH FIELD 6" SOUTH FIELD
STRAINER ST-2 3" NORTH FIELD 6" SOUTH FIELD
BYPASS FLOW CONTROL VALVE BELL & GOSSETT CIRCUIT SETTER CB-1 NORTH FIELD CB-1½ SOUTH FIELD
TEMPERATURE REGULATOR 3" NORTH FIELD 6" SOUTH FIELD
TEMPERATURE REGULATOR
15 GPM-TYPICAL 30 ROWS
½" RELIEF VALVE 150 PSI
COLLECTORS
DRAIN 1" PIPE CAP
45°Y WITH THERMOWELL (TYP)
3' SPOOL FOR TEMP & PRESS. SENSORS
10' SPOOL FOR TEMP & FLOW SENSORS; TEMP, PRESS & FLOW SWITCHES
8' SPOOL FOR TEMP & FLOW SENSORS; AND FLOW SWITCH
3' SPOOL FOR TEMP, PRESS & FLOW SENSORS
45-Y WITH THERMOWELL
NEW CONNECTION
SOUTH COLLECTOR FIELD SUPPLY LINE 330 GPM
4" VENTURI METER
6" VENTURI METER
NORTH COLLECTOR FIELD SUPPLY LINE 120 GPM
NORTH
½" RELIEF VALVE 150 PSI
2' SPOOL FOR TEMP & PRESS SENSORS
5' SPOOL FOR TEMP & FLOW SENSORS
PUMP SUPPLY LINE (450 GPM)
7' SPOOL FOR TEMP & FLOW SENSORS; TEMP PRESS & FLOW SWITCH
DRAIN GL-1
EXISTING HHWR
5' SPOOL FOR TEMP PRESS & FLOW SENSORS
AUTOMATIC AIR VENT 4 PLACES
ROOF
SECOND FLOOR
FIRST FLOOR
4" BALL VALVE BA 4
TO COLLECTOR SUPPLY LINES
4" CHECK VALVE CK 6
PRESSURE GAGE 2-PLACES
BP-69
TEMPERTURE INDICATOR 2-PLACES
6" BALL VALVE BA 4 2-PLACES
BP-68
6"x5" ECC RED. 2 PLACES
PRESSURE GAGE 2-PLACES
CIRCULATION PUMP
ISOLATION VALVE BOTH ENDS OF EACH COLLECTOR ROW
FLOW CONTROL VALVE, INLET END OF EACH COLLECTOR ROW BELL & GOSSETT CIRCUIT SETTER CB-1¼
COLLECTOR END CONNECTIONS
CATERPILLAR TRACTOR CO
SAN LEANDRO
SAN LEANDRO, CALIF.
B-B SOLAR COLLECTOR DATA ACQUIS. SENSOR ELE. LOC.
SOUTHWEST RESEARCH INSTITUTE
4/80 NONE
02-532
CI262



DATE | REASON FOR ISSUE

RECORD OF ISSUANCES

CATERPILLAR TRACTOR CO.

PLANT SAN LEANDRO CITY SAN LEANDRO STATE CALIF.

E-E SENSOR ELEMENT CABLE TERMINATION DIAGRAM

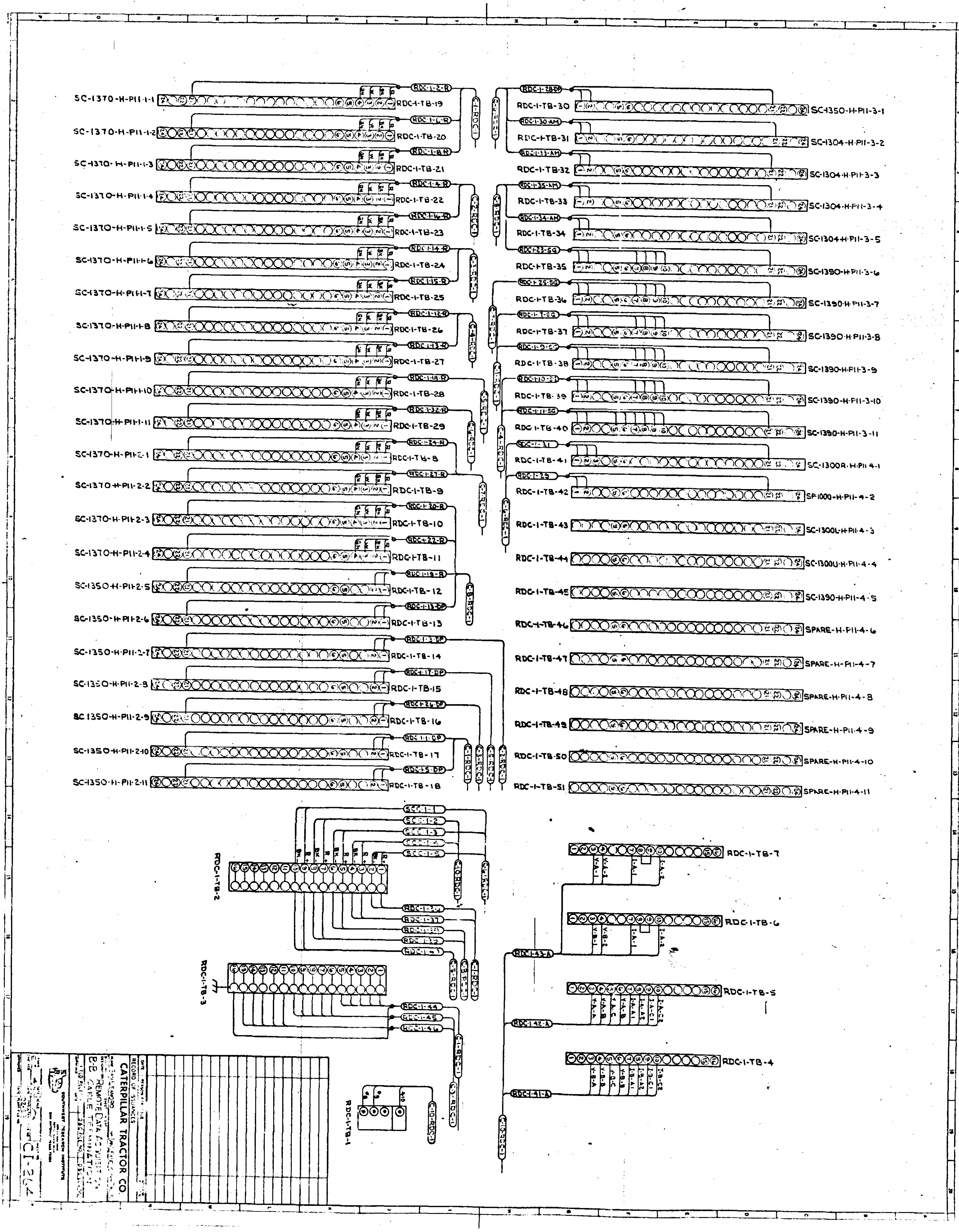
SOUTHWEST RESEARCH INSTITUTE

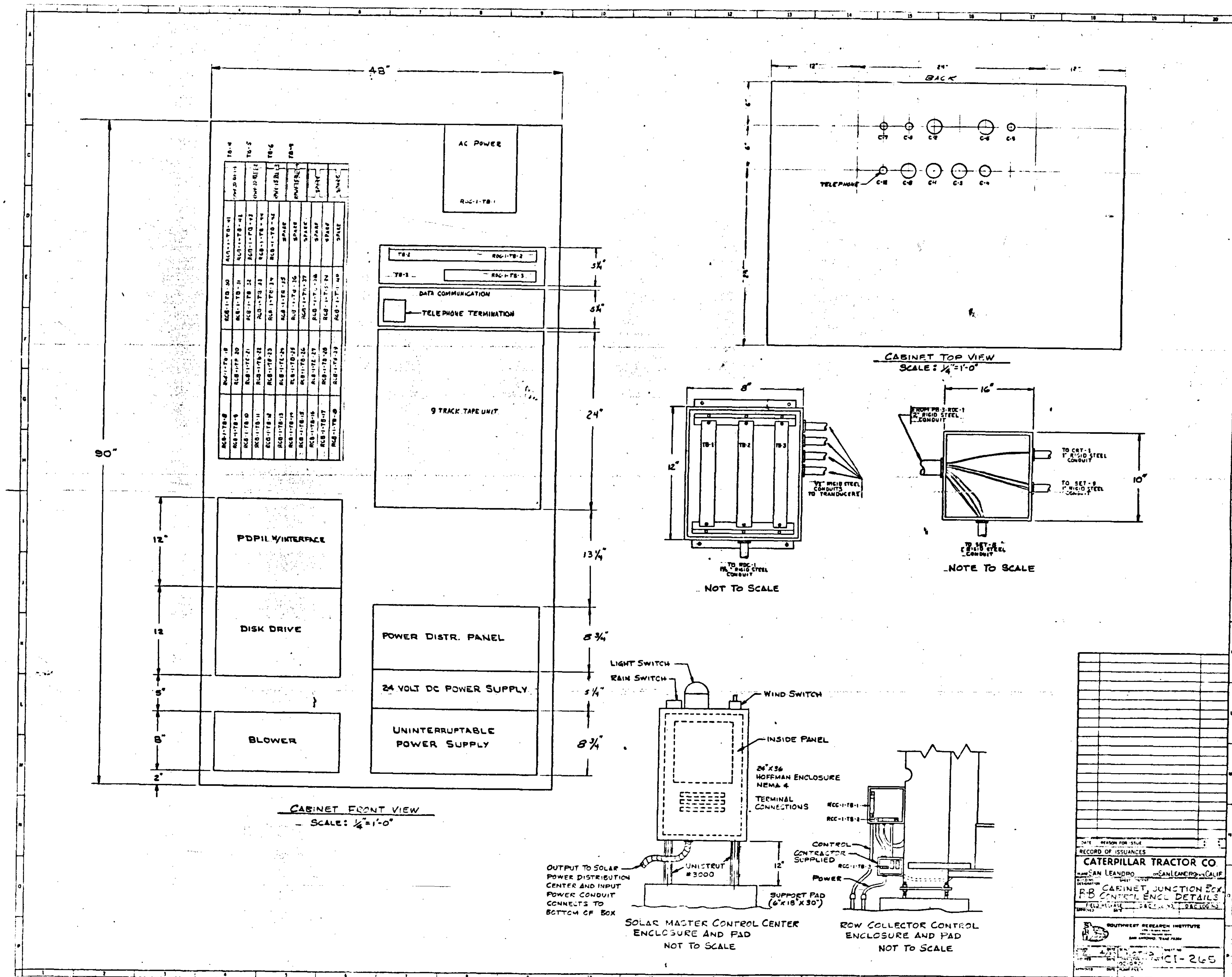
SAN ANTONIO, TEXAS

DRAWN | DATE | SCALE | SHEET NO.

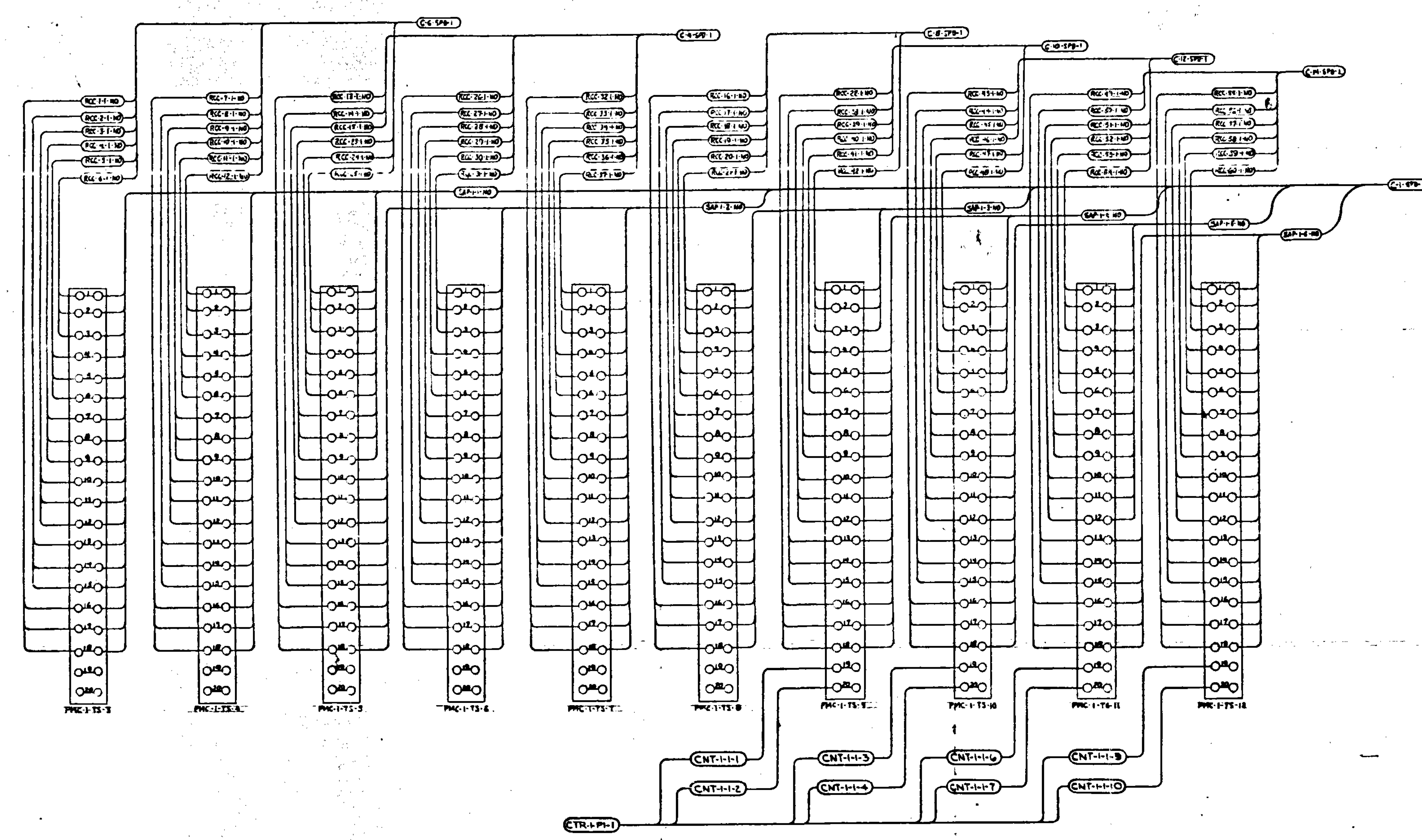
CHECKED | DATE | CI-263

APPROVED | DATE | PLANT FILE NO.


SC-1370-H-P11-1-1
RDC-1-TB-19
SC-1370-H-P11-1-2
RDC-1-TB-20
SC-1370-H-P11-1-3
RDC-1-TB-21
SC-1370-H-P11-1-4
RDC-1-TB-22
SC-1370-H-P11-1-5
RDC-1-TB-23
SC-1370-H-P11-1-6
RDC-1-TB-24
SC-1370-H-P11-1-7
RDC-1-TB-25
SC-1370-H-P11-1-8
RDC-1-TB-26
SC-1370-H-P11-1-9
RDC-1-TB-27
SC-1370-H-P11-1-10
RDC-1-TB-28
SC-1370-H-P11-1-11
RDC-1-TB-29
SC-1370-H-P11-2-1
RDC-1-TB-8
SC-1370-H-P11-2-2
RDC-1-TB-9
SC-1370-H-P11-2-3
RDC-1-TB-10
SC-1370-H-P11-2-4
RDC-1-TB-11
SC-1350-H-P11-2-5
RDC-1-TB-12
SC-1350-H-P11-2-6
RDC-1-TB-13
SC-1350-H-P11-2-7
RDC-1-TB-14
SC-1350-H-P11-2-8
RDC-1-TB-15
SC-1350-H-P11-2-9
RDC-1-TB-16
SC-1350-H-P11-2-10
RDC-1-TB-17
SC-1350-H-P11-2-11
RDC-1-TB-18
RDC-1-TB-30
SC-1350-H-P11-3-1
RDC-1-TB-31
SC-1304-H-P11-3-2
RDC-1-TB-32
SC-1304-H-P11-3-3
RDC-1-TB-33
SC-1304-H-P11-3-4
RDC-1-TB-34
SC-1304-H-P11-3-5
RDC-1-TB-35
SC-1390-H-P11-3-6
RDC-1-TB-36
SC-1390-H-P11-3-7
RDC-1-TB-37
SC-1390-H-P11-3-8
RDC-1-TB-38
SC-1390-H-P11-3-9
RDC-1-TB-39
SC-1390-H-P11-3-10
RDC-1-TB-40
SC-1390-H-P11-3-11
RDC-1-TB-41
SC-1300R-H-P11-4-1
RDC-1-TB-42
SP1000-H-P11-4-2
RDC-1-TB-43
SC-1300L-H-P11-4-3
RDC-1-TB-44
SC-1300U-H-P11-4-4
RDC-1-TB-45
SC-1390-H-P11-4-5
RDC-1-TB-46
SPARE-H-P11-4-6
RDC-1-TB-47
SPARE-H-P11-4-7
RDC-1-TB-48
SPARE-H-P11-4-8
RDC-1-TB-49
SPARE-H-P11-4-9
RDC-1-TB-50
SPARE-H-P11-4-10
RDC-1-TB-51
SPARE-H-P11-4-11
RDC-1-TB-2
RDC-1-TB-3
RDC-1-TB-1
RDC-1-TB-7
RDC-1-TB-6
RDC-1-TB-5
RDC-1-TB-4
RECORD OF ISSUANCES
CATERPILLAR TRACTOR CO.
SOUTHWEST RESEARCH INSTITUTE



48"
90"
AC POWER
TELEPHONE TERMINATION
DATA COMMUNICATION
9 TRACK TAPE UNIT
PDPIL W/INTERFACE
DISK DRIVE
BLOWER
POWER DISTR. PANEL
24 VOLT DC POWER SUPPLY
UNINTERRUPTABLE POWER SUPPLY
CABINET FRONT VIEW
SCALE: 1/4"=1'-0"
BACK
TELEPHONE
CABINET TOP VIEW
SCALE: 1/4"=1'-0"
NOT TO SCALE
NOTE TO SCALE
LIGHT SWITCH
RAIN SWITCH
WIND SWITCH
INSIDE PANEL
24"X36 HOFFMAN ENCLOSURE NEMA 4
TERMINAL CONNECTIONS
UNISTRUT #3000
OUTPUT TO SOLAR POWER DISTRIBUTION CENTER AND INPUT POWER CONDUIT CONNECTS TO BOTTOM OF BOX
SUPPORT PAD (6"X18"X30")
SOLAR MASTER CONTROL CENTER ENCLOSURE AND PAD
NOT TO SCALE
CONTROL
CONTRACTOR SUPPLIED
POWER
ROW COLLECTOR CONTROL ENCLOSURE AND PAD
NOT TO SCALE
RECORD OF ISSUANCES
CATERPILLAR TRACTOR CO.
SAN LEANDRO
CABINET, JUNCTION BOX, R-B CONTROL ENCL. DETAILS
SOUTHWEST RESEARCH INSTITUTE
CI-265



DATE	REASON FOR ISSUE	

RECORD OF ISSUANCES

CATERPILLAR TRACTOR CO.

PLANT SAN LEANDRO CITY SAN LEANDRO STATE CALIF.

BUILDING DESIGNATION B-B

SHEET CONTENT ALARM CABLE TERMINATION

FIELD RELEASE APPROVED DATE

SOUTHWEST RESEARCH INSTITUTE
SAN ANTONIO, TEXAS

DRAWN EZ DATE 6/63 SCALE NL

CHECKED DATE 02-5631

APPROVED DATE PLANT FILE NO.

SHEET NO. CI-266

CABLE	LENGTH	MANUFACTURE & AND MODEL *	RDC TERMINAL BLOCK	CONDUIT	TRANSDUCER / FUNCTION	MANUFACTURE & AND MODEL *	DESCRIPTION
RDC-1-1		BELDON 9154	RDC-1-TB-17	C-1-RDC-1	FE-100-DP	ITT SNYDER 7202	SOLAR COLLECTOR FIELD "A" INLET FLOW
RDC-1-2		8723	RDC-1-TB-19	C-1-RDC-1	TE-100-R	OMEGA PR12-2-100-¼-7-E	SOLAR COLLECTOR FIELD "A" INLET TEMPERATURE
RDC-1-3		9154	RDC-1-TB-14	C-2-RDC-1	FE-102-DP	ITT SNYDER 7202	SOLAR COLLECTOR FIELD "A" OUTLET FLOW
RDC-1-4		8723	RDC-1-TB-22	C-2-RDC-1	TE-102-R	OMEGA PR12-2-100-¼-7-E	SOLAR COLLECTOR FIELD "A" OUTLET TEMPERATURE
RDC-1-5		9154	RDC-1-TB-18	C-1-RDC-1	FE-104-DP	ITT SNYDER 7202	SINGLE COLLECTOR ROW FIELD "A" FLOW
RDC-1-6		8723	RDC-1-TB-20	C-1-RDC-1	TE-104-R	OMEGA PR12-2-100-¼-7-E	SINGLE COLLECTOR ROW FIELD "A" INLET TEMPERATURE
RDC-1-7		8723	RDC-1-TB-37	C-1-RDC-1	PE-104-SG	SENSOTEC A-5-SPL-CNT	SINGLE COLLECTOR ROW FIELD "A" INLET PRESSURE
RDC-1-8		8723	RDC-1-TB-21	C-1-RDC-1	TE-106-R	OMEGA PR12-2-100-¼-7-E	SINGLE COLLECTOR ROW FIELD "A" OUTLET TEMPERATURE
RDC-1-9		8723	RDC-1-TB-38	C-1-RDC-1	PE-106-SG	SENSOTEC A-5-SPL-CNT	SINGLE COLLECTOR ROW FIELD "A" OUTLET PRESSURE
RDC-1-10		8723	RDC-1-TB-39	C-4-RDC-1	PE-100-SG	SENSOTEC A-5-SPL-CNT	SOLAR FIELD SUPPLY PUMP INLET PRESSURE
RDC-1-11		8723	RDC-1-TB-40	C-4-RDC-1	PE-102-SG	SENSOTEC A-5-SPL-CNT	SOLAR FIELD SUPPLY PUMP OUTLET PRESSURE
RDC-1-12		8723	RDC-1-TB-26	C-4-RDC-1	TE-112-R	OMEGA PR12-2-100-¼-7-E	SOLAR FIELD SUPPLY PUMP INLET TEMPERATURE
RDC-1-13		8723	RDC-1-TB-27	C-4-RDC-1	TE-110-R	OMEGA PR12-2-100-¼-7-E	SOLAR FIELD SUPPLY PUMP OUTLET TEMPERATURE
RDC-1-14		8723	RDC-1-TB-24	C-3-RDC-1	TE-200-R	OMEGA PR12-2-100-¼-7-E	BOILER OUTLET TEMPERATURE
RDC-1-15		8723	RDC-1-TB-25	C-3-RDC-1	TE-202-R	OMEGA PR12-2-100-¼-7-E	BOILER INLET TEMPERATURE
RDC-1-16		8723	RDC-1-TB-23	C-2-RDC-1	TE-108-R	OMEGA PR12-2-100-¼-7-E	COLLECTOR FIELD "A" COLLECTOR TUBE TEMPERATURE
RDC-1-17		9154	RDC-1-TB-15	C-5-RDC-1	FE-101-DP	ITT SNYDER 7202	SOLAR COLLECTOR FIELD "B" INLET FLOW
RDC-1-18		8723	RDC-1-TB-28	C-5-RDC-1	TE-101-R	OMEGA PR12-2-100-¼-7-E	SOLAR COLLECTOR FIELD "B" INLET TEMPERATURE
RDC-1-19		9154	RDC-1-TB-12	C-8-RDC-1	FE-103-DP	ITT SNYDER 7202	SOLAR COLLECTOR FIELD "B" OUTLET FLOW
RDC-1-20		8723	RDC-1-TB-10	C-8-RDC-1	TE-103-R	OMEGA PR12-2-100-¼-7-E	SOLAR COLLECTOR FIELD "B" OUTLET TEMPERATURE
RDC-1-13		9154	RDC-1-TB-13	C-8-RDC-1	FE-105-DP	ITT SNYDER 7201	SINGLE COLLECTOR ROW FIELD "B" INLET FLOW
RDC-1-22		8723	RDC-1-TB-11	C-8-RDC-1	TE-105-R	OMEGA PR12-2-100-¼-7-E	SINGLE COLLECTOR ROW FIELD "B" INLET TEMPERATURE
RDC-1-23		8723	RDC-1-TB-35	C-8-RDC-1	PE-105-SG	SENSOTEC-A-5-SPL-CNT	SINGLE COLLECTOR ROW FIELD "B" INLET PRESSURE
RDC-1-24		8723	RDC-1-TB-8	C-7-RDC-1	TE-107-R	OMEGA PR12-2-100-¼-7-E	SINGLE COLLECTOR ROW FIELD "B" OUTLET TEMPERATURE
RDC-1-25		8723	RDC-1-TB-36	C-7-RDC-1	PE-107-SG	SENSOTEC A-5-SPL-CNT	SINGLE COLLECTOR ROW FIELD "B" OUTLET PRESSURE
RDC-1-26		9154	RDC-1-TB-16	C-3-RDC-1	FE-200-DP	ITT SNYDER 7202	BOILER FLOW
RDC-1-27		8723	RDC-1-TB-9	C-7-RDC-1	TE-109-R	OMEGA PR12-2-100-¼-7-E	COLLECTOR FIELD "B" COLLECTOR TUBE TEMPERATURE
RDC-1-28		9154	RDC-1-TB-30	C-6-RDC-1	WV-001-DP	WEATHERTRONICS 2030	WIND VELOCITY OPEN ROOF
RDC-1-29		9154	RDC-1-TB-42	C-6-RDC-1	RF-001-DC	WEATHERTRONICS 6010	RAIN FALL
RDC-1-30		9154	RDC-1-TB-31	C-6-RDC-1	RH-001-AM	WEATHERTRONICS 5120	RELATIVE HUMIDITY
RDC-1-31		8723	RDC-1-TB-41	C-6-RDC-1	WD-001-P	WEATHERTRONICS 2020	WIND DIRECTION ON OPEN ROOT
RDC-1-32		8723	RDC-1-TB-29	C-6-RDC-1	TE-001-R	OMEGA PR12-2-100-¼-7-E	AMBIENT AIR TEMPERATURE
RDC-1-33		9154	RDC-1-TB-32	C-6-RDC-1	SI-102-AM	EPPLEY PSP	SOLAR INSOLATION TOTAL HORIZONTAL
RDC-1-34		9154	RDC-1-TB-34	C-8-RDC-1	SI-100-AM	EPPLEY PSP	SOLAR INSOLATION TOTAL TRACKED
RDC-1-35		9154	RDC-1-TB-33	C-8-RDC-1	SI-101-AM	EPPLEY PSP	SOLAR INSOLATION TOTAL TRACKED WITH SHADOW BAND
RDC-1-36		9154	RDC-1-TB-2	C-1-RDC-1	FS-100-NO	BALL MFG. D-3500S-S: 2" NPT	FLOW SWITCH FIELD "A" OUTPUT
RDC-1-37		9154	RDC-1-TB-2	C-8-RDC-1	FS-101-NO	BALL MFG. D-3500S-S: 2" NPT	FLOW SWITCH FIELD "A" OUTPUT
RDC-1-38		9154	RDC-1-TB-2	C-10-RDC-1	FS-102-NO	BALL MFG. D-3500S-S: 2" NPT	FLOW SWITCH FIELD "B" OUTPUT
RDC-1-39		9154	RDC-1-TB-2	C-6-RDC-1	FS-102-NO	BALL MFG. D-3500S-S: 2" NPT	FLOW SWITCH FIELD "B" OUTPUT
RDC-1-40		9154	RDC-1-TB-2	C-5-RDC-1	FS-104-NO	BALL MFG. D-3500S-S: 2" NPT	FLOW SWITCH FIELD "A" - "B" INLET
RDC-1-41		}	RDC-1-TB-4	C-10-RDC-1	EP-600-A		ELECTRICAL POWER PUMP MOTOR PRIMARY
RDC-1-42			RDC-1-TB-5	C-10-RDC-1	EP-601-A		ELECTRICAL POWER PUMP MOTOR BACKUP
RDC-1-43			RDC-1-TB-6, TB7	C-10-RDC-1	EP-602-A		ELECTRICAL POWER SOLAR COLLECTOR FIELD "A", FIELD "B"
RDC-1-44			RDC-1-TB-3	C-1-RDC-1	ENG. MAINT. CRT	DEC VT 105	ENGR. & MAINTENANCE DISPLAY CRT
RDC-1-45			RDC-1-TB-3	C-3-RDC-1	ENG. MAINT. PRINTER	DEC LA-120	ENGR. & MAINTENANCE PRINTER FOR PERFORMANCE EVALUATION
RDC-1-46			RDC-1-TB-3	C-3-RDC-1	SOLAR DEMOS. CRT	DEC VT 105	DISPLAY FOR SOLAR DEMOSTRATION & SOLAR FIELD OPERATION
RDC-1-47		TEL CO	RDC-1-TB-53	C-12-RDC-1	TELEPHONE LINE	TELCO RJ455	COMMUNCATION LINK FOR REMOTE MODEN OPERATION
			RDC-1-TB-1	C-10-RDC-1			

DATE | REASON FOR ISSUE

RECORD OF ISSUANCES

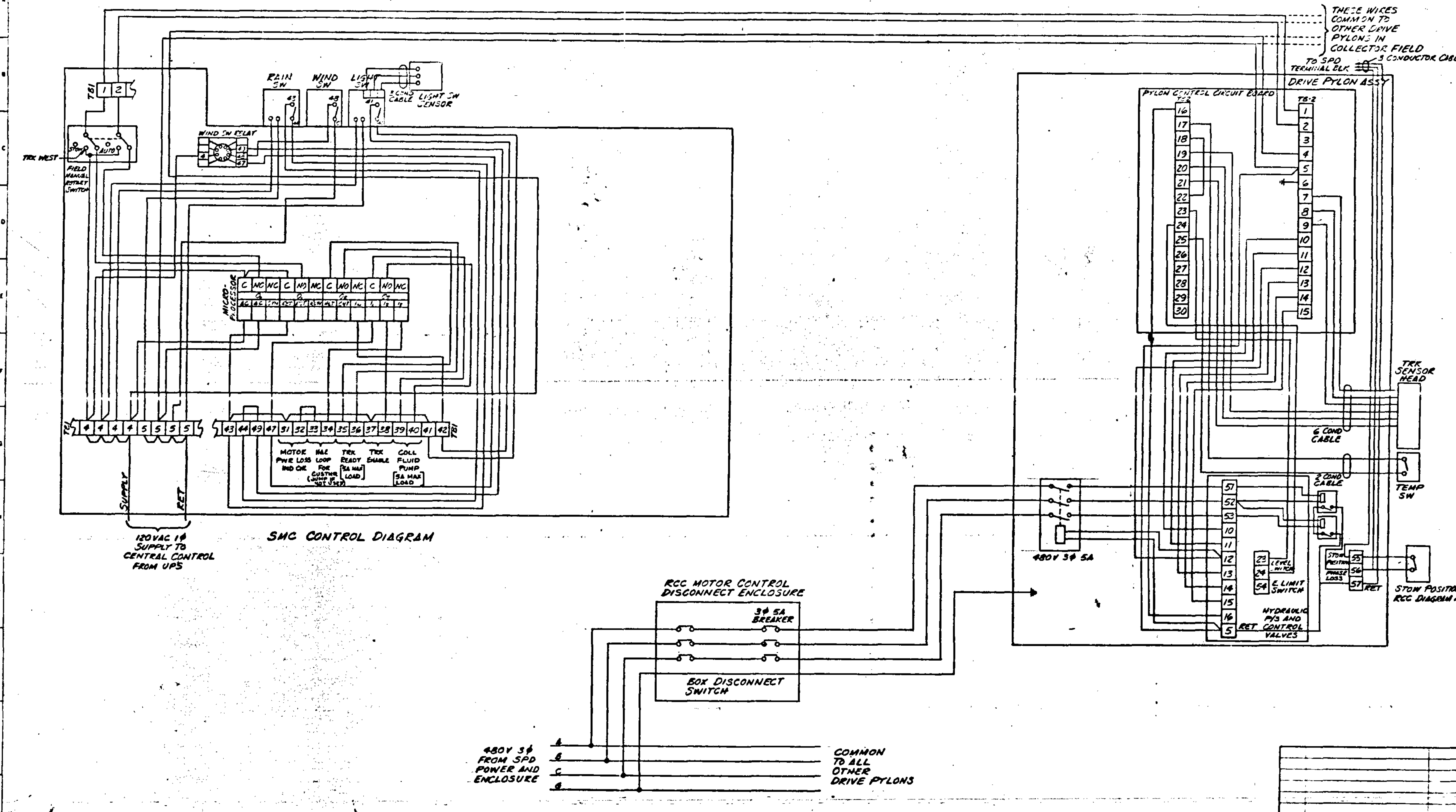
CATERPILLAR TRACTOR CO.

SAN LEANDRO — SAN LEANDRO CALIF.

CABLE & SENSOR ELEMENT
B-B SPECIFICATIONS LIST

SOUTHWEST RESEARCH INSTITUTE

CI-2?7



RECORD OF ISSUANCES

CATERPILLAR TRACTOR CO.

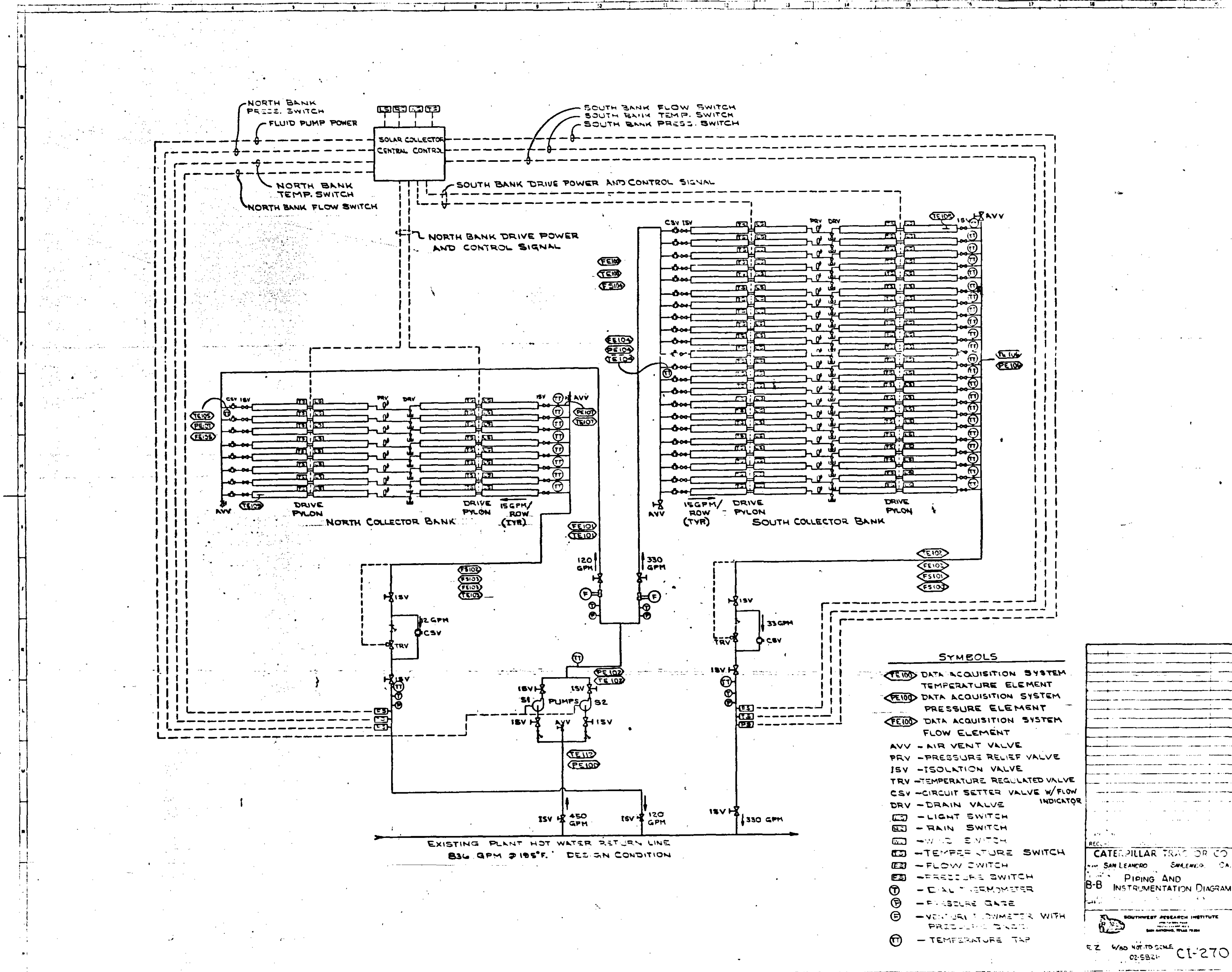
SAN LEANDRO   SAN LEANDRO CALIF.

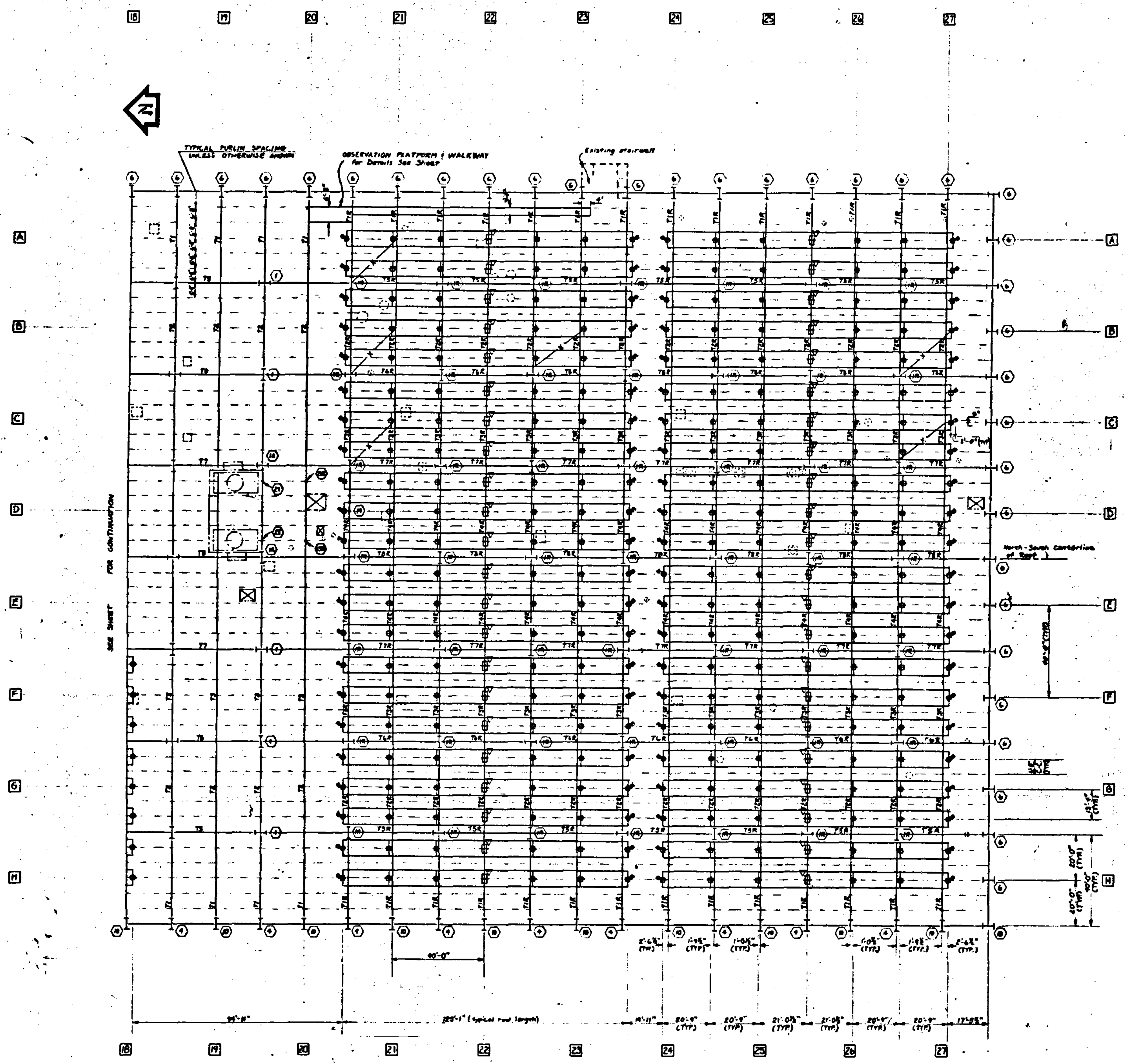
B-B   SOLAR CENTRAL CONTROL TO ROW CONTROL

SOUTHWEST RESEARCH INSTITUTE

J.M.   6/80   NOT TO SCALE

02-5921   CI-263


NORTH BANK PRESS. SWITCH
FLUID PUMP POWER
SOLAR COLLECTOR CENTRAL CONTROL
SOUTH BANK FLOW SWITCH
SOUTH BANK TEMP. SWITCH
SOUTH BANK PRESS. SWITCH
NORTH BANK TEMP. SWITCH
NORTH BANK FLOW SWITCH
SOUTH BANK DRIVE POWER AND CONTROL SIGNAL
NORTH BANK DRIVE POWER AND CONTROL SIGNAL
CSV ISV
PRV DRV
AVV
DRIVE PYLON
NORTH COLLECTOR BANK
15GPM/ ROW (TYP)
SOUTH COLLECTOR BANK
120 GPM
330 GPM
ISV
12 GPM
CSV
TRV
33GPM
PUMPS
S1
S2
450 GPM
120 GPM
330 GPM
EXISTING PLANT HOT WATER RETURN LINE
836 GPM @ 185°F. DESIGN CONDITION
SYMBOLS
DATA ACQUISITION SYSTEM TEMPERATURE ELEMENT
DATA ACQUISITION SYSTEM PRESSURE ELEMENT
DATA ACQUISITION SYSTEM FLOW ELEMENT
AVV - AIR VENT VALVE
PRV - PRESSURE RELIEF VALVE
ISV - ISOLATION VALVE
TRV - TEMPERATURE REGULATED VALVE
CSV - CIRCUIT SETTER VALVE W/FLOW INDICATOR
DRV - DRAIN VALVE
- LIGHT SWITCH
- RAIN SWITCH
- TEMPERATURE SWITCH
- FLOW SWITCH
- PRESSURE SWITCH
- TEMPERATURE TAP
CATERPILLAR TRACTOR CO
SAN LEANDRO
CA.
B-B
PIPING AND INSTRUMENTATION DIAGRAM
SOUTHWEST RESEARCH INSTITUTE
NOT TO SCALE
02-5321
CI-270



ROOF FRAMING PLAN

SCALE: 1/16"=1'

LEGEND:

- TRUSS BAY DESIGNATION
- TRUSS BAY DESIGNATION
- EXISTING COLUMN
- SUPPORT PYLONS
- DRIVE PYLONS
- T3 TRUSS TYPE
- PYLON CONNECTION
- DRIVE PYLON CONNECTION
- COLUMN TYPE
- WATER LINE PENETRATION
- ELECTRICAL PENETRATION
- BOTTOM SWAY CHORD (REPAIR OR REPLACE)

Notes:

1. All member loads shown are in kips. Sign convention: minus sign (-) indicates member is in compression; plus sign (+) indicates member is in tension.
2. For Trusses T1R to T4R, member loads shown are the worst load due to the worst loading condition for the member. The loading condition shown for Trusses T1R to T4R is the Roof Dead Load plus the Truss Dead Load plus the Roof Live Load plus a one kip crane load per bottom panel point of the truss.
3. Truss Loads:
   a. Roof Live Load = 20 psf
   b. Roof Dead Load = 26.1 psf
   c. Truss Dead Load = varies
   d. Trusses T1R to T4R Bottom Panel Point Crane Load = 1 kip
   e. Piping & miscellaneous (added into Roof D.L.) = [illegible] psf
   f. Earthquake Loads = .16 of DL
   g. Wind Load = varies
      For T1R to T4R (Wind V = [illegible] mph) θ = 0° is critical: [illegible]
      For T5R to T8R (Wind V = [illegible] mph) θ = [illegible]° is critical: [illegible]
4. The truss designations shown correspond to the original construction plans. The suffix R, i.e. T4R, indicates that the truss is a T4 truss that is to be reinforced per these plans & specifications. The suffix A corresponds to previously modified trusses.
5. The Bay Designations shown herein are Caterpillar Tractor Company's designations and do not correspond to the Bay Designations of the original construction drawings.
6. The column designations correspond to the original Construction Plans. The suffix R indicates that the column is to be reinforced per these plans and specifications.

ROBERT J. CROSSETT
REGISTERED CIVIL ENGINEER NO 10675

DATE	REASON FOR ISSUE	ADDENDA BULLETIN
7-1-80	OWNER'S 4TH CHECK	
4-30-80	OWNER'S 3RD CHECK	
3-31-80	OWNER'S 2ND CHECK	
3-1-80	OWNER'S 1ST CHECK	

RECORD OF ISSUANCES

CATERPILLAR TRACTOR CO.

PLANT SAN LEANDRO CITY SAN LEANDRO STATE CA.

BUILDING DESIGNATION: BB

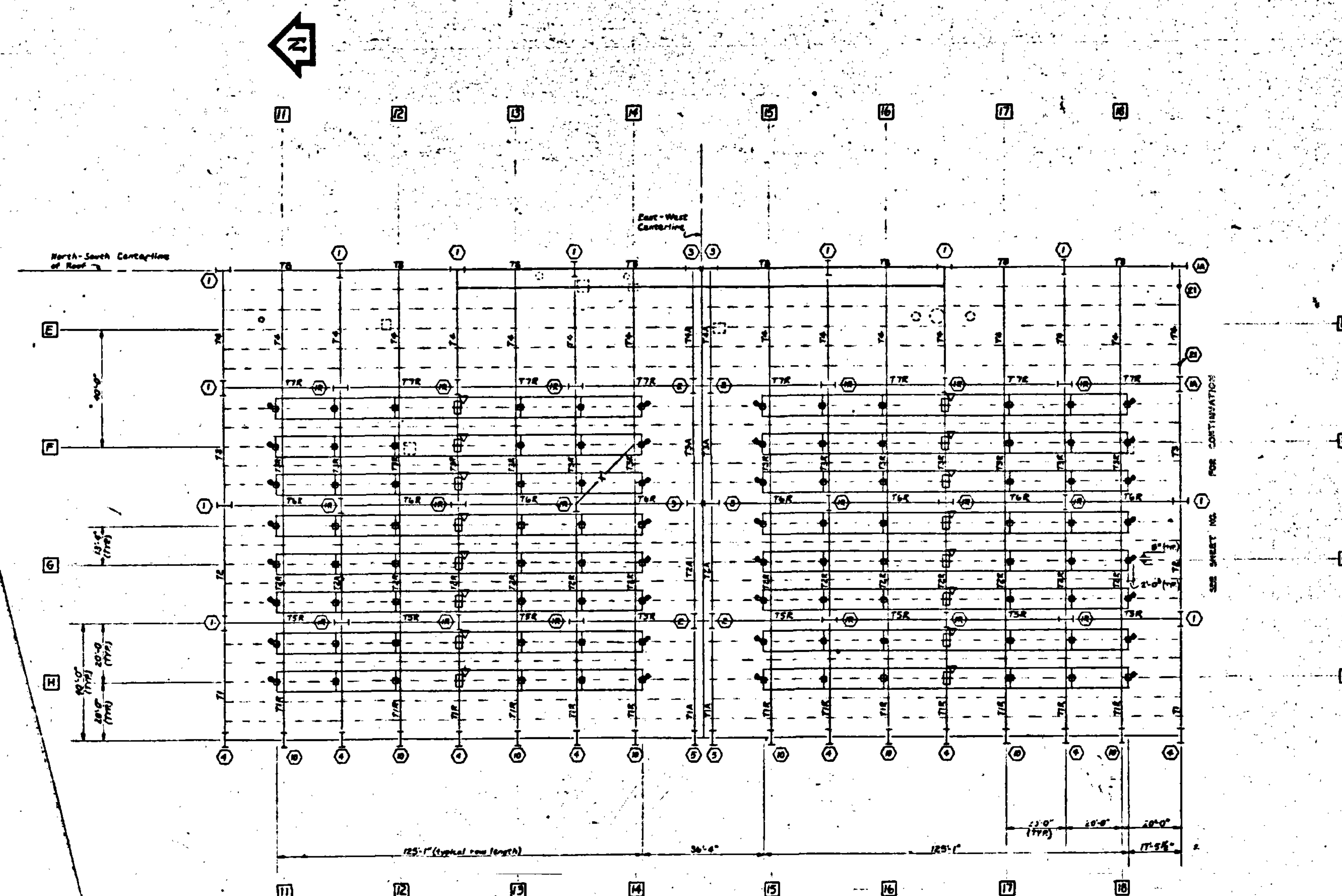
SHEET CONTENT: ROOF TRUSS STRUCTURAL REINFORCEMENT PLAN

FIELD RELEASE | D&C FILE NO. | D&C LOG NO.

BISSELL & KARN, INC.
CIVIL ENGINEERS
2551 MERCED STREET
SAN LEANDRO, CALIFORNIA 94577
(415) 483-2170

DRAWN RMB DATE 2-80 SCALE AS SHOWN SHEET NO S 280
CHECKED DATE CONSULTANTS FILE NO B&K 6953
APPROVED DATE PLANT FILE NO

JUL 1980



ROOF FRAMING PLAN

SCALE: 1/16" = 1'

ROBERT J. CROSSETT
Registered Civil Engineer No. 10879

DATE	REASON FOR ISSUE	ADDENDA BULLETIN
7-1-80	OWNER'S 4TH CHECK	
4-30-80	OWNER'S 3RD CHECK	
3-31-80	OWNER'S 2ND CHECK	
3-1-80	OWNER'S 1ST CHECK	

RECORD OF ISSUANCES

CATERPILLAR TRACTOR CO.

PLANT SAN LEANDRO CITY SAN LEANDRO STATE CA.

BUILDING DESIGNATION: BB

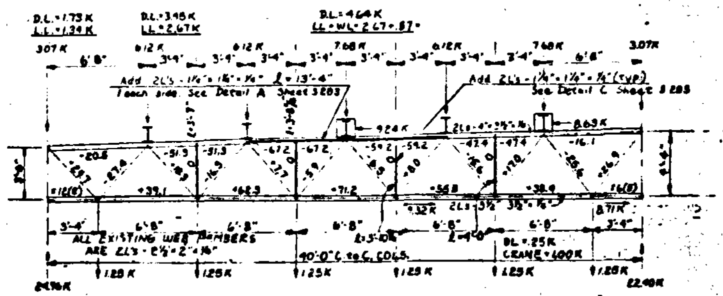
SHEET CONTENT: ROOF TRUSS STRUCTURAL REINFORCEMENT PLAN

FIELD RELEASE — APPROVED — DATE | D&C FILE NO. | D&C LOG NO.

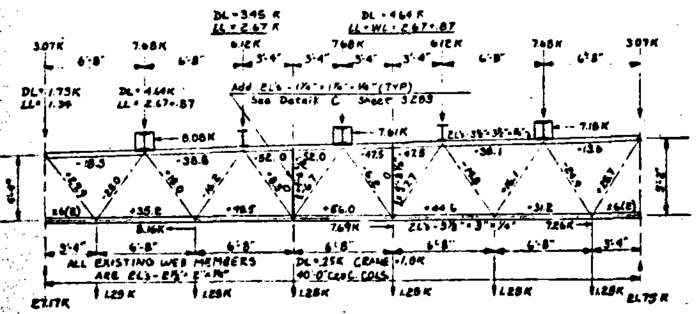
BISSELL & KARN, INC.
CIVIL ENGINEERS
2551 MERCED STREET
SAN LEANDRO, CALIFORNIA 94577
(415) 483-2170

DRAWN	DATE	SCALE	SHEET NO.
RMB	2-80	AS SHOWN	S 281
CHECKED	DATE	CONSULTANTS FILE NO. BBK 6953	
APPROVED	DATE	PLANT FILE NO.	

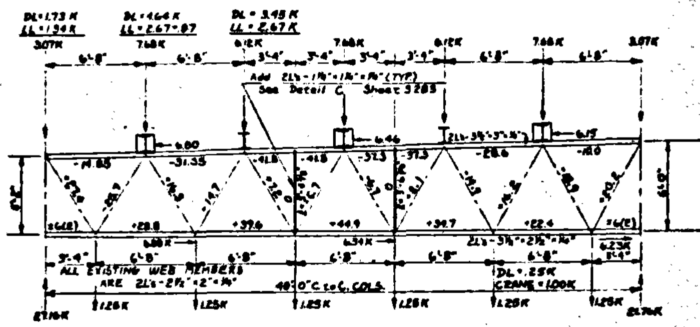
JUL 1 1980



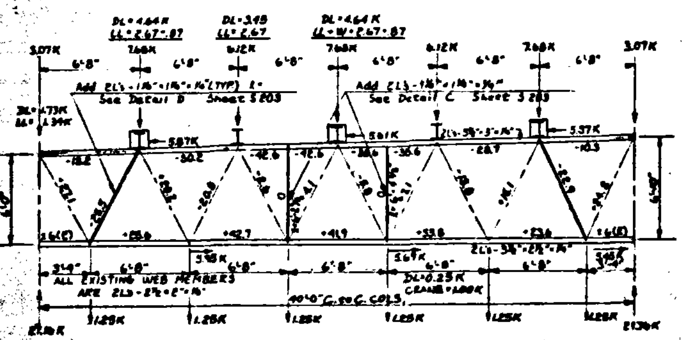
TRUSS T1R



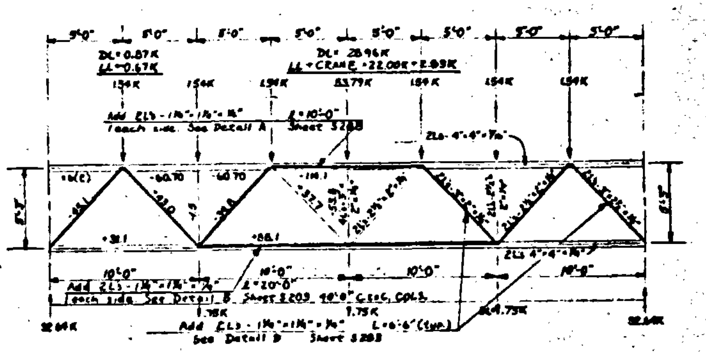
TRUSS T2R



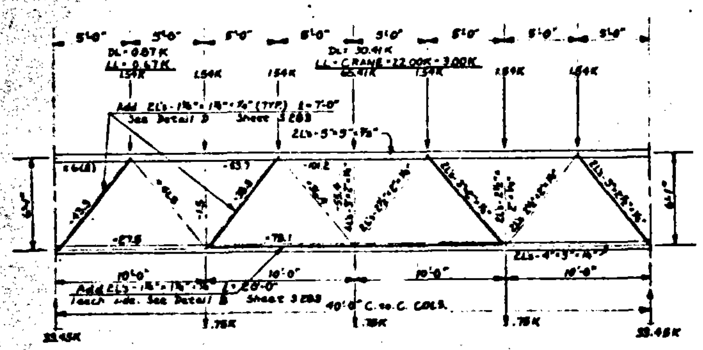
TRUSS T3R



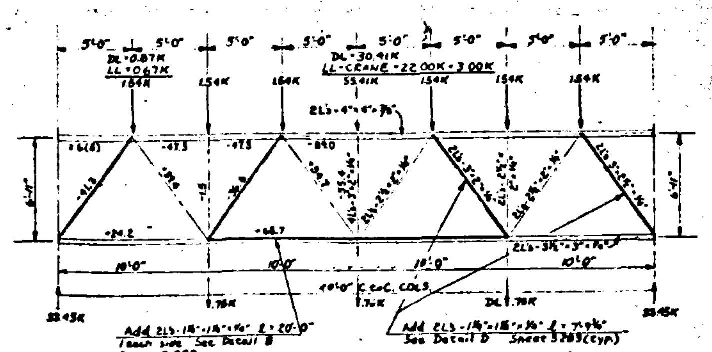
TRUSS T4R



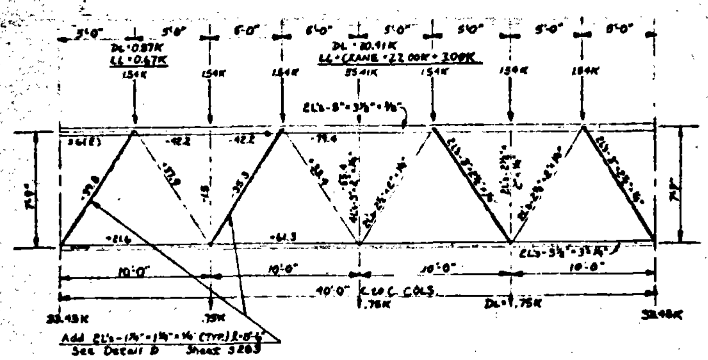
TRUSS T5R



TRUSS T6R



TRUSS T7R



TRUSS T8R

Notes:

1. Trusses T5R, T6R, T7R and T8R are symmetric about the centerline of the truss. The governing load condition for Trusses T5R to T8R, the dead load plus the live load, plus the crane load plus the vertical panel wind load for θ = 60°, is also symmetric about the centerline of the truss. Hence, the member loads are symmetric about the centerline.

2. The tabulations of the Panel Point Loads shown, are typical for Panel Point Loads of the same value on the same truss.

3. All added reinforcing members shall be ASTM A36 steel and shall be installed by welding with E 60XX electrodes.

4. The Contractor shall verify all dimensions shown hereon in the building prior to ordering any materials or the commencement of any work. Any discrepancies found shall be reported to the Owner's representative immediately for disposition.

5. The horizontal loading shown on Trusses T1R to T4R are due to the Overturning Moment minus the horizontal shear due to the wind acting on the collector panels.

ROBERT J. CROISETT
Registered Civil Engineer No. 10679

DATE	REASON FOR ISSUE	ADDENDA BULLETIN
7-1-80	OWNER'S 4TH CHECK	
4-30-80	OWNER'S 3RD CHECK	
3-31-80	OWNER'S 2ND CHECK	
3-1-80	OWNER'S 1ST CHECK	

RECORD OF ISSUANCES

CATERPILLAR TRACTOR CO.

PLANT SAN LEANDRO CITY SAN LEANDRO STATE CA.

BUILDING DESIGNATION BB

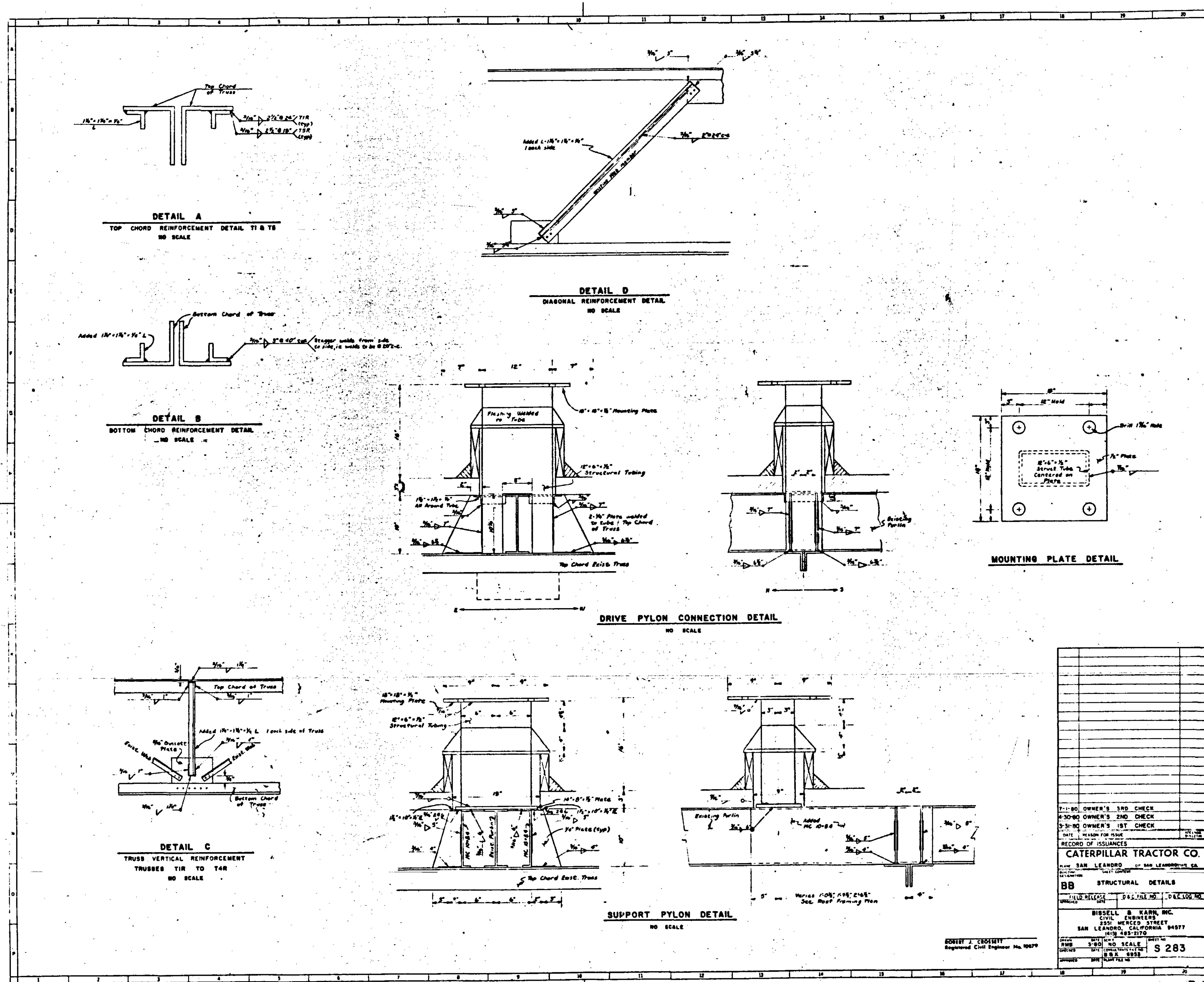
SHEET CONTENT TRUSS REINFORCEMENT DETAILS

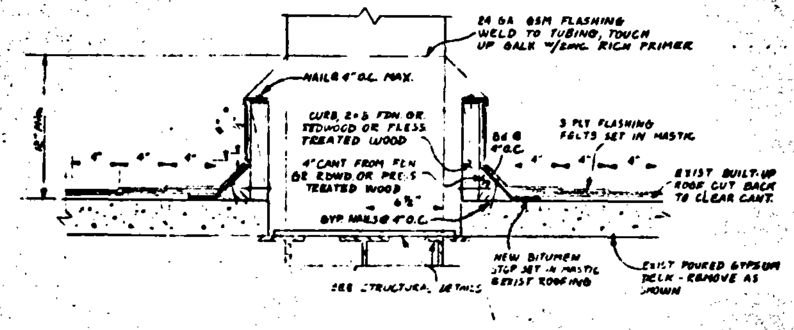
FIELD RELEASE APPROVED DATE | D&C FILE NO. | D&C LOG NO.

BISSELL & KARN, INC.
CIVIL ENGINEERS
2551 MERCED STREET
SAN LEANDRO, CALIFORNIA 94577
(415) 483-2170

DRAWN RMB DATE 2-80 SCALE 1/4" = 1'
CHECKED DATE CONSULTANT'S FILE NO. B&K 6953
APPROVED DATE PLANT FILE NO.
SHEET NO. S 282

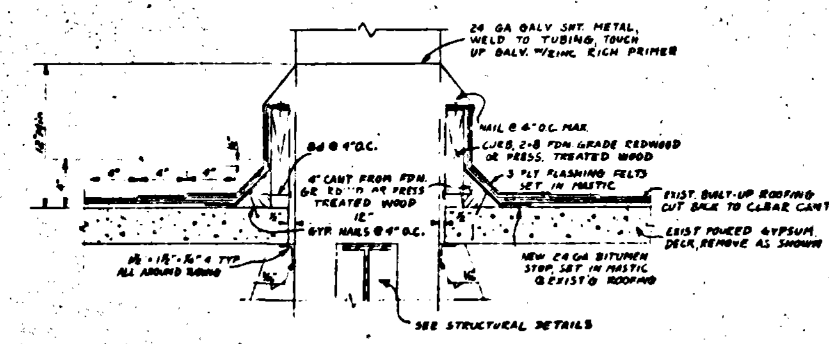
JUL 1 1980


DETAIL A
TOP CHORD REINFORCEMENT DETAIL T1 & T8
NO SCALE
DETAIL D
DIAGONAL REINFORCEMENT DETAIL
NO SCALE
DETAIL B
BOTTOM CHORD REINFORCEMENT DETAIL
NO SCALE
DRIVE PYLON CONNECTION DETAIL
NO SCALE
MOUNTING PLATE DETAIL
DETAIL C
TRUSS VERTICAL REINFORCEMENT
TRUSSES T1R TO T4R
NO SCALE
SUPPORT PYLON DETAIL
NO SCALE
ROBERT J. CROSSETT
Registered Civil Engineer No. 10679
7-1-80 OWNER'S 3RD CHECK
4-30-80 OWNER'S 2ND CHECK
3-31-80 OWNER'S 1ST CHECK
DATE REASON FOR ISSUE
RECORD OF ISSUANCES
CATERPILLAR TRACTOR CO.
PLANT SAN LEANDRO
SHEET CONTENTS
BB STRUCTURAL DETAILS
FIELD RELEASE
D&C FILE NO.
D&C LOG NO.
BISSELL & KARN, INC.
CIVIL ENGINEERS
2551 MERCED STREET
SAN LEANDRO, CALIFORNIA 94577
(415) 483-2170
DRAWN RMB DATE 5-80
SCALE NO SCALE
CONSULTANTS FILE NO. BBK 6953
SHEET NO. S 283



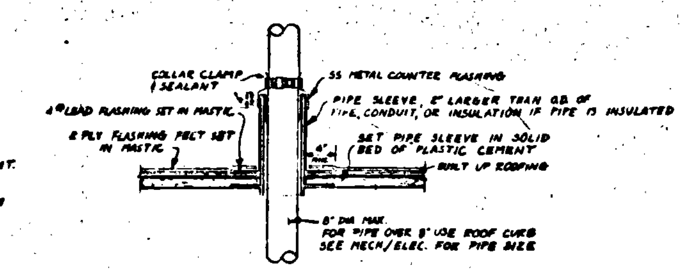
SUPPORT PYLON FLASHING DETAIL

NOT TO SCALE



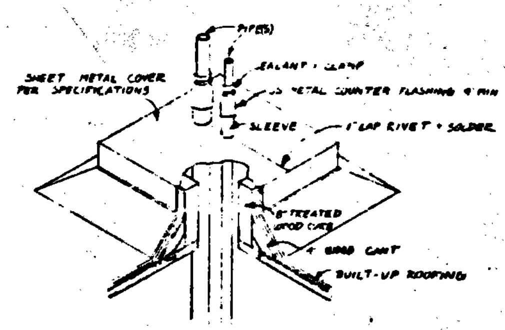
DRIVE PYLON FLASHING DETAIL

NOT TO SCALE



TYPICAL PIPING THRU ROOF

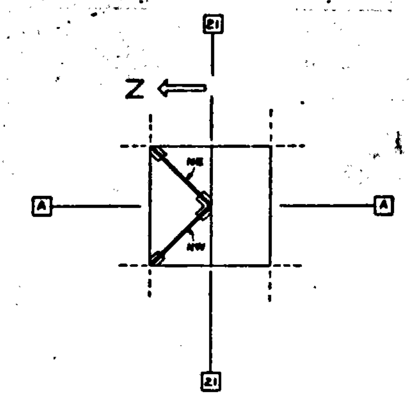
NOT TO SCALE



PIPE THROUGH ROOF, PIPE O.D. GREATER THAN 8" OR MULTIPLE PIPING

NOT TO SCALE

NAILS @ GYP DECK TO BE SQUARE CUT BRIGHT STEEL, LENGTH TO PENETRATE MIN. 1½" INTO DECK, OR SELF CLINCHING FASTENERS OF APPROVED TYPE.

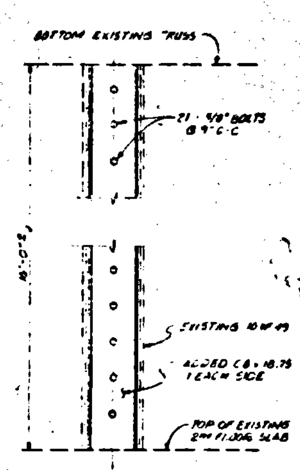


BOTTOM CHORD SWAY BAR REPAIR SCHEDULE

BOTTOM CHORD SWAY BAR REPAIR SCHEDULE			
BAY NO.	MEMBER QUADRANT	NO. OF BOLTS EACH END	COMMENTS
A21	NW	3	MISSING
B21	NW	3	MISSING
B23	NE	3	MISSING
B27	NW	3	MISSING
C21	NW	3	MISSING
C27	NW	2	MISSING
D14	NW	3	MISSING
	NE	3	MISSING
D18	NE	3	MISSING
	NE	3	REMOVE & REPLACE DAMAGED MEMBER
F14	NW	3	REMOVE & REPLACE DAMAGED MEMBER

1. All missing and damaged members shall be replaced with L-3" x 3" x 1/4" x [illegible]

2. All bolts shall be 5/8" bolts.



COLUMN 1R AND 11R REINFORCEMENT DETAIL

NOT TO SCALE

ROBERT J. CROSSETT
Registered Civil Engineer No. 10879

2-1-80	OWNER'S 2ND CHECK
4-30-80	OWNER'S 1ST CHECK
DATE	REASON FOR ISSUE

RECORD OF ISSUANCES

CATERPILLAR TRACTOR CO.

PLANT SAN LEANDRO CITY SAN LEANDRO STATE CALIF

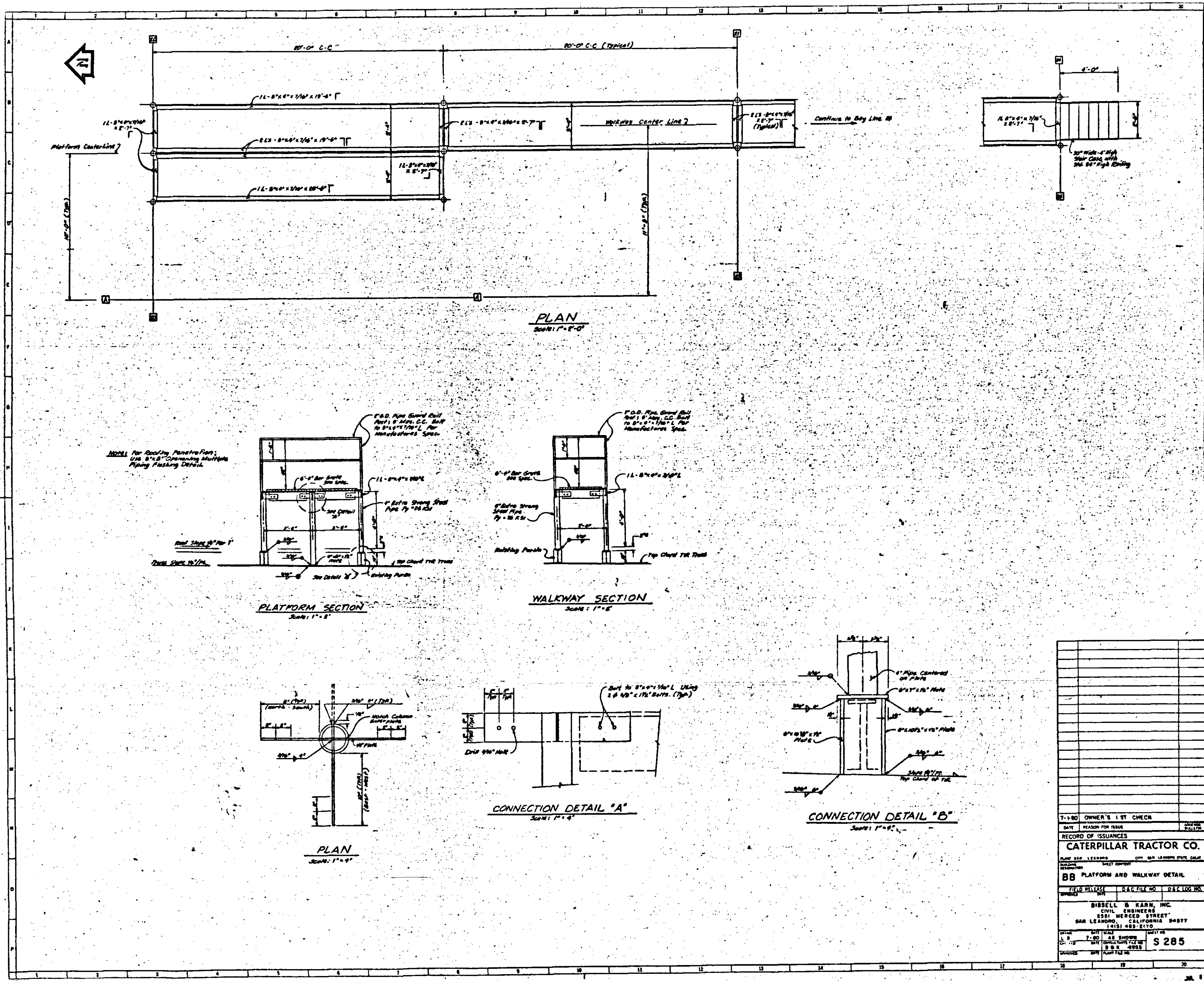
BB STRUCTURAL DETAILS

FIELD RELEASE | D&C FILE NO. | D&C LOG NO.

BISSELL & KARN, INC.
CIVIL ENGINEERS
2551 MERCED STREET
SAN LEANDRO, CALIFORNIA 94577
(415) 483-2170

DRAWN RMB 4-80 | SCALE NO SCALE | SHEET NO S 284
CHECKED | B&K 6953
APPROVED | PLANT FILE NO

JUL 1 1980


PLAN
Walkway Center Line
Continue to Bay Line
PLATFORM SECTION
WALKWAY SECTION
PLAN
CONNECTION DETAIL "A"
CONNECTION DETAIL "B"
7-1-80 OWNER'S 1ST CHECK
DATE
REASON FOR ISSUE
RECORD OF ISSUANCES
CATERPILLAR TRACTOR CO.
BB PLATFORM AND WALKWAY DETAIL
FIELD RELEASE
D&C FILE NO.
D&C LOG NO.
BISSELL & KARN, INC.
CIVIL ENGINEERS
2551 MERCED STREET
SAN LEANDRO, CALIFORNIA 94577
(415) 483-2170
7-80
AS SHOWN
S 285

APPENDIX B

SPECIFICATIONS FOR SOLAR PROCESS HEAT SYSTEM CATERPILLAR TRACTOR CO. SAN LEANDRO, CALIFORNIA

JULY 31, 1980

SOUTHWEST RESEARCH INSTITUTE
6220 CULEBRA ROAD
SAN ANTONIO, TEXAS 78284
TELEPHONE: (512) 684-5111, EXT. 2384

INDEX

CATERPILLAR TRACTOR CO.
SOUTHWEST RESEARCH INSTITUTE - PROJECT NO. 02-5821
SOLAR PROCESS HEAT SYSTEM
SAN LEANDRO, CALIFORNIA

FINAL DESIGN DRAWINGS

Drawing No.	Title
H200	Collector Layout
H201	Collector Row
H202	Support Pylons
H203	Mirror Module
H204	Receiver Tube Assembly
H205	Glass Cover Assembly
H206	Flex Hose Assembly
H220	Collector Piping Schematic
H221	Second Floor Piping Plan
H222	Second Floor Piping Sections
H223	First Floor Piping
H224	Collector Piping - Roof
H225	Solar HHW Pumps
H226	Pump Outlet Piping & Floor Meter Details
H227	Piping Support Details
E240	Power Distribution Floor Plan
E241	Power Distribution Sections
E242	Power Distribution Details
E243	Power to Motor Controls
E244	Power Cabinet
CI260	Symbols and Definitions
CI261	Solar Collector Control Floor Plan
CI262	Data Acquisition Sensor Element Location
CI263	Sensor Element Cable Termination Diagram
CI264	Remote Data Acquisition Cable Termination
CI265	Cabinet Junction and Control Enclosure Detail
CI266	Alarm Cable Termination
CI267	Cable & Sensor Element Specification List
CI268	Solar Central Control to Row Control
CI270	Piping and Instrumentation Diagram
S280	Roof Truss Structural Reinforcement Plan (South Field)
S281	Roof Truss Structural Reinforcement Plan (North Field)
S282	Truss Reinforcement Details
S283	Structural Details
S284	Structural Details
S285	Platform and Walkway Details

INSTRUCTIONS
TO
BIDDERS
FOR

SOLAR PROCESS HEAT SYSTEM
CATERPILLAR TRACTOR CO.
SAN LEANDRO, CALIFORNIA

7/31/80

DATE ________________________, 19___

Proposals for the work as described in the accompanying Contract Documents will be received until the following time which has been set for the termination of bidding: 10:A.M., PDT, ____________________, 1980.

1.00 PROPOSAL FORMS

Proposals must be submitted in triplicate on the proposal form provided herewith, and the three copies shall be enclosed in a sealed opaque envelope marked:

Solar Process Heat System
Caterpillar Tractor Co.
San Leandro, California

and addressed and delivered to:

Attn: Gaylord Kraus, Buyer
Caterpillar Tractor Co.
800 Davis Street
San Leandro, California 94577

on or before the time and date set for the termination of bidding. No other form of proposal or means of transmittal will be considered.

2.00 WITHDRAWAL OF PROPOSALS

Any bidder may withdraw his proposal at any time prior to the time and date set for the termination of bidding. No bidder may withdraw his proposal for a period of thirty (30) days after the time and date set for the termination of bidding.

3.00 REJECTION OF PROPOSALS

Caterpillar Tractor Co., hereinafter called "Owner," reserves the right to reject any or all proposals and to waive any technical or formal defect therein. Owner shall not be required to accept the lowest or any other proposal nor to accept a proposal in any definite time.

4.00 NOTICE OF ACCEPTANCE

Owner will notify the successful bidder of its acceptance of his proposal by depositing an executed copy thereof in the United States mail. Such notice shall be sent by certified mail, with postage prepaid, to the name and address of such bidder as stated in his proposal.

5.00 ARCHITECT/ENGINEER

The term "Architect/Engineer" shall mean the following names person or firm or such other person or firm as may be designated in writing from time to time by Owner:

Southwest Research Institute
6220 Culebra Road
San Antonio, Texas 78284

6.00 USE, CLARIFICATION AND RETURN OF DRAWINGS AND SPECIFICATIONS

6.01 All Drawings and Specifications for the work are the sole property of Owner and are intended solely for use in the work contemplated in such Drawings and Specifications. Except for a bidder whose proposal is accepted, said Drawings and Specifications shall be returned in good condition immediately upon receipt of notification that a proposal has been accepted or that no proposal will be accepted.

6.02 If there are any discrepancies in, or omissions from, the Drawings or Specifications, or if the bidder is in doubt as to the true meaning of any part of the Contract Documents, he shall request clarification from Architect/Engineer. Such request shall be in writing and shall be made not less than forty-eight (48) hours prior to the time scheduled for the termination of bidding. Interpretations in response to inquiries from any bidder or any clarification or corrections issued, will be mailed to each bidder. If the bidder fails to request clarification of a conflict regarding methods of performing work or the material required, his proposal shall be deemed to include the method requiring the greater quantity of work or material or upon the material of greatest cost indicated.

6.03 Any item mentioned in either the Drawings or Specifications, and not included in the other, shall be considered as included in both and shall be provided as a part of the work.

7.00 ADDENDA DURING BIDDING

During the bidding period, Architect/Engineer may advise the bidders by addenda of additions, deletions, omissions, or alterations in the Contract Documents. All such addenda shall become a part of the Contract Documents as if originally submitted.

8.00 SITE INVESTIGATION

8.01 Each bidder shall carefully examine the Contract Documents, the entire site of the work, the adjacent premises and various means of approach to the site and shall make all necessary investigations to fully inform himself of all the subsurface, natural, labor and legal conditions which will affect the cost and completion of the work to be performed. Each bidder shall determine the quantities of work required and the conditions under which the work will be performed.

8.02 Visits to the site shall be arranged with Owner's Representative, Mr. Don Lucas, telephone number (415) 483-6000, Ext. 238.

9.00 APPROVED MANUFACTURERS & SUBSTITUTIONS

9.01 When the Drawings or Specifications require material or equipment of a specified manufacturer, or specific method of performing the work, bidder shall provide that particular material, equipment or method. When more than one manufacturer is authorized to supply specified material, equipment or method, bidder may select the manufacturer he prefers. However, if the selected material, equipment or method results in an installation differing from that shown on the Contract Documents, bidder shall be responsible for any modifications to the installation, for coordination necessary with subcontractors and for all associated costs caused by such selection. All modifications due to such selections shall be submitted as shop drawings to Architect/Engineer for approval.

9.02 Extensive deviations from the Drawings or Specifications will not be approved. Deviations or substitutions will be considered only when their purpose is:

a. Increased value, or

b. superior function, or

c. decreased cost to Owner, or

d. specified items are not procurable.

9.03 The bidder may request approval from Architect/Engineer to substitute material, equipment or methods of like quality as material, equipment or methods required by the Drawings or Specifications at least five (5) days prior to the time set for the termination of bidding, and Architect/Engineer will notify each bidder of any such substitution which is approved. Any or all proposed substitutions may be rejected. All requests for substitutions shall be accompanied with supportive data and necessary information to permit proper evaluation. Any modifications in the work caused by an approved substitution shall be the responsibility of bidder, and shall be submitted as shop drawings to Architect/Engineer for approval.

10.00 SEQUENCE, SCHEDULE AND LUMP SUM AMOUNT

10.01 Owner has provided a sequence and scheduled completion date(s) for the work. Each bidder shall state a lump sum amount for performance of the work in accordance with such sequence and scheduled completion date(s).

10.02 Each bidder may provide alternate scheduled completion date(s) for the work in accordance with Owner's sequence. In such event, bidder shall state a lump sum amount for performance of the work in accordance with Owner's sequence and such alternate scheduled completion date(s).

11.00 UNIT PRICES

Each bidder shall submit unit prices where called for in the proposal form.

12.00 FEES FOR CHANGES IN WORK

Each bidder shall quote percentage fees for changes in the work as called for in the proposal form.

13.00 FEES FOR ADMINISTRATIVE CONTRACTS

Each bidder shall state, where called for in the proposal form, the percentage fees for which he will agree to assume and administer contracts for related work, if directed by Owner to assume any additional contracts.

14.00 DRAWINGS AND SPECIFICATIONS

The Drawings and Specifications upon which the proposal is to be based are as shown in the Index Sheet.

LUMP SUM
PROPOSAL
TO
CATERPILLAR TRACTOR CO.
FOR
SOLAR PROCESS HEAT SYSTEM
CATERPILLAR TRACTOR CO.
SAN LEANDRO, CALIFORNIA

Submitted by:

Name: ______________________

Mailing Address: ______________________

____

____

______________________________, herein called "Contractor", acknowledges receipt of the following documents, which are incorporated herein by reference and, together with this Proposal, are herein called "Contract Documents".

a. Instructions to Bidders, dated ______________, 19___.

b. General Conditions, dated ______________, 19___.

c. Specifications, dated ______________, 19___.

d. Drawings, dated ______________, 19___.

e. Addenda as follows:

Addendum Number	Date

(Note: If no Addenda have been received, write in "none".)

Contract Documents will bear the following title:

Solar Process Heat System
Caterpillar Tractor Co.
San Leandro, California

Contractor hereby submits this Proposal to Caterpillar Tractor Co., herein called "Owner".

1.00 SCOPE OF THE WORK

Contractor agrees to furnish all services, labor, materials, equipment, tools, and all other items required for the full execution of all work as specified by, and in accordance with, the Contract Documents.

2.00 CONTRACT PRICE

2.01 The lump sum amount stated in Section 2.02 or 2.03, whichever is accepted by Owner, shall be the consideration, herein called "Contract Price", to be paid by Owner and accepted by Contractor for the performance of such work.

2.02 Lump sum amount of ______________________________ Dollars ($______________), said amount based on performance and completion of the work in accordance with Owner's sequence and Owner's schedule stated in Section 3.02.

2.03 Lump sum amount of ______________________________ Dollars ($______________), said amount based on performance and completion of the work in accordance with Owner's sequence and Contractor's schedule stated in Section 3.03.

3.00 SEQUENCES AND SCHEDULES

3.01 Contractor agrees to start the work immediately upon Owner's acceptance of this Proposal and to do the work continuously to completion.

3.02 Contractor declares each area designated below will be completed in accordance with Owner's sequence and Owner's schedule as follows:

Area	Initial Occupancy	Beneficial Occupancy	Completion

3.03 Contractor declares each area designated below will be completed in accordance with Owner's sequence and Contractor's schedule as follows:

Area	Initial Occupancy	Beneficial Occupancy	Completion

3.04 Initial occupancy of an area occurs on the date when Owner begins installation of process equipment (suspended bridge cranes, overhead conveying systems, machines, etc.). The area shall be weathertight, required floor finishes shall be installed, and heating, ventilating, lighting, power and other utilities shall be available. Coordination of completion of Contractor's remaining work shall be Contractor's responsibility and shall not interfere with Owner's activities. Owner's use of space shall take precedence over remaining activities of Contractor, and Contractor shall protect, at his expense, Owner's equipment as directed by Owner's Representative.

3.05 Beneficial occupancy of an area occurs on the date when all building systems are operational on an uninterrupted basis and final clean-up is complete. Any remaining punch list items shall not prevent Owner's total use of area.

4.00 UNIT PRICES

Contractor submits the following schedule of unit prices for minor additions to or deductions from the work. The unit price shall be applied to the net addition or deduction of all quantities of the same item specified in a single Bulletin or Field Order. These prices shall include all of Contractor's costs, overhead, profit, insurance, taxes and other incidental expenses.

	Unit Prices For	
Item and Unit of Measure	Additions to the Work	Deductions from the Work

5.00 FEES FOR CHANGES IN WORK

For all changes in the work which may be ordered by Owner which are not covered by the foregoing unit prices, the following percentages shall be used, as applicable, in contract price adjustments in accordance with the General Conditions, Section 11.00:

a. Work performed directly by Contractor's own personnel: ____________% of the cost of such additional work, such percentage to provide compensation for costs of hand tools, small equipment, field overhead (supervision above working foremen level and all other indirect labor and material costs), home office overhead, and profit.

b. Work performed by subcontractors: ____________% of the cost of such additional work, such percentage to provide compensation for Contractor's field overhead (supervision above working foremen level and all other indirect labor and material costs), home office overhead, and profit.

6.00 SUBCONTRACTORS

6.01 It is the policy of Owner that minority business enterprises shall have the maximum practicable opportunity to participate in the performance of its contracts. Contractor agrees to use his best efforts to carry out this policy in the letting of his subcontracts to the fullest extent consistent with the efficient performance of the work. As used herein, the term "minority business enterprise" means a business, at least fifty (50) percent of which is owned by minority group members or, in case of publicly owned businesses, at least fifty-one (51) percent of the stock of which is owned by minority group members. For the purpose of this definition, minority group members are Negroes, Spanish-speaking American persons, American-Orientals, American-Indians, American-Eskimos, and American Aleuts. Contractor may rely on written representations by subcontractors regarding their status as minority business enterprises in lieu of a independent investigation.

6.02 Contractor, within ten (10) days after notification by Owner of acceptance of this Proposal, shall submit to Owner a list of all subcontractors which he proposes to employ for the principal parts of the work, indicating which of such subcontractors are minority business enterprises. Contractor will let no subcontracts nor authorize any proposed subcontractor to start work or assume obligations for equipment or materials until he receives from Owner written approval of such subcontractors. If any proposed subcontractor is not approved by Owner, Contractor shall submit as soon as possible, in substitution, another proposed subcontractor for Owner's approval. Upon written request by Owner, Contractor will provide experience histories, financial data and such other qualifying information as may be required by Owner to evaluate fairly and completely the proposed subcontractor's qualifications.

7.00 TAXES

7.01 All federal, state and local taxes of all types, including but not limited to any excise taxes, taxes upon personal property and sales and use taxes when applicable, are included in the prices stated herein and, whenever required by law, are separately stated.

7.02 Contractor shall not include in the contract price the amount of any tax on items pertaining to facilities which are designated in Section 1.02 of the Specifications as being exempt from such tax. Owner will obtain any required tax exemption certificates after the proposal is accepted.

8.00 BONDS

If required by Owner, Contractor will furnish performance and payment bonds, the bond premium to be charged separately and in addition to the contract price. Contractor represents that this Proposal does not include any amount for the cost of such bonds.

9.00 PAYMENT

9.01 Owner will make partial payments as the work progresses and is found satisfactory by Owner's Representative. Contractor may submit to Owner, not more often than once a month, a partial payment invoice, satisfactory in form to Owner, setting forth the value, based on the prices in this Proposal, of labor, materials and supplies furnished and incorporated in the work to the satisfaction of Owner's Representative and of materials suitable stored at the site at the date of such submission. Within twenty (20) days after receipt thereof, Owner shall pay to Contractor, subject to General Conditions, Section 31.00, ninety percent (90%) of the amount of such partial payment invoice, less the total amount of previous partial payments, if any.

9.02 Upon completion of the work, submission of documents as specified in General Conditions, Section 31.00, and acceptance of the work by Owner, Contractor shall submit a final payment invoice, satisfactory in form to Owner. Within twenty (20) days after receipt thereof, Owner shall pay to Contractor the amount of such invoice, less the total amount of previous partial payments, if any.

10.00 ASSIGNMENT

Contractor represents that no assignment, sublease, or transfer of all or any part of his interest in this Proposal has been made, or will be made prior to Owner's acceptance hereof, and agrees thereafter not to assign, sublet or transfer all or any part of his interest herein without the written consent of Owner.

11.00 AGREEMENT

If Owner accepts this Proposal, the Contract Documents, as enumerated above, shall constitute the entire agreement between Contractor and Owner. No other form of agreement between Contractor and Owner is contemplated.

12.00 LEGAL STATUS

12.01 Contractor's legal status is as checked below:

[ ] Individual.

[ ] Partnership.

[ ] Corporation, incorporated under the laws of the State of ______________________.

12.02 The names and addresses of (a) partners, if Contractor is a partnership, or (b) directors and officers, if Contractor is a corporation, are as follows:

Name	Address

CONTRACTOR: ______________________

By: ______________________

Title: ______________________

Date: ______________________, 19____

ACCEPTANCE OF PROPOSAL

Caterpillar Tractor Co. hereby accepts the foregoing Proposal in accordance with its acceptance or rejections as follows:

Section	Accept	Reject
2.02	________	________
2.03	________	________

Contract Price: $________________

CATERPILLAR TRACTOR CO.

By: ________________________________

Title: ________________________________

Date: ____________________________, 19____

GENERAL CONDITIONS
INDEX

10/12/78

1.00 DEFINITIONS

1.01 The "Contract Documents" consist of the Instructions to Bidders, the Proposal of Contractor accepted by Owner, the Drawings, Specifications, Addenda incorporated in said Proposal, and these General Conditions.

1.02 The term "work" means all equipment, labor, material and services necessary to produce the construction in accordance with the Contract Documents.

1.03 The term "Owner" means Caterpillar Tractor Co.

1.04 The term "Owner's Representative" means the on-site delegate of Owner.

1.05 The term "Contractor" means the individual, firm or corporation whose Proposal for performance of the work is accepted by Owner.

1.06 The term "subcontractor" means an individual, firm or corporation, other than Contractor, who contracts for performance of a portion of the work.

1.07 The term "Architect/Engineer" means an individual, firm or corporation designated by Owner to perform architectural and engineering services relating to the design work.

1.08 The term "Bulletin" means a form of instruction issued by Architect/Engineer after Owner's acceptance of Contractor's Proposal indicating contemplated changes in the work on which pricing is requested.

1.09 The term "Field Order" means a form of instruction issued by Owner's Representative after Owner's acceptance of Contractor's Proposal authorizing changes in the work, the cost of which will be determined in accordance with the applicable provisions of the Contract Documents.

1.10 The term "Change Order" means a document executed by Owner and Contractor (a) authorizing Contractor to make changes in the work pursuant to a Bulletin or (b) approving the pricing of changes in the work required by a Field Order.

1.11 The term "site" means the general physical location where the work is to be performed.

2.00 INTENT OF CONTRACT DOCUMENTS

2.01 The Contract Documents are complementary and are intended to coordinate and provide for the proper and complete execution and finishing of the work by Contractor whether or not specifically identified. The organization of the Specifications into divisions and sections, and the arrangement of Drawings is for ease of reference only and is not intended to control Contractor in dividing the work among subcontractors or in establishing the extent of work to be performed by any trade.

2.02 After award of contract, Contractor shall procure from Owner's Representative all necessary interpretations of the Drawings and Specifications and shall check for discrepancies in the Drawings. He shall secure written instructions from Owner's Representative before proceeding with any part of the work affected by omissions or discrepancies; failing to secure such instructions, Contractor will be considered to have proceeded at his own risk and expense. In the event of any doubt or question arising with respect to the true meaning of the Drawings and Specifications, the decision of Owner's Representative thereon shall be final and conclusive.

3.00 DRAWINGS AND SPECIFICATIONS

3.01 The Drawings and Specifications, and copies thereof, are the property of Owner and shall not be copied or used for any other work by Contractor or any subcontractor.

3.02 Owner will furnish Contractor with the number of sets of Specifications and copies of Drawings which are agreed upon as reasonable and necessary by both Owner and Contractor.

4.00 APPROVED MANUFACTURERS & SUBSTITUTIONS

4.01 When the Drawings or Specifications require material or equipment of a specified manufacturer, or specific method of performing the work, Contractor shall provide that particular material, equipment or method. When more than one manufacturer is authorized to supply specified material, equipment or method, Contractor may select the manufacturer he prefers. However, if the selected material, equipment or method results in an installation differing from that shown on the Contract Documents, Contractor shall be responsible for any modifications to the installation, for coordination necessary with subcontractors and for all associated costs caused by such selection. All modifications due to such selections shall be submitted as shop drawings to Architect/Engineer for approval.

4.02 Extensive deviations from the Drawings or Specifications will not be approved. Deviations or substitutions will be considered only when their purpose is:

a. Increased value, or
b. superior function, or
c. decreased cost to Owner, or
d. specified items are not procurable.

4.03 After award of contract, Contractor may request approval from Owner's Representative to substitute material, equipment or methods of like quality as material, equipment or methods required by the Drawings or Specifications, and Owner's Representative will notify Contractor within thirty (30) days of any such substitution which is approved or disapproved. Any or all requests for substitutions may be rejected. All requests for substitutions shall be accompanied with supportive data and necessary information to permit proper evaluation. Any modifications in the work caused by an approved substitution shall be the responsibility of Contractor, and shall be submitted as shop drawings to Architect/Engineer for approval.

5.00 CONTRACTOR'S SIGNS

5.01 Contractor may display on the site only those advertising signs which are specifically authorized by Owner's Representative. Such signs shall be furnished, erected and, on completion of the work, removed at the expense of Contractor.

5.02 Contractor shall provide signs, as directed and approved by Owner's Representative, to clearly identify construction workers' entrances to the site.

6.00 SHOP DRAWINGS

6.01 Shop drawings are fabrication drawings, erection drawings, setting drawings, manufacturers' drawings, wiring and control diagrams, cuts or catalogs, pamphlets, descriptive literature, performance data, test data and other data which is prepared by Contractor or any subcontractor, manufacturer, supplier or distributor, and which illustrate some portion of the work.

6.02 Shop drawings required for the work of various trades, properly identified, shall be furnished by Contractor and must be submitted to Architect/Engineer for approval in sufficient time to prevent delay in his work or in that of any other contractor.

6.03 The approval of shop drawings by Architect/Engineer shall be general in character, and shall not mean that dimensions on drawings have been checked, and will not relieve Contractor of responsibility for proper fitting and construction of the work, nor from the necessity of furnishing materials or doing the work required by the Drawings or Specifications which may not be indicated on shop drawings when approved.

7.00 LAYOUT

7.01 Owner will establish baselines and permanent bench marks. All other lines and levels necessary for the location and construction of the work shall be established and maintained by an engineer or surveyor licensed by the state in which the site is located and employed by Contractor.

7.02 Contractor shall continuously compare all lines, grades, and other information appearing on the Drawings with the actual lines, grades and site conditions. Any discrepancies discovered shall be submitted to Owner for disposition before Contractor proceeds with the work.

8.00 QUALITY OF MATERIAL

All materials and equipment incorporated in the work shall be new. Salvage or short dimension material, even though new, will not be used. All work which does not conform to these requirements shall be considered defective. Contractor shall, if required, furnish evidence as to the kind and quality of materials and equipment. If any dispute arises as to the quality or fitness of materials or equipment, Owner's Representative shall make the final determination thereof, which shall be based upon the requirements of the Specifications.

9.00 SAMPLES

9.01 Samples are physical examples furnished by Contractor to illustrate materials, finishes, equipment or workmanship and to establish standards by which the work will be judged.

9.02 Samples, properly identified, shall be furnished by Contractor as specified. Samples must be submitted for approval in sufficient time to prevent delay in the work or in the work of any other contractor. Work provided shall be similar and equal to approved samples.

10.00 SCHEDULE AND COMPLETION

10.01 The work shall be performed in accordance with a construction schedule provided by Contractor and approved by Owner's Representative. Such schedule shall be in accordance with instructions in the Specifications and shall support the occupancy and completion dates in the Proposal.

10.02 If, in the opinion of Owner's Representative, performance of the work fails to progress in accordance with the construction schedules, Owner's Representative may request, and Contractor shall submit for approval, a program of activities to be undertaken by Contractor to assure performance in accordance with the construction schedule. Such program of activities as approved in writing by Owner's Representative shall be undertaken and performed by Contractor without additional cost to Owner.

10.03 If a delay in the performance of activities on the critical path of the work as set forth in such construction schedule, beyond the control of Contractor, is caused by an act or neglect of Owner, a strike, civil disorder, or a severe act of God, Owner shall grant an extension to the schedule activities, as appropriate, upon application therefor by Contractor within twenty (20) working days after such event. Owner shall not reimburse Contractor for any additional costs resulting from any such extension.

11.00 DEVIATIONS AND EXTRA WORK

11.01 No change in the work shall be performed by Contractor until authorized by issuance of a Field Order or execution of a Change Order by Owner. At any time Owner may make changes in the Drawings or Specifications evidenced by a Bulletin issued by Architect/Engineer and authorized by a Change Order or by a Field Order and subsequent Change Order. If any such change shall materially affect the scope of the work or shall increase or decrease the cost of the work to Contractor, an equitable adjustment in the contract price shall be made in accordance with one of the following methods selected by Owner:

A. by a change proposal to be submitted promptly by Contractor to Owner stating the net amount of the increase or decrease in the contract price and supported by a detailed breakdown prepared as follows:

1. for work to be performed by Contractor's own personnel:

a. direct productive labor costs, including applicable insurance and taxes thereon, but exclusive of any labor cost penalties or premiums, such as, but not limited to, those associated with overtime and extra shift work included therein (see e. below); plus

b. net cost of direct materials including applicable taxes and transportation charges thereon; plus

c. net amount of major equipment charges; plus

d. costs of hand tools, small equipment, field overhead (supervision above working foremen level and all other indirect labor and material costs), home office overhead, and profit at the designated percentage of 1.a., 1.b. and 1.c. above, as set forth in the Proposal; plus

e. any labor cost penalties or premiums, such as, but not limited to, those associated with overtime and extra shift work, including applicable insurance and taxes thereon.

2. for work performed by subcontractors:

a. net price to Contractor of subcontractors' work, this price to be fully detailed by the subcontractor and to be broken down to indicate estimated labor, material and equipment costs, and a percentage for subcontractor hand tools, small equipment, field overhead (supervision above working foremen level and all other indirect labor and material costs), home office overhead, profit and any labor cost penalties or premiums, such as, but not limited to, those associated with overtime and extra shift work, in the same manner as is required for Contractor's own work; plus

b. Contractor's field and home office overhead and profit at the designated percentage of 2.a. as set forth in the Proposal. Contractor's percentage shall not be applicable to any labor cost penalties or premiums of subcontractors, such as, but not limited to, those associated with overtime and extra shift work.

3. when both additions and deductions are included in a single Bulletin or Field Order the change proposal shall be based upon the net addition or deduction of all quantities of the same item.

B. by the unit prices as provided in the Proposal; or

C. by actual cost plus a mutually acceptable fixed or percentage fee, when such costs are supported by accurate records of labor, material and equipment charges. Any labor cost penalties or premiums, such as, but not limited to, those associated with overtime and extra shift work, shall be directly reimbursable and not subject to a fee.

11.02 Contractor shall obtain and verify all cost proposals from subcontractors to ensure fair and reasonable prices and compliance with the approved schedule.

12.00 DAMAGED WORK

12.01 Contractor shall not endanger any work by cutting, fitting or otherwise altering. Contractor shall not cut or alter the work of any other contractor without the prior consent of Owner's Representative. Contractor shall properly complete, patch and finish his work after any cutting and fitting.

12.02 Contractor shall be responsible for damages to existing work or to completed new work, either of Owner or of other contractors, that may be caused by his or his subcontractors' work or workmen. The repair or replacement of all such damaged work shall be done by Contractor at his own expense.

13.00 COOPERATION OF CONTRACTORS

13.01 Owner reserves the right to award other contracts in connection with the work. Contractor shall afford other contractors adequate opportunity for the introduction and storage of their materials, equipment and for the execution of their work, and shall properly connect and coordinate his work with theirs. Contractor shall furnish any and all other contractors, whose work is fitted to his, detail and erection drawings giving full information regarding the fabrication and assembly of his work. To the extent possible, such drawings will show checked field measurements.

13.02 If any part of Contractor's work depends, for proper execution or results, upon the work of any other contractor on the site, Contractor shall inspect and promptly report to Owner's Representative any apparent discrepancies or defects in such other contractors' work that render it unsuitable for proper execution and results of his work. Such dependent work shall not progress until written direction is provided by Owner's Representative. Failure of Contractor to inspect and report such discrepancies or defects shall constitute an acceptance of the other contractors' work as suitable for the receipt of his work.

14.00 WARRANTY

14.01 Contractor shall perform the work in accordance with the Contract Documents and shall furnish all labor, equipment, material or other necessary services for the complete performance of the work in a good, substantial and workmanlike manner. Neither acceptance of, nor payment for, the work or any part thereof, nor the partial or entire use or occupancy of the work by Owner, shall release Contractor from liability for any special or extended warranties of material or equipment installed, or for workmanship which is faulty, unsound, improper or not in accordance with the Contract Documents.

14.02 Contractor shall, at its own expense, remove and replace all defective portions of the work performed by Contractor or subcontractors and shall remedy any defects which shall appear within (a) a period of one year after the date on which the completed work is accepted by Owner in writing or (b) a period of time as set forth in the Specifications, whichever is longer. Owner shall give notice of observed defects with reasonable promptness.

15.00 SUPERVISION

15.01 Contractor shall direct, supervise, and coordinate all portions of the work. Contractor shall have a competent person, satisfactory to Owner, as project manager on the site at all times. The project manager shall be authorized to receive instructions from Owner, Owner's Representative and Architect/Engineer and to act with authority for Contractor. The project manager shall have such assistants as are necessary. Contractor shall replace any project manager unsatisfactory to Owner and shall not replace any project manager satisfactory to Owner without Owner's prior consent.

15.02 Contractor shall be responsible for the acts and omissions of his employees and for the acts and omissions of subcontractors and their employees.

16.00 PROTECTION OF MATERIAL AND WORK

All work (whether or not completed), materials and equipment shall be fully protected against damage from any source and shall receive such additional protection as Owner's Representative may deem advisable without additional expense to Owner. Contractor shall be obliged to replace or pay for any materials, equipment or work damaged from any cause whatsoever or lost by theft before final acceptance of the work, except materials, equipment or work which are insured by Owner as provided in Section 30.00.

17.00 RECEIVING MATERIALS FURNISHED BY OWNER

When Owner elects to furnish materials or equipment, they will be listed in the Specifications. Contractor shall be responsible for unloading and handling of materials or equipment furnished by Owner to the site. Contractor receiving such items shall give receipts for the items delivered, and thereafter will be held responsible for the care and storage of such items and shall pay for the cost of replacing or repairing any items damaged or stolen while in Contractor's care and custody.

18.00 CLEANING

Contractor shall at all times keep the site, Owner's premises and adjoining premises, driveways and streets clean of rubbish. At the completion of the work, Contractor shall remove all rubbish from and about the premises, as well as all tools, equipment, surplus material and temporary structures and installations, and shall leave the premises clean and ready for use. No burning of rubbish will be permitted on the premises. If Contractor does not perform such cleaning with reasonable promptness or upon request, Owner's Representative may cause such cleaning to be done by others, and charge the cost of the same to Contractor.

19.00 LAWS AND REGULATIONS

19.01 Contractor shall give all notices and comply with all applicable federal, state and local laws, rules and regulations governing building construction, testing, use of equipment and safety of persons or property.

19.02 If Contractor observes that any of the Contract Documents are at variance with any applicable federal, state or local law, rules or regulation, he shall promptly notify Owner's Representative, in writing, and any necessary change in the work shall be made. Contractor shall pay for all fees and assessments, except those applicable to permits to be obtained by Owner as specifically listed in the Specifications. If Contractor performs any work contrary to such laws, rules or regulations, he shall assume full responsibility therefor and shall bear all attributable costs and fines.

19.03 All regulations and rules of Owner which may be in effect on Owner occupied areas of the site and on Owner's premises exclusive of the site regarding passes, badges, smoking, fire prevention and conduct on the property shall be observed by Contractor, subcontractors, and their employees. Contractor shall at all times enforce discipline and good order among Contractor's and subcontractors' employees and shall not employ on the work any unfit person or anyone not skilled in the work assigned to him. Contractor and subcontractors shall not take photographs of the site or on the site without written authorization of Owner.

19.04 During the performance of the work, Contractor shall not hinder, interfere with, molest or delay the operation of Owner at the site or any other contractor employed by Owner. Contractor shall confine his equipment, storage of materials, and operation of his workmen to the limits indicated by local ordinances, permits or by direction of Owner and shall not unreasonably encumber the premises with materials or equipment.

20.00 SAFETY MEASURES

20.01 Contractor shall designate in writing to Owner's Representative a responsible member of his organization at the site of the work whose duty shall be personnel safety and the prevention of accidents.

20.02 Contractor shall not load or permit any part of the structure to be loaded with a weight that will endanger its safety. Contractor shall provide and maintain the necessary precautions and safeguards for the safety of all persons on the site.

20.03 Contractor shall furnish all equipment, including but not limited to tools, scaffolding, hoists, tarpaulins, derricks, cranes, ladders, ramps and runways, for the completion of the work, all of which must be suitable, safe and sufficient to perform the work properly, safely and within the time specified. Contractor shall be responsible for the condition of all such equipment throughout its entire use.

20.04 In the event of an accident involving personal injury or property damage, Contractor shall immediately notify Owner, furnishing as much information concerning the accident as is available. As soon as practical within the following twenty-four (24) hours, he shall furnish Owner written reports stating the extent of damage, names of persons involved or witnessing the occurrence, names of employers of persons involved, name of attending physician, his diagnosis and prognosis, and subsequently any other information required by Owner.

21.00 TITLE TO WORK AND MATERIALS

The title to all materials and equipment shall remain with Contractor until such time as they are incorporated into the work on the site. Until incorporated into the work on the site, they will be subject to a lien of Owner to the extent that money has been advanced therefor.

22.00 OWNER'S REPRESENTATIVE

Owner's Representative generally will be on the site during working hours and generally will be available at other times as may be necessary. Owner's Representative shall have authority on behalf of Owner to:

a. decide questions which arise as to the quality and acceptability of materials furnished, work performed, and to reject that which does not conform to the Contract Documents;

b. require minor alterations in, additions to, or deductions from the work shown on the Drawings or described in the Specifications through the issuance of a Field Order;

c. interpret the Contract Documents and determine acceptability of rate of progress of the work;

d. suspend any portion of the work which does not conform to the quality and/or workmanship established by the contract Documents;

e. suspend any work that will be superseded by the issuance of a Bulletin.

23.00 INSPECTION AND TESTING

Owner shall have the right to inspect and test all work in progress. Contractor shall provide sufficient time for such inspection and testing, particularly with respect to work to be concealed.

24.00 ACCESS TO SITE

Architect/Engineer, Owner's Representative, Owner and its agents shall have access to the site at all times.

25.00 TERMINATION FOR OWNER CONVENIENCE

25.01 If Owner elects to cease or postpone the work he may terminate the contract by written notice to Contractor. Such termination shall be effective in the manner specified in said notice and shall be without prejudice to any claims which Owner may have against Contractor. On receipt of such notice Contractor shall, unless the notice directs otherwise, immediately discontinue work and the placing of orders for materials, facilities and supplies in connection with the performance of the work, and shall, if requested, make every reasonable effort to procure cancellation of existing orders and subcontracts upon terms satisfactory to Owner. Thereafter Contractor shall do only such work as may be necessary to preserve and protect work already in progress and to protect the material, equipment or supplies on the site or in transit thereto.

25.02 A complete settlement of all claims of Contractor upon termination of the contract as provided in this Section 25.00 shall be made as follows: (A) Owner shall reimburse Contractor for all work satisfactorily completed by Contractor prior to date of contract termination. (B) Owner shall assume and become liable for all obligations and commitments that Contractor may have in good faith undertaken or incurred in connection with work performed in accordance with the Contract Documents which have not been included in prior partial payments. (C) Owner shall compensate Contractor for such services incurred after the date of termination for the reasonable cost of protecting Owner's property and for accounting services in connection with the settlement of the contract, as are required or approved by Owner in advance. Prior to final settlement, Contractor shall furnish Owner a release of all claims which may have arisen, and execute and deliver all documents, and take such other steps as are necessary, to vest fully in Owner the rights and benefits of Contractor arising from such obligations and commitments.

26.00 OWNER'S TERMINATION FOR CAUSE

26.01 If at any time during the performance of the work, Contractor

a. makes an assignment for the benefit of its creditors, or a receiver or trustee of any property of Contractor is appointed, or a petition is filed, either by or against Contractor, in any bankruptcy or insolvency proceedings; or

b. abandons or fails to commence the work; or

c. at any time after notice, fails (i) to prosecute the work diligently in accordance with the schedule and any extensions granted pursuant to Section 10.00, or (ii) to pay subcontractors for materials, supplies or labor, or (iii) violates any condition of this agreement;

Owner may, upon written notice to Contractor, terminate the contract, and may enter upon the site and take possession of all tools, equipment and materials which may be owned by or be in the possession of Contractor and which are at the site and required for the completion of the work, and may exercise all options, privileges and rights with respect thereto, and may complete, or employ any other person or persons to complete the work at Contractor's expense. In the event Contractor shall correct the situation which has caused the notice of termination to be given by Owner within the period of fifteen (15) days from the date of receipt of such notice, the cause of termination shall be deemed waived, and the contract shall continue in effect in the same manner as though such cause of termination had not existed, Owner, however, reserving its right to damages for breach of any provision of this contract.

26.02 In the event of termination of the employment of Contractor as provided in this Section 26.00, Contractor shall prepare a statement of cost to that date, plus all obligations incurred in the interest of the work but not yet due. The net amount of such statement shall become due and payable when approved by Owner after completion of the remainder of the work by Owner or its agents. If the expense incurred by Owner in completing the work exceeds the difference between the contract price and the total amount paid to Contractor, Contractor shall pay such excess to Owner.

27.00 CONTRACTOR'S TERMINATION FOR CAUSE

27.01 If at any time during the performance of this contract (a) all work shall be stopped for a period of three (3) months because of Owner's election to cease or postpone the work or because of action by any public authority for which neither Contractor nor any of its employees is responsible, or (b) if Owner shall fail to pay to Contractor any sum of money within thirty (30) days after it is due and payable, Contractor may, upon written notice to Owner, terminate the contract. In the event Owner shall correct the situation which has caused the notice of termination to be given by Contractor within the period of fifteen (15) days from the date of receipt of such notice, the cause of termination shall be deemed waived, and the contract shall continue in effect in the same manner as though such cause of termination had not existed, Contractor, however, reserving its right to damages for breach of any provision of this contract.

27.02 In the event of termination of the contract as provided in this Section 27.00, Contractor shall be entitled to a complete settlement of all claims on the same basis as provided in Section 25.02.

28.00 INDEMNIFICATION

Contractor shall indemnify, defend and hold harmless Owner, its officers, employees and agents, from and against any and all claims and demands, including costs, litigation expenses, counsel fees and liabilities incurred in connection therewith, arising out of injury to, or death of, any person whatsoever or damage to property of any kind by whomsoever owned, caused in whole or in part by the acts or omissions of Contractor, any subcontractor, or any other person directly or indirectly employed by them, or any of them, while engaged in the performance of the work or any activity associated therewith or relative thereto.

29.00 INSURANCE

29.01 Contractor shall maintain insurance which will insure the performance by Contractor of his obligations to indemnify and hold harmless, as previously stated, and protect Owner from claims under Workers' Compensation and Occupational Diseases Act.

29.02 Such insurance shall be for not less than the following minimum limits of liability:

a. Workers' Compensation and Occupational Disease Insurance and U. S. Longshoremen & Harbor Workers' Compensation Insurance (where required) - Statutory Limit.

b. Employer's Liability Insurance - $100,000 per person.

c. Comprehensive General Liability Insurance including Products - Completed Operations and Broad Form Contractual Liability:

Bodily Injury	$1,000,000 per occurrence.
Property Damage	$1,000,000 per occurrence.

d. Automobile Liability Insurance:

Bodily Injury	$ 500,000 per person.
	$1,000,000 per occurrence.
Property Damage	$1,000,000 per occurrence.

29.03 Contractor's Comprehensive General Liability policy shall be endorsed in such manner as to provide primary insurance coverage for Owner for any claims which may arise from and during performance of the work. This shall be accomplished by naming Owner as an additional insured under Contractor's policy. In lieu of such endorsement Owner will accept an Owners' and Contractors' Protective Liability Policy.

29.04 Contractor shall, not less than seven (7) days prior to the start of work at the site, submit to Owner's Representative:

a. Duplicate copies of certificates of insurance with respect to Contractor's obligations as set forth in Sections 29.01 and 29.02. Such certificates shall include provisions that no material change or cancellation of the policy will be made without ten (10) days' prior written notice to Owner's Representative: and,

b. A copy of the endorsement to Contractor's Comprehensive General Liability policy which names Owner as an additional insured or the original of the applicable Owner's and Contractor's Protective Liability policy as set forth in Section 29.03.

29.05 It is Contractor's responsibility to determine the adequacy of the subcontractors' insurance and indemnification obligations.

30.00 FIRE & E.C. AND D.I.C. INSURANCE

30.01 On the entire structure on which work is to be done including all materials, equipment and supplies stored at the site which are intended to become part of the permanent structure and including work performed thereon and Contractor's interest in such values, Owner will effect and maintain Fire and Extended Coverage (Fire & E.C.) insurance at 100% of insurable value and Difference in Conditions (DIC) insurance for $15,000,000 subject to normal exclusions under such DIC insurance, but covering water damage, flood, earthquake and collapse.

30.02 DEDUCTIBLE APPLICABLE TO CONTRACTOR: The first $1,000 of any loss or damage caused by Fire & E.C. perils, to the structure, materials, equipment and/or supplies stored on site which are intended to become part of the permanent structure shall be for the account of Contractor. Any loss caused by DIC perils shall be for the account of Owner (no deductible applicable to Contractor).

30.03 EXCLUSIONS APPLICABLE TO CONTRACTOR: Insurance provided under Section 30.01 will not cover loss or damage caused by:

a. Theft

b. Exposure to normal elements of the weather

c. Acts, negligence or failure of Contractor to provide reasonable precautions or care

Said insurance will not cover temporary structures, tools owned by mechanics, tools, equipment, scaffolding, stagings, towers or forms owned, rented or leased by Contractor, or any other items which are not intended to become part of the permanent structure.

30.04 WAIVER: Owner hereby extends to Contractor, and hereby authorizes Contractor to extend to subcontractors, waiver of subrogation rights by Owner's Insurance carrier(s) in connection with losses or damage incurred which are caused by perils covered by Owner's insurance policies.

30.05 Any loss is to be made adjustable with and payable to Owner, who will make all settlements for loss with Contractor.

31.00 LIENS

31.01 Contractor agrees to remove immediately any lien or encumbrance which, because of any act or default of Contractor or his subcontractors, materialmen or employees is filed against the premises; and to indemnify and save Owner harmless against all resulting loss and expenses including litigation expenses and counsel fees. Contractor further agrees that as much of the monies due under the contract as may be considered necessary by Owner, may be retained by Owner until all such suits, claims for damages, or expenses as aforesaid shall have been settled or paid.

31.02 Contractor shall submit a waiver of his lien for material and labor with each application for partial payment. With the second and subsequent applications for partial payment, Contractor also shall submit waivers of lien for material and labor from each subcontractor as of the date of the last prior application for partial payment. In addition, Contractor shall include an affidavit, in a form satisfactory to Owner, stating the amounts due or to become due each person, firm, or corporation furnishing material and/or labor for the work. All waivers shall be duly acknowledge, and all affidavits duly sworn to, before a notary or other authorized officer.

31.03 Prior to receiving final payment, Contractor shall deliver to Owner a complete waiver of all liens for material, labor and other charges arising out of this contract. Contractor shall include an affidavit, in a form satisfactory to Owner, stating the amounts due or to become due each person, firm or corporation furnishing material or labor for the work. All waivers shall be duly acknowledged, and all affidavits duly sworn to before a notary or other authorized officer.

31.04 If a subcontractor refuses to furnish a waiver of lien, Contractor may furnish a bond satisfactory to Owner to indemnify Owner against any lien.

32.00 PATENT, COPYRIGHT AND TRADE SECRET RIGHTS AND OBLIGATIONS

32.01 Contractor shall pay all royalties and license fees required under any patent, copyright or trade secret right owned by another pertaining to any process, system, machine, equipment, combination, material, or part specified by either party for the work.

32.02 Except as provided in Section 32.03, Contractor shall defend at its own expense all suits, actions, or proceedings brought against Owner for actual or alleged infringement or violation of any letters patent, copyright or trade secret because or on account of any system, machine, equipment, combination, material or part supplied by Contractor or its subcontractors pursuant to this contract or because of the use thereof or the use of any method normally practiced therewith, and Contractor further agrees to pay and discharge any and all judgments and decrees which may be rendered against Owner in any such suit, action or proceeding provided Contractor is given prompt notice and is tendered charge thereof. If in any such suit, said system, machine, equipment, combination, material, part, the use thereof, or the use of any method normally practiced therewith is held to constitute infringement and is enjoined, Contractor at its own expense shall either: (a) procure for Owner the free right to continue using said system, machine, equipment, combination, material, or (b) replace or modify such systems, machine, equipment, combination, material or part in a manner satisfactory to Owner so that it, or the method of its use, become noninfringing.

32.03 To the extent that Drawings or Specifications inherently and of necessity require Contractor to supply to Owner any system, machine, equipment, combination, material or part, the manufacture, method of use or sale of which actually or allegedly infringes any letters patent, copyright or trade secret, Owner undertakes and agrees to defend at its own expense all suits, actions or proceedings for such actual or alledged infringement, and Owner further agrees to pay and discharge any and all judgments and decrees which may be rendered in any such suit, action or proceeding provided Owner is given or has prompt notice and is tendered charge thereof, but such obligation by Owner to defend and to pay shall not apply to any such system, machine, equipment, combination, material or part if the Contractor has information that it or its method of use is covered by or infringes any letters patent, copyright or trade secret owned by another and fails to give such information promptly to Owner, or if Owner has notified Contractor, prior to accepting his Proposal, that such system, machine, equipment, combination, material, part or method is allegedly covered by or infringes any letters patent, copyright or trade secret owned by another.

33.00 WAIVERS

No waiver, modification or amendment of any term, condition, or provision of any Contract Document shall be valid or of any force or effect unless made in writing and signed by the parties to the contract, and specifying with particularity the nature and extent of such waiver, modification or amendment. The signing of such writing or writings in any instance or instances shall in no event be construed to be a general waiver, abandonment, modification, or amendment of any of the terms, conditions or provisions of the Contract Documents, but the same shall be strictly limited and restricted to the extent and occasion specified in such signed writing or writings.

34.00 LAW OF CONTRACT

The laws of the state in which the work is to be performed shall govern the interpretation, validity and effect of the contract.

SEQUENCES AND RESTRAINTS

SEQUENCES AND RESTRAINTS

1.00 RESTRAINTS

1.01 Work under this contract in the first floor truss space over production areas must be performed to minimize disruption of Owner's production activities and to protect Owner's machinery and material. The Contractors and Subcontractors will be required to work after 3:00 p.m. and before 7:00 a.m. on weekdays and any time on Saturday or Sunday in production areas. The Contractor and Subcontractors will be required to cover the Owner's machinery and material for protection from overhead work to the satisfaction of the Owner's Representative.

1.02 Work under this Contract in construction areas must be performed in such a manner and at such times to not interfere with other contractors or the Owner's installation crew working in construction areas.

1.03 Interruptions to established utilities will be limited to Sundays only. Written prior notice must be given to the Owner and accepted by the Owner before utility interruptions are scheduled.

1.04 Schedules for work in Owner occupied bays must be submitted to the Owner in writing two (2) weeks in advance and accepted by the Owner before such work is begun.

2.00 SECOND FLOOR ACCESS

2.01 The Contractor may use the North and South Blockhouse elevators to move equipment and material to the second floor level. Maximum loading is <u>20,000 pounds</u>. The Owner will maintain the elevators in a reasonable manner. If the Contractor plans to utilize the elevators, the Contractor will assume full risk for delays should the elevators become inoperable or are judged unsafe by the Owner's Representative.

INVOICE AND ACCOUNTING REQUIREMENTS

SCHEDULES AND REPORTS

SCHEDULES AND REPORTS

1.00 CONSTRUCTION SCHEDULING

1.01 Contractor will be required to employ the arrow diagram method of scheduling and reporting the work under this contract.

1.02 Within 30 days after Owner's acceptance of the Proposal, Contractor shall prepare and submit for Owner's Representative's approval, a complete time oriented construction schedule showing in graphic form the logic for all significant activities including, but not limited to, fabrication and delivery of materials and equipment, on-site operations to be performed by Contractor's own forces, subcontractor's forces, and other contractual activities supplied by Owner. Duration of each activity shall be expressed in calendar days and the activities shall specifically show interrelation of interfaces and restraints. Each activity shall have a separate identification number for start and completion.

1.03 After Owner's Representative has reviewed and evaluated the construction schedule, he may request Contractor to complete or modify portions of the schedule prior to his approval. Contractor shall provide two copies of the approved schedule to Owner's Representative.

1.04 Contractor shall also maintain an approved construction progress schedule at the job site. The schedule shall be updated regularly by Contractor so as to maintain an effective plan for accomplishing the work. The actual percentages and scheduled percentages of completion for each activity shall be posted on the schedule throughout the duration of the job and shall be updated consistent with the updating of the schedule. Contractor shall provide two copies of all updated schedules to Owner's Representative.

1.05 Within 30 days after Owner's acceptance of the Proposal, Contractor shall also submit to Owner's Representative for approval, a list of all proposed manufacturers and suppliers Contractor and subcontractors intend to engage for the work. The format for this list shall be arranged to include the applicable section number and title of the Specifications for each manufacturer and supplier. After approval, Contractor shall not deviate from the approved list without first seeking written permission from Owner's Representative.

1.06 Within 60 days after Contract Award, Contractor shall submit a schedule of specific target dates for the submission and return of shop drawings required by the Contract Documents. This schedule of dates shall be consistent with and comply with the overall construction schedule prepared by Contractor.

SCHEDULES AND REPORTS

2.00 CONTRACTOR'S REPORTS

2.01 Contractor shall submit to Owner's Representative a Daily Progress Report for each day he and/or his subcontractors have personnel on the job site. Included on the report will be Contractor's name, building designation, temperature, weather conditions and additional comments required for clarification. Total manpower shall be allocated to the nearest manday by trade and general description of the work being performed.

2.02 Twenty-four (24) hours prior to Contractor's weekly scheduled job progress meeting, Contractor shall submit a weekly progress report to Owner's Representative in a form agreed upon between Contractor and Owner's Representative which shall include the following:

a. The scheduled activities completed during the previous week.

b. The scheduled activities to be started during the current week, including the activities carried over from the previous week. and the estimated working days required to complete the activities in the current week.

c. Activities to be started in the week after the current week including the estimated working days to complete.

FIRE PREVENTION

FIRE PREVENTION

1.00 FIRE PRECAUTIONS

1.01 Contractor shall take necessary actions to eliminate possible fire hazards and to prevent damage to any construction work, building materials, equipment, temporary field offices, storage sheds and all other property.

1.02 During the construction, Contractor shall provide the quantity of fire extinguishers and hose to meet safety and fire prevention practices established under N.F.P.A. Standard #241.

1.03 Welding, flame cutting or other operations involving the use of flame, arcs or sparking devices, will not be allowed without adequate protection. All combustible or flammable material shall be removed from the immediate working area or, if removal is impossible, all flammable or combustible materials shall be protected with suitable noncumbustible shields to prevent spark, flames, or hot metal from reaching the flammable or combustible materials.

2.00 FLAMMABLE MATERIALS

2.01 Not more than one day's supply of flammable liquids such as oil, gasoline, paint or paint solvent shall be brought into the building at any one time. All flammable liquids having a flash point of 110 degrees F or below which must be brought into the building shall be confined in Underwriters' Laboratories labeled safety cans. If one day's supply requires quantities greater than a safety can will hold, one 55 gallon drum may be used. Drums are to be equipped with safety bungs and U.L.-listed pumps. The bulk supply of all flammables shall be stored at least 75 feet from the building or other combustible materials. Spigots on drums containing flammable liquids are prohibited on the project site.

2.02 Flammable building materials located inside the building shall be kept to an absolute minimum.

2.03 Oil-soaked rags, papers, and other combustible debris shall be removed from the building at the close of each day's work. This material shall be stored in a suitable approved area away from all buildings and hauled away prior to reaching large accumulations. Burning of debris and rubbish on the site is not permitted.

2.04 Materials and/or equipment stored within the building in cardboard cartons, wood crates or other combustible containers shall be stored in an orderly manner and accessibly located. Fire fighting equipment of approved types shall be placed in the immediate vicinity of any materials or equipment stored in this type of crate or carton.

2.05 No gasoline, benzine or like combustible materials shall be poured into sewers, manholes, or traps.

FIRE PREVENTION

3.00 COMPRESSED GAS CYLINDERS

3.01 The following rules and regulations shall apply to the operation and maintenance of all gas welding and cutting, brazing, flame heating, flame hardening, soldering, and similar operations to guard against and eliminate all possible hazards and to prevent damage.

a. The gases used for welding and cutting shall be purchased in cylinders. These cylinders shall be constructed and maintained in accordance with regulations of the U.S. Department of Transportation. The cylinders shall bear DOT markings and the contents of each cylinder shall be legibly marked in large letters.

b. Cylinders of oxygen and acetylene inside buildings shall be stored in areas that are well ventilated and free from moisture or water.

   Flammable substances, such as oil and volatile liquids, shall not be stored in the same area. The area assigned to cylinder storage shall be well protected by location from possible damage by other types of activity. Oxygen cylinders stored inside shall be separated by a fire-resistant partition from cylinders containing flammable gases.

c. Cylinders of oxygen and acetylene are to be protected from the hot sun by such means as canopies and/or sheds. Cylinders shall have valves and safety devices protected from snow and ice.

d. To avoid confusion, full cylinders and empty cylinders should be stored in separate groups. All empty cylinders shall be marked "Empty" or "MT."

e. Flammable gas, such as acetylene, and other gases shall not be premixed with air or oxygen, prior to consumption, except at burner or in a cutting or welding torch designed for that purpose.

f. Oxygen and acetylene shall be withdrawn from cylinders provided with regulators and/or pressure-reducing valves specifically designed for such purposes.

g. All cylinders shall be set in a vertical position in portable carts when in use and shall be fastened to insure against tipping.

4.00 GENERAL RULES

4.01 Heaters in field offices or storage sheds shall have fire resistant material underneath and at sides near partitions and walls. Pipe sleeves and noncombustible coverings shall be used where flue pipes penetrate wall or roof, with 6-inch clearance provided.

FIRE PREVENTION

4.02 Contractor's site offices, trailers, or sheds shall not be placed within the building structure. They shall be located at least 75 feet from the building.

4.03 Tarpaulins used for temporary enclosures or other purposes shall be flameproofed by an approved process before delivery to the job, and shall be reprocessed during the progress of the work as required. Polyethylene may be used to provide temporary enclosures where designated by Owner's Representative.

4.04 Employees' vehicles shall not be allowed to park within the building. Trucks and other motor vehicles used in connection with the construction of the project shall not be parked within any building at any time except when construction is in progress and the operator responsible for the vehicle is present.

SUBMITTALS

SUBMITTALS

1.00 DEFINITION

1.01 Submittals are defined as shop drawings, samples, catalog cuts or other data pertaining to the construction of the project which the Contractor is required by Contract Documents to submit to Architect/Engineer and/or Owner's Representative for approval.

2.00 GENERAL

2.01 Reference is made to Section 1.03, Schedules and Reports, for required listing of scheduled dates for submission and return of all submittals.

2.02 After award of contract, Owner will provide Contractor with flow charts for the method of handling all submittals.

2.03 Submittals shall be scheduled to permit Architect/Engineer and/or Owner not less than 15 working days for review without causing any delay in the performance of the work by Contractor or any subcontractor. A copy of each letter transmitting submittals to Architect/Engineer for approval, but not copies of the submittals, shall be furnished simultaneously to Owner's Representative.

2.04 Contractor's transmittal shall contain the following information:

a. Manufacturer's name,
b. Specification Section, page and article
c. Name of item on submittal

2.05 Any fabrication, erection, setting or other work done in advance of "approved" or "Approved as noted" submittal shall be done entirely at Contractor's risk. Review of submittal by the Architect/Engineer and/or Owner will be made only for general arrangement, appearances, and conformity to the intent of the design.

2.06 The Contractor shall keep available for use at the job site a copy of each approved submittal.

2.07 Refer to Section 15.01, General Mechanical Requirements, and Section 16.01, General Electrical Requirements, for specific requirements for mechanical and electrical work.

SUBMITTALS

3.00 SHOP DRAWINGS, CATALOG CUTS, SCHEDULES, ETC.

3.01 The submission of submittals shall be by means of a single reproducible copy of each of Contractor's tracings. All sheets of submittals shall have a blank area (8" x 3") adjacent to the title block where "approval" or "resubmit" notations may be indicated. If reproducibles of catalogs or cuts and similar material are not available, Contractor shall furnish five (5) copies. All reproducibles or copies shall be labeled giving the name of the project, name of Architect/Engineer, name of Contractor and subcontractor, specification section, page and article, plus manufacturer and trade name. Submittals showing more than one size or model shall be marked to indicate the proposed equipment. Each submittal shall have evidence of Contractor's review and approval.

3.02 Submittals shall be fully detailed and dimensioned for the work descfibed in these Contract Documents.

3.03 After having been reviewed, each reproducible tracing or one copy of any printed material submitted shall be returned to the Contractor marked "Approved", "Approved as Noted", "Revise and Resubmit", or "Not Approved". If marked "Revise and Resubmit" or "Not Approved", the Contractor's original drawing shall be revised and resubmitted for approval to the Architect/Engineer.

4.00 REPORTS/WARRANTIES/CERTIFICATES/AFFIDAVITS/INSTRUMENTATION MANUALS

4.01 Contractor shall submit all warranties, certificates, affidavits, etc., as required by the specifications to Owner's Representative.

TEMPORARY FACILITIES

TEMPORARY FACILITIES

1.00 SCOPE OF THE WORK

1.01 The Contractor shall furnish, install and maintain temporary facilities as hereinafter defined and remove all such facilities promptly upon completion of construction or when directed by Owner's Representative.

2.00 CONTRACTOR'S AREA

2.01 The Contractor's employees shall park in the Contractor's parking lot at the Contractor's gate. The Contractor's construction storage and construction field offices will be as agreed to by Owner's Representative. Maintenance of these areas shall be the responsibility of the Contractor. Upon completion of the work, the Contractor shall restore the areas to original condition unless specifically directed otherwise by Owner's Representative.

3.00 CONTRACTOR'S TEMPORARY STRUCTURE

3.01 The Contractor's trailers, field offices, sheds and all required temporary structures for the Contractor's employees, material or equipment services shall be constructed and maintained to provide a safe work area and present a neat appearance at all times.

4.00 TOILET FACILITIES

4.01 The Contractor can use existing plant sanitary facilities for all persons engaged in the work. The Contractor will bear the cost of clean-up if the Contractor's employees track debris into the toilet facilities beyond normal wear and tear.

5.00 TEMPORARY UTILITIES

5.01 The Contractor shall provide, maintain and service the following temporary utilities including all distribution systems complete with piping, valves, hoses, wiring, outlets, fixtures, fuses, transformers, etc. Removal of all temporary utility systems shall be by the Contractor at the completion of the work or as directed by Owner's Representative.

a. The Contractor shall secure and provide telephone service for his use.

b. The Owner will supply domestic water for the Contractor's use at no cost. The water connections are 2 inch valved outlets in the first floor truss area in every second Bay.

TEMPORARY FACILITIES

5.01 Cont.

c. The Owner will provide 120V, 1Ø and 480 Volt 3Ø power at no cost to the Contractor. The 120 Volt will be from three wire twist-lock outlets at various locations. The 480 V will be from the first floor overhead bus in every second Bay. The Owner will supply up to a 100 amp bus plug for the 480V temporary service.

5.02 All other utilities required for the work shall be furnished by the Contractor.

6.00 TEMPORARY ENCLOSURES

6.01 The Contractor shall provide and maintain temporary weathertight, dust-tight enclosures as required to protect all parts of the work, including material and equipment stored on the site, against damage during construction. In addition, temporary partitions shall be constructed as shown on the Drawings to separate the construction areas from Owner's existing plant operations.

7.00 TEMPORARY LIGHTING

7.01 The Owner's standard plant lighting will be available on the first floor.

7.02 The Contractor shall provide and maintain any additional temporary lighting as required for safe, efficient execution of the work. Such temporary lighting system shall be in accordance with all applicable codes and regulations.

8.00 ROOF PENETRATION COVERING

8.01 All roof penetrations shall be made watertight each day before the Contractor leaves the site. If rainfall occurs during construction activities, the Contractor shall take steps as agreed by the Owner to protect the Owner's machinery and materials.

MISCELLANEOUS REQUIREMENTS

MISCELLANEOUS REQUIREMENTS

1.00 SITE MAINTENANCE

1.01 Contractor is responsible for site maintenance. All areas of the site are to be maintained in a neat, orderly manner. Debris will not be allowed to remain on-site and shall be disposed of by Contractor off-site as it accumulates.

2.00 OWNER'S CONVENIENCE

2.01 The Contractor shall so conduct his operations on the Owner's property as to cause the minimum disruption to the traffic entering the plant through the main gate. Precision manufacturing operations are in process within the building. The Contractor will conduct all his operations, including demolition, so that no dust or other airborne contaminants can leave the construction area. Contractor's operations which, in the opinion of the Owner's Representative, either obstruct traffic or jeopardize plant operations, shall immediately cease. The Contractor's operations shall be altered, or additional precautions shall be taken to correct the situation, to the satisfaction of the Owner's Representative at no additional cost to the Owner.

3.00 DISPOSAL OF MATERIAL

3.01 Material and equipment dismantled, or demolished and not indicated in these documents or the contract drawings to be reinstalled or delivered to Owner, will become the property of the Contractor and shall be disposed of by him. Debris and other scrap materials shall be removed from the job site and disposed of in a manner which complies with all local, state and national regulations.

4.00 CONTRACTOR'S ENTRANCE GATE AND IDENTIFICATION

4.01 The Contractor and his employees shall enter and leave the Owner's property through the "Contractor's Gate". The Owner's Security Officer will issue identification badges at the start of each work day and collect badges at the end of each work day. Badges not returned for five (5) calendar days will be assumed lost and the Owner will deduct one dollar ($1.00) for each missing badge from the Contractor's next billing. The badges must be worn by the Contractor's employees. The Contractor's Gate will open on week days from 7:30 a.m. to 3:30 p.m., except holidays. If entrance or exit is required at other times, arrange in advance with Security or the Owner's Representative.

4.02 Personal vehicles belonging to the Contractor or his employees shall not be parked within the Secure Area. Personal vehicles will be parked in the Contractor's parking lot. The Secure Area includes all of the Owner's property within the Security fence.

MISCELLANEOUS REQUIREMENTS

4.02 The number of the Contractor's company vehicles allowed within the Secure Area of the premises shall be limited to pick up or delivery of materials, tools, or personnel; and to those vehicles actively engaged in the construction activity. Idle vehicles will be removed to the Contractor's parking area. Specialized equipment may be left inside the Secure Area or building if properly secured. One additional supervisor's vehicle may be in the Secure Area during the Contractor's working hours. Fueling of Contractor's equipment is governed by Section 1.04 of these Specifications.

5.00 OWNER'S STORED MATERIALS

5.01 All movable materials or products belonging to Owner and situated or stored along the route or at location of work will be removed by Owner without cost to the Contractor. Contractor shall notify Owner's Representative not less than one week prior to need for Owner material to be moved.

6.00 SITE ACCESS AND ROADWAYS

6.01 Contractor shall have access to site only where shown on site diagram, and as directed by Owner's Representative.

6.02 Contractor shall coordinate all construction activities to permit travel of normal plant traffic throughout plant site. Any cuts in existing plant roads shall be maintained by Contractor in a safe condition to permit a minimum of one-way traffic on all plant roads at all times.

6.03 Owner's existing plant roads which are used by Contractor shall be maintained and kept free of all Contractor's debris and materials as directed by Owner's Representative. Contractor will be subject to Owner's traffic and safety regulations when using plant roads. Maximum speed limit is 10 MPH.

7.00 USE OF PREMISES

7.01 Contractor shall confine his operations within the Construction Area as shown on the Drawings and as defined by Owner's Representative.

7.02 Contractor shall instruct his workmen and subcontractors that access to all buildings belonging to Owner, except as required for the work of this Contract, is strictly prohibited unless otherwise authorized by Owner's Representative.

MISCELLANEOUS REQUIREMENTS

7.03 Contractor's employees shall not use Owner's existing canteen and lunch room.

7.04 Contractor may have temporary use of Owner's standard railroad facilities at the plant site for delivery of equipment and material. Use of the railroad shall be coordinated through Owner's Representative and shall not interfere with Owner's normal plant operations. Rail expenses for switching and handling of Contractor's deliveries to and within Owner's plant site shall be borne by Contractor.

8.00 MOVING MATERIALS, EQUIPMENT AND TOOLS

8.01 When it becomes necessary at any time during execution of the work to move materials or equipment which have been temporarily placed on site, Contractor shall, when so instructed by Owner, move them or cause them to be moved without cost to Owner.

8.02 Contractor's personnel shall obtain a gate pass to carry material, equipment, tools, personal property, scrap materials or Owner's property from site. The Contractor shall request the gate pass 4 hours in advance from the Owner's Representative.

9.00 CUTTING, DRILLING, AND PATCHING

9.01 Contractor shall do all cutting, drilling and patching of new and existing work that is necessary for its installation in accordance to Contract Documents.

9.02 All existing construction that is disturbed in the process of new construction shall be repaired or replaced in its original condition.

9.03 Cutting and drilling of structural steel members and cutting through floors, walls, footings and partitions shall not be permitted unless shown on the Drawings. When cuttint is necessary, it shall be done in a careful manner and under strict supervision of Contractor's Superintendent.

9.04 Holes caused by cutting through structural steel, masonry or other materials shall be patched or filled in with approved materials as instructed by Owner's Representative.

10.00 PERMITS AND FEES

10.01 All Building Permits, other fees, permits and licenses required for execution of work shall be secured and paid for by the Contractor.

11.00 ADDITIONAL REQUIREMENTS

11.01 Contractor's employees shall wear industrial safety glasses while working within Owner's existing buildings and where Owner's employees are present.

MISCELLANEOUS REQUIREMENTS

12.00 LABOR AGREEMENTS

12.01 Within thirty (30) days after Owner's acceptance of the Proposal, Contractor shall submit to Owner's Representative, pertinent data regarding all albor agreements which affect the work. Such data shall include, but not be limited to:

a. Date of expiration of agreement

b. Hourly and overtime rates of employees to be used on work.

c. Number of men per foreman.

d. Travel time benefits, if any, to employees.

e. Welfare charges.

12.02 Should any changes in these agreements occur during the course of the work, Contractor shall inform Owner's Representative immediately.

13.00 ORGANIZATION CHARTS

13.01 Within 15 days after Owner's acceptance of Proposal, Contractor shall submit to Owner's Representative two copies of an organization chart for his field personnel as well as two copies of an organization chart for the field personnel of both the mechanical and electrical subcontractors. These charts shall indicate the names and job functions and/or titles of all field supervisory, support and clerical personnel.

When significant changes occur, Contractor shall submit two copies of updated charts.

14.00 SITE MAINTENANCE

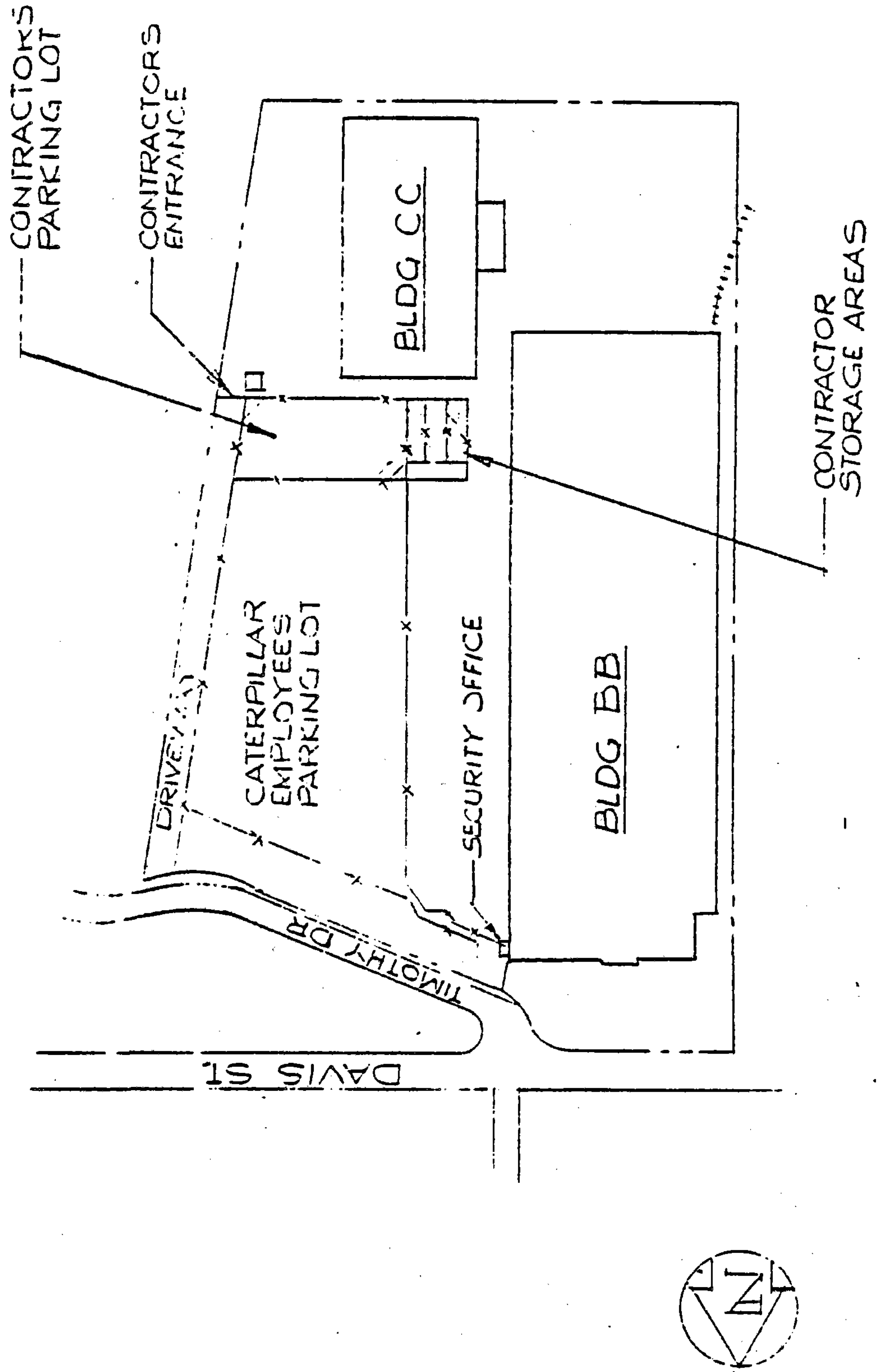
14.01 Contractor is responsible for site maintenance. All areas of the site are to be maintained in a neat, orderly manner. Debris will not be allowed to remain on-site and shall be disposed of by Contractor off-site as it accumulates.

15.00 RECORD DRAWINGS

15.01 Contractor shall furnish Owner with a complete set of "Record" Drawings at the completion of the Contract. These drawings shall be updates during the progress of the work by Contractor and his subcontractors as changes occur. Record Drawings shall consist of a set of Contract Drawings marked to show all changes made to the work of the contract and not shown on any bulletin, drawing or field sketch previously issued by the Architect/Engineer.

MISCELLANEOUS REQUIREMENTS

16.00 SITE DIAGRAM



SITE DIAGRAM

ALTERATION

ALTERATION

1.00 SCOPE OF THE WORK

Provide all labor, materials and equipment required to perform all alteration work in accordance with the Contract Documents, including the following:

a. Alteration work required to expand and/or modify the existing structure including cutting of openings, pockets, chases or depressions.

b. Alteration work involving materials classified as "Remove", "Relocate", "Salvage", or "Trash."

2.00 DEFINITIONS

2.01 "Remove" - Extract the item from its position. Dispose of the item as directed in compliance with the specified classifications.

a. Concrete and masonry shall be removed in small sections and dampened to keep down dust during removal.

b. After materials are removed, the structure to remain in place shall be inspected and Owner's Representative shall be notified of defects uncovered.

2.02
When procedure of the work prevents the immediate reinstallation of items specified or indicated as "Relocate", such items shall be protected, transported and stored until such time as reinstallation is possible.

In lieu of relocating an existing item, Contractor may provide a new item, subject to approval of Owner's Representative and classify the item to be relocated as trash.

2.03 "Salvage" - This term shall be applied to useful material or equipment which will not be reused as part of the project. Such material shall be dismantled to useable sizes, shapes or components, set up or packaged for storage as specified, and delivered to Owner on the site. Equipment shall be placed on wood skids for ease of handling. Removal of paint, degreasing or cleaning, except that required for normal handling, shall not be a part of this classification. Material and equipment salvaged from the operation shall remain the property of the Owner.

2.04 "Trash" - All unusable or unsalvable materials, such as used lumber, broken concrete, masonry, glass roofing and sheetmetal, pipe and steel, shall be classified as trash, become the property of the Contractor, be removed as the work progresses, and be disposed of off the site.

ALTERATION

2.05 Questions of classification shall be referred to the Owner's Representative for decision.

3.00 PERFORMANCE

3.01 No alternation work shall be performed without prior approval by Owner's Representative.

3.02 Alteration work shall be conducted carefully and only to the extent required with a minimum of noise, dust or other disturbance.

3.03 Remove all loose or damaged material caused by alteration or dismantling operations as well as that material noted in the Contract Documents.

3.04 Remove debris from the building by lowering in containers through enclosed chutes or by hoist. Do not drop debris free of restraining devices for a distance greater than ten feet.

3.05 Clean all floors, walls, ceilings, fixtures, etc., after alteration work in any area is completed and before any new construction is started.

3.06 Provide temporary support for services and equipment which are to remain in service and are presently attached to walls or structures to be removed in this contact. Remove temporary supports when so directed by Owner's Representative.

SAFETY

SAFETY

1.00 SCOPE

1.01 The Safety Section of these Specifications covers the basic safety procedures and rules to be followed by the Contractor while on Caterpillar property.

2.00 INTENT

2.01 It is the intent of this Specification that the Contractor so conduct his activities that all possibility of injury and damage to Caterpillar employees and property is eliminated.

3.00 GENERAL

3.01 The State of California, Division of Industrial Safety, General Industry Safety Orders, shall serve as the minimum safety standard unless specified otherwise.

3.02 Under no condition will the Contractor use Caterpillar owned tools, ladders, scaffolds or any other type of equipment in the performance of his work.

3.03 Contractor personnel shall wear safety glasses at all times while on Caterpillar property with the sole exception that safety glasses are not required when entering or leaving Caterpillar property at the begining or end of the work day.

4.00 APPLICATION

4.01 When the Contractor's work area includes a trucking aisle, the Contractor shall clear the work areas as described in Section 1.07, Article 5.01. However, the Contractor shall so schedule his work that no more than one half (1/2) of the aisle is blocked at one time. Traffic barriers shall be placed adjacent to the Contractor work area.

4.02 When working overhead, the Contractor work area shall include all areas below locations occupied or likely to be occupied by Contractor personnel.

5.00 FIRE AND BURN PERMIT

The Contractor will be required to obtain a daily fire or burn permit from the plant security office. Normally any time during, welding, or burning occurs, a fire watch will be required for each location when a permit is requested. Owner will supply a Security Guard to act as fire watch when required. The Contractor must give Owner's Representative 24 hours notice so a Security Guard can be scheduled for each area requiring a fire watch.

SECONDARY STEEL

SECONDARY STEEL

1.00 SCOPE OF WORK

1.01 Provide all labor, material, and equipment required to furnish, deliver and erect secondary steel, in accordance with Contract Documents.

1.02 The work shall include the following principal items:

a. Roof curb framing.

b. Girts, clips and sag rods.

c. Truss Reinforcement

d. Roof stair & observation Platform

e. Shop inspection.

f. Shop painting and field touch-up.

g. Structural steel items where so noted on the Drawings.

1.03 The furnishing and erection of primary structural steel, miscellaneous metals, and all finish painting is specified under other Sections of the Specifications.

2.00 APPLICIABLE STANDARDS

Secondary steel shall conform to the current following standards:

a. AWS D1.1 - American Welding Society - Structural Welding Code.

b. ASTM D2200 - Standard Pictorical Surface Preparation Standards for Painting Steel Surfaces.

c. American Institute of Steel Construction - Specification for Design, Fabrication & Erection of Structural Steel Buildings.

d. American Institute of Steel Construction - Code for Standard Practice for Steel Buildings and Bridges.

3.00 SHOP DRAWINGS

Submit shop drawings based on current AISC Specification and in accordance with Division I of these Specifications.

4.00 SHOP INSPECTION

4.01 It is expected that Contractor will perform his own quality control operations to ensure that all work is of acceptable quality.

4.02 In addition, all materials and workmanship shall be subject to inspection and test by Owner's Representative who shall have access to all parts of the shop where materials are being fabricated and be provided with reasonable inspection facilities. Material shall not be painted or shipped without a release from Owner's Representative, unless inspection is waived in writing.

4.03 Acceptance by Owner's Representative does not relieve Contractor from replacing or correcting any defective material or workmanship found later nor does it relieve Contractor from errors in dimensions or sizes of finished pieces.

4.04 Contractor shall be responsible for the cost of replacing rejected materials.

5.00 MATERIALS AND WEIGHTS

5.01 All structural steel shall conform to the requirements of ASTM A36 "Specification for Structural Steel, " unless otherwise indicated.

5.02 Material shall not be rolled from rejected new billets or from material previously rolled.

5.03 Material to be incorporated into the work shall be free from rust pitting visible to the naked eye. Rust Grade "D" steel as indicated in Steel Structures Painting Council's "Pictorial Surface Preparation Standards for Painting Steel Surfaces" will be rejected.

5.04 Weights for additions or deletions shall be computed in accordance with the American Institute of Steel Construction "Code for Standard Practice for Steel Buildings and Bridges."

6.00 MEASUREMENTS

6.01 Contractor shall verify all dimensions given on Drawings and shall make such field measurements as are necessary to lay out the work properly.

6.02 Contractor shall be fully responsible for accuracy of all measurements and lay out of the work.

7.00 BURNING

Burned members shall be finished to an acceptable appearance equivalent to that of a sheared finish. Burning of holes will not be permitted either in the shop or in the field.

8.00 CONNECTIONS, FITTINGS AND DETAILS

8.01 Connections of main members shall be detailed as indicated on the Drawings. Connection details not shown shall be designed to support half of the total uniform load capacity of the member for the shape, span and steel specified. The effect of concentrated loads must also be accounted for.

8.02 Bracing members connections shall develop at least 50 percent of the strength of the member, but not less than 10,000 lbs. All bolted connections shall have not less than two bolts.

8.03 All shop connections may be welded or high strength steel bolted unless otherwise noted or specified. Field connections shall be high strength steel bolted. Bolting shall be used where holes are indicated on the primary steel drawings. All field welding shall be approved by Owner's Representative, unless shown on Drawings.

8.04 Only light drifting will be permitted to draw parts together. Drifting to match unaligned holes will not be permitted. Any enlargement of holes necessary to make connections shall be done by reaming and twist drills, and the proper size bolts used.

8.05 Provide "draw" (tautness) in all tension bracing.

9.00 CONNECTIONS FOR OTHER WORK

Contractor shall make provisions for other work where details of connections are made available prior to fabrication. These connections shall be open holes, unless shown otherwise.

SECONDARY STEEL

10.00 HIGH STRENGTH STEEL BOLTING

10.01 All bolting materials, design and fabrication shall be in accordance with the "Specifications for Structural Joints Using ASTM A325 Bolts," as approved by the Research Council on Riveted and Bolted Structural Joints, of the Engineering Foundation, unless otherwise indicated.

10.02 High strength bolted connections shall be bearing type. Design shall be based on allowable stress with threads in the shear plane. All high strength bolts shall have hardened washers under the turned element.

11.00 WELDING

11.01 All welding whether shop or field shall be by the electric-arc method. Field welders shall be qualified for the type of work involved by means of qualification tests, review of qualification records or other evidence acceptable to Owner's Representative.

11.02 Qualification tests, when required by Owner's Representative, shall be at the Contractor's expense.

11.03 Edges and ends of pieces to be joined by other than fillet welding shall be beveled, grooved or otherwise prepared by planing, grinding or gas cutting method.

11.04 Precautions shall be taken in making continuous welds to avoid distortion of the member due to the welding operation. Unless otherwise approved on basis of results obtained through the use of automatic equipment, continuous welds shall be made up of intermittent welds spaced to prevent excessive heating of the metal and joined into a continuous weld by filling in between intermittent welds with a series of short welds.

11.05 Welds shall be solid and homogeneously a part of the metals joined and free from pits or incorporated slag or scale. Weld splatter shall also be removed from adjacent areas.

11.06 Surfaces of welds shall be uniform and regular and shall be full area indicated or required to develop the necessary strength of the joint.

11.07 Welding shall be in accordance with the requirements of the current "Structural Welding Code, AWS D1.1." E60XX electrodes conforming to AWS A5.1 or A5.5 shall be used for shielded metal-arc method and F7X-E flux-electrode combination conforming to AWS A5.17 for submerged-arc method.

SECONDARY STEEL

12.00 COLUMNS AND BASE PLATES

12.01 Columns shall have milled bottom surfaces and shall be assembled to base plates prior to erection. Base plates shall be true on all metal to metal contact surfaces. Bolt holes shall be 1-1/3 times the anchor bolt diameter.

12.02 Set columns plumb and shim base plates to required elevation.

12.03 Clean all dirt and foreign matter from piers, anchor bolts and base plates and grout with non-shrink grout in accordance with grout manufacturer's directions.

13.00 OMITTED

14.00 BRACING AND STRUTS

14.01 Bracing and struts shall be of rolled sections of the sizes shown. Bracing, in general, shall consist of single angles or tees, as indicated, with plane of bracing kept as near the tops of beams and trusses as is practicable.

15.00 STEEL ERECTION

15.01 Secondary steel shall be set accurately to the lines and elevations shown on Drawings. Members shall be connected temporarily with sufficient bolts to insure safety of the structure until permanent connections are made. Columns shall be erected in place on the foundations, securely braced and guyed, and held plumb and in line until after connections have been completed.

15.02 Connection shimming shall be limited to 1/4 inch. Erection of steel in temperatures more than ± 20 degrees from a norm of 70 degrees shall be adjusted to achieve plumbness at 70 degree conditions.

15.03 If members do not fit properly in the field, any new necessary holes shall be drilled. Cutting with torch will not be allowed in the primary steel except where specifically approved by Owner's Representative. Misfit holes shall be plug welded prior to drilling of new holes.

15.04 Warped or bent members shall be straightened to the approval of Owner's Representative or shall be replaced with new material before being erected.

15.05 All high strength bolts shall be tightened with compressed air powered standard impact wrenches with a minimum pressure of 90 PSI at the wrench for 7/8 inch or smaller bolts. For bolts larger than 7/8 inch, the required minimum air pressure will be the greater of the following:

a. 90 PSI or

b. that recommended by the bolt manufacturer.

15.06 Contractor shall provide a bolt tension calibrator for the use of his personnel in checking bolting procedures, and for Owner's Representative for inspection of bolted connections.

15.07 Owner recommends the use of the "turn of the nut" method. Wrench sockets shall be marked at ninety degree intervals for proper measurement of nut rotation.

15.08 If the "turn of the nut" method is used, Contractor shall at the start of bolting and occasionally thereafter verify by checking in the bolt tension calibrator that his bolting crew's execution of this method produces the required minimum bolt tension.

15.09 If Contractor elects to use the calibrated wrench method, the wrenches used shall be calibrated at least once each day by tightening not less than three typical bolts of each diameter from the bolts being installed.

15.10 All high strength bolts shall have hardened washers under the turned element and shall be tightened progressively away from the fixed or rigid points toward the free edges. Nut rotation, required fastener tensions and all other items not covered by these Specifications shall be in accord with the current edition of the Specifications for Structural Joints as approved by the Research Council on Riveted and Bolted Structural Joints of the Engineering Foundation.

16.00 SURFACE PREPARATION AND SHOP PAINTING

16.01 Thoroughly clean all structural steel in accordance with the Steel Structures Painting Council Specification SP6 (commercial blast cleaning). Acceptance criteria for cleaning shall be in accordance with the "Pictorial Surface Preparation Standards for Painting Steel Surfaces" approved by SSPC and ASTM D2200.

Pre-Cleaning Condition	Final Acceptance Criteria
A & B	B SA2
C	C SA2

16.02 After cleaning all steel shall be given one shop coat of gray primer applied to produce a minimum dry thickness of 2.5 mils of one of the following: Mobil No. 13-F-25, Rust-Oleum No. 7086, or Tnemec No. 1009.

16.03 Surfaces to be painted shall be thoroughly dry immediately before paint is applied. All surfaces not in contact but inaccessible for painting after aseembly shall receive a second coat of the same primer before assembly. Surfaces in contact after assembling or surfaces to be embedded in concrete need not be painted. Paint shall not be applied when the temperature is below 40°F.

16.04 After erection, Contractor shall clean all abraded or damaged painted surfaces and give such surfaces and all unpainted surfaces one coat of primer.

16.05 All steel erected under this Section shall be cleaned of any dirt, mud, or grease and left in a condition to receive finish paint coats.

MISCELLANEOUS METALS

MISCELLANEOUS METALS

1.00 SCOPE OF WORK

Provide all labor, materials and equipment required to furnish and install all miscellaneous metals in accordance with the Contract Documents.

2.00 APPLICABLE STANDARDS

Miscellaneous metals shall conform to the following standards:

a. Structural steel shapes & plates: ASTM A283 or ASTM A36
b. Metal pipe: Schedule 40 ASTM A120 or ASTM A53 Grade B.
c. Structural steel tubing: ASTM A500 & ASTM A501, 3/16 inch minimum wall thickness.
d. Fabrication & erection: NAAMM current standards & specifications.
e. Steel welding: AWS, Standard Code for Arc & Gas Welding in Building Construction.
f. Bolts for steel work: ASTM A325, for high strength bolts
g. Steel galvanizing: ASTM A123 hot dip galvanizing zinc coatings on products fabricated from rolled, pressed and forged steel shapes.
h. Metal Bar type grating: NAAMM Metal Bar Grating Manual, fabrication.
i. Design of cold formed steel structural members: AISI, Limit of defection, L/120.
j. Connections of main steel members: AISC standard connections.
k. Preparation for painting steel: Steel Structures Painting Council Specifications SP-1.

3.00 SUBMITTALS

3.01 Submittals shall be in accordance with Division I of these Specifications.

3.02 Submit shop and erection drawings showing methods of fabrication, connections, locations, attachments, finishes and materials. Marked up copies of the design Drawings and catalog cuts will not be acceptable.

3.03 Submit notice when fabrications are ready for shop inspection.

4.00 SHOP INSPECTION

4.01 All materials and workmanship shall be subject to shop inspection and test by Owner's Representative.

4.02 Contractor shall be responsible for the cost of replacing the rejected materials.

5.00 MEASUREMENTS & INSPECTION

Contractor shall verify all dimensions given on the Drawings and shall make such field measurements as are necessary to lay out the work properly. He shall be fully responsible for the accuracy of all measurements and layout of the work.

6.00 FABRICATION

6.01 Workmanship

a. Fabricate and erect all work in accordance with current standards and specifications, subject to any required modification by these Specifications, the Drawings and/or local laws and codes.

b. Steel welding, whether shop or field, shall be done by certified welders using the electric arc method. Electrodes shall be E-60 or E-70.

c. All welds shall be solid, homogeneous, free from pits, slag or weld splatter. All exposed welds shall be ground smooth where required for appearance.

d. Insofar as possible, fit and assemble work in the shop prior to delivery. Field fitting should be kept to a minimum.

e. All workmanship must be first class in all respects and any members not representing a finished and workmanlike appearance will be rejected. All finished members shall be free from twists, bends, distortions or open joints.

6.02 Burning

Burned members shall be finished to an acceptable appearance which shall be equal in appearance to a sheared finish. Burning of holes will not be permitted either in the shop or in the field.

6.03 Connections, Fittings & Details

a. All details shall develop full strength of main members. However, all connections of main members shall be at least equivalent to an AISC standard connection. In bracing, the connection shall develop the greater of the following; the calculated force, 50% of the strength of the member, or 10,000 pounds.

b. Bolts for steel work shall conform to ASTM A325 "Specifications for High-Strength Bolts for Structural Steel Joints". Design shall be for bearing type connections with threads in the shear plane.

6.04 Surface Preparation & Shop Painting

a. Thoroughly clean all miscellaneous steel of loose mill scale, rust and dirt by wire brushing or similar means. Remove weld flux and spatter, grind smooth all sharp projections. Completely remove oil and grease with Stoddard Solvent, ASTM D484, or approved equal. All surface preparation work shall be in accord with Steel Structures Painting Council Specifications SP-1, 2 and 3. All surfaces to be painted shall be thoroughly dry immediately before paint is applied.

b. After cleaning all steel shall be given one shop coat of gray primer applied to produce a minimum dry thickness of 2.4 mils. Shop primer shall be one of the following: Mobil No. 13-F-814, Rust-Oleum No. 7086 or Tnemec No. 1009. All surfaces not in contact but inaccessible for painting after assembly shall receive a second coat of the same primer before assembly. Surfaces in contact after assembling or surfaces to be embedded in concrete need not be painted.

c. After erection all abraded or damaged painted surfaces, bolts, or other unpainted surfaces shall be cleaned and given one coat of shop primer.

d. All steel erected under this Section shall be cleaned of any dirt, mud or grease and left in a condition for receiving finish field coats of paint.

e. Interior aluminum top and intermediate handrails of all railings shall have a rubbed satin finish by sanding in one direction only, parallel to the length of handrail bar with #120, #240 and #320 grit. After installation handrail bars shall be polished with No. 0 steel wool, immersed in paste wax, then rubbed to a luster with a soft dry cloth.

7.00 INSTALLATION

7.01 All miscellaneous metal items shall be completely fabricated, include all parts and be complete with bolts, anchor clips, etc., ready for installation. All work shall be erected to the proper lines and elevations in correct relation to the adjoining work.

7.02 Methods of attachment of miscellaneous metal items shall be concealed wherever possible.

7.03 Throughout the work, anchors and inserts shall be provided wherever possible for building in the adjoining work. Where lugs are shown or specified for building into adjoining masonry, the parts having lugs shall be erected in place before the masonry is built. Elsewhere the work shall be brought to the facility in as large pieces as practicable and attached with anchors or inserts during the erection.

8.00 LOOSE LINTELS

8.01 Loose lintels shall be defined as lintels for all openings which are not a part of or bolted to primary or secondary steel members.

8.02 Loose lintels shall be provided for all openings as shown on the Drawings and for all masonry openings for ducts and similar items.

8.03 Unless otherwise shown lintels shall be standard structural shapes, selected for trueness of line, bearing 6 inches on each end for angles and at least 8 inches on each end for built-up members.

8.04 Size of lintels for each 4 inches of masonry thickness shall be in accordance with the following schedule, unless shown otherwise on the Drawings:

Opening Width in Feet	Member Size in inches
0-1 0-1	Use 1/4" steel plate
1-4	3-1/2 x 3-1/2 x 1/4" angle
4-6	5 x 3-1/2 x 5/16" angle (Long leg vertical)

9.00 STEEL FRAMING

9.01 Provide all miscellaneous metal framing where indicated on the Drawings for support of platforms, catwalks and grating.

9.02 Connections to primary and secondary building framing shall be as shown on the Drawings. Field welding will be permitted for connections not shown otherwise if properly detailed on the shop drawings and approved by the Architect/Engineer. All other connections shall be clamped.

10.00 METAL GRATING, BAR TYPE

10.01 Bar type grating shall be fabricated and installed in accordance with the NAAMM Metal Bar Grating Manual, unless otherwise shown on the Drawings.

10.02 Unless shown otherwise, steel grating shall be welded, with cross bars 4 inches on center and bearing bars 1-3/16 inch on center. Bearing bars shall have a minimum thickness of 3/16 inch. Ends of bearing bars shall be banded.

10.03 Anchorage of grating shall be by welding to supporting members or if grating is to be removable saddle clips and stud bolts shall be used.

10.04 Grating treads shall be in standard widths, with carrier plates and checkered plate nosings unless shown otherwise.

10.05 All cutouts shall be banded.

10.06 Grating shall be serrated or of definite non-slip design.

11.00 STEEL CURBS AND FRAMES

11.01 Provide steel curbs and frames, assembled from structural shapes, for openings in the floor and roof, for support of gratings, around dock levelers, at dock bumpers, at doors to buildings and wherever indicated on the Drawings.

11.02 Anchors for embedding in concrete shall be Nelson studs of the proper size and spacing.

12.03 Provide channel frames with angle rims for all gantry crane floor rails, as detailed on the Drawings.

12.04 Provide steel angle edging between wood block flooring and concrete floors. Angles shall be of sizes shown on the Drawings, set flush with the concrete floor finish and anchored with Nelson studs, spaced not more than 24 inches on centers.

13.00 STRUCTURAL STEEL DOOR FRAMES

13.01 Frames shall be fabricated from one piece structural members. Butt welding will not be permitted. Where lintels or jamb reinforcing members attach to the frame they shall be welded sufficiently to transfer horizontal shear and bending forces.

13.02 Sections shall be selected for trueness of web and flange so that the finished product is uniform, square and true.

13.03 All exposed welds shall be ground smooth, without cups or dipping. Joints exposed to the weather shall be continuous welded. Door stops shall be plug welded to the frames on 12 inch centers.

13.04 All frames except full bound frames shall be fitted with temporary spreaders to prevent springing out of shape prior to and during erection.

13.05 Where stops are required they shall be steel, sized 1/2 inch thick, with 5/8 inch thick stops used for fire doors.

12.00 PIPE RAILINGS

12.01 Pipe railings shall be standard black steel pipe, schedule 40, of pipe size shown on the Drawings, fabricated in flush welded construction. Weld elbows shall be used instead of mitered connections. Welds shall be ground or filed smooth and neatly filleted.

13.00 STEEL STAIRS

13.01 Fabricate and erect all steel stairs, complete with stringers, treads, risers, pans, platforms and all other parts indicated on the Drawings or specified herein, including structural supports, struts and hangers necessary for the work, and incidental thereto, unless otherwise noted.

13.02 All pieces entering into the stair construction, where exposed, shall be neatly finished and cut straight and square. All edges and ends shall be smoothly finished, equal to a sheared finish with sharp edges and corners ground smooth. Projecting bolts shall be limited to 1/8 inch out from the face of the nut.

13.03 Treads and risers shall be interlocking, formed from a minimum No. 12 gage sheet steel. Treads shall be designed for 2 inch thickness of concrete fill, with a formed sanitary bead at the intersection of tread line with riser. Stairs shall be laid out so that all treads are equal and risers are equal between floors. Nosing configuration shall be as shown on the Drawings.

13.04 Abrasive nosings when specified or shown shall be cast aluminum as manufactured by American Abrasive Metals or Wooster Products, Inc., and be bolted to the stair pan in an approved manner.

13.05 All stair fabrication work, such as cutting, drilling, tapping and fitting shall be done in the shop prior to field installation. No field cutting of structural members, slabs, masonry walls or finished work shall be done without prior approval of Owner's Representative. Where work is to be built into or attached to concrete or masonry, provide necessary anchors, inserts, or attachment in time for same to be built into place and supervise their placement to meet stair requirements.

MISCELLANEOUS METALS

13.06 In general, materials, fabrication and erection shall be the same for grating type stairs as specified for steel pan type stairs except that all grating treads shall be bolted to the stringers and have checkered plate nosings unless specified otherwise. Platforms need not have stringers extended as a base, but kick plates shall be provided as indicated on the Drawings.

13.07 All stairs shall be erected in place and secured to building construction in a substantial manner, with stringers true and parallel to each other and adjacent walls. Railings shall be installed straight, plumb and true with all connections concealed or ground smooth. Railings must be absolutely rigid.

ROOFING

ROOFING

1.00 SCOPE OF WORK

1.01 Provide all labor, materials and equipment required to furnish and install roofing, and all other work associated therewith in accordance with Contract Documents.

2.00 APPROVED MANUFACTURERS

Roofing materials shall be manufactured by one of the following:

The Celotex Corporation
J. & P. Petroleum Products Corp.
Johns-Manville
Koppers Company Inc.
Gibson-Homan Co.
Grefco Construction Fasteners, Inc.
Lexsuco Inc. (B.F. Goodrich)
Owens-Corning Fiberglas Corp.

3.00 APPLICABLE STANDARDS

Materials and methods shall conform to the following standards:

Factory Mutual Class I Construction.

UL for Fire Rated Roof Deck Constructions under Guide No. 360RO for use in roof deck construction Nos. 1 and 14.

Federal Specification SS-R-620B - glass fiber roofing felts
ASTM D 312 - Airblown Asphalt (steep)
Federal Specification SS-A-666 Type III Steep Asphalt
Federal Specification SS-C153 Type I Plastic Cement
ASTM Specification D2824 Type II Asphalt based Aluminum Roof Coating

4.00 AFFIDAVITS

4.01 Submit three copies of the following affidavit to the Owner's Representative.

4.02 The affidavit shall state that all materials and workmanship in connection with the specified work have been furnished and installed in compliance with the Drawings and Specifications.

5.00 WARRANTY

In accordance with the General Conditions, furnish a written warranty against defects in workmanship and materials for a period of two years after the date on which the completed work is accepted by Owner in writing.

6.00 MATERIALS

6.01 Built-up roofing and composition flashing materials including primers, bitumens, felts, surfaced cap sheets, and flashing cements shall be the products of, or approved by, the manufacturer of the built-up roofing and composition flashing used.

6.02 Roof tape shall be glass fiber reinforced roof tape, Type B, 6 inches wide manufactured by Owens-Corning Fiberglas.

6.03 Glass Fiber Roofing Felts for flashing and roofing shall be Perma Ply R, as manufactured by Owens-Corning Fiberglas.

6.04 Asphalt: Airblown steep asphalt manufactured specially for roofing purposes and complying with the current edition or latest revision of ASTM Specifications D 312 or Federal Specification SS-A666, Type III, shall be used.

6.05 Base flashing shall be KMM aluminum as manufactured by Koppers, or Quick Silver as manufactured by Rocktred.

6.06 Plastic Cement: Fiber glass plastic cement or any recognized blend of asphalt plastic cement conforming to Federal Specifications SS-C153, Type I or latest revision thereof.

6.07 Fasteners penetrating gypsum roof decking shall be square cut bright steel of length sufficient to provide a minimum of 1-1/2" penetration into roof deck.

6.08 Nails for securing felt to wood blocking shall be standard galvanized roofing nails with 2-1/8" diameter tin caps.

6.09 Roof walkway pads shall be 1/2" thick, "Tex-Mastic Roofwalk," as manufactured by J & P Petroleum Products, Inc., Dallas, Texas, or Carey Tread Manufactured by Celotex Corp.

6.10 Cant strips and tapered edges strip shall be manufactured from fiber-board which complies with Federal Specification LLL-1-535, unless indicated otherwise.

6.11 Asphalt based aluminum roof coating shall conform to ASTM Specification D2824, Type II and contain not less than 3 lbs. of leaf aluminum per gallon. Koppers non-fibrated aluminum #434 or Gibson-Homan Co. AIA File #25-B-34 material shall be used.

ROOFING

7.00 GENERAL REQUIREMENTS

7.01 The surface on which the roofing felts are to be applied shall be frost-free, dry, smooth, firm, and free from dirt, projections, and foreign materials. Vents and other items penetrating the roof shall be secured in position and properly prepared for flashing.

7.02 Installer's Qualifications: Specified work to be installed only by a qualified roofing contracting firm which has been in business for not less than 5 years.

7.03 Examination and acceptance of work in place: Examine work in place on which specified work is to be applied to ensure that conditions are satisfactory for the installation of specified materials. Report in writing to Owner's Representative any defects or conditions which may adversely influence completion or performance of specified work. Absence of such notification will be construed as acceptance of work in place.

7.04 The entire roof deck construction of any section of the building shall be completed before roofing work is begun thereon. A section is defined as that portion of the building bounded by a parapet wall, siding or expansion joint.

7.05 Locate heating kettles and pumping equipment on the ground at a minimum of 20 feet from buildings. Materials to be heated shall be so located and dispersed as to prevent a fire hazard. Operators of kettles and pumping equipment shall be in attendance at all times such equipment is in use and kettles shall be provided with thermometers to provide a continous check on temperature of materials. Asphalt shall not be heated to exceed 450 degrees F.

7.06 Loads placed on the roof at any point shall not exceed the safe load for which the roof is designed as shown on structural drawings.

7.07 Storage of materials: Roofing materials and accessories shall be stored in dry storage facilities until ready for use. All materials stored on the job shall be protected from the weather by the proper use of raised platforms and waterproof coverings and shall be maintained at a temperature of 50 degrees F. or above for not less than 24 hours prior to installation. Remove any wet materials from the site. Roof insulation shall be stored in stacks and in a flat position, and rolls of roofing felt on end, at all times.

7.08 The roofing contractor shall be responsible for the proper attachment of specified work to any roofing metal work that is embedded in or in contact with and becomes an integral part of specified roofing system, including such roofing metal work furnished under other Sections of the Specifications.

7.09 Labels: All roofing materials shall be clearly labeled with all pertinent information including UL and FM Labels. Materials delivered in hot bulk equipment shall be accompanied by a certificate prepared by an independent testing laboratory clearly stating the viscosity and melting point, ductility, etc., and citing UL, FM, or ASTM Specifications to which they conform.

7.10 All materials shall be securely fastened in place in a watertight, neat and workmanlike manner by workmen experienced in the particular class of work upon which employed.

8.00 BUILT-UP ROOFING APPLICATION

8.01 General: Roofing shall be applied over all roof areas where indicated on the Drawings and shall be applied parallel to the long dimension of the roof. The installation of insulation and roof membrane including flashings and except for the top surfacing shall be completed each day. No phased construction will be permitted.

8.02 Built-up roofing shall consist of the following minimum amount of materials per 100 square feet of roof surface.

(NOTE: Plants located at or north of Aurora, Illinois; Davenport, Iowa; or Joliet, Illinois, use 4 ply system.)

a. Type III roofing asphalt between plies - 96 lbs.

b. 3 plies of glass fiber roofing felt - 27 lbs.

c. Asphalt - roof tape (steep) - 8 lbs.

d. Aluminum roof coating - 2 gals.

8.03 The surface of the felts shall be broomed in with a 30 inch wide, soft fiber floor broom to obtain complete adhesion between plies and to eliminate air pockets. The method of mopping a half sheet width and turning the sheet back to mop under the other half shall not be used. Workmen shall not walk on mopped surfaces when the bitumen is in a sticky condition.

8.04 Three plies of glass fiber roofing felt shall be embedded in shingle fashion, lapped 24 3/4" inch, using starter sheets to insure three plies throughout roof, into 30 pounds of hot asphalt per 100 square feet per ply. End laps shall be 4 inch minimum, with plies extending a minimum of 2 inches above cants at vertical surfaces and at perimeter of building and expansion joints or as indicated by details on Drawings. The weight of asphalt shall not exceed 35 pounds per sq. ft. per layer.

8.05 Felts may be applied by a mechanical felt layer or rolled into a hand mopping of hot asphalt. They shall be shingled in, free of buckles and fishmouths. Each ply shall be laid so that the flow of water is over or parallel to but never against the lap. End laps shall be a minimum of 12 inches apart.

8.06 Embed the full 36 inch width of each ply in hot asphalt applied at a nominal rate of 30 pounds, (minimum of 25 pounds, and maximum of 35 pounds) per 100 square feet of felts. The total asphalt requirement per ply per square (30 pounds) is based on 108 square feet of felts. The asphalt shall be sufficiently hot to insure a complete bond of ply to ply. "Brooming-in" is required whether mechanical layer or hand mopping is used. Brooming in cold weather is especially essential and must be done promptly and effectively to insure adequate adhesion. (Cold weather when outside temperature is below 40°F.) When "rolling in" by hand, the mopping asphalt shall be kept within six feet of the roll. Keep the mop full, and flow the asphalt on the roof. Do not scrub with the mop.

8.07 Valleys and waterways shall receive an additional layer of fiber glass felt which shall extend at least 18 inches up the incline out of the valleys. This ply shall be laid prior to the application of the roofing felts.

8.08 Expansion joint and transitions, including roof to wall, shall be installed watertight as recommended by the manufacturer.

8.09 Roof walkway pads shall be set in a solid mopping of hot bitumen, with 2" minimum space between adjoining pad edges.

8.10 Coat roofing, with asphalt based aluminum coating at the rate of not less than 2 gals. per 100 sq. ft.

8.11 All roof felts shall extend up and over cant strips.

9.00 FLASHING APPLICATION

9.01 Embed fiber glass roof tape in hot steep asphalt applied at the rate of 15 lbs. - 20 lbs./100 square feet of tape, 4 inch end laps and centered over roof insulation joints, wood nailer and insulation stops.

9.02 Embed cant strips in 30 lbs./100 square feet moppings of steep asphalt or set in plastic cement.

9.03 Embed layer of glass fiber felt in a uniform layer of hot asphalt. Glass fiber felt strips shall not be more than 12 feet long with minimum 6 inch end laps. Glass fiber felt shall extend from a point not less than 8 inches above the intersection of the cant face and vertical wall, to a point on the roofing at least 4 inches beyond the toe of the cant or as indicated in detailed drawings.

9.04 Embed a second layer of glass fiber felt in a smooth uniform layer of hot asphalt. Glass fiber felt strips shall not be more than 12 feet long with minimum 6 inch end laps staggered on no less than 24 inch centers from the previous laid ply. This layer shall extend 4" inches further out over the roof than the first layer.

9.05 Over second layer of fiberglass felt, install 1 layer of KMM aluminum, or Quick Silver base flashing in accordance with the manufacturer's recommendations. Base flashing shall extend over the top of the cant and down the exterior face of the wall and overlap the top of the siding 1 inch, and shall extend down the cant and out over the roof a minimum of 4".

KMM shall be installed over a smooth coat of KMM adhesive. All joints shall be lapped 2" min. and sealed by the application of heat.

Quick Silver shall be installed on a uniform coat of primer. All joints shall be lapped 2" min.

After installing base flashings the Contractor shall roll the entire surface to eliminate air pockets and assure positive adhesion.

9.06 Nail through flashing felt on 4 inch centers along a line above the top of the cant where nailer is located.

9.07 Apply a layer of plastic cement to extend from 1 inch above the top edge of the flashing felt to a line 1 inch below the nail heads.

9.08 Install Vent Flashing: Flashing at vent shall be done with 4 lb. lead sheet and should extend not less than 16 inches on all sides of unit to be flashed.

9.09 Installation of Gravel Stops and Metal Fascias: Embed 2 layers of glass fiber felt on roofing plies in accordance with "Application of Flashing." Set gravel stop or fascia in a 1/8" inch thick layer of plastic cement and fasten flange with pan head No. 12 x 1-3/4" inch stainless steel screws with washers in two rows, 4 inch OC in each row, staggered.

9.10 Flashing at Roofing Drains: Embed one layer of glass fiber felt in a layer of plastic cement covering the drain base and extending 6 inches over the roof area. Apply built-up roofing extending all plies and moppings over the drain base. Embed a 3 lbs. lead flange in plastic cement on top of the roofing covering the drain base and extending 16 inches on all sides over the roofing. Apply three layers of glass fiber felt over the flange. Set all layers in plastic cement. The first layer shall extend 3 inches beyond the outer edge of the lead flange, the second shall extend 4 inches beyond the first and the third 4 inches beyond the second. Set flashing ring in a coat of plastic cement and draw uniformly tight.

10.00 FIELD QUALITY CONTROL

10.01 Test for dryness: The surface to which felts are to be applied shall not be considered dry and application shall not be started until the following conditions are met:

1. Foaming: When poured on the surface to which felts are to be applied, the bitumen, heated to 350 to 400 degrees F., shall not foam upon contact with the surface.

2. Stripability: After the bitumen used in the foaming test application has cooled to ambient temperature, the coating shall be tested for adherence. Should any portion of the sample to readily cleaned from the deck or insulation, the surface shall not be considered dry and application shall not be started. Should rain or snow occur during application the work shall be stopped and shall not be resumed until the deck has been retested by the methods specified above and found to be dry.

10.02 Test cuts of roofing: Cut test samples of installed roofing as directed by Owner's Representative. Test samples shall be taken after application of top ply and shall be approximately 4 x 40 inches in size, taken perpendicular to the long dimension of the felts so that head-laps are included.

10.03 Defective Work: Testing will be performed at Owner's expense. If analysis of test samples indicates the built-up roofing system or a portion thereof does not meet requirements specified herein, such defective work shall be removed and replaced to meet requirements of the Specifications without extra cost to Owner. Immediately after cutting test samples, Contractor shall patch roof to conform to adjacent built-up roofing construction as required by original Specifications.

11.00 CLEAN UP

11.01 During the work, Contractor shall be responsible for the proper protection of all existing work, grounds, and vegetation. Damaged existing work, grounds, and vegetation shall be repaired to their original condition at Contractor's expense. Material shall be stored and handled in such a manner as not to be spilled, spattered, or sprayed on surfaces not intended. Spills, spatters, or other unauthorized application shall be immediately removed. At completion of the work, the premises shall be restored to their original condition. Care shall be taken to protect vehicles in the vicinity: Full responsibility for damage to vehicles shall be assumed by the roofing contractor.

FLASHING AND SHEET METAL WORK

FLASHING AND SHEET METAL WORK

1.00 SCOPE OF WORK

1.01 Provide all labor, materials and equipment required to furnish and install metal roof flashing, sheet metal work and related items in accordance with the contract documents.

1.02 Composition base flashing is furnished and installed under Specification Section for "Roofing and Roof Insulation."

2.00 APPROVED MANUFACTURERS

2.01 Each type of material listed in the specification shall be the product of one of the following manufacturers.

a. Republic Steel
b. Allegheny Ludlum
c. Bethlehem Steel Corp.
d. General Electric Inc.
e. Revere Copper and Brass Inc.
f. Johns-Manville
g. Wasco
h. AFCO

3.00 APPLICABLE STANDARDS

3.01 Materials and workmanship shall conform to the following standards:

a. The National Association of Architectural Metals Manufacturer's. "Metal Products - Division 5 Metals,"

b. Sheet Metal and Air Conditioning Contractors National Association Inc. - "Architectural Sheet Metal Manual,"

c. ASTM A176 "Stainless and Heat-Resisting Chromium Steel Plate, Sheet, and Strip."

d. ASTM B32 "Solder Metal."

e. ASTM B101-40 "Lead-Coated Copper Sheets."

f. Federal Specification - FS-O-F-506C "Flux, Soldering; Paste and Liquid."

g. Federal Specification - FF-S-107C (1) "Screws, Tapping and Drive"

h. Federal Specification - SS-C-153B
"Cement, Bituminous, Plastic"

i. Federal Specification - TT-S-00230C (2)
Sealing Compound: Elastomeric Type Single Component."

j. Design Thickness of Flashings shall conform to FM Standards 1-49 Latest Revision.

k. Federal Specification - QQ-S-775E Steel Sheets, Carbon, Zinc-coated

l. American welding society (AWS) D1-1-75 Structural welding code.

4.00 SHOP DRAWINGS

4.01 Submit shop drawings in accordance with Division I of these Specifications.

4.02 Shop drawings shall indicate the materials being furnished and the type and frequency of fasteners.

5.00 WARRANTY

Furnish a written warranty in accordance with the General Conditions against defects in workmanship and materials for a period of two years.

6.00 MATERIALS

6.01 Stainless steel sheet: ASTM A167, Type 302 or 304 sheets or strips, dead soft fully annealed, 2D or 2B finish per ASTM A480 .015 inches (.38MM).

Fastenings: Stainless steel nails or screws.

Solder: ASTM B32, alloy Grade 60A bar form, (40 percent PIG lead and 60 percent pure block TIM).

Flux: Acid type for pretinning and activated-rosin-alcohol type for soldering.

6.02 Lead sheet: Alloy of hard lead containing lead complying with FS QQ-L-201F, Grade B, and between 4 and 6 percent antimony and weighing 4 lbs. per square foot.

6.03 Interlocking thru-wall flashing: D.010 inches (0.25MM) stainless steel sheet, deformed to provide a keyed mortar bond.

6.04 Coated Flashing: Wasco Products Inc., "Copperseal" or AFCO Products Inc. "Cop-A-Cote", .005" (0.17 MM) copper sheet coated both sides with flexible bituminous compound.

6.05 Reglet for flashing in concrete wall: No. 28 U.S. Gage (0.4 MM) stainless steel, complete with prepunched nail holes at 10 inches (250 MM) on center and required matching nails or screws.

6.06 Bituminous Paint: FS TT-C-494, Type II.

6.07 Mastic: Asphalt and asbestos fiber mixture complying with FS SS-C-153B, Type I.

6.08 Metal joint sealant (general) a non-drying, non-skinning, non-oxidizing, polybutene sealant complying with NAAMM Specification 5C-1.1 for non-skinning bulk sealing compounds.

6.09 Sheet metal indicated for welding: FS QQ-S-775 E.

7.00 APPLICATION

7.01 General: Soft stainless steel shall be used for all sheetmetal work unless indicated for welding, and shall be carried out in accordance with best standard practice. Work shall be formed to details and dimensions indicated, and shall be straight and true to line with flat surfaces, free of warping and bulging.

701.1 Sheet metal work indicated as welded shall be galvanized steel and shall be carried out in accordance with best standard practice. Work shall be formed to details and dimensions indicated, and shall be straight and true to line with flat surfaces, free of warping and bulging.

7.02 As far as practicable, design all work to be secured with concealed fastenings. Where heads of nails, screws, etc., are exposed, they shall be capped and soldered.

7.03 Seaming: All joints in sheet metal shall be flat lock seamed and soldered. Make ample provisions for expansion and contraction. Seams shall conform to the following requirements:

Standing Seams - Finish not less than one inch (25 MM) high.
Flat Seams - Finish not less than 3/4 inch (19 MM) wide.
Soldered Lap Seams - Finish not less than one inch (25 MM) wide.
Unsoldered Plain Lap Seams - Lap not less than 3 inches (76 MM)
All Seams on Sloped Surfaces - In direction of waterflow.

7.04 Specific Requirements - Stainless Steel Work: Edges of sheet metal to be soldered shall be cleaned and roughened as required, and pretinned. All flux residue from acid type flux shall be removed by scrubbing, neutralizing with ammonia or washing soda, and rinsing with water. After pretinning and assembling of parts, soldering shall be done and surfaces shall be thoroughly cleaned, as recommended by manufacturer of stainless steel sheet.

7.05 Stainless steel surfaces shall be cleaned, using detergent for loose dirt and commercial cleaner containing phosphoric or oxalic acid for stubborn deposits.

7.06 The metal cap flashing shall be bent to provide spring action against the base flashing, be not less than 4 inches (100 MM) wide, have lower edge folded back 1/2 inch (13 MM) and lap composition base flashing not less than 4 inches (100 MM).

7.07 Corner flashing shall be lapped 3 inches to provide for expansion and shall be installed to create a neat concealed joint.

7.08 Galvanized flashing or sheet metal shall be welded in accordance with AWS Standard D1-1.

PAINTING AND FINISHING

PAINTING AND FINISHING

1.00 SCOPE OF THE WORK

1.01 Provide all labor, materials, equipment and supervision required to prepare and finish all surfaces in accordance with the Contract Documents. The following listing of specific areas to be painted is not to be considered all inclusive but merely indicative of the general scope of painting work:

a. Concrete and concrete masonry walls and sills inside of buildings.

b. Plastered surfaces.

c. Underside of precast or poured concrete slabs when forming an exposed ceiling.

d. Interior surfaces of metal siding.

e. Draft curtains and metal closures.

f. Structural steel and miscellaneous iron items including building framing, lintels, frames, curbs, railings, stairs, ladders and cages on the interior of buildings, steel floor plate and grating, steel guards and pipe bumpers, catwalks, suspended crane runways and monorail, floor supported monorail and monorail support structure, top running bridge crane girders, etc.

g. Wood and hollow metal doors and frames.

h. Fire doors and vertical lift doors, frames and door related metals finish hardware.

i. Window operators and related hardware and all other hardware furnished with prime finish only.

j. Mechanical and electrical installations except that equipment which is specified and furnished with factory applied finish coats. Surfaces to be painted include insulated or bare piping and ductwork exposed in rooms or open areas inside and outside of buildings including all hangers and supports, and electrical conduit, boxes, and fittings including all hangers and supports required for electrical and telephone installations.

k. Steel light poles.

PAINTING AND FINISHING

l. Painting of bay location numbers on building columns, as directed.

m. Any special finishes noted in the Finish Schedule on the Drawings, or in the Contract Documents.

n. Special considerations for front panels of recessed fire hose cabinets, lighting and receptacle panels, telephone cabinets, etc.: Paint same color as surrounding wall unless otherwise indicated.

o. All items specified to receive Safety Colors.

2.00 PAINTING INCLUDED IN OTHER SECTIONS

2.01 The following painting work is specified to be performed under other Sections of the Specifications:

a. Prime coat on structural steel, hollow metal doors and frames, vertical lift steel doors, insulated metal wall panels, steel light poles, roof mounted hose cabinets, and draft curtains:

b. Prime and finish coats on the following:

Metal toilet partitions.
Movable metal partitions.
Wire mesh partitions.
Metal lockers and benches.
Mechanical and electrical equipment as follows:

Elevated Water Tanks
Pumps
Motors
Engines and Generators
Air Compressors and Drives
Refrigeration Compressors
Fans and Roof Exhausters
Top Running Bridge Cranes
Underhung Bridge Cranes
Jib Cranes and Hoists
Unit Heaters
Air Supply Diffusers
Packaged Air Handling Units
Drinking Water Coolers
Lighting Fixtures
Bus Duct and Trolley Duct
Power and Lighting Distribution Panels
Motor Starters, Pushbuttons and Disconnect Switches

PAINTING AND FINISHING

3.00 WORK NOT TO BE PAINTED

3.01 The following shall not be painted unless specifically noted otherwise.

a. Structural steel which is to receive fireproofing.
b. Aluminum or galvanized steel sash.
c. Aluminum or galvanized steel electrical cable tray.
d. Aluminum, copper, or stainless steel work.
e. Composition roof planking.

4.00 APPROVED MANUFACTURERS

4.01 Paint products shall be as manufactured by one of the following:

Devoe Paint Division - Celanese Coatings Company
E. I. DuPont De-Nemours & Company (Inc.)
Glidden - Durkee
Mobil Chemical Company
Pratt & Lambert Inc.
Sherwin-Williams Co.
Tnemec Company, Inc.

4.02 Substitution of products not listed hereinafter or of products by manufacturers not listed above shall be allowed only if the requirements of the General Conditions are met.

5.00 APPROVED PRODUCTS

Guide Specification Product Code Numbers

Code Number Series	Product
001-099	Primers & Undercoaters
100-199	Exterior Finishes
200-299	Interior Finishes
300-399	Special Coatings (See Section 9.13)

PAINTING AND FINISHING

5.01 Approved Product Tables

TABLE 1 PRIMERS & UNDERCOATERS

CTCo. Guide Spec. Code Number	Generic Type	Manu-facturer	Product-Name and/or Catalog Number	Min. Dry Film thickness in mils
001	Alkyd-oil	Tnemec	1069 Gray Primer	2.9
002	Alkyd-oil	Tnemec	1009 Gray Primer	2.4
003	Phenolic-Alkyd	Tnemec	77 Chem-Prime	2.1
004	Zinc dust	Devoe	Zinc Dust Primer & Finish Cat #14000	2.0
005	Latex	P & L	Galvanized Metal Latex Primer	1.3
006	Vinyl	Tnemec	89 Tmeme-Grip	0.3 to 0.5 max.
007	Zinc dust	S-W	Galvanized Iron Primer	1.5
008	Zinc-Alkyd	DuPont	67-774 Dulux Galvanized Metal Primer	1.5
009	Oleoresin	P & L	Interior Trim Primer	1.25
010	Alykyd	P & L	Vitralite Enamel Under-coating	1.25
011	Alkyd	Glidden	Glid-Guard Alkyd Metal Primer Cat. #4570	1.4
012	Alkyd	Glidden	Ultra-Hide Enamel Under-coat Cat. #5005	1.6
013	Alkyd	Tnemec	603 Enamel Undercoat	1.3
014	Alkyd	Devoe	Enamel Undercoat	1.3
015	Alkyd	Glidden	Enamel Undercoat 555	1.4
016	Alkyd	Mobil	Int. Enamel Undercoater No. 47-W-5	1.5
017	Alkyd	S-W	Enamel Undercoater B49W2	1.5
018	Polyester	Tnemec	561 Masonry Surfacer	8.0
019	Epoxy-Ester	Glidden	Glid-Guard Glid-Tile Epoxide Block Filler	4.0 - 8.0
020	Latex	P & L	Primafil 100	4.0 - 16.0
021	Latex	Mobil	Mobil Latex Block Filler No. 79-W-8	8.0
022	Epoxy	Mobil	Mobil Tile Body Coat #99-X-2	5.0
023	Acrylic	DuPont	Acrylic Block Filler	4.0 - 8.0

PAINTING AND FINISHING

TABLE 2 EXTERIOR FINISHES

CTCo. Guide Spec. Code Number	Generic Type	Manu-facturer	Product-Name and/or Catalog Number	Min. Dry Film thickness in Mils
100	Alkyd	Tnemec	Tneme-Gloss (Series 2)	1.5
101	Alkyd	P & L	Effecto Enamel	1.5
102	Alkyd	Devoe	Bar-Ox Finish Coats (Series 41800)	2.0
103	Alkyd	DuPont	Dulux Metal Protective Paint 25 - Line	2.0
104	Alkyd	S-W	Metalastic II Enamel	2.0
105	Chlorinated Rubber	Tnemec	Traffic Paint, 520 White	4.0 to 6.0
106	Alkyd	S-W	Traffic Marking Paint B46 W16 White	10.0 to 12.0
107	Alkyd	DuPont	Fast Dry Aisle Paint (7102-7103) White 690	3.0
108	Chlorinated Rubber	Mobil	Marking Paint Chlorinated Rubber White 18-W-7	1.5 to 3.0

TABLE 3 INTERIOR FINISHES

CTCo. Guide Spec. Code Number	Generic Type	Manu-facturer	Product-Name and/or Catalog Number	Min. Dry Film thickness in Mils
200	Alkyd	Tnemec	Enduratone (Series 23)	2.1
201	Alkyd	Glidden	Ultra-Hide Semi-Gloss Enamel (Series 5600)	2.0
202	Alkyd	S-W	Semi-Gloss Alkyd Enamel B47W8	2.2
203	Alkyd	P & L	Cellu-Tone Satin	1.75
204	Acrylic	Tnemec	Tneme-Cryl (Series G)	2.3
205	Latex	S-W	Quali-Kote Latex Flat Wall Paint Series B45	1.5
206	Latex	P & L	Vapex Masonry Paint	2.25
207	Latex	Glidden	Spred-Glide-On 3500 Series	1.7
208	Acrylic	DuPont	DuPont Acrylic Latex 345-462	1.5
209	Alkyd	P & L	Vitralite Enamel-Eggshell	1.75
210	Alkyd	Glidden	Ultra-Hide Alkyd-Eggshell Enamel #5086	1.7
211	Alkyd	Tnemec	Tneme-Gloss (Series 2)	1.9
212	Alkyd	P & L	Effecto-Enamel	1.0
213	Alkyd	Devoe	Mirrolac Int/Ext Enamel, 7000 Series	1.4

PAINTING AND FINISHING

CT. Co. Guide Spec. Code Number	Generic Type	Manu-facturer	Product-Name and/or Catalog Number	Min. Dry Film thickness in Mils
214	Alkyd	S-W	Metalastic II Enamel	2.0
215	Alkyd	DuPont	Dulux High Gloss Enamel 88 Line	1.5
216	Alkyd	Mobil	Mobil M & F Enamel 20 Series	1.5
217	Alkyd	Mobil	Mobil Alkyd Satin Enamel 31 Series	1.5
218	Epoxy	Tnemec	Tneme-Tile Series 54	2.7
219	Epoxy	Glidden	Glid-Tile Epoxide Semi-Gloss 5598/5597	6.0
220	Epoxy	P & L	Palgard Epoxy Coating	2.0
221	Epoxy	Mobil	Mobil-Tile Glaze Coat 99 Series	2.0
222	Epoxy	DuPont	DuPont Organic "Corlar Epoxy" Tile System, Semi-Gloss VG8336, 823 line	2.0

6.00 APPROVED SYSTEMS (EXTERIOR)

6.01 Exterior Steel (shop primed) including: doors and frames, stairs and landings, ladders, railings, guard rails, rail support posts, bumper posts, plates, platforms, miscellaneous supports, piping, tie downs, racks, clamps, bracing, etc. Electrical boxes and miscellaneous steel, hangers, brackets, light poles, etc. (Any galvanized steel items not shaped primed shall receive a primer coat of galvanized iron primer.)

System No.	Primer	*1st Coat Product	*2nd Coat Product
A1	Touch-up	100	100
A2	"	101	101
A3	"	102	102
A4	"	103	103
A5	"	104	104

*CTCo. Guide Specification Code Number - see 4.02.

6.02 Galvanized Steel surfaces where specified to be painted including: ductwork, heating, cooling and ventilating units, piping, hangers, clamps, tie downs, bracing, etc. Electrical conduit and boxes, fittings, flashings, tie downs and other miscellaneous items.

PAINTING AND FINISHING

System No.	Primer Product	1st Coat Product	2nd Coat Product
A10	004	102	102
A11	005	101	101
A12	006	100	100
A13	008	103	103
A14	007	104	104

6.03 Parking Lot Lines

System No.	1st Coat Product
A16	105
A17	106
A18	107
A19	108

7.00 APPROVED PAINTING SYSTEMS (INTERIOR)

7.01 Interior precast concrete wall panels, plaster wall surfaces (not to receive other finishes), concrete ceilings, precast concrete roof deck where scheduled to be painted, concrete block walls where scheduled for flat finish, and gypsum board partitions.

System No.	1st Coat Product	2nd Coat Product	Additional coats if necessary for Owner's Approval of Coverage
B1	204	204	204
B2	205	205	205
B3	206	206	206
B4	207	207	207
B5	208	208	208

7.02 Interior structural steel (shop primed) above and below bottom chord of trusses including trusses, columns, purlins, beams, bracing, etc.; monorail systems including columns, beams, and support structure, hangers, and bracing; suspended and top running crane rails or girders; shop primed galvanized items such as draft curtains, closures, etc.; metal siding above concrete sill walls; miscellaneous metals such as platforms, railings, ladders, floor plate, grating, batches, stair structures, etc.

Touch up all welds and damaged areas with primer.

System No.	Finish Coat Product
B10	200
B11	201
B12	202
B13	203

7.03 Interior hollow metal doors and frames (shop primed).

Touch up welds and damaged areas with primer before applying full coat of primer or undercoat.

System No.	Primer Product	Undercoat Product	1st Finish Coat Product
B20	009	010	209
B21	011	012	201

7.04 Interior woodwork where specified to be painted. Sand lightly between coats.

System No.	Primer Product	Undercoat Product	1st Coat Product	2nd Coat Product
B20	009		203	203
B21		013	200	200
B22		016	217	217
B23		017	202	202

7.05 Interior concrete and/or concrete block scheduled to receive epoxy coatings.

System No.	Primer-filler Product	1st Coat Product	2nd Coat Product
B25	018	218	218
B26	019	219	--
B27	020	220	220
B28	023	222	222
B29	021	022	221

7.06 Interior woodwork and millwork to receive Natural Finish.

System No. B30

7.07 In general, all exposed millwork and woodwork, cabinets, cases, paneling, trim, etc., specified to be finished naturally shall receive not less than the following:

1. Touch-up imperfections with shellac.
2. One coat wood filler, sanded.
3. One coat wood stain.
4. Two coats alkyd gloss varnish, each sanded lightly.
5. One coat alkyd satin varnish.

Those items specified to be pre-finished or factory finished shall not receive field-applied finish coats.

PAINTING AND FINISHING

7.08 Interior exposed galvanized mechanical or electrical work including: ductwork pipe, etc.

System No.	Primer Product	Finish Coat Product
B35	006	200
B36	005	203
B37	007	202

7.09 Interior exposed fabric covered insulated pipe and ductwork.

System No.	Primer Coat Product	Finish Coat Product
B40	204	200
B41	205	202
B42	206	203
B43	207	201

8.00 SAMPLES

8.01 No painting work shall be begun until the Contractor has obtained approval from the Owner on all products and color matching.

8.02 The Contractor shall, at least 60 days before painting work begins, submit to the Owner's Representative for approval color-product sample chips of all colors contained in the Color Schedule in the Contract Documents; and he shall also submit for approval at this time, a list of all products, brands and types of paint, etc., including complete manufacturer's catalog numbers, formulae numbers, label analyses, and descriptive literature. Color-product chips and lists shall be submitted in triplicate.

8.03 Color-product sample chips shall be prepared for each Finish Schedule color for each generic type specified or required in the Contract Documents.

8.04 Color-product chips shall be prepared on manufacturer's standard phosphatized or sandblasted steel tags (minimum size - 3" x 5"). A label identifying the product, the manufacturer and Finish Schedule color code shall be affixed to the back of each chip.

8.05 Colors submitted shall match the colors as identified or defined in the Contract Documents.

8.06 Field Samples of coating systems shall be applied to sections of walls, siding, truss work, columns, ductwork, piping, etc., for approval of finish and workmanship. Specific areas or items to be finished as Field Samples shall be designated by the Owner's Representative. The Contractor shall not proceed with painting work until all required Field Samples have been approved.

PAINTING AND FINISHING

9.00 STORAGE AND HANDLING OF MATERIALS

9.01 All materials used on the project shall be stored in an area approved by the Owner's Representative. The area shall be enclosed and shall be kept locked at all times except when actually in use. The storage area shall be kept neat and clean and all soiled rags, waste, etc., shall be removed from the storage area and from all work areas at the completion of each day's work. The Contractor shall be totally responsible for the prevention of fire or explosion caused by improper storage or handling of paint, solvents, rags, etc. All paint, solvent, etc., shall be stored and handled in strict accordance with these Specifications.

9.02 All damage to the storage area or adjacent areas caused by improper storage or unsafe handling shall be corrected by the Contractor at no cost to the Owner.

10.00 SURFACE PREPARATION

10.01 Brush or scrape all surfaces to remove any dirt, dust or other foreign substances and prepare surfaces for painting in accordance with the manufacturer's printed surface preparation instructions and these Specifications.

10.02 Any interior and exterior ferrous metal surfaces except galvanized metal, which have not been shop primed shall be thoroughly cleaned of all rust, loose mill scale, weld slag, and oil and grease removed before priming.

10.03 Galvanized metal: Before application of specified galvanized metal primer surfaces shall be cleaned thoroughly with mineral spirits to remove dirt, grease, or other foreign matter and wiped dry with clean cloths.

10.04 Interior concrete and masonry surfaces: Scrape or wire brush to remove excess mortar, loose dirt, and dust and any efflorescence from surfaces to be painted. Patch small imperfections with crack filler. Where cracks or surface imperfections larger than can be repaired by such means are present report same in writing to the General Contractor with a copy to the Owner's Representative so that proper repairs can be made before any painting work is started.

10.05 Woodwork and millwork to be painted: Clean and sandpaper smooth before applying prime coat. Touch up all imperfections with shellac, then sand with #00 or #000 sandpaper before applying undercoater (tinted). Sand undercoater with #00 or #000 sandpaper before applying finish coats.

10.06 Woodwork and millwork to be painted: Clean and sandpaper smooth before applying stain or filler. Touch up imperfections with shellac. Sand lightly between coats of varnish.

10.07 Plaster: Check for visible surface cracks, checks or other surface blemishes and patch with crack filler and sand to smooth finish as required.

10.08 Parking Lots: Where new striping is to be applied over an existing parking stripe pattern on new parking lots, the existing stripes are to be removed or obliterated before final striping pattern is applied.

11.00 GENERAL REQUIREMENTS

11.01 All paint materials shall be delivered to the job site in original sealed containers bearing the manufacturer's name, paint identification, formulae number, etc., with labels intact.

11.02 In general, paint application shall be by spraying; paint application on concrete or masonry walls and plaster shall be by roller or spraying. Paint applications in any case may be by brushing provided the final finish meets the approval of the Owner's Representative.

11.03 Coatings applied by any approved method shall be thinned in accordance with the manufacturer's recommendation only to provide the required workability. Apply all products at the coverage rate necessary to produce specified dry film thickness. Coatings shall be applied uniformly, free from runs, skips, streaks, or brush marks.

11.04 Containers used in storage, mixing and application of painting materials shall be clean and free of foreign materials or residue. Materials shall be thoroughly mixed as per the manufacturer's instructions before and during application to obtain a mixture of uniform density.

11.05 All coatings shall be applied in accordance with the manufacturer's printed directions for the paint used, only when the relative humidity is below 85% and ambient temperature is 55°F or over. No plaster or other surfaces to receive paint shall contain more than 8% moisture. No paint shall be applied until the preceding coat has dried.

11.06 Prime coats on bare steel or iron surfaces shall be applied within 24 hours after surface preparation is performed.

11.07 All finished work in place such as floors, partitions, glass, mechanical and electrical equipment, light fixtures, finished electrical and control panels and bus duct and factory finishes of all kinds shall be properly protected from paint applications, drippings or overspray. Plastic bags or other protective covers on sprinkler heads, valves, valve stems, etc., shall be removed after completion of finish painting work.

11.08 Equipment nameplates and identification tags, and finish hardware shall be masked and protected and masking removed after painting is completed. Hardware, grilles and registered with primed finish shall be painted in with adjacent surfaces.

11.09 Building columns in factory or storage areas shall have area designation numbers painted on four sides. Characters are to be block type, six inches high, painted with enamel of contrasting color over the final finish coat. Assume an average of six characters on each column, the Owner to provide a schedule of numbering. Characters shall be located 8 feet from the floor unless otherwise directed.

11.10 Painting work will not be considered complete until all spatters, drippings, smears and overspray have been cleaned or removed to the satisfaction of the Owner's Representative.

11.11 The Owner reserves the right to take samples of materials for chemical analysis; to gauge wet or dry film thickness; or to utilize any other standard inspection procedures necessary to assure quality and compliance with the requirements of the Contract Documents.

12.00 SAFETY COLOR CODING

12.01 Safety colors shall be high gloss enamels. Safety colors shall match the Federal Standard 595a colors as follows:

High Visibility Yellow	#13655
Alert Orange	#12246
Safety Green	#14260
Precaution Blue	#15102
Fire Protection Red	#11105
Black	#17038
Green	#14062

12.02 Safety colors shall be applied on all surfaces as listed in the tables below and scheduled or specified in the Contract Documents.

Table 1: High Visibility Yellow, F.S. 595a 13655

Curb or edge of: pits, loading docks, platforms, elevator platforms, trap doors.
Dead end hazards.
Guard posts and horizontal guard rails.
Hand rails on stairways where scheduled.
Ladders and cages as shown or noted.

PAINTING AND FINISHING

Table 2: Alert Orange, F.S. 595a 12246

Inside face of doors on lighting and receptacle panels.

Table 3: Safety Green, F.S. 595a 14260

Emergency gas shutoff valves and instruction signs for same.
Emergency shower stalls or areas, walls, etc., where shown on the Drawings.

Table 4: Precaution Blue, F.S. 595a 15102

Exterior surfaces of enclosures of following electrical devices:

Pull and junction boxes above 208 volts.
Wireways.
Automatic transfer switches.

Table 5: Fire Protection Red, F.S. 595a 11105

1-1/2 inch fire hose drops and inspection test pipes.
Emergency manual fire valves.
Hose houses.
Sprinkler risers to first elbow above bottom chord of truss.
Signal and supervisory system boxes.
Fire protection system valve indicator posts.

Table 6: Alternating Black & Yellow Stripes where specifically shown or noted on the Drawings.

Exposed and/or unguarded edges of platforms, pits.
Vertical surfaces of unguarded movable platforms.
Vertical surfaces of abrupt changes in floor level, curbs, steel or concrete equipment platforms.
Columns, posts, pillars, and corner guards.

Table 7: Green, F.S. 595a 14062

Fire protection, sectional valve indicator posts.

GENERAL MECHANICAL REQUIREMENTS

GENERAL MECHANICAL REQUIREMENTS

1.00 GENERAL

1.01 All work in this Section shall be performed in accordance with the Contract Documents.

1.02 All equipment and systems shall be completely assembled, installed, tested, adjusted and demonstrated to be ready for permanent operation to the satisfaction of Owner's Representative.

1.03 Electrical work furnished with or as an integral part of mechanical equipment shall conform to applicable requirements of Division 16, "Electrical", and any specific requirements of this Division.

2.00 APPROVED MANUFACTURERS

2.01 Use of the product of a specified manufacturer shall be in accordance with General Conditions Section, "Approved Manufacturers & Substitutions", of this specification.

3.00 REGULATORY AGENCIES, CODES AND STANDARDS

3.01 Governing federal, state, local government laws, ordinances, referenced codes and standards, constitute minimum requirements. Compliance therewith is required but does not relieve Contractor from any more stringent requirements of the Contract Documents.

3.02 Portions or all of certain recognized industry or association standards referred to herein as being a requirement of these Specifications shall be considered as binding as though reproduced in full herein. Unless otherwise stated the reference standard shall be the standard which is current as of the date of issuance of these Specifications. Reference may be made to standards either by full name or for the sake of brevity by letter designation as follows:

AFBMA	Anti-Friction Bearing Manufacturers Association
AMCA	Air Moving and Conditioning Association
ANSI	American National Standards Institute
ASHRAE	American Society of Heating, Refrigeration and Air Conditioning Engineers, Inc.
ASME	American Society of Mechanical Engineers
ASTM	American Society for Testing and Materials
AWS	American Welding Society

GENERAL MECHANICAL REQUIREMENTS

FM	Factory Mutual Engineering Corporation
JIC	Joint Industrial Council
NBS	National Bureau of Standards
NEC	National Electrical Code
NEMA	National Electrical Manufacturers Association
NFPA	National Fire Protection Association
NPC	National Plumbing Code
OSHA	Occupational Safety and Health Administration
SSPC	Steel Structures Painting Council
UL	Underwirters' Laboratories, Inc.

4.00 QUALITY STANDARDS

4.01 Quality of material shall conform to applicable Specifications under General Conditions.

4.02 Where more than one of any specific item is required, all shall be of the same type and manufacture.

4.03 Materials and equipment not herein specified or indicated as to manufacture but necessary for complete functioning systems, shall be provided from sources conforming to the quality levels and functional requirements for corresponding materials and equipment set forth herein.

5.00 SHOP DRAWINGS

5.01 Shop drawings for all equipment and work furnished under this division shall be submitted for approval in accordance with the procedures outlined in "General Conditions", and "Submittals" Division 1.

5.02 Prior to submittal of shop drawings contractor shall coordinate the work of all trades, disciplines and various sections of the Specifications to assure that only shop drawings for compatible equipment are submitted.

5.03 Shop drawings shall include complete data including physical dimensions and other information required for installation, performance capabilities and limitations, and schedules indicating locations when more than one type of an item is to be used.

5.04 Shop drawings, brochures or catalog cuts showing more than one size or model shall be marked to indicate the size or model proposed for the particular application.

5.05 Shop drawings shall be identified as to the specific equipment for which the shop drawing relates. Identification shall be by reference to equipment numbers as shown on the Drawings or by reference to the appropriate Article of the Specifications in which the equipment is specified.

6.00 INSTRUCTION MANUALS

6.01 Four sets of Instruction Manuals shall be furnished to Owner's Representative prior to the start of inspection start-up and tests required elsewhere in this section. Each set is to include the following:

a. Manufacturer's parts list identified with the make, model and serial number of the equipment furnished.

b. Schematic control, flow and wiring diagrams identifying the location and function of all system components, valves and controls.

c. Installation, operation, lubrication and maintenance instructions.

d. Manufacturer's recommended spare parts list.

e. Test data and performance curves where applicable.

6.02 Manuals shall incorporate design basis, drawings, flow diagrams, brochures and operating instructions in sufficient detail to enable operators to understand the equipment or system, its potentialities, limitations and maintenance needs. Data on design, construction, installation and operating features required by regulations of state or local governing agencies shall be included. Sample forms for operating and control records essential for evaluation of performance and collection of costs are desirable.

7.00 LOCATION VERIFICATION AND FIELD MEASUREMENTS

7.01 All dimensions and clearances affecting the installation of work shall be verified in the field in relation to established datum, to building openings and to the work of other trades.

7.02 Location of all equipment and systems shall be coordinated to preclude interferences with other construction.

7.03 Should interferences or ambiguities occur which will necessitate deviations from layout or dimensions shown on the Drawings, Owner's Representative shall be notified and any changes approved before proceeding with the work.

GENERAL MECHANICAL REQUIREMENTS

8.00 AS-BUILT DRAWINGS

8.01 A written record shall be kept of all deviations in location or elevation of any concealed installation from that shown on the Drawings. Records shall consist of marked Drawings or Shop Drawings and shall be submitted to the Owner's Representative at any time upon request during or after completion of construction. No such deviations from the Drawings or approved shop drawings shall be made without prior approval by Owner's Representative.

9.00 ACCESSIBILITY

9.01 All work shall be installed so as to be accessible for operation, maintenance and repair with particular attention given to locating valves, controls and equipment requiring periodic lubrication, cleaning, adjusting or servicing of any kind. Access panels shall be provided when work is built in or concealed.

10.00 FASTENING TO BUILDING STRUCTURES

10.01 The methods of attaching or fastening equipment or equipment supports or hangers to the building structure shall be subject to approval by Owner's Representative at all times. Submit shop drawings or samples for approval before proceeding with the work.

10.02 Cutting, burning, drilling, welding or the use of explosive driven fasteners on building structures shall require prior approval by Owner's Representative for each type of application unless specifically shown on the Drawings.

10.03 Equipment or piping shall not be attached to or supported from the roof deck, from removable or knockout panels, or temporary walls or partitions, unless specifically indicated on the Drawings.

11.00 THERMAL METAL JOINING AND CUTTING

11.01 All welding, brazing, soldering and cutting work shall conform to applicable provisions of the following codes and requirements:

ASME Boiler and Pressure Vessel Code.

American National Standards (ANSI) B31.1-1973 Power Piping and Addenda

American Welding Society (AWS) D1.1-72 Structural Welding Code.

11.02 Welding shall be performed only by qualified welders. Welders and welding procedures employed on pressure vessel or pressure piping work shall be qualified in accordance with Section IX of the ASME Boiler and Pressure Vessel Code or with local codes where they take precedence.

11.03 A record shall be maintained on the job showing the date and results of qualification test for each welder employed on the job. One certified copy of the qualification test for each welder so employed shall be furnished to Owner's Representative.

12.00 EQUIPMENT GUARDS

12.01 All rotating equipment including couplings, flywheels, gear trains and belt drives shall be provided with adequate guards for personnel protection and compliance with Article 3.00 of this section of the Specifications. Wherever possible the guards shall be provided by the equipment manufacturer. The guards shall be supported to prevent vibration or interference with the rotating equipment and readily capable of removal and reinstallation with tools normally available to local craftsmen. The removable guards shall be finished in a high visibility yellow color. The equipment exposed with the guard removed is to be finished in alert orange color.

13.00 LIFTING ATTACHMENTS

13.01 All equipment requiring hoisting for installation and/or maintenance shall be provided with suitable lifting attachments by the manufacturer. Manufacturers installation instructions shall detail correct lifting procedures to preclude equipment damage.

14.00 EQUIPMENT PROTECTION

14.01 Equipment openings and connections shall be provided with adequate covers at the factory to protect the internals, threads, and flanges and prevent entrance of any foreign matter prior to installation and/or acceptance by Owner's Representative.

14.02 Exposed machined surfaces of equipment and shafts, bearing surfaces, gasket surfaces, gears, etc., shall be provided with adequate protection at the factory to prevent physical damage and corrosion prior to installation and/or acceptance by Owner's Representative.

14.03 Equipment subject to deterioration, either externally or internally, due to atmospheric conditions prior to acceptance by Owner's Representative shall be preserved and/or maintained by Contractor in accordance with the equipment supplier's recommendations.

15.00 NAMEPLATES

15.01 All equipment shall have factory applied permanent nameplates indicating the manufacturer's name, model and serial numbers, temperature and pressure design, and any other data necessary to conform with specified requirements.

GENERAL MECHANICAL REQUIREMENTS

16.00 PAINTING AND FINISHING

16.01 All purchased equipment shall have a factory applied standard finish of the manufacturer's standard color unless otherwise specified.

16.02 Equipment which will be subject to abnormal conditions of high temperature, corrosive environment, etc., shall have finishes and/or protective coatings suitable for the service as noted on the Drawings and/or in the Specifications.

16.03 Finishes which are marred during shipping, handling or installation shall be touched up to match the original finish. All finishes, including paint, enamel, galvanized high lustre bare metal or plated surfaces, etc., are included in this requirement.

16.04 Field fabricated bare iron or steel items required for installation of work under this Division shall have rough or sharp edges removed, be thoroughly cleaned of dirt, rust, weld slag, grease or oil and be painted one coat of Tnemec 1009 rust inhibiting metal primer as a requirement under this Division.

17.00 LUBRICATION AND TOOLS

17.01 Provide a fresh charge of lubricant in accordance with the manufacturer's recommendations to all equipment requiring lubrication prior to start-up and maintain lubrication as required until acceptance by Owner's Representative.

17.02 Provide for each piece of equipment any special tools required for the operation or adjustment of the equipment. Turn over any such tools to Owner's Representative prior to final acceptance of the equipment.

18.00 INSPECTION, START-UP AND TESTS

18.01 Any equipment or system placed in temporary operation for testing or for the convenience of Contractor during construction and before Owner takes over operation shall be properly operated and maintained by Contractor.

18.02 All equipment and systems shall be protected against freezing, flooding, corrosion or other form of damage prior to acceptance by the Owner's Representative.

18.03 Tests shall be performed to the satisfaction of Owner's Representative on all piping, fixtures, equipment, system components, controls, and complete systems as required by this and/or other divisions of the Specifications.

GENERAL MECHANICAL REQUIREMENTS

18.04 Provide all labor, materials, tools, instruments, air, water, power and supplies of any kind required for testing and adjusting of equipment and systems. The cost of gas, electricity and water supplied through Owner's meters will be borne by Owner.

18.05 Operational and performance tests on equipment which normally operates only during certain seasons of the year shall be made during the appropriate season and/or at such time as ability to perform at rated capacities can be demonstrated.

18.06 Material or equipment damaged, shown to be defective, not in accordance with the Specifications or not able to meet acceptance test requirements shall be repaired or replaced to the satisfaction of Owner's Representative.

18.07 All tests shall be made after notification to and in the presence of Owner's Representative and the authorities having jurisdiction.

18.08 Written records shall be kept by Contractor for each test showing the date, system or equipment tested, method of test, test results and any approval signature of Owner's Representative. Three copies of the test records along with any certificates of final inspection or approval issued by the authorities having jurisdiction shall be furnished to Owner's Representative at the successful completion of each test, but not later than 10 working days after such successful completion.

18.09 Before starting up any system each piece of equipment comprising a part of the system, whether covered by this and/or other divisions of the Specifications, shall be checked for proper lubrication, drive rotation, belt tension, continuity of controls, and any other condition which may cause damage to equipment or endanger personnel. Where called for in the Specifications or by industry practice, a competent service representative trained in servicing the respective equipment for which he is responsible shall be present to supervise the start-up and test runs of equipment and/or systems.

18.10 Test runs shall be made over the full design load range where possible, or simulated to the satisfaction of Owner's Representative for other conditions. Tests shall continue for as long as necessary to demonstrate that systems will operate as designed. During test runs all necessary adjustments shall be made, controls checked for proper operation, motors checked for possible overload, and the entire system checked by Contractor for any abnormal condition.

18.11 During the test runs and prior to acceptance of any system Owner's designated operating personnel shall be instructed in the operation of the system as called for in the specifications.

GENERAL MECHANICAL REQUIREMENTS

18.12 After test runs have been concluded and systems have been demonstrated to be satisfactory and ready for permanent operation, all permanent pipe line strainers and filters shall be cleaned, air filters cleaned or replaced, valve and pump packings properly adjusted, belt tensions adjusted, drive guards secured in place, lubrication checked and replenished if required. Temporary piping, wiring, instrument connections, etc., shall be removed, and openings restored in a permanent manner acceptable to Owner's Representative.

PIPING MATERIALS & FABRICATION

PIPING MATERIALS & FABRICATION

1.00 GENERAL

All work of this Section shall be performed in accordance with the Contract Documents.

2.00 SCOPE OF WORK

2.01 This Section of the Specifications covers the requirements for materials, fabrication, installation, cleaning and testing of piping systems as specified herein and shown on the Drawings. Piping shall be installed complete, including all required final connections to equipment and other systems, and turned over to the Owner fully operational.

3.00 SHOP DRAWINGS

3.01 Submit shop drawings in accordance with Division I of these Specifications. Prior to installation of any piping, the following shop drawings and data shall be submitted:

a. A schedule of all materials and equipment, including all accessory items, giving complete details and data.

b. Reproducible scale drawings of all Contractor fabricated items such as anchors, braces, supports, guides, supplementary supporting steel, etc., including locations and methods of attachment to building structure.

c. Reproducible scale drawings of piping layout giving complete locating dimensions and indicating each hanger and support.

3.02 The shop drawings shall indicate the coordination of this work with the work of other Divisions and Sections of the Specifications.

4.00 PIPE ERECTION & LAYING

4.01 Carefully inspect all pipe, fittings, valves, equipment and accessories prior to installation. Any items which are unsuitable, cracked or otherwise defective shall be rejected and removed from the job immediately.

4.02 Exercise all necessary care at every stage of storage, handling, laying and erecting to prevent entry of foreign matter into piping, fittings, valves, equipment and accessories. Do not erect or install any item which is not clean. During construction, until system is fully operational, all openings in piping and equipment must be kept closed at all times except when actual work is being performed on that item or system. Closures shall be plugs, caps, blind flanges or other items specifically designed and intended for this purpose.

PIPING MATERIALS & FABRICATION

4.03 Run pipe lines straight and true, parallel to building lines with a minimum use of offsets and couplings. Provide only such offsets as may be required to provide necessary headroom or clearance and to provide necessary flexibility in pipe lines.

4.04 Changes in direction of pipe lines shall be made only with fittings or pipe bends. Changes in size shall be made only with fittings. Miter fittings, face or flush bushings, or street elbows shall not be used.

4.05 Provide flanges or unions at all final connections to equipment, traps and valves to facilitate dismantling. Arrange piping and piping connections so that equipment being served may be serviced or totally removed without disturbing piping beyond final connections and associated shut-off valves.

4.06 Use full and double lengths of pipe wherever possible.

4.07 Install all supply piping, including shut off valves and strainers, to coils, pumps and other equipment at line size with reduction in size being made only at inlet to control valve or pump. Install supply piping from outlet of control valve at full size of connection to equipment served. Install outlet piping including dirt pockets or mud legs from equipment full size of connection from equipment served. Install piping, check valves, strainers and shut off valves in these equipment outlet or return lines beyond dirt pockets the size of tapping in the trap or if no trap, the size of the equipment connection.

4.08 All pipe shall be cut to exact measurement and installed without springing or forcing. Particular care shall be taken to avoid creating, even temporarily, undue loads, forces or strains on valves, equipment or building elements with piping connections or piping supports.

4.09 Branch take-offs shall be from top, bottom or side of mains or headers.

5.00 JOINING OF PIPE

5.01 Screwed Joints: Screw threads shall conform to ANSI B2.1 "Pipe Threads". Protect plated pipe and brass valve bodies from wrench marks when making up joints. Apply thread lubricant or sealant to male threads only as follows:

Teflon Tape:

All Services

PIPING MATERIALS & FABRICATION

5.02 Flanged Joints: Steel pipe flanges shall conform to ANSI B16.5 "Steel Pipe Flanges and Flanged Fittings". Galvanized iron pipe flanges shall conform to ANSI B16.1 "Cast Iron Flanges and Flanged Fittings". Steel flanges shall be raised face except when bolted to flat face cast iron flange in which case they shall be flat faced.

Bolting for services up to 500°F shall be ASTM A307 Grade B with bolts and nuts conforming to ANSI B18.2.1 "Square and Hex Bolts" and B18.2.2 "Square and Hex Nuts".

Set flange bolts beyond finger tightness with an indicating torque wrench to insure equal tension in all bolts. Tighten bolts such that those 180° apart or directly opposite are torqued in sequence.

Gaskets for flat face flanges shall be full face type unless otherwise specified. Gaskets for raised faced flanges shall conform to requirements for "Group I Gaskets" in ANSI B16.5. Unless otherwise specified gaskets shall be 3/32 or 1/8 inch thick of following types.

Water

- Natural Rubber -

Natural red rubber, hardness 35 $\pm$5 durometer, 400 psi tensile, 600% elongation, temperature limit 250°F, plate finish.

Approved Manufacturers and types:

A. W. Chesterton Co.	100
Crane Packing Co.	555
Garlock, Inc.	6023

5.03 Welded Joints: The welding of all pipe joints, both as to procedures and qualification of welders, shall be in accordance with Section IX, ASME "Boiler and Pressure Vessel Code" unless mandatory local codes take precedence. Furnish to Owner's Representative prior to start of work certificates qualifying each welder. Owner's Representative reserves the right to require qualifying demonstration, at Contractor's expense, of any welders assigned to the job.

Backing rings shall be used for all butt weld joints 2-1/2" pipe size and over. Backing rings shall be of a material compatible with pipe material being welded.

5.04 Tubing Joints: Tubing joints shall be of the flareless "bite" type, brass. Fitting shall be used with annealed copper tubing.

Approved Manufacturers and Types:

Crawford	"Swagelok"
Parker	"Intrulok"

5.04(Cont.)	Hoke	"Gyrolok"
	Imperial	"Hi-Seal"
	Weatherhead	"Self-Align"

6.00 HANGERS & SUPPORTS

6.01 Supports for piping and piping connected equipment, including valves, strainers, traps and other specialties and accessories shall be installed in a manner that will not result in or produce excessive stress, deflection, swaying, sagging or vibration in the piping or in the building structure either during erection, cleaning, testing or normal operation of the systems. Piping shall not be so restrained, however, as to cause it to snake or buckle between supports or anchors or to prevent movement due to expansion and contraction. Piping shall be installed at equipment such that equipment can be disconnected and removed without further supporting the piping. Piping shall not introduce any strains or distortion to the connected equipment.

6.02 It shall be the responsibility of Contractor to coordinate the location of the piping support systems with that of all installations under other Divisions and Sections of the Specifications.

6.03 Hangers and supports shall be installed complete, including lock nuts, clamps, rods, bolts, couplings, swivels, inserts and required accessory items.

6.04 Pipes shall be supported individually unless shown otherwise on drawings.

6.05 Attach piping or auxiliary steel to building structure as detailed on drawings and specified below:

a) Piping and auxiliary steel shall be supported only from purlins, top chords of jack trusses, top or bottom panel points of bar joists, beam and girders and not from carrying trusses. No cutting, or burning of building structural members will be allowed. Piping 2-1/2" and up, shall not be eccentrically supported from building structural steel members.

b) Piping running horizontally through carrying trusses (parallel to roof purlins) shall be supported from auxiliary steel or roof purlins.

c) Piping running horizontally through jack trusses (perpendicular to roof purlins) shall be supported from top chord of jack trusses and purlins.

PIPING MATERIALS AND FABRICATION

6.06 Auxiliary steel for supporting a single pipe run or multiple runs is listed in the chart below. Any other sizes, shapes, or cold rolled metal framing sections, giving equal or greater section modulus are acceptable. Combinations of pipes may be supported by the same auxiliary steel provided the total weight does not exceed the capacity of the auxiliary steel.

Auxiliary Steel (Up to 8' span)	Capacity, Lbs.	Size	Weight (lbs.) of water filled Std.Wt. Steel Pipe @ Max. Spacing (per 6.07
3" x 2" x 1/4" LLV	105	1/2"	7
3-1/2" x 2-1/2" x 5/16" LLV	225	3/4"	10
4" x 3" x 5/16" LLV	535	1"	14
5" x 3-1/2" x 5/16" LLV	950	1-1/2"	35
6" x 4" x 1/4" LLV	1565	2"	50
		2-1/2"	78
		3"	105
		4"	225
		6"	535

6.07 Maximum spacing of horizontal piping 6" and under shall be as follows:

STEEL PIPE	MAXIMUM SPACING
1-1/2" and under	7'-0"
2", 2-1/2", 3"	10'-0"
4", 5"	14'-0"
6"	17'-0"

6.08 Provide supports, where pipe changes direction, adjacent to flanged valves, strainers, and fittings, and at equipment connections.

6.09 Vertical pipe runs shall be supported and laterally braced at every floor level in multi-story structures and laterally braced only, at intervals not exceeding 15 feet (10 feet for 3" pipe and under) in other structures. Unless otherwise indicated on the Drawings, support vertical pipe with riser clamps installed below hubs, couplings or lugs welded to the pipe.

Approved Manufacturers:

Elcen	Fig. 39, 339
Fee & Mason	Fig. 241, 368, 378, 380
F & S Central	Fig. 91, 91CT, 91PC, 93
Grinnel	Fig. 261, CT-121, 261C, CT-121C
Super Strut	Fig. C720, CT720

PIPING MATERIALS AND FABRICATION

6.10 Hanger rods for single and double rod hangers shall conform to the following:

PIPE SIZE	HANGER ROD DIAMETER
2"	3/8"
2-1/2" thru 3-1/2"	1/2"
4" and 5"	5/8"
6"	3/4"

6.11 Hangers for insulated piping shall be sized for the O.D. of the pipe insulation or the insulation protection saddle.

a. On insulated hot piping, tack weld to the pipe at each support point, steel saddles of a depth not less than the specified adjacent insulation.

Approved Manufacturers:

Elcen	Fig. 251, 252, 253, 254, 255, 256
Fee & Mason	Fig. 171, 172, 1710, 1712, 1732
F&S Central	Fig. 900,901, 902, 903, 904, 905
Grinnell	Fig. 160, 161, 162, 163, 164, 165, 166A
Super Strut	Fig. C789, C789A, C789C, C789D, C789E, C789X, C789Y

As an option, provide at each support point, a 360° insert of high density, 100 psi, waterproofed calcium silicate, encased in a 360° sheet metal shield. Insert to be same thickness as adjoining pipe insulation. Shield length, gauge, and installation procedure shall be as per manufacturer's standard. Where pipe hanger spacing exceeds 10 feet, a double layer shield on the bearing surface shall be utilized.

Approved Manufacturer and Models:

Pipe Shields, Inc.	CS, CSX

PIPING MATERIALS & FABRICATION

b. As an option on insulated hot piping 2" and under, provide at each support point an insulation protection shield unit consisting of a 360° or semicylindrical segment of high density precompressed insulation of the same depth as specified adjacent insulation, fire resistant vapor barrier jacket, and a 360° or semi-cylindrical shield. Where pipe hanger spacing exceeds 10 feet, a double layer shield on the bearing surface shall be utilized.

Approved Manufacturers and Models:

Fee & Mason	Fig. 81, Fig. 800
Insul-Coustic/Birma Corp.	I-C Pipe Support & Shield
Elcen Metal Products Co.	Fig. 241, Type 2
Pipe Shields, Inc.	Model CS, CSX, CS-CW, CSX-CW
F & S Central Mfg. Co.	No. 5020

6.12 Unless otherwise indicated hangers shall be as follows:

Insulated hot pipe.
Clevis or Roller Type.

Approved Manufacturers and Models:

	(Clevis Type)	(Roller Type	)
	1/2" thru 2"	2-1/2" thru 6"	8" and above
Elcen	Fig. 12	Fig. 14A, 19	Fig. 15, 19
Fee & Mason	Fig. 239	Fig. 2729, 160	Fig. 170, 160
Grinnell	Fig. 260	Fig. 174, 271	Fig. 171, 271
F&S Central	Fig. 86	Fig. 72S, 79	Fig. 77, 79
Super Strut	Fig. C710	Fig. MR729,R730L	Fig. 719A, R730C

6.13 Unless otherwise shown or specified, upper attachments shall be adjustable center loading beam clamps with extension piece or eye as listed and shown on drawings.

Approved Manufacturers and Models:

	6" and under	2" and under (Optional C-Clamp) w/locknut & retainer
Elcen	Fig. 95 w/235	Fig. 29A 2/29B
Fee & Mason	Fig. 246	Fig. 255 w/255S
Grinnell	Fig. 229	Fig. 87 86/w89
F&S Central	Fig. 229	Fig. 57L w/570
Super Strut		Fig. M775LR

PIPING MATERIALS AND FABRICATION

7.00 EXPANSION, ANCHORING, GUIDING & THRUSTING

7.01 Pipe expansion loops and offsets shall be provided where shown on Drawings.

7.02 Mechanical expansion joints and flexible pipe connectors shall be provided where shown on Drawings and shall be as specified in the appropriate Sections of the Specifications.

7.03 Anchors shall be provided where shown and fabricated and installed as detailed on Drawings.

7.04 Field fabricated alignment guides shall be installed where shown and as detailed on Drawings.

7.05 Factory fabricated alignment guides shall be installed where shown and as detailed on Drawings. Guides shall consist of a bolted semi-steel spider and a bolted guiding cylinder with supporting legs welded to the pipe support.

Approved Manufacturers and Models:

Elcen	Type 41
Tube-Turn	
Keflex, Inc.	Type P, CP
ITT Grinnell	Fig. 256
Flexonics	

8.00 SLEEVES & PLATES

8.01 Furnish and install sleeves for all pipes passing through floors, walls, partitions, slabs, grade beams and foundations.

8.02 Sleeves shall be standard weight steel pipe having square cut ends with anchoring lugs welded on. Horizontal sleeves through walls, foundations and partitions shall be flush with finished wall faces. Vertical sleeves through floors shall extend 2 inches above finished floor and be flush on ceiling or under side.

8.03 Size sleeves such that internal diameter is a minimum of 2 inches larger than O.D. of bare pipe for uninsulated lines and 2 inches larger than O.D. of insulation and jacket for insulated lines. Center pipes in sleeves.

8.04 Above grade: On lines passing through walls and floors above grade, the annular space between outside of pipe of insulation and inside of sleeve shall be packed tight with mineral wool insulation. For walls only, in place of the steel sleeve and mineral wool insulation, Contractor may use a fire-rated barrier. It shall be an adjustable or fixed length metal can of a minimum 24 gauge, sized for maximum 1" spacing between bare pipe or insulation shield and can. Insulation when appropriate for the service shall consist of a 360° water-proofed calcium silicate insert encased in a split sheet metal 360° shield, sized to extend to a minimum of 1" beyond wall or floor penetration and shall be the same thickness as the adjoining pipe insulation. Spacing between bare pipe or shield and can shall be packed on each end with double neoprene coated asbestos rope positively fastened. Sleeve shall have a two hour rating.

Approved Manufacturer:

Pipe Shields, Inc.

8.05 All pipes passing through walls or floors of finished areas and firewalls in all areas shall be provided with chrome plated brass solid type escutcheon plates large enough to conceal the pipe sleeve and fitting snugly around pipe or insulation O.D.

Approved Manufacturer and Model Numbers:

Ritter Foundry Products, Inc. — 1770, 1771, 1772
751 E. 132nd Street
Bronx, NY 10454

9.00 DRAINING AND VENTING

9.01 Unless otherwise indicated on the Drawings, all horizontal water lines, including runouts and branches, shall pitch to low points to provide for complete drainage and venting. Slope unless otherwise indicated, shall be 1 inch in 40 feet.

9.02 Maintain constant slope where lines are pitched for venting and drainage. No lines shall have pockets due to changes in elevation unless indicated on the Drawings. In such instances proper provisions for draining and venting shall be provided.

9.03 Provide 3/4 inch drain valves fitted with 3/4 inch hose thread adapter at all low points of water piping systems and where indicated on Drawings to permit complete or sectionalized draining.

9.04 Use eccentric reducing fittings on horizontal runs when changing size of lines in order to provide proper drainage and venting. Install lines with top of pipe and eccentric reducers in a continuous line.

9.05 Provide automatic air vents in mechanical equipment rooms, at the high points of heating water piping systems and where shown on drawings. Automatic vents shall be cast iron or semi-steel body with stainless steel float and mechanism and operating pressure rating not less than 150 psig.

PIPING MATERIALS AND FABRICATION

Approved Manufacturers and Model Numbers:

Anderson, IBEC, Div. of International Basic Economy Corp.	70A
Armstrong Machine Works	21AR
Metraflex Co.	MV-15
Sarco	13W
Bell & Gossett	

9.06 Provide manual air vents at the high points of heating water piping systems and where shown on drawings.

9.07 All vent and drain piping shall be of the same materials and construction as specified for the service involved.

10.00 BRANCH CONNECTIONS

10.01 Branch connections shall be made with standard tees and 45° laterals of the type required for the service.

10.02 In place of standard tees and 45° laterals, Contractor may provide weld-on fittings. Use of weld-on fittings is limited as follows:

a) For use in black steel piping systems only.
b) Branch line is at least two pipe sizes under run pipe size.

Approved Manufacturers and Models:

Bonney Forge Div. Gulf & Western Co.	
Allied Piping Products Co., Inc.	Type 1
WFI International, Inc.	Integrally Reinforced Type

10.03 Branch connections shall be made with cross fittings in place of tee fittings where shown on Drawings.

11.00 DIELECTRIC CONNECTIONS

11.01 Pipe joints connecting dissimilar metals shall be insulating, dielectric connections. Dielectric connections shall also be furnished for joining similar metals in order to isolate cathodically protected pipelines from adjoining pipe sections. Such joints, including dielectric material, shall be rated to withstand the temperature, pressure and other characteristics of the service for which it is to be used, including testing pressure.

11.02 Screwed joints shall be made with insulating unions and couplings.

Approved Manufacturers:

Calpico, Inc.
EPco Sales, Inc.
Stockham Valves & Fittings
PSI Industries
Central

11.03 Flanged joints shall be made with insulating gaskets, bolt sleeves and washers.

Approved Manufacturers:

Gaskets:
Calpico, Inc.
Duriron Co.
EPco Sales, Inc.
Pipeline Development Co. (Philco)
Central

Bolt Sleeves & Washers
Calpico, Inc.
E. I. DuPont deNemours & Co.
EPco Sales, Inc.
Pipeline Development Co. (Philco)
Central

12.00 LEAKAGE TESTING

12.01 All tests shall be performed in accordance with Section 15.01 "General Mechanical Requirements".

12.02 Tests shall be performed and approval of tests obtained in writing prior to cleaning, insulating, painting or conceiling.

12.03 Prepare and keep records of each system or section of system tested. Test reports shall be signed as approved by Owner's Representative and transmitted to Architect/Engineer with one copy to Owner's Representative. If additional copies are required by those persons having legal jurisdiction, Contractor shall furnish them. Test reports shall include, but not necessarily be limited to, the following:

a. Identification of piping system or section tested.

b. Date of test and date of Owner's Representative approval signature.

c. Testing medium, test equipment description (sketch if necessary), and method or description of test procedure.

d. Test pressure, duration of test and recorded pressure drop.

PIPING MATERIALS AND FABRICATION

12.04 Tests shall be observed after the pipe and contents have stabilized at the ambient temperature and the source of test pressure shut off. Pressure tests in general shall apply to piping only with all equipment, traps, relief valves and instruments blocked off or disconnected. In no case shall piping or any component be subjected to pressures exceeding their rating. All system valves within section being tested shall be open. Provide temporary restraints on expansion joints and flexible connections during pressure testing.

12.05 Unless otherwise indicated hydrostatic testing medium shall be water. Gauges used for pressure testing shall be checked and calibrated against a dead weight tester at least once per month and certified correct over the range of the gauge, to Owner's Representative. Gauges used for testing shall conform to ANSI B40.1 grade "AA" with minimum dial diameter of 6 inches and scale divisions equal to or less than the maximum allowable pressure drop.

12.06 Hydrostatic tests shall apply to piping as indicated in the following schedule. The pressure shall be gradually raised to the value given and the source then blocked off. The pressure shall not drop more than the amount indicated during the corresponding minimum time interval. If an audible or visible leak is detected during testing, this shall be cause to disapprove the test even though the maximum allowable pressure drop has not been exceeded. All joints shall be visually examined during test. Leaks shall be repaired and complete testing procedure repeated. Upon successful completion and approval of the tests, the piping shall be relieved of pressure, drained, cleaned, and put into normal operation except for potable water which shall first be disinfected.

a. Testing over occupied areas shall be done during non-production times

HYDROSTATIC & PNEUMATIC TEST SCHEDULE

Symbol	Service	Normal Work Pres. psig	Hydrostatic Test Pressure psig	Pneumatic Test Pressure psig	Max. Pres. Drop psi	Min. Time Hours
HHW	Heating Hot Water	to 100	150	---	2	2

12.07 After testing and cleaning, all open ended pipelines and valves shall be capped or plugged with polyethylene closures.

Approved manufacturer:

Protective Closures Col, Caplugs Div.

PIPING MATERIALS AND FABRICATION

13.00 CLEANING OF PIPE

13.01 Prior to assembly of pipe and piping components, all loose dirt, scale, oil and other foreign matter on internal or external surfaces shall be removed by means consistent with good piping practice. Chips and burrs from thread cutting operations shall be blown out of pipe before assembly. Cutting oil shall be removed from internal and external surfaces.

13.02 During fabrication and assembly, slag and weld spatter shall be removed from pipe joints by peening, chipping and wire brushing.

15.03 All completed piping systems shall be cleaned:

Waste Oil
Industrial Waste
Engine Crankcase Breather Vent
Storm
San
Vents
AAO

13.04 Notify Owner's Representative prior to starting any post-test cleaning operation. Consult with Owner's Representative with regard to specific procedures and scheduling. It shall be Contractor's responsibility to arrange for proper disposal of cleaning and flushing fluids.

13.05 Prior to blowing or flushing piping systems, disconnect all instrumentation and equipment, open wide all valves, and be certain all strainer screens are in place.

13.06 Water flush: Flush all pipe and components with clean water until all discharge from system is clean. Flow shall be in same direction as when system is in normal operation. Discharge shall be from low points of lines, ends of headers and as otherwise required to flush entire system.

13.07 Following flushing operations, all items disconnected or blanked off shall be reconnected. Strainer screens shall be removed, cleaned and replaced.

14.00 PIPE MATERIALS

14.01 All pipe, tubing and fittings shall conform to all applicable ASTM and ANSI standards as well as all specific requirements as indicated in Appendix C of this Specification Section. Owner reserves the right to require any and all additional tests as deemed necessary at Owner's expense.

14.02 All pipe, fittings, valves, equipment and accessories shall have factory applied markings, stampings or nameplates with sufficient data for identification to determine their conformance with specified requirements.

PIPING MATERIALS AND FABRICATION

14.03 Piping materials such as flanges and welding fittings, generally specified for sizes 2-1/2" and larger in Appendix C, shall be provided in sizes 2" IPS and smaller where necessary for connection to flanged valves and equipment and for underground welded piping.

15.00 VALVES

15.01 Furnish and install all valves as specified herein and as shown on the Drawings. Submit for approval by Architect/Engineer a schedule of all valves indicating the service, size, end connections, make, model number and any special features such as chain wheel operators, etc. As nearly as possible, all valves shall be of a single manufacturer.

15.02 Valves shall conform to specifications in Appendix B. All packings, gaskets, discs, seats, diaphragms, lubricants, etc., not specifically mentioned shall conform to recommendations of the valve manufacturer for the intended service.

15.03 If space permits, install valves with stems horizontal or extending vertically upward unless specifically shown otherwise. All valves shall be installed in accessible locations for operation as well as for removal, repair or replacement.

15.04 Provide to Owner's Representative two operating wrenches for each type valve not equipped with handwheels or levers. Provide an additional wrench for every ten valves of each type installed.

15.05 Provide shut off valves in both supply and return lines at each item of equipment.

16.00 STRAINERS

16.01 Furnish and install strainers at locations indicated on the drawings and as specified. Unless otherwise indicated on the Drawings or specified, pipe line strainers shall be Y-pattern and have stainless steel screens with openings of 1/16".

Furnish pipe nipple with GL-1 globe valve where indicated on Drawings for blowing down strainer screen.

17.00 THERMOMETERS

17.01 Furnish and install thermometers at locations indicated on the Drawings and as specified. Thermometers shall be located such that they can be easily read from floor level or operating platform.

17.02 Unless otherwise indicated or specified, all thermometers shall be 9 inch vertical scale adjustable all-angle type or 4-1/2 inch diameter dial adjustable all-angle type for direct mount, and 4-1/2 inch diameter dial type with remote bulb type for remote mount.

PIPING MATERIALS AND FABRICATION

Additional Requirements:

for all types

a) aluminum case

b) mercury filled

c) white face with black scale markings

d) separable socket well

e) unless otherwise indicated or specified, thermometer scale ranges and scale divisions in degrees F shall be as indicated in the thermometer schedule

for all dial types

a) brass or stainless steel movement

b) copper or brass bulb

c) adjustment provision for calibration without removing pointer

d) ambient temperature compensated case

for remote bulb type

a) bronze braided armored capillary of required length

b) ambient temperature compensated capillary

Approved Manufacturers:

Dresser Industries, Inc. (Ashcroft)
Palmer Instruments
H. O. Trerice Co.
U. S. Gauge Division, Ametek, Inc.
Weksler Instruments Corp.
Weiss Instruments

PIPING MATERIALS AND FABRICATION

17.03 Install thermometers in piping and equipment in stainless steel wells filled with non-solidifying high thermal conductivity heat conducting paste or liquid such as glycerine and graphite mixture. Wells and sensing elements shall be located and arranged such that sensing element is in the path of the moving fluid and not positioned in stagnant or dead end locations. Wells shall not obstruct the flow of the fluid being measured. Pipes one inch and smaller shall be increased at least one pipe size at point of insertion. Provide extension necks on thermometers directly mounted on insulated piping, vessels and equipment.

17.04 When temperature sensing element location is 8 feet or more above floor level, provide remote bulb type with dial located 4'-6" above floor or operating platform mounted on building structure.

17.05 THERMOMETER SCHEDULE

		Dial Type		Vertical Type	
Symbol	Service	Range, Deg. F.	Max. Div.	Range, Deg. F.	Max. Div.
HHW	Heating Hot Water	30 to 240	2	30 to 240	2

18.00 PRESSURE GAUGES

18.01 Furnish and install pressure gauges at locations indicated on the Drawings and as specified. Pressure gauges shall be located such that they can be easily read from floor level or operating platform.

18.02 Unless otherwise indicated or specified, all pressure gauges shall be Bourdon tube type with 4-1/2 inch diameter dial, aluminum case, white face with black scale markings, brass or stainless steel bushed movement, phosphor bronze tube, and brass or stainless steel socket. Units shall have adjustment provisions for calibration without removing or bending pointer. Scale divisions for all pressure gauges shall be a maximum of 1 psi for ranges 0 to 50 psig, and a maximum of 2 psi for ranges above 0 to 50 up to 0 to 200 psig, and 5 psi for ranges greater than 0 to 200 psig. All gauges shall be ANSI Grade "A". Accuracy shall be ±1% or better of scale range for middle half of scale and ±1-1/2% or better for remainder of scale. Scale ranges shall be selected such that normal pressure condition will fall approximately at mid-scale. Scale range shall be wide enough to cover all expected extremes but should not exceed more than 15 psig beyond these extremes. Compound gauges shall be provided where normal operating pressure is at or near atmospheric.

Approved Manufacturers:

Dresser Industries, Inc.	Ashcroft "Quality Series
J. P. Marsh Instrument Co.	"Quality" Series
H. O. Trerice	600 Series
U. S. Gauge Div., Ametek, Inc.	"A" Line 5800 Series
Weksler Instruments Corp.	"Regal" Series

PIPING MATERIALS AND FABRICATION

18.03 Pressure gauges installed in piping shall be located in straight runs of pipe and be provided with shut-off cock in sensing line. Locate pressure sensing tap so as to accurately sense fluid pressure according to manufacturer's recommendation. Provide extension necks on pressure taps in insulated piping, vessels and equipment.

Approved Manufacturers:

Gauge cocks	
Dresser Industries, Inc.	
(Ashcroft)	No. 1095
H.O. Trerice Co.	No. 865

18.04 Provide pulsation dampeners on all gauges installed on discharge of pumps. Provide isolating seals where fluid can injure gauge.

PIPING MATERIALS & FABRICATION

PIPING SCHEDULE

WATER SYMBOL	WATER SERVICE	OPER. PRESS. PSIG	PIPE SPEC. NO.	SHUT-OFF	VALVE TYPE THROTTLING	VALVE TYPE CHECK	STRAINER TYPE
HHW	Heating Hot Water (Aboveground)	to 100	5	GA-2 GA-5 GA-12 GA-13 PL-11 PL-12 BA-2 BA-4	PL-9 PL-10	CK-1 CK-10 CK-13	ST-1 ST-5

PIPING MATERIALS & FABRICATION

GATE VALVE SPECIFICATIONS

TYPE	SIZE	PRESSURE PSIG	MISCELLANEOUS REQUIREMENTS	MANUFACTURER'S NUMBER
GA-2	2-1/2" thru 12"	125 S 200 WOG	Flanged Iron body Bronze mounted OS & Y	Crane 465-1/2 Hammond IR1140 ITT-Grinnell 0611 Jenkins 651A Lunkenheimer 1430 Milwaukee F-2885 Nibco F-617-0 Powell 1793 Stockham G623 Walworth 726F, 8726F
GA-5	2" and under	125 S 200 WOG	Solder, Bronze, Rising stem Screw-in bonnet	Lunkenheimer 2132 Crane 1334 Hammond 1B635 Jenkins 1242 Nibco S-111 Powell 1821 Stockham B109 Walworth 55SJ ITT Grinnell 425SJ
GA-12	3" and under	150 S 225 WOG	Flanged, Bronze Rising Stem, Double wedge disc	Lunkenheimer 2229 Powell 515 Walworth 11-F
GA-13	3" and under	125 S 200 WOG	Screwed, Bronze Rising stem, Union bonnet.	Lunkenheimer 3127 Crane 428-UB Nibco T-124 Powell 2700S Walworth 2 Milwaukee 1152 Jenkins 47-U Hammond 1B617 Stockham B-105

PIPING MATERIALS & FABRICATION

BALL VALVE SPECIFICATIONS

TYPE	SIZE	PRESSURE PSIG	MISCELLANEOUS REQUIREMENTS	MANUFACTURER'S NUMBER
BA-2	2" and under	125 S 200 WOG	Screwed, All bronze, Teflon seat.	W-K-M B136 Conbraco Apollo Series 70 (original) Nibco T-580 Lunkenheimer 728XLT Powell 4210T Worcester Econ-o-Mite 4211T Clayton Mark BR-780-T-T Hills McCanna F502-BR-T-B Jamesbury A11TT Jenkins 1101-T Parker & Harper Gemini 86-1-RT-1 Stockham S216 BR-R-T Rockwood 105T Crane 930-TF
BA-4	3" thru 8"	150 S 200 WOG	Flanged, end entry, Ductile iron or Carbon steel body, Teflon seat.	Clayton Mark FIC 400 Hill McCanna F151-D1-T-CS Powell 4 222T Worcester Miser 444T 150 Lunkenheimer 715-T Rockwood 552 Crane 941 TF W-K-M B101, B102, B104 Jamesbury A150F21TT

PIPING MATERIALS & FABRICATION

PLUG VALVE SPECIFICATIONS

TYPE	SIZE	PRESSURE PSIG	MISCELLANEOUS REQUIREMENTS	MANUFACTURER'S NUMBER
PL-9	4" and under	200 WOG	Screwed Bronze body, resilient plug Non-lubricated Full opening Viton Packing, High temp facing	DeZurik Series 100
PL-10	6" thru 16"	200 WOG	Flanged Bronze body, resilient plug Non-lubricated Full opening Viton Packing High Temp Facing	DeZurik Series 100
PL-11	4" and under	175 WOG	Screwed Semi-Steel Non-lubricated Full Opening E.P.T.	DeZurik Series 400 Homestead Ballcentric
PL-12	1" thru 16"	175 WOG	Flanged Semi-steel Non-lubricated Full Opening E.P.T.	DeZurik Series 400 Homestead Ballcentric

PIPING MATERIALS & FABRICATION

CHECK VALVE SPECIFICATIONS

TYPE	SIZE	PRESSURE PSIG	MISCELLANEOUS REQUIREMENTS	MANUFACTURER'S NUMBER
CK-1	3" and under	125 S 200 WOG	Screwed Bronze Horizontal swing	Lunkenheimer 2144 Crane 37 Hammond IB940 Jenkins 92A Nibco T-413 Powell 57B Stockham B319 Walworth 406 ITT-Grinnell 440 Milwaukee 509M
CK-10	2" - 14"	125 S 200 WOG	Flanged Iron Body bronze mounted Horizontal swing	Lunkenheimer 1790 Crane 373 Hammond IR880F Jenkins 264 Powell 559 Stockham G-931 Walworth 8928F, 928F Nibco F-91B-B
CK-13	2" thru 10"	125 S 200 WOG	Wafer type ends Semi-steel body Bronze trim Silent non-slam type Buna-N seat with bolts	FMC CV12C20B Metraflex 700 Series TRW Mission Duo-Check 12BMP Nibco W-910-W Clow 329 Mueller 101-AP Technocheck Short Form 5118 CPV 10B-R Smolensky Style 11

PIPING MATERIALS & FABRICATION

STRAINER SPECIFICATIONS

TYPE					
ST-1	1/2" to 3"	250S	Screwed Bronze Screwed Cover	Armstrong Machine Works	F4SC
				Metraflex Co.	539S
				Mueller Steam Specialty	352
				Sarco Co.	BT.
				Strong	SYB
ST-5	2" to 12"	150 S 225 WOG	Flanged Bronze Bolted Cover	Armstrong Machine Works	F4FL
				Mueller Steam Specialty	851
				Sarco Co.	BF-150
				Strong	SYFB-15

PIPING MATERIALS & FABRICATION

GLOBE VALVE SPECIFICATIONS

TYPE	SIZE	PRESSURE PSIG	MISCELLANEOUS REQUIREMENTS	MANUFACTURER'S NUMBER
GL-1	2" and under	150 S 300 WOG	Screwed, Bronze, Teflon disc	Crane 7 Hammond IB413 ITT-Grinnell 89 Jenkins 106A Lunkenheimer 123 Milwaukee 590 Nibco T-235 Powell 150 Stockham B22 Walworth 95

PIPING MATERIALS & FABRICATION

SPECIAL VALVE SPECIFICATION

TYPE	SIZE	PRESSURE PSIG	MISCELLANEOUS REQUIREMENTS	MANUFACTURER'S NUMBER
CB-1	1"	125 WOG	Screwed, Bronze with Differential Meter for every 10 units	Bell & Gossett Circuit Setter Balance Valve
CB-1¼	1¼"	125 WOG	Screwed, Bronze with Differential Meter for every 10 units	Bell & Gossett Circuit Setter Balance Valve
CB-1½	1½"	125 WOG	Screwed, Bronze with Differential Meter for every 10 units	Bell & Gossett Circuit Setter Balance Valve

PIPING MATERIALS & FABRICATION

Pipe Specification No. 2
Design Pressure: 125 psig
Maximum Design Temperature: 350°F

2" and under

Pipe:	Standard weight black steel, ASTM A53 or A135, Type E, Grade A, electric resistance welded
Joints:	Screwed.*
Fittings:	150 lb.(S) - 300 lb.(WOG), black malleable iron, banded, ASTM A197 ANSI B16.3.
Unions:	250 lb.(S) - 500 lb.(WOG), black malleable iron, ground joint with brass seat.

2-1/2" and over

Pipe:	Standard weight black steel, ASTM A53 or A135, Type E, Grade A, electric resistance welded.
Joints:	Butt welded and flanged.
Fittings:	Standard weight seamless steel, butt weld type, ASTM A234 Grade WPB, ANSI B16.9.
Flanges:	150 lb. forged steel, welding neck or slip-on, ASTM A181 Grade I, ANSI B16.5.

*NOTE: For belowground, all sizes to have welded joints.

NON-POTABLE WATER SYSTEMS

NON-POTABLE WATER SYSTEMS

1.00 GENERAL

All work in this Section shall be performed in accordance with the Contract Documents.

2.00 SCOPE OF THE WORK

2.01 This Section of the Specifications covers the furnishing of all materials and performing all labor for the systems as specified herein and as indicated on the Drawings.

2.02 Non-potable water systems shall include the following:

Heating hot water	HHW

2.03 These systems shall include the distribution piping and final connections to all equipment in each system, complete with vents, relief lines, drains and accessories.

3.00 GENERAL REQUIREMENTS

3.01 All non-potable water piping materials, fabrication, installation, cleaning and testing shall conform to Section 15.02 "Piping Materials and Fabrication".

3.02 Connections to equipment, tanks and vessels shall be screwed type for sizes 2 inches or smaller and flanged type for sizes 2-1/2 inches or larger unless otherwise indicated on the Drawings.

4.00 RELIEF VALVES

4.01 Type RV-10: Furnish and install pressure relief valves, with cast iron or bronze body and bronze internal parts, capable of relieving steam as well as liquid where indicated on the Drawings. The valves shall be constructed, tested and marked with the code symbol and data as required by the A.S.M.E. Boiler and Pressure Vessel Code. The valves shall be direct spring loaded automatic reseating type with side test lever. Valves shall be located, sized and factory set for pressures as indicated on the Drawings.

Approved manufacturers:

Bell & Gossett (Div. of ITT)	Series 250 through 4100
A.W. Cash Valve Mfg. Corp. (Cash-Acme)	Types F-51, F-52 & F-53
Crane Co.	Cat. No. 2606
McDonnell & Miller, Inc.	Series 230 and 240
Watts Regulator Co.	Series 174A

5.00 AIR VENTS & SEPARATORS

NON-POTABLE WATER SYSTEMS

5.01 Type AV-11: In-line air separators shall be furnished and installed where shown on the Drawings to insure proper air control in closed loop system with closed expansion tanks. Unit shall be constructed of cast iron or steel in conformance with ASME Boiler and Pressure Vessel Code, Section VIII, Unfired Pressure Vessels for 125 psig and shall bear ASME Label.

Approved manufacturers:

Bell & Gosset (Div. of ITT)   Rolairtrol

6.00 TEMPERATURE & REGULATING VALVES

6.01 Temperature regulating valves shall be furnished and installed in the size, type and pressure shown on the Drawings.

6.02 Type TRV-1: Valves shall be a self-operating type with balances construction for clatter free and slam free service. Valves should be self piloting with cast iron or bronze bodies, stainless steel or bronze internal parts and complete with strainer. Valves shall have an adjustable set point with a 350°F temperature rating.

Approved manufacturer:

Spencer Engineering Co., Inc.   Type C 34 T 52

7.00 FLEXIBLE CONNECTORS

7.01 Flexible connectors shall be furnished and installed where shown on the Drawings.

7.02 Type FC-10: Flexible connectors shall be single braided bronze or stainless steel, packless, corrugated element type. Connector length, pressure and temperature ratings shall be as indicated on the Drawings. Unless otherwise indicated, connector size shall match adjoining piping.

Approved manufacturers:

Anaconda American Brass Co.
Flexonics (Div. of Universal Oil Products Co.)
Metraflex Co.

7.03 Type FC-11: Flexible connectors shall be duck and rubber, spool type design complete with ANSI standard flanged ends. Connectors with non-metallic flanges shall be furnished with galvanized retaining rings. Connectors shall be furnished with control units to prevent excessive elongation. Pressure and temperature ratings shall be as indicated on the Drawings. Unless otherwise indicated, connector size shall match adjoining piping.

Approved manufacturers:

NON-POTABLE WATER SYSTEMS

Garlock Inc.	Garflex
Mercer Rubber Co.	Invincible
Metraflex Co.	Style 100 through 300
Red Valve Company, Inc.	Redflex
Uniroyal, Inc. (U.S. Rubber Co.)	Style AMR

7.04 Type FC-12: Flexible connectors shall be nylon and neoprene body, spherical design complete with tapped steel flanges for connection to 150 psi ANSI piping flanges. Connectors shall be rated for 10" Hg vacuum to 225 psig at temperatures to 240°F.

Approved Manufacturers:

Metraflex Co.	Metrasphere

THERMAL INSULATION

THERMAL INSULATION

1.00 GENERAL

1.01 All work of this Section shall be performed in accordance with the Contract Documents.

2.00 SCOPE OF THE WORK

2.01 The work shall consist of furnishing all material and performing all labor required for the thermal insulation of piping, equipment and ductwork as called for in these Specifications and as shown on the Drawings.

3.00 GENERAL REQUIREMENTS

3.01 Insulation shall be installed in a smooth, clean, workmanlike manner. Joints shall be tight and finished smooth. Cracked, chipped, and torn sections shall not be used in the work.

3.02 All surfaces to be insulated shall be dry and free of loose scale, rust, dirt, oil or water when insulation is applied.

3.03 Insulation shall fit tightly against surface to which it is applied.

3.04 Insulation applied to piping and equipment which is cold shall be completely vapor sealed and free of pinholes or other openings.

3.05 Sealant or cement shall not be applied until all previous applications of adhesives and cement have thoroughly dried.

3.06 Existing insulation and surface finishes disturbed or damaged during the course of the work shall be restored in a manner acceptable to the Owner's Representative.

3.07 All required tests on piping, equipment and ductwork must be completed, and satisfactory test reports must be submitted to the Owner's Representative prior to application of insulation.

3.08 Apply insulation so as to permit expansion or contraction of pipe lines without causing damage to insulation or surface finish.

3.09 Specified pipe insulation jackets shall be factory applied whenever available.

3.10 Preformed pipe covering shall be terminated at a sufficient distance from valve flanges to permit removal of bolts.

THERMAL INSULATION

3.11 Insulation on flanges shall overlap adjacent pipe covering 2 inches. Valves shall be insulated up to the gland.

3.12 Insulation shall be continuous through pipe covering protection saddles, or shall butt tightly against insulation protection shield units installed as part of the piping work.

3.13 Pipe line strainers shall be insulated in such a manner as to permit removal of strainer basket without disturbing insulation on the strainer body.

3.14 Pipe insulation and vapor barrier shall be continuous through sleeves or openings in walls and floors.

3.15 Premolded pipe insulation shall be furnished with extended leg when used on pipes traced with either piping or cable.

3.16 All insulation and accessories shall be installed per the manufacurer's recommendation.

4.00 DEFINITIONS

4.01 The term "concealed" as used herein refers to piping above suspended ceilings and within walls, partitions, shafts and service spaces not normally exposed to view.

4.02 The term "exposed" refers to all other piping.

5.00 FIBER GLASS PIPE INSULATION - TYPE H-2

5.01 Insulation: Rigid molded glass fiber pipe covering having a density of 4 lb/cu.ft., in compliance with ASTM C547, having a k-factor of approximately .22 @ 75°F, and suitable for temperatures from -40°F to 450°F.

5.02 Jacket: Factory applied vapor barrier all-service type with self-sealing lap and butt strips.

5.03 Application:

a. Pipe-Stagger longitudinal joints. Tightly butt the sections and seal longitudinal seams of vapor barrier jacket with vapor barrier lap adhesive in addition to the self sealing feature. Seal circumferential end joints with butt strips of vapor barrier material and vapor barrier lap adhesive. Above a fluid operating temperature of 80°F, outward clinch staples may be used in place of adhesive. Seal pipe ends, valves, and fittings of cold piping with vapor barrier coating.

THERMAL INSULATION

b. Valves, fittings, and flanges - Cover with pre-molded glass fiber covering having same thickness as adjacent insulation. Cover with PVC cover. Seal cover joints on cold piping with vapor barrier coating or vapor barrier adhesive tape. When premolded fitting covers are not available, proceed as follows:

1. On pipe sizes 2 1/2 inches and under, apply insulating cement in successive layers not exceeding 3/4 inch thickness per layer to a thickness equal to insulation on adjacent pipe. Finish with canvas or glass cloth covered with a seal coat of lagging adhesive. On cold piping apply coat of vapor barrier coating.

2. On pipe sizes 3 inches and over, apply mitered fiberglas insulation to a thickness equal to insulation on adjacent pipe. Fasten with wire mesh or galvanized wire. Point with insulating cement. Finish with 1/4 inch of finishing cement and canvas or glass cloth covered with a seal coat of lagging adhesive. On cold piping apply coat of vapor barrier coating.

5.04 Surface Finish:

a. Indoor - no further finish required.

b. Outdoor - cover with a factory or field applied .016 in. smooth 5005 alloy aluminum jacket. Lap joints downward to shed water. Finish circumferential joints with prefabricated aluminum or stainless steel straps and waterproof metal lap sealant.

5.05 Approved manufacturers:

a. Insulation:

Certain-Teed Products	CSG Snap-On ASJ-SSL
Johns-Manville	Micro-Lok 650 Type AP-T
Owens-Corning Fiberglas	Fiberglas 25 ASJ/SSL

b. Fitting Covers:

Insul-Coustic/Birma	Insul-Sure Heavy Density
Johns-Manville	J-M Zeston PVC Cover with fiberglas insert
Certain-Teed Products	Snap Form
Coverite	S-800
Ceel-Co.	Ceel-Tite 100 Series

c. Metal pipe jacket with Moisture Barrier

Childers Products	Lock-on
Insul-Coustic/Birma	Metal-Clad
Johns-Manville	Micro-Lok 650 ML
Preformed Metal Products	Loc-Jac

d. Metal Fitting Jackets with Moisture Barrier

Childers Products	Ell Jacks, Univera-ells
Johns-Manville	J-M Flame-Safe ML-Miter-Seals
Preformed Metal Products	Combination Aluminels
General Aluminum Supply	GASCO Humped Cover

6.00 INSULATION SCHEDULE

6.01 All insulation shall be installed in the thickness given in the following schedule:

Pipe Size	Insulation Type	Insulation Thickness
1" - 1-1/2"	H-2	1"
2" - 4"	H-2	2"
6"	H-2	2-1/2"

PUMPING EQUIPMENT

PUMP EQUIPMENT

1.00 GENERAL

1.01 All work of this section shall be performed in accordance with the Contract Documents.

2.00 SCOPE OF THE WORK

2.01 This Section of the Specifications covers the requirements for furnishing and installing all pumping equipment as specified herein. The work shall include making such running tests as are required to insure that pumps will operate satisfactorily under specified operating conditions.

3.00 GENERAL REQUIREMENTS

3.01 Pump size, type, capacity, arrangement and configuration shall be as indicated on the Drawings and specified herein.

3.02 Pump base when specified shall be rigid, sized to eliminate flexing and to maintain alignment of pump, driver plus other accessories.

3.03 Materials of construction shall be suitable for continuous operation at specified conditions.

3.04 Rotating parts shall be statically, hydraulically, and dynamically balanced at factory prior to shipment.

3.05 Pump bearings are to be complete with a fitting for manual lubrication.

3.06 All rotating equipment including couplings and drives shall be complete with adequate guards for personnel protection as specified in Section 15.01.

3.07 All units shall perform at conditions specified as well as other points on performance curve without pulsating, vibrating or internal recirculating.

3.08 Each unit to be complete with a stainless steel nameplate securely attached to pump itemizing pump data including model number, serial number, impeller diameter and part number, plus part number, and size of seal where pump is equipped with mechanical seals.

4.00 SHOP DRAWINGS

4.01 Shop drawings shall be submitted for approval. Each submittal shall be clearly referenced with the equipment number, job description plus the following information:

a. Factory hydrostatic test pressure and/or rating.

b. Detailed construction and/or assembly drawings clearly indicating dimensions, anchor points, materials of construction.

c. Performance curves noting capacity and power requirements at varying pump heads from zero to shut off. Specified conditions are to be clearly indicated. Performance curve must list actual impeller code number and diameter.

d. Pump to motor alignment.

e. Lubrication requirements.

f. Assembly and adjustment procedures for field assembled units.

g. Manufacturer's parts catalogs with a recommended inventory of spare parts for each assembly.

h. Manufacturer's data to describe mechanical seal or shaft packing.

i. Motor make, HP, RPM, voltage and other data.

j. Manufacturer's data identifying and describing each bearing.

5.00 ELECTRICAL REQUIREMENTS

5.01 Electrical requirements for pumping equipment shall be as per Section 15.01, General Mechanical Requirements.

6.00 SHAFT SEALS

6.01 Pump shafts shall be fitted with packing or mechanical seals as indicated. Actual selection of seal or packing shall conform to manufacturer's recommendation for service conditions noted.

6.02 Each mechanical seal except those noted otherwise on drawings details, those used on potable water pumps, or those used on U.L. Labeled pumps shall be complete with a fluid flush arrangement bolted to pump, consisting of piping from pump discharge to an abrasive separator or filter. Route piping from clean liquid separator, or filter, outlet to mechanical seal. Route piping from separator discharge to floor drain. Piping arrangement to be complete with pressure gage on discharge side of separator and shut off valve on pressure side. Filters shall be used on closed systems such as hot water.

6.03 Approved manufacturer:

Cartridge Filter - Cuno Engineering
Micro Klean Series 1 Bl
with replacement cartridge

7.00 VIBRATION

7.01 Pump vibration shall not exceed limits as recommended by Hydraulics Institute when operating at design conditions.

8.00 FLEXIBLE COUPLINGS

8.01 Each pump shall be connected to its driver by a flexible coupling unless they are direct coupled, belt or gear driven.

8.02 Flexible couplings shall conform to the following types:

a. Greasable type for drivers that exceed 5 HP.

8.03 Manufacturer is responsible for sizing and selection of flexible coupling as per scheduled service conditions.

PUMPING EQUIPMENT

9.00 INSTALLATION

9.01 Pumps shall be installed on concrete bases or foundations.

9.02 Contractor shall verify the following before operating any pump.

a. System filled with fluid

b. Alignment of pump and motor are within manufacturer's limitations

c. Unit lubricated as per manufacturer's recommendation

d. Proper pump rotation and speed

e. Packing gland adjusted as per manufacturers recommendation. Cooling or flushing fluid available for mechanical seals.

f. Clearance of impellar or other rotating parts within manufacturers limits.

g. Motor load within limits of motor rating.

9.03 After one hour of operation at operating temperature but not more than four hours after start up recheck pump drive alignment with an approved type of dial indicator. Check and adjust V-belts on belt driven pumps. Adjust impeller clearance where required. Check for any sign of overheating of motors, bearings, seals, etc.

10.00 PERFORMANCE TESTS

10.01 Following initial running of individual pumps to demonstrate satisfactory mechanical operation, tests shall be conducted to demonstrate performance as part of their respective systems during which the Contractor shall determine and record the proper set point for all automatic pump control devices (temperature, pressure, level, etc.). This data shall be incorporated in the "Instruction Manual" for each system.

PUMPING EQUIPMENT

11.00 END SUCTION PUMP TYPE ESP

11.01 Pump shall be centrifugal type single stage, end suction, driven thru a flexible coupling with pump and drive motor mounted on a common base plate. Pump and motor to be foot mounted.

11.02 Volute type casing to be cast iron or semi-steel with replaceable bronze wearing rings. Bronze impeller to be enclosed, and bolted or keyed to shaft.

11.03 Shafts for pumps fitted with packing shall be ground and polished stainless steel.

11.04 Pumps fitted with mechanical seals shall be complete with removable stainless steel sleeves and shaft.

11.05 Type ESP - 1: Shall be mounted on a cast iron drip lip base plate.

11.06 Type ESP - 2: Shall be mounted on a fabricated structural steel base plate.

11.07 Type ESP - 3: Shall be mounted on a channel steel base plate.

11.08 Approved Manufacturers and Equipment - Models:

Aurora Pump Co.	Series 320-340-360
Bell & Gossett	Series 1510
Deming Div. Crane Corp.	Series 4000
Ingersoll Rand Co.	Series HC
Peerless Pump Div. FMC Corp.	Series F
Worthington Corp.	Series D
Weil Pump Co.	Series 3200
Goulds Pump Co.	Series 3700

EQUIPMENT SUPPORTS, BASES & FOUNDATIONS

EQUIPMENT SUPPORTS, BASES & FOUNDATIONS

1.00 GENERAL

1.01 All work of this Section shall be performed in accordance with the Contract Documents.

2.00 SCOPE OF THE WORK

2.01 This Section of the Specification includes furnishing and installing equipment supports, bases and foundations as specified herein and as shown on the Drawings.

3.00 GENERAL REQUIREMENTS

3.01 Install equipment in accordance with manufacturer's approved certified shop drawings as well as published recommendations for setting, leveling, anchoring, alignment and grouting.

3.02 Equipment supports, bases and foundations shown on the Drawings shall be modified as required to conform to approved certified shop drawings of specific equipment actually furnished unless noted otherwise on the Drawings or in the Specifications.

3.03 Grout when required shall be Master Builders' Embeco premixed, nonshrink, mixed and applied in accordance with the manufacturer's recommendation. Grout must be complete, continuous and free from voids.

3.04 Shims, when required, shall be cut from sheet or plate steel, sized and positioned to provide proper bearing surface.

3.05 Furnish and position anchor bolts as shown on the Drawings as well as approved manufacturer's certified shop drawings.

4.00 SHOP DRAWINGS

4.01 Section 15.01, General Mechanical Requirements, defines shop drawing submittal requirements and procedures.

4.02 A shop drawing shall be submitted for each item which includes:

a. Dimensional details of each item
b. Individual load points and weights
c. Spring diameter
d. Spring deflection
e. Compressed spring height
f. Solid spring height

4.03 Each submittal shall be identified by specification type and the equipment to which it applies.

EQUIPMENT SUPPORTS, BASES AND FOUNDATIONS

5.00 FOUNDATIONS

5.01 Exposed edges of concrete foundation bases shall be formed with chamfer strips. Unless noted otherwise on the Drawings, chamfers to be 1-1/2 x 1-1/2 x 45°. All surfaces are to be troweled smooth, except areas that will receive grout which are to be left rough, to remove form marks and voids filled.

5.02 Concrete shall be in accordance with the structural drawings. All concrete shall develope a minimum strength of 4000 psi at 28 days except when the thickness of the foundations are greater than 2' the minimum strength shall be 2500 psi at 28 days.

5.03 Size, location and quantity of anchor bolts shall be modified as required to conform to approved certified shop drawings of specific equipment actually furnished unless noted otherwise on Drawings or in Specifications.

5.04 Type F-1: Shall be special concrete foundation base sized, arranged and located as shown on the Drawings as well as approved certified manufacturer's shop drawings.

6.00 SUPPORTS

6.01 Type BS #1: Shall be a structural or special framed support, arrangement as defined by the Drawings as well as approved certified manufacturer's shop drawings.

SOLAR THERMAL COLLECTORS

SOLAR THERMAL COLLECTORS

1.00 GENERAL

1.01 All work in this section shall be performed in accordance with the Contract Documents.

1.02 All collector equipment shall be completed, assembled, installed, tested, adjusted, and demonstrated to be ready for permanent operation to the satisfaction of the owner's representative.

1.03 All design changes to the collector equipment from that indicated in the Contract Documents which require a change in the mechanical, electrical or structural designs shall be submitted in writing to the owner's representative 60 days in advance of the scheduled equipment delivery.

2.00 REQUIREMENTS

2.01 The solar collector shall absorb the incident solar flux by tracking the solar position and concentrating the insolation on an absorber assembly. The ratio of solar aperature area to absorber tube area shall be no less than twenty to one.

2.02 The collector shall consist of reflectors, module bearings, supports, tracking sensor, tracking controls, safety controls (collector only), receiver assembly and tracking actuator.

2.03 The collector shall be designed to give 20 years of service life and shall be guaranteed against defects in material and workmanship for one year.

SOLAR THERMAL COLLECTORS

3.00 PERFORMANCE

3.01 The collector shall withstand extended weather conditions including wind loads up to 90 mph without damage.

3.02 The reflectors shall have a minimum specular reflectance of .8 average over the solar spectrum at the time of delivery. The reflectors shall have an impact resistance equal to 0.040" aluminum sheet with 42,000 psi tensil and 37,000 psi yield.

3.03 All collector equipment shall be constructed of corrosion free materials or suitably coated with corrosion resistant materials.

3.04 The tracking mechanism shall automatically track and focus on the solar position throughout the day and drive the module to the protected "stow" position at night. The tracking mechanism shall have an overall accuracy of at least 5 milliradians. The maximum tracking rate shall be 0.1 RPM and the stow rate shall be a minimum of 1 RPM.

3.05 The total weight of the laden system shall be less than 6 lbs/ sq. ft. of solar aperture.

3.06 The receiver (absorber) shall accommodate a flow rate of up to 25 gpm and shall have a pressure drop of less than 5 psi/100' @ 5 gpm water.

3.07 Thermal expansion shall be allowed with flexible hose assemblies and all wetted surfaces shall be ferrous or stainless alloys.

3.08 The receiver (absorber) surface shall have an optical absorptance of 0.95 minimum and an emissivity of not more than .30 @ 200°C. The absorber surface shall be protected from weather with a water tight seal.

3.09 The receiver (absorber) assembly shall have a thermal loss rate of less than 10 BTU/ sq. ft. of solar aperture @ 70°F ambient with absorber shadowed under system operating temperature.

3.10 The reflector/receiver assembly shall have an optical efficiency of at least 66% upon equipment installation.

3.11 Approved manufacturer:

Solar Kinetics Inc. T-700

4.00 INSTALLATION

4.01 All collector pylons shall be mounted per Contract Documents.

4.02 All mirror modules and receiver/hose assemblies shall be mounted per Contract Documents.

4.03 All power central wiring and central controller shall be wired per Contract Documents.

4.04 Contractor shall verify the following automatic operational characteristics:

a. When the central direct normal light switch indicates minimum present direct normal levels for a minimum period of 15 minutes, the central controller shall issue a "track ready" command which shall be used to start the fluid pump

b. After a 5 minute delay to allow fluid flow to be established, the central controller shall direct the collector out of the stow position.

c. This signal shall continue for a minimum period which allows each row to acquire the sun. As each collector row approaches the sun and falls within 20° of focus, the central controller shall be overridden by the individual row trackers.

d. The collector row automatic tracker shall maintain focused sunlight on the receiver until the minimum direct normal light level is not met. At this point, a dead band signal shall hold collector position until the central controller resumes tracking.

e. If direct normal minimums are not met for a preset period (up to 45 minutes) the central controller shall provide a stow signal. At which time the collector shall be driven to the stow position and shall remain there until the original automatic scenario is reinitialized.

f. Other conditions that shall provide a stow signal are nightfall, rainfall, high wind speed, loss of flow, overpressure, overtemperature and loss of AC power.

GENERAL ELECTRICAL REQUIREMENTS

GENERAL ELECTRICAL REQUIREMENTS

1.00 GENERAL

All work in the Electrical Division of these Specifications shall be in accordance with the Contract Documents, as defined in the General Conditions. All systems shall be completely assembled, tested, adjusted, and demonstrated to be ready for operation prior to Owner's acceptance.

2.00 REFERENCE STANDARDS

2.01 Portions or all of certain recognized industry or association standards referred to herein as being a requirement of these Specifications shall be considered as binding as though reproduced in full herein. Unless otherwise stated, the reference standard shall be the standard which is current as of the date of issuance of Contract Documents. Referenced Codes and Standards constitute minimum requirements and strict compliance is required therewith unless supplemented and/or modified by more stringent requirements in these Specifications. Reference may be made to standards either by full name or by letter designation as follows:

AEIC	Association of Edison Illuminating Companies
ANSI	American National Standards Institute, Inc.
ASTM	American Society for Testing & Materials
IES	Illuminating Engineering Society
IEEE	Institute of Electrical & Electronics Engineers
IPCEA	Insulated Power Cable Engineers Association
JIC	Joint Industrial Council
NEC	National Electrical Code of NFPA
NEMA	National Electrical Manufacturer's Association
NESC	National Electrical Safety Code
NFPA	National Fire Protection Association
OSHA	Occupational Safety & Health Act
UL	Underwriters' Laboratories, Inc.

3.00 QUALITY STANDARDS

3.01 All materials and equipment furnished under these Specifications shall be to new and the extent possible standard products of the various manufacturers except where special construction or performance features are called for. Where more than one of any specific item is required, all shall be of the same type and manufacture.

3.02 All electrical equipment or materials shall have a label, symbol or identifying mark of a nationally recognized testing laboratory, inspection agency, or other organization concerned with product evaluation that maintains periodic inspection of production of labeled equipment or materials and by whose labeling is indicated compliance with nationally recognized standards or tests to determine suitable usage in a specific manner.

3.03 The product of specified approved manufacturers shall be acceptable only when that product complies with or is modified as necessary to comply with all requirements in the Contract Documents.

3.04 Items of equipment or material which are not specifically defined herein shall conform to the general standard of quality established herein.

4.00 PERMITS, CODES

4.01 Electrical installations shall comply with all applicable laws and ordinances in effect at the building site, with applicable regulations of the NEC and with regulations of the utility companies furnishing power to the site.

5.00 FIELD MEASUREMENTS

5.01 Contractor shall verify in the field all dimensions and clearances affecting the installation of his work in relation to established datum, to building openings and clearances, and to the work of other trades.

5.02 Should interferences occur which will necessitate any deviation from layout or dimensions shown on the Drawings, Owner's Representative shall be notified immediately to authorize any changes before proceeding with the work.

GENERAL ELECTRICAL REQUIREMENTS

6.00 FASTENING TO BUILDING STRUCTURES

6.01 The methods of attaching or fastening equipment or equipment supports or hangers to the building structure shall be subject to approval by Owner's Representative at all times.

6.02 Drilling, welding or the use of explosive driven fasteners on building structures shall require written prior approval by Owner's Representative for each type of application except where so detailed on the Drawings.

6.03 Equipment shall not be attached to or supported from the roof deck, from removable or knockout panels, or temporary walls or partitions.

6.04 All electrical equipment mounted against the interior surface of exterior walls shall be mounted at least 1 inch away from the wall surface.

6.05 All electrical equipment mounted against interior walls situated in damp or wet locations and/or adjacent to liquid piping shall be installed at least 1/2 inch away from the interior surface.

7.00 SHOP DRAWINGS & OWNERS MANUALS

7.01 Submit shop drawings and Owners manuals in accordance with Division I of the Specification.

7.02 Shop drawings shall include complete data on the equipment to be provided and shall include sufficient contractor prepared installation drawings to complete the work. All shop drawings shall be coordinated with the work of all other trades prior to submittal. Shop drawings shall be accumulated and submitted on a system basis to the extent possible. Complete sets of shop drawings shall be submitted on equipment such as substations and primary switchgear.

7.03 Shop drawings shall include but not be limited to the following: each cable type, and manufacturer's test data on high voltage cables, busways and their joint connections, fuses with their curve characteristics, cable tray, contactors, dry type transformers, motor control centers, panelboards, primary cable and fittings, primary switchgear, safety switches, signal and supervisory system, special control systems, transfer switches, unit substations, and methods of fastening to building structures.

GENERAL ELECTRICAL REQUIREMENTS

7.04 Manufacturer's drawings shall be certified for and properly identified with the application for which they are being proposed and shall use the same equipment identification as shown in the Contract Documents.

7.05 Standard shop drawings showing more than one model or size shall be marked to indicate the model or size being proposed.

7.06 Standard shop drawings will not be accepted for primary switchgear, unit substations and motor control centers.

7.07 Wiring and interconnection diagrams shall be provided for each system and their inter-connected systems. Wiring diagrams shall be developed in accordance with J.I.C. Standards. The diagram shall show detailed multi-line wiring with all terminal points and wire numbers identified and cross referenced to associated equipment shop drawings. The diagrams shall be detailed to the degree required for field installation and show all interfacing with other equipment and/or systems.

7.08 Shop drawings for owner furnished equipment will be provided to Contractor as specified in the individual sections of these Specifications.

7.09 Immediately subsequent to energization of each system or equipment arrangement as specified herein, Contractor shall transmit to Owner's Representative four (4) bound copies of an Owner's manual. Said manual shall include a full set of approved shop drawings as well as maintenance procedures, serial numbers, full parts list, suggested spare parts list, and manufacturers published catalog information on the material. Manuals shall be identified by system or equipment arrangement. Manuals shall be provided as called for in individual sections of this Division and/or as specified below:

> Primary Switchgear, Substations, Lighting Controls, Signal & Supervisory System, communications systems, alternate power distribution system, ABC system, all control systems not specified in other Divisions.

GENERAL ELECTRICAL REQUIREMENTS

8.00 AS-BUILT DRAWINGS

8.01 A record shall be kept of all deviations in location or elevation of any underground or concealed installation from that shown on the Drawings or shop drawings. Records shall also be kept of any significant changes in above ground installations and all changes to circuiting and control diagrams. Records shall consist of marked drawings or shop drawings and shall be submitted to Owner's Representative at any time upon request during and all changes to circuiting and control diagrams. All records shall be submitted to the Owner's Representative on construction completion. No such deviations from the drawings or approved shop drawings shall be made without prior approval by Owner's Representative.

8.02 Drawings shall include conduit, wiring routes, boxes and access panels in concealed spaces. Locations for wiring splices, splice boxes, and equipment for systems and/or equipment not detailed on the Drawings shall also be provided.

9.00 PAINTING & FINISHING

9.01 Wherever "precaution blue" is called for in these Specifications, the color shall match Federal Standard 595a-15102.

9.02 Finishes marred, scratched and/or dented during shipping, handling or installation shall be repaired and touched up to match the original finish.

9.03 Finish painting of conduit, hangers and other installation materials will be performed along with general painting of the structure under specification section for "Painting and Finishing" in Division 9.

10.00 START UP

10.01 Contractor shall be responsible for operation and maintenance including all costs thereof for systems or equipment temporarily placed in operation for testing and adjusting purposes or for the convenience or necessity of Contractor prior to final acceptance by Owner.

10.02 Contractor shall instruct Owner's operating personnel in the operation of electrical equipment during energization prior to acceptance by Owner.

10.03 Contractor shall be responsible for protecting all electrical equipment intended exclusively to function indoors. Such equipment must be stored indoors and protected against exposure to or accumulation of dust, moisture, flooding, corrosion or other form of damage. Contractor shall clean and restore damaged finishes as required to place installation in a "like new" condition before acceptance by Owner.

11.00 INSPECTIONS & TESTS

11.01 Tests shall be performed on all electrical equipment and complete systems as required under the various sections of these Specifications.

11.02 All tests shall be made after notification to and in the presence of Owner's Representative and authorities having jurisdiction.

11.03 The cost of labor, materials, instruments, and supplies of any kind required for testing shall be borne by Contractor.

11.04 Operational and performance tests on equipment which normally operates only during certain seasons of the year shall be made during the appropriate season and at such time when ability of equipment to perform at design capacity can be demonstrated.

11.05 Material and equipment damaged or shown to be defective during tests or unable to perform at design or rated capacity shall be replaced at no cost to Owner.

11.06 Owner reserves the right to witness manufacturer's tests and/or the manufacture and assembly of electrical equipment, as specified in these Specifications, prior to shipment to the site.

12.00 EQUIPMENT IDENTIFICATION

12.01 Equipment identification covers the furnishing and installing of nameplates and labels as specified herein and as shown on the Drawings. The nameplate shall identify the equipment's purpose, Drawing identification number, and the equipment's feeder name and location and any special operational notes.

12.02 Nameplates shall be engraved laminated phenolic plastic with black letters on white background, unless specified to the contrary. The size of the nameplates shall be compatible with the application but not less than 1/4" letters.

12.03 Labels associated with capacitor equipped motors shall be as shown on the Drawings.

12.04 Equipment identification shall be visible after installation without the need for disturbing or being exposed to the interior parts or wiring. Titles and method shall conform to equipment identification, as shown on the Drawings.

GROUNDING

Article	Title	Page
1.00	Scope of the Work	1
2.00	Ground Connections	1
3.00	Equipment Ground Loop	2

GROUNDING

1.00 SCOPE OF THE WORK

All work in this Section of the Specifications shall be in accordance with the Contract Documents, as defined in the General Conditions.

1.02 This Section covers the furnishing, installing, and testing of the grounding system as specified herein and shown on the Drawings. The installation shall adhere to the requirements as described in the Section 250 NEC latest edition. Any special application, or deviation to the NEC shall be approved in writing by Owner's Representative.

2.00 GROUND CONNECTIONS

2.01 Nonconductive coatings (such as paint, lacquer and enamel) on equipment to be grounded shall be removed from threads and other contact surfaces to assure good electrical continuity.

2.02 Bolted connections shall be made with Everdur hardware, bolts and lock washers.

2.03 Welded connections shall be made either with Erico "Cadweld Process", or Continental Industries "Thermoweld Process". The manufacturer's specific instructions and molds shall be used for each weld.

2.04 Compression connections for the site grounding system shall be made with Thomas & Betts series 53000 fittings. The manufacturer's specific instructions and tools shall be used for each connection.

2.05 When ground cables run through conduit of magnetic materials (ex: rigid conduit) ground bushings shall be used on both ends of the conduit run. A bonding jumper will be installed between each ground bushing and the ground conductor.

GROUNDING

3.00 EQUIPMENT GROUND LOOP

3.01 Equipment ground shall consist of a conductor used to connect all metallic noncurrent carrying parts of electrical equipment to the equipment ground loop. The equipment ground loop(s) shall be connected to the primary switchyard distribution conductor.

3.02 Each electrical penthouse or main electrical distribution center shall be installed as a source of the equipment ground.

3.03 The types of equipment grounding conductors to be used shall be as described in Section 250-91 of the NEC (latest edition).

3.04 All switchgear ground buses, power transformer cases, all transformer neutrals, all rotating electrical equipment, and all high voltage cable sheaths and shielding shall be directly grounded through a conductor sized in accordance to the NEC (latest edition). The minimum size ground conductor shall be No. 6 and not larger than 4/0 bare stranded copper. Grounding conductors and bonding jumper connection devices or fittings that depend on solder shall not be used.

3.05 The frames and metallic enclosures of all electrical equipment and electrically operated equipment such as motor controllers, panelboards, raceways, cabinets, busways, etc., unless otherwise indicated shall be grounded to the nearest source of equipment ground. Where motors are connected to the conduit system, by means of flexible conduit, a full sized, but not larger than 4/0, grounding shunt shall be spiral wrapped around the flexible conduit and terminated in ground bushings.

3.06 The grounding pole of all receptacles shall be firmly connected to the conduit system. All flexible cords shall have an insulated grounding conductor, color coded green which shall be properly connected at each termination.

RACEWAYS AND FITTINGS

RACEWAYS AND FITTINGS

1.00 SCOPE OF THE WORK

1.01 All work in this Section of the Specification shall be in accordance with the Contract Documents, as defined in the General Conditions.

1.02 This Section covers the furnishing and installing of conduit, fittings, boxes, and cable tray as specified herein and shown on the Drawings.

1.03 Work shall include all material, devices, and accessories as required for a complete installation.

2.00 SHOP DRAWINGS/OWNER'S MANUAL

2.01 Shop drawing submittals shall be made in accordance with Division I of these Specifications.

2.02 Standard shop drawings and/or catalog cuts showing more than one size, type or model shall be marked to indicate the size, type or model being proposed for conduit, EMT, boxes or wireways.

2.03 Complete shop drawings shall be submitted for each cable tray system. Shop drawings, catalog cuts or engineering drawings shall indicate the specific cable tray system including cable tray type, fittings, supports, etc.

2.04 When the cable tray system has been accepted, Contractor shall submit to Owner's Representative four (4) bound copies of the following information: a full set of approved shop drawings, full parts list, and manufacturer's published catalog information on the material.

3.00 AS BUILT DRAWINGS

3.01 A record shall be kept of all deviations in location or elevation of any underground or concealed installation from that shown on the Drawings or shop drawings. Records shall also be kept of any significant changes in aboveground installations. Records shall consist of marked drawings or shop drawings and shall be submitted to Owner's Representative at any time upon request during or after completion of construction. No such deviations from the drawings or approved shop drawings shall be made without prior approval by Owner's Representative.

3.02 Drawings shall include conduit, wiring routes, boxes and access panels in concealed spaces. Locations for wiring splices, splice boxes, and equipment for systems and/or equipment not detailed on the Drawings shall also be provided.

4.00 CONDUIT INSTALLATION

4.01 Minimum size of conduit shall be 3/4 inch. The maximum number of conductors in trade sizes of conduit in accordance to the NEC shall be observed in the sizing of all conduit runs. The minimum size conduit of all home runs shall be 1 inch. All conduit sizes shown on the Drawings shall be minimum acceptable size. All conduit, unless otherwise indicated on the Drawings or in the Specifications, shall be rigid or intermediate metal as specified in this Section.

4.02 Exposed conduit shall be supported by hangers, clamps, or clips fastened by machine screws to expansion sleeves in inserts or lead anchors. Exposed conduit and extensions from concealed conduit systems shall be neatly run parallel with or at right angles to the walls of the building. Conduit shall be supported on each side of bends. Spacing of clamps or hangers for supporting conduit shall not be greater than the distance specified below:

Conduit sizes	Spacing of Supports in Feet
Up to 1-1/2 inch	8
2, 2-1/2, 3, & 4 inch	15

4.03 Conduit pipe straps shall be 1-hole malleable iron. Individual conduits not supported on pipe straps shall be provided with clevis type hangers as shown on the Drawings.

4.04 Groups of conduits shall be supported on trapeze type hangers. Hanger supports shall be rod or pipe with threaded connections as shown the Drawings.

4.05 Conduit runs shall be installed to avoid proximity to steam and hot water pipes. Conduit shall not cross pipe shafts or vent duct openings, but shall be routed to avoid such present or future openings in floor, wall, or ceiling construction.

4.06 Conduit laid in earth or outside building areas shall be rigid, intermediate or plastic and have minimum slope of 1% to end bells in buildings or manholes. Backfill shall be sand or base course material as specified in Specification Section for "Base Course for Pavement" in Division 2 or the excavated soil if approved by the Owner's Representative.

4.07 Rigid or intermediate metal conduit shall be used within or below floor slabs and beneath roadways, railroads and storage slabs and to extend at least 5 feet beyond both sides.

4.08 The use of running threads at conduit joints and terminations is prohibited. All cut ends of conduits shall be reamed to remove rough edges. Where conduit couplings are required, a 3-piece conduit coupling shall be used.

4.09 Rigid or intermediate conduit sleeves in walls, foundations, ceilings, or floors shall be rigidly installed so that proper position and alignment will maintained during construction of forms and pouring of concrete or setting of masonry. Conduit sleeves passing through penthouse floors shall consist of a 4 inch conduit coupling, set flush in the floor with conduit extension to the floor slab bottom surface. All floor sleeves for future work shall be closed with a threaded pipe plug. All sleeves with cables installed shall be packed with fiberglass wool after cables have been trained to their final location. Packing shall extend the full depth of the coupling.

4.10 Riser conduit shall be supported at each floor level by clamp hangers. Hangers shall be arranged for minimum obstruction of opening when installed in pipe shafts.

4.11 Conduit entering sheet metal enclosures, junction boxes and outlet boxes, when not terminated in a threaded hub, shall be secured in place by two locknuts and terminated with a bushing. Entering a NEMA 12 enclosure, without a threaded hub, the termination shall include a Neoprene "O" ring. Locknuts shall be placed on the inside of the enclosure.

4.12 Conduit expansion joints shall be provided at building expansion joints for conduit runs 2 inches and larger. Conduit expansion joints or flexible conduit connections shall be provided at building expansion joints for conduit runs less than 2 inches.

5.00 RIGID AND INTERMEDIATE METAL CONDUIT

5.01 Metal conduit, zinc coated, threaded type shall conform to ANSI Standard C80.1, "Specifications for Rigid Steel Conduit (zinc-coated)". Manufacturer shall be Allied, Triangle, Steelduct, ETP, Cerro, Wheeling, Wheatland, or Cyprus.

5.02 All metal conduit fittings shall conform to ANSI C80.4 "Fittings for Rigid Metal Conduit and Electrical Metal Tubing". Manufacturer shall be Appleton Electric, Crouse-Hinds, O. Z. Electric, Pyle-National, Russel & Stoll, Thomas & Betts, or Red Dot.

5.03 End bell fittings, for terminating conduit in concrete or masonry wall, shall be threaded flare type with provision for mounting to form. End bell fitting shall be O. Z. Electric Type TNS.

5.04 Expansion joint for metal conduit shall consist of a sleeve with fittings to provide for the telescoping of the conduits into the sleeve. Movable conduits shall be fitted with an insulating bushing and joint shall be weatherproof. Joint shall be malleable iron with a corrosion-resistant covering. A bonding jumper or ground clamp shall connect the conduits. Expansion joint fitting shall be O. Z. Electric Type AX.

5.05 Expansion joint for metal conduit encased in concrete shall consist of a flexible tube with end fittings to receive the conduit. End fittings shall be connected with a braided band jumper. Expansion joint fitting shall be O. Z. Electric, Type DX or C-H Type XD.

6.00 ALUMINUM CONDUIT

6.01 Conduit and fittings of rigid aluminum shall be threaded type, conforming to ANSI C80.5 "Specifications for Rigid Aluminum Conduit". Manufacturer shall be Kaiser Aluminum or Conalco.

6.02 Aluminum conduit or fittings may be used above the finished floor. They shall not be installed in concrete. Manufacturer shall be Appleton, Red Dot, or Pyle-National.

7.00 PLASTIC CONDUIT

7.01 Conduit and fittings shall be rigid polyvinyl chloride (PVC), be UL labeled for 90°C and Nema-40-PVC. Material shall permit chemical solvent sealing of joints in field, providing continuity of mechanical strength and water tightness.

7.02 Plastic conduit shall be Amoco Type 40, Carlon Type 40 or Robintech.

8.00 FLEXIBLE METAL CONDUIT

8.01 Flexible steel, zinc coated shall be threadless type formed from a continuous length of spirally wound, interlocked zinc coated strip steel. Manufacturer shall be H. K. Porter or Triangle.

8.02 Fittings for flexible conduit shall be of the threadless hinged clamp type, galvanized zinc coated cadmium plated malleable cast iron. Manufacturer shall be Appleton Electric or Thomas & Betts.

9.00 LIQUIDTIGHT FLEXIBLE METAL CONDUIT

9.01 Liquidtight flexible steel conduit shall be constructed of a flexible galvanized steel core made from continuous strip metal and an extruded PVC cover. Conduit shall be Anaconda Type UA or Electri-Flex Type LA.

9.02 . Fittings shall have insulated throat and be UL labeled. An "O" ring assembly shall be used on each fitting. Fittings shall be manufactured by Appleton Electric, Ideal Industries, Efcor, Thomas & Bett, or Midwest.

10.00 ELECTRIC METALLIC TUBING

10.01 Electrical metallic tubing shall be zinc coated, threadless type and shall conform to ANSI C80.3 "Specifications for Electrical Metallic Tubing (zinc coated)".

10.02 Manufacturer of EMT conduit shall be Allied, Triangle, Steelduct, Cerro, or Wheatland.

10.03 Fittings shall be compression type designed and manufactured for their specific application.

10.04 Manufacturer of EMT conduit fittings shall be Appleton Electric, Efcor, or Raco All-Steel.

10.05 EMT conduit may be used above suspended ceilings in areas such as offices, dining areas, toilets and locker rooms, with prior approval of Owner's Representative.

10.06 The maximum number of conductors in trade sizes of EMT in accordance of the NEC shall be observed in the sizing of all EMT runs unless otherwise shown on Drawings.

11.00 BOXES, GENERAL

11.01 In locating outlet boxes, caution shall be taken to allow for overhead pipes, ducts, thickness of finish, window trim, paneling and other architectural construction. Any condition that would place an outlet box in an unsuitable location, such as a molding or break in wall finish, shall be relocated to a more suitable location.

11.02 All outlet boxes shall be securely fastened.

11.03 Openings for electrical outlets in metal partitions, stone work and paneling will be provided under the applicable Specifications for this work.

11.04 Where metal wainscot or finish is removable, the electrical work shall be installed in such a manner that the removal of the outlet plate or similar fitting will permit the removal of the metal wainscot or finish without removing the outlet box or disconnecting the electrical device.

11.05 Outlet boxes and cover plates for switches and receptacles in metal partitions will be provided under the Specification Section for "Metal Partitions" in Division 10.

11.06 Boxes for receptacles in offices, cafeterias and similar commercial areas shall be installed 18 inches above floor, measured to centerline of box, unless otherwise shown on the Drawings. Boxes for office switches, factory switches and factory receptacles shall be installed 4 feet above floor, measured to centerline of box, unless otherwise shown on the Drawings.

12.00 CONCEALED BOXES

12.01 Boxes for concealed indoor work and boxes for ceiling and wall lighting fixture outlets shall be galvanized steel. Boxes shall be provided with a galvanized steel cover or extension ring, as required.

12.02 Boxes for installation in concrete slabs shall be galvanized 4 inches square or octagonal having a minimum depth of 1-1/2 inch with a removable backplate and 3/8 inch fixture stud.

12.03 Boxes for switches and receptacles for concealed work shall be a nominal 4 inches square, 1-1/2 inch or 2-1/8 inch deep as required, with a raised cover.

12.04 Boxes for lighting fixtures shall be 4 inch octagonal with 3/8 inch fixture stud. Boxes for lighting fixtures for suspended ceiling work shall be 4 inch octagon with parallel bar for securing to cross furring channels where required.

12.05 Manufacturer shall be Appleton Electric, Steel City, or Raco All-Steel.

13.00 EXPOSED BOXES

13.01 Outlet boxes for exposed switches and receptacles shall be "copper-free" cast aluminum or cadmium plated, cast or malleable iron with threaded hubs, Type FS or FD.

13.02 Outlet boxes in factory areas shall be mounted on the web of the column and shall not project beyond the column flanges.

13.03 Exposed outlet boxes mounted on concrete walls shall be attached to permanent inserts similar to Unistrut channels, or with lead anchors and machine screws.

13.04 Manufacturer shall be Appleton Electric, Crouse-Hinds, Killark, Pyle-National, Russell & Stoll, or Red Dot.

14.00 FLOOR BOXES

14.01 Single outlet boxes shall be for installation in concrete floor and shall be and adjustable, round type, watertight, cast iron, having a corrosion-resistant finish and gasketed cover. Cover and flange shall be brass with a brushed finish, free of any markings other than required for mounting screws. Boxes shall be drilled and tapped for conduit sizes as indicated on the Drawings. Box shall be similar to Hubbell, Catalog No. B-2536 and S-2525 cover.

14.02 Manufacturer shall be Hubbell, Steel City, or Thomas & Betts.

14.03 Outlet boxes shall be for installation in a concrete floor and shall be an adjustable, rectangular, 2-, 3-, 4- or 5-gang type as required. It shall be cast iron, have a corrosion-resistant finish, gasketed cover, be watertight and contain integral partitions between compartments. Cover and flange shall be brass with brushed finish free of any markings other than required for mounting screws and shall contain separate rectangular brass covers over the individual compartments. Boxes shall be drilled and tapped for conduit sizes as indicated on the Drawings. Floor boxes shall be similar to Hubbell B-4233 as required for the installation.

14.04 Manufacturer shall be Hubbel or Steel City.

15.00 SPECIAL JUNCTION BOXES

15.01 Junction boxes for installation in outdoor or vapor-proof areas or in Class I, Group C and D explosion-proof areas shall be cadmium plated cast or malleable iron or "copper-free" cast aluminum. Each junction box shall be of the type and size as shown on the Drawings and be drilled for conduit sizes as shown on the Drawings.

15.02 Manufacturer shall be Appleton Electric, Russell & Stoll, Crouse-Hinds, Killark, or Red Dot.

16.00 PULL AND JUNCTION BOXES

16.01 Pull and junction boxes for cable rated 600 volts and below shall be of the sized and installed as shown on the Drawings. Boxes shall be constructed of code gage glavanized steel, reinforced where required, and with removable covers secured with brass machine screws.

16.02 Sheet steel boxes which contain circuits above 208 volts shall be finished "precaution blue". Boxes containing Signal and Supervisory System wires shall be finished "fire protection red" Federal Standard 595a-11105. All other boxes shall be the manufacturer's standard color.

16.03 Where size of box is not indicated, it shall be of sufficient size to pull, rack and splice the cables to be contained therein in accordance with the requirements of the NEC.

16.04 Manufacturer shall be Columbia Metal Products, Steel City, Hoffman Engineering or Control Engineering.

17.00 WIREWAYS

17.01 Wireways shall be used for exposed indoor work where shown on the Drawings.

17.02 Wireways shall have screw covers, be securely supported, and finished in "precaution blue".

17.03 Wireways shall be as manufactured by Columbia Metal Products, H. K. Porter or Square D.

18.00 CABLE TRAY

18.01 Cable trays shall be galvanized steel or aluminum to match cable armor or as shown on the Drawings.

18.02 Steel cable trays shall be hot dipped galvanized after fabrication, in accordance with ASTM A386 "Specifications for Zinc Coating (Hot Dip) on Assembled Steel Products".

18.03 Aluminum cable trays shall be fabricated from 6061-T6 or 6063-T6 aluminum alloy.

18.04 Cable tray shall conform to NEMA VE-1-1976 "Cable Tray Systems."

18.05 Ladder type cable tray shall be used for power cables and corrugated trough type cable tray for telephone, control signal and communication cables.

18.06 Ladder type cable tray shall have a 4 inch nominal $\pm$ 1/4 inch clear inside depth (measured from top of side rail support to top of rung), 9 inch rung spacing and shall sustain a 50 pound per linear foot load on a 12 foot space with a safety factor of 2.

18.07 Trough type cable tray shall have a 3 inch nominal $\pm$ 1/4 inch clear inside depth (measured from top of side rail support to top of corrugated trough), and shall sustain a 35 pound per linear foot load on a 12 foot space with a safety factor of 2.

18.08 Cable tray expansion joints shall be provided at building expansion joints.

18.09 Cable tray elevations and locations shall be as shown on the Drawings.

RACEWAYS AND FITTINGS

18.10 Cable tray width, radii straight sections, fittings and number of trays shall be as shown on the Drawings.

18.11 Cable tray shall be as manufactured by B-Line, Chalfant Products, Globe Co., Husky Products, or Metal Products.

19.00 CABLE TRAY INSTALLATION

19.01 Cable trays shall be mechanically connected at joints, fittings, and terminations to provide a continuous ground path.

19.02 Cable trays shall conform to the installation details of NEMA VE-1-1976 "Cable Tray Systems" unless otherwise shown on Drawings.

19.03 The cable tray system shall be continuous. Cable tray fittings shall be used for the purpose of changing the size, direction or elevation of the cable tray system.

19.04 Cable tray to box connector shall be used to connect a section of cable tray to a control or distribution center.

CABLE

CABLE

1.00 SCOPE OF WORK

1.01 All work in this Section of the Specifications shall be in accordance with the Contract Documents, as defined in the General Conditions.

1.02 This Section covers the furnishing, installing, testing and placing in operation all cables, splices, terminations and other accessories required for a complete and functional cable distribution system.

2.00 SHOP DRAWINGS/OWNER'S MANUAL

2.01 Shop drawing submittals and approvals shall be made in accordance with Division 1 of these Specifications.

2.02 Complete shop drawings shall be submitted for each cable type to be installed. Shop drawings, catalog cuts or engineering drawings shall indicate the specific cable types and contain sufficient information to verify compliance with these specifications. Such data shall show cable diameters, thermal rating, ampacities and designated U.L. listing numbers.

2.03 When all cable shop drawing submittals have been approved and accepted, the Contractor shall submit four (4) bound copies of the cable data to the Owner's Representative.

3.00 INSTALLATION

3.01 Cables shall be installed in accordance with manufacturers installation recommendations relative to maximum pulling tensions and minimum bending radii. Contractor shall use the necessary guides, rollers, pulleys, sheaves and other installation and pulling aids to prevent abrasion, elongation and other damage to cables during installation.

3.02 Cable shall be installed in cable tray or rigid conduit as shown on the drawings.

CABLE

3.03 Where cable is to be installed in cable tray the following methods shall be used: Install armored cables in cable tray as indicated on the drawings. Use appropriate roller guides to control the position of the cable during installation. Support guides on or from cable tray or supports providing that forces transmitted to the cable tray and supports as a result of cable tension do not loosen, strain or deform the cable tray system or its supports; otherwise, support guides independently from building or trestle structural members. Repair or replace all strained or deformed items, and tighten all loose connections, as directed by Owner's Representative.

Install cables in tray at locations indicated on the drawings with spaces left clear for the addition of future cables. Install cables with one cable diameter space between cables, unless otherwise indicated on the drawings, and allow sufficient slack to permit expansion or contraction of cables. Clamp cables to tray at intervals of not more than 10 feet in horizontal runs and 2 feet in vertical or sloping runs. Do not splice cables except where indicated on the drawings or where shown on appropriate shop drawings.

Fasteners on horizontal runs shall be Thomas and Betts self-locking nylon ties. Clamps shall be designed for the cable tray. Fasteners on vertical runs shall be clamps which shall be of a material compatible with the cable tray material and cable armor - steel clamps for rigid galvanized tray and steel cable armor and aluminum clamps for aluminum tray and aluminum cable armor.

3.04 Cable in riser tray shall be supported at both top and bottom of the riser, and at intermediate points not more than 3 feet apart.

3.05 Cables terminating in outlet boxes shall be a minimum of 8 inches long.

3.06 The inside of conduit and raceways shall be dry and clean before cables are pulled. Care shall be exercised in pulling to avoid damage to the cable. An approved type of lubricant may be used, to facilitate pulling of cable into, and through, conduit.

3.07 The following list of pulling lubricants is approved for use with the jacket material designated in the following table.

CABLE

JACKET MATERIAL

a) P.V.C. b) Chlorosulfinated Polyethelene. c) Neoprene. d) Lead

American Colloid Co. (Slip-X 100 "Summer" grade and Slip-X 200 "Winter" grade)

Johns-Manville (Wyoming Bentonite. This can be used in water slurry with Ethylene Glycol if necessary.)

Mac Products (Mac Lube CA-51)

Minerallac (H-2B Bentonite)

Electro Compound (Y-ER EAS. Do not use with lead)

Ideal (Yellow 77. Do not use with lead)

Mac Products (Wirepull. Do not use with lead)

Minerallac (100. Do not use with lead)

Proctor and Gamble (Ivory Snow. Do not use with lead)

Sherman-Williams (Talc. Do not use with lead)

Sherman-Williams (Bentonite clay. This can be used in water slurry with Ethylene Glycol if necessary.)

For severe pulls on PVC and NEOPRENE jackets only:

Dow Corning (36 Emulsion)

Other manufacturers products are available, but Contractor must make application for deviation from lubricant types and manufacturers listed herein, before using any product other than those specified herein. Such request for deviation shall be in accordance with the Contract Documents.

3.08 Compliance with requirements of the NEC for conduit fill is mandatory on all installation. The Contractor shall be responsible for complying with the NEC requirements relative to conduit fill. Contractor shall check cable diameters prior to purchasing cable and submit, to the Architect/Engineer, a chart showing conduit fill, for approval, before any installation is made.

CABLE

3.09 Cable furnished and installed shall be in strict compliance with these specifications.

4.00 CABLE FIREPROOFING

4.01 The cable shall be cleaned of all oil, grease and cable pulling compounds using suitable cleaners and solvents non-injurious to cable and then wiped completely dry.

4.02 The cables shall be trained as closely as possible to their final positions.

5.00 CABLE IDENTIFICATION

5.01 Each conductor, except control and signal conductors, shall be color coded with 3M No. 35 tape or colored insulation. Color coding shall be black for phase A or 1, red for phase B or 2, blue for phase C or 3, white for neutral, and green for equipment ground. Switch legs for local wall switches shall be yellow, orange or brown.

5.02 Power mains and feeders, branch circuits, control and signal wires and cables shall be tagged in all manholes, pull and junction boxes and wireways. Tags for No. 4/0 AWG and smaller wires and cables shall be W. H. Brady Co. Type B-700 or T&B WSL Series. Tags for cable 250 MCM and larger in pull and junction boxes and wireways, shall be 1 inch diameter brass with stamped numbers and letters. Tags shall be secured to the cable with tinned copper wire.

5.03 Each individual conductor of a multiconductor cable shall also be identified by tags. The tag number shall correspond to the terminal number to which the conductor is terminated. The tags shall be T & B "Shur-code" Tubular Markers, Series SM.

5.04 Identify cables in cable tray at each column line on each side of walls and at terminations and splices by means of strip aluminum with raised letters.

5.05 Designate source and load, or cable identification on tags. Submit identification for approval of the Owner's Representative.

5.06 Duplicate copies of a typewritten master identification chart shall be submitted by the Contractor giving terminal numbers and corresponding circuit designation; i.e., (fan, pump, pressure switch, relay, etc.) at all site locations of manholes and all building locations of pull and junction boxes and wireways. At locations where more than two circuits pass through a pull or junction box or wireway, terminals and circuit designation may be shown on an 8-1/2 x 11 inch reproducible sketch and identified by location on master chart.

CABLE

5.07 The color coding of the individual conductor insulation of multi-conductor cables shall comply with Appendix I.

5.08 Where special color coding is required, such coding will be supplied by the Owner, and shown on the drawings.

6.00 CABLE CONDUCTORS

6.01 Conductors shall be uncoated, annealed copper wire, in accordance with ASTM B3, unless otherwise shown under individual cable type headings in this specification.

6.02 Conductors shall be concentric-stranded and conform to ASTM B8, unless otherwise shown under individual cable type headings in this specification.

6.03 All uncoated, annealed stranded copper conductors shall be minimum 12 AWG, unless otherwise shown in these specifications or on the drawings.

6.04 Where solid conductors are specified, these shall be 8 AWG or smaller.

6.05 Stranded conductors shall be in accordance with IPCEA-S-68-516 and NEMA WC8, table 2-2 for "Concentric Stranded Class 'B' copper conductors" unless otherwise stated under individual cable types.

6.06 Solid conductors shall be in accordance with IPCEA-S-68-516 and NEMA WC8, table 2-1 for "Solid Copper Conductors".

6.07 The direct-current resistance at 20°C or 25°C of the conductor in completed single conductor cables shall not exceed by more than 2% the values given in IPCEA-S-68-516. (Table 2-12 for annealed uncoated copper concentric stranded Class B conductors and Table 210 for annealed uncoated solid copper conductors)

6.08 Conductors shall comply with IPCEA-S-19-81 sections 2-6 for electrical requirements.

CABLE

7.00 NON-METALLIC JACKETS

7.01 The three non-metallic jacket materials approved for use in this specification are:

a) Polyvinyl Chloride
b) Chlorosulfinated Polyethylene, heavy duty
c) Neoprene, Heavy Duty Black

Use of specific type of jacket is specified under individual cable types.

7.02 Polyvinyl Chloride Jacket shall consist of a polyvinyl chloride compound (PVC) suitable for installation at a minimum temperature of minus 10°C (+14°F). Manufacturer shall guarantee that the jacketing complies with or is better than the values given in the Appendix section of these specifications, IPCEA-S-68-516 and NEMA WC8.

7.03 Chlorosulfinated Polyethylene jacket shall consist of a vulcanized chlorosulfinated polyet-ylene compound meeting the guaranteed values given in Appendix section of these specifications and IPCEA-S-68-516, IPCEA-S-61-402, NEMA WC5 and NEMA WC8.

7.04 Neoprene, Heavy Duty Black jacketing shall meet the guaranteed values given in the Appendix section of these specifications, IPCEA-S-68-516 and NEMA WC8, and IPCEA-S-66-524 and NEMA WC7.

7.05 Jacket requirements are given in Appendix section of this specification.

8.00 MISCELLANEOUS REQUIREMENTS

8.01 Where special requirements for specific cable types are required, such requirements will be specified under the individual cable types specified hereinafter.

8.02 Various types of cable are specified herein under individual headings. Data contained under such individual headings shall be correlated to data given in the preceding portions of this specification.

CABLE

9.00 POWER LIMITED INSTRUMENTATION CABLE

9.01 This article covers the specification for power limited instrumentation cable. The cable shall be rated 300 volts at 105°C and be UL listed for use in Class 2 or 3 circuits as described in Article 725 of the N.E.C., where the power supply is rated at 300 volts, or less, and the maximum operating temperature does not exceed 105°C (221°F).

The following industry standards apply:

a) U.L. File E-54094
b) U.L. Subject 13. Requirements for Power Limited Circuit Cable Class 2 and 3.
c) IPCEA S-61-402 latest edition

9.02 Cables for use on instrumentation circuits where shielding is not required, shall comply with the following:

a) <u>Conductor</u>. Bare, soft annealed copper in compliance with ASTM B3, Class "B", 7 strand concentric per ASTM B8. Conductors shall be sized #20 - #16 AWG. Cross sectional area shall comply with IPCEA-S-61-402, Section 2.5. Conductor resistance shall comply with IPCEA-S-16-402 Section 2.6.

b) <u>Insulation</u> shall be PVC, extruded directly over surface of conductor and shall fit tightly to that surface. Insulation thickness shall be 0.15" minimum, and rated for 105°C in accordance with Part 1 of Appendix "F".

c) Conductor identification shall be in accordance with the color coding in Appendix I.

d) Pair/triad assembly shall be, twisted, with left hand lay. The lay shall not exceed 2.5" for pairs, nor 3.5" for triads. A polyester separator tape shall be wound around the pair or triad.

e) An overall PVC jacket, in compliance with Part 1 of Appendix "F" shall be extruded over the pair of triad. A rip cord shall be laid longitudinally under the jacket to facilitate removal of the jacket.

9.03 Where armored instrumentation cable of the non-shielded type is shown on the drawings, construction shall be identical to that described in 8.02 with the following additions:

a) An overall sheath shall be provided over the PVC jacket to provide mechanical strength and equipment grounding. This overall sheath can be a close fitting impervious, continuously welded and corrugated aluminum sheath, or, an interlocking, galvanized steel armor, which shall be galvanized on all four sides to prevent corrosion, or a serving of soft, annealed galvanized steel wires applied with a left hand lay and 90% minimum coverage.

b) An overall PVC jacket, in compliance with Part 1 of Appendix "B" shall be extruded over the armor.

CABLE

9.04 Pairs and triads, shielded, cabled with overall shield and jacketed shall comply with the following:

a) Conductors. Bare, soft annealed copper in compliance with ASTM B3, Class "B", 7 strand concentric per ASTM B8. Conductors shall be sized #20 - #16 AWG. Cross sectional area shall comply with IPCEA-S-16-402, Section 2.5. Conductor resistance shall comply with IPCEA S-16-402, Section 2.6.

b) The communication wire shall be #22 AWG and in accordance with data for conductors given in 20.04 a), and pigmented orange.

c) Insulation shall be PVC, extruded directly over surface of conductor and shall fit tightly to that surface. Insulation shall be 0.15" minimum and rated for 105°C in accordance with Part 1 of Appendix "F".

d) Conductor and circuit identification shall be: Black/white for pairs and black/white/red for triads. The white conductor in each pair or triad shall be numeric printed to provide circuit identification. Numbers shall start at "1" and continue through "37" as required. For cables with more than 37 pairs or triads, the 37 circuit numbers shall be repeated to the extent necessary to provide identification of all conductors.

e) Pair/Triad assembly shall be such that each pair or triad is twisted together with one 7 strand drain wire. This drain wire shall be two sizes smaller than the conductors but not less than #22 AWG.

f) Lay shall not exceed 2.5" for pairs nor 3.5" for triads.

g) A red foil-free-edge aluminum-polyester tape shall be wrapped around each pair or triad with an overlap to ensure 100% shielding coverage.

h) The shielded pairs or triads shall be assembled with a left hand lay. Lay shall not exceed the values given in Part 2 of Appendix "F".

j) Flame retardant, moisture resistant fillers shall be placed in the interstices to produce a round cable.

CABLE

9.04

k) Aluminum polyester tape shall be applied over the assembled core with overlap to ensure 100% shielding. The aluminum tape shall have a copolymer covering on the inside.

l) A seven strand tinned copper drain wire, equal in size to the conductors in the pairs/triads shall be applied over the aluminum polyester shield. A binder shall be applied over the drain wire to ensure continuous contact with the shield.

m) A black, flame-retardant PVC jacket, rated for operation at 105°C, in compliance with Part 1 of Appendix "F" shall be extruded over the shielded assembly. The jacket thickness shall comply with Part 3 of Appendix "F".

n) A nylon rip cord shall be laid longitudinally under the jacket to facilitate jacket removal without damage to the pairs/triads.

o) The following legend shall be printed in yellow on the surface of the jacket, at intervals not exceeding 24 inches. Manufacturer; UL listing; Power Limited Circuit Cable Class 2 or 3; Number of pairs or triads; conductor size; 105°C; 300v; for CT use.

p) A UL tag shall be securely fastened to each reel, or coil, of cable.

q) The completed cable shall be tested in accordance with UL subject 13, Outline of Investigation of PowerLimited (Low-energy) Circuit Cable, latest issue. Electrical specifications for completed cable shall comply with Part 4 of Appendix "F".

CABLE

9.05 Where armored instrument cable of the shielded type is required the following armor types, as specified, or shown on the drawings shall be applied over the completed cable described in 20.04.

a) Aluminum. A continuously welded and corrugated, impervious aluminum sheath shall be applied over the jacketed cable. Thickness of this armor shall comply with Part 5 of Appendix "F".

b) Copper or Bronze. A continuously welded corrugated, impervious copper (or bronze) sheath shall be applied over the jacketed armor. Thickness of this armor shall comply with Part 6 of Appendix "F".

c) Galvanized Steel (or Aluminum) Tape Armor. A galvanized steel (or aluminum) interlocking tape armor shall be applied over the jacketed cable. The steel tape shall have all four sides galvanized. Thickness of interlocking tape armor shall comply with Part 7 of Appendix "F".

d) Steel Wire Armor. A serving of soft annealed galvanized steel wires shall be applied with a left hand lay over the jacketed cable. Armor shall comply with 4.4.8 of IPCEA-S-61-402.

9.06 Where an overall jacket is required over the armor, see Appendix "F" for jacket thicknesses. Jackets shall comply with Appendix "F" Part 7. A legend, described in Paragraph 8.04 p) shall be printed, in yellow, on the overall outer jacket.

Jacket Thickness:

a) Corrugated Aluminum armor, copper (or bronze) corrugated armor and galvanized steel or aluminum tape armor shall comply with Appendix "F" Part 8.

b) Steel Wire Armor, shall comply with Appendix "F" Part 9.

9.07 Conductor size AWG and numbers of pairs and/or triads shall be as specified on the drawings.

9.08 Approved Manufacturers: Power Limited Instrumentation Cable - Alpha, Belden, Boston Insulated Wire and Cable, Brand-Rex, Columbia, Dearborn, Manhattan, Okonite, Tamaqua.

CABLE

10.00 FLAME RETARDANT INSTRUMENTATION CABLE-300 VOLT AND 600 VOLT

10.01 This article covers the specification for 300 volt and 600 volt instrumentation cable of the flame retardant type. Cables shall be suitable for use in fossil fueled steam generating plants and certified for continuous operation at 90°C, in wet, or dry, locations. Cables shall be suitable for installation in tray, conduits (above and below ground) in exposed runs or directly in the ground. Insulation shall be ethylene-propylene type elastomer. The following industry standards shall apply:

a) IPCEA S-68-516
b) IEEE Standard 383 latest issue.

10.02 One, or more, pairs and triads when manufactured shall comply with the following:

a) Conductor. Soft annealed copper wire covered with a continuous coating of tin or lead alloy. Tensile, electrical and coating properties shall comply with ASTM Specification B.33. Stranded conductors shall comply with ASTM Specification B.8. Conductor resistance shall comply with IPCEA S-68-516, Section 2.5.2

b) Insulation. Individual conductors shall be insulated with a flame retardant dielectric based on an ethylene-propylene type elastomer. Insulation shall fit tightly to the conductor but shall be "clean-stripping" from the conductor.

Electrical and physical characteristics of the insulation shall comply with Part 1 of Appendix "G". Wall thicknesses shall comply with Part 2 of Appendix "G". All cable shall pass the following Preliminary Single Conductor Tests, designated herein and specified in Part 7 of Appendix "G".

a) High Voltage A.C.

b) Insulation Resistance Test

c) Flame-Resistance Test

10.03 The color coding of the individual conductor insulation of multi-conductor cables shall comply with Appendix I.

10.04 Twisting and shielding of pairs/triads. Each pair or triad shall be twisted with one tinned 7 strand copper drain wire in one interstice. The drain wire shall be two sizes smaller than the insulated conductor, but not less than 20 AWG. A red foil-free aluminum-polyester tape shall be helically wrapped over the assembly with a 12.5% minimum lap with the aluminum metal side in 100% contact with the drain wire. The foil-free edges shall provide 100% isolation between shields on adjacent pairs or triads. Maximum lay for pairs shall be 2.5 inches and 3.5 inches for triads. (Where unshielded pairs or triads are called for on the drawings, the drain wire and aluminum-polyester shield shall be omitted on the construction of each pair or triad).

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10.05 For a single pair, or triad, shielded cable, moisture resistant fillers shall be added to make a smooth round cable. A glass-polyester tape, with a 12.5% minimum lap shall be applied over the aluminum-polyester shield. Communication wire shall not be included.

10.06 Assembly of Multi-Pair/Triad cable shall comply with the following:

a) Shielded pair, or triads, shall be assembled in accordance with IPCEA S-68-516 Part 5.

b) A 20 AWG, 7 strand uncoated copper communication wire, insulated with .025" EPR shall be included in the assembly along with flame and moisture resistant fillers, as required, to produce a substantially round core. A 2 mil aluminum-polyester tape shall be applied over the assembly with 12.5% overlap and aluminum face out.

c) A tinned copper drain were of the same size and stranding as the conductor in the pair, or triad, shall be applied over the taped core and a glass-polyester tape applied over the complete assembly with a 12.5% minimum lap.

10.07 Jacket. An overall jacket shall be applied over the completed cable and shall be either a black flame and oil resistant chlorosulfonated polyethylene base compound, in accordance with Part 5 of Appendix "G" and IPCEA-S-68-516 or a neoprene jacket in accordance with Part 6 of Appendix "G". The jacket thickness shall be in accordance with Part 3 of Appendix "G".

10.08 An identification legend shall be printed on the jacket surface in accordance with Part 4 of Appendix "G" and shall be printed at intervals not exceeding 24 inches.

10.09 Final tests on completed cable shall be in accordance with Part 7 of Appendix "G".

10.10 Approved Manufacturers. Flame retardant Instrumentation Cable. 300 volt and 600 volt. Alpha, Belden, Boston Insulated Wire and Cable, Brand-Rex, Columbia, Dearborn, Manhattan, Okonite, Tamaqua.

11.00 THERMOCOUPLE EXTENSION CABLE

11.01 This article covers the specification for Thermocouple Extension Cable. Cable shall be rated 300 volts at 105°C and suitable for installation in wet or dry locations. Cable shall be suitable for installation in cable tray, conduits (above or below ground) in exposed runs or installed directly in the ground. Insulation shall be an ethylene propylene type elastomers. The following industry standards shall apply:

a) IPCEA S-68-516
b) IEEE Standard 383 latest issue
c) ANSI MC96 latest issue. Cables shall be one or more shielded pairs and constructed in accordance with the data contained herein.

CABLE

11.02 Conductor. The conductor shall be solid alloy in accordance with ANSI MC 96.1 - 1975. The conductor size shall be #14, 16, 18 or 20 AWG as required by the drawings. The conductor materials shall have the properties tabulated in Part 1 of Appendix"H" and comply with requirements of Part 2 of Appendix "H".

11.03 The individual conductors shall be insulated with a flame retardant dielectric based on an ethylene-propylene type elastomer. The insulation shall fit tightly to the conductor but shall be "clean-stripping" from the conductor.

The electrical and physical characteristics of the insulation shall be in accord with Part 4 of Appendix "H". Wall thickness of the insulation shall comply with Part 3 of Appendix "H".

23.04 Preliminary single conductor tests shall comply with the following:

a) High Voltage AC Test. (Appendix H, Part 9 a)
b) Flame Resistance Test. (Appendix H, Part 9 c)

11.05 Conductor and Circuit Identification. The insulation compound shall be paint color coded for conductor identification as shown in Part 2 of Appendix "H". The red conductor in each pair shall be numeric printed to provide circuit identification. The numbers shall start at "1" and continue as required through "37". For cables with more than 37 pairs, the 37 circuit numbers shall be repeated to the extent necessary to provide identification of all conductors. The communication wire shall be pigmented orange.

11.06 Twisting and Shielding of Pairs. Each pair shall be twisted with one 7 strand tinned copper drain wire in one interstice. Drain wire shall be two sizes smaller than the conductor but not less than 20 AWG. A red foilfree aluminum-polyester tape shall be helically wrapped over the assembly with 12.5% minimum lay and the aluminum metal side in 100% contact with the drain wire. The foil-free edge shall provide 100% isolation between shields on adjacent pairs. Maximum twisting lay for pairs shall be 2.5 inches. (Where unshielded pairs are called for on the drawings, the aluminum-polyester shield and drain wire shall be omitted). For a single pair shielded cable, fire retardant, moisture resistant fillers shall be added to make a smooth round cable. A glass-polyester tape with a 12.5%minimum lap shall be applied over the aluminum polyester shield. Communication wire is not required.

11.07 Assembly of Multi-Pair Cable. The shielded pairs shall be assembled in accordance with IPCEA-S-66-524, Part 5. A 7 strand, 20 AWG COPPER communication wire, insulated with 0.020" of EPR insulation, painted orange, shall be included in the assembly along with flame and moisture resistant fillers, as required, to produce a substantially round core. A 2 mil aluminum-polyester tape shall be applied over the assembly with 12.5% lap and aluminum face out. A tinned copper drain wire of the same size as the conductor shall be applied over the taped core, and a glass-polyester tape applied overall with a 12.5% minimum lap.

11.08 Jacket. The jacket over the cable core shall be a tough flame and oil resistant chlorosulfonated base compound in accordance with Part 5 of Appendix "H". The jacket thickness shall comply with Part 6 of Appendix "H". The jacket color shall comply with Part 7 of Appendix "H". Identification legend shall be printed on the jacket surface as shown in Part 8 of Appendix "H".

11.09 Final Tests on Completed Cable. These shall comply with Part 9 of Appendix "H".

11.10 Approved manufactures. Thermocouple Extension Cable. Alnor Instrument Co., Continental, Honeywell, Okonite, Omega, Thermo Electric.

12.00 TESTS

12.01 Field tests on cable installations shall be performed as specified in the "Test" Section of these Specifications. Factory tests shall be performed on cable and wire as specified herein.

CABLE

APPENDIX "A" - Part 1

Physical and Electrical Characteristics of the Insulation (EPR) When samples from completed cable are tested in accordance with IPCEA specifications, the vulcanized insulation shall meet the following guaranteed values:

	Guaranteed Value
Physical Requirements - Unaged	
Tensile Strength, psi, min. at room temperature	900
Elongation, % min., at room temperature	250
200% modulus, psi, min. at room temperature	600
100% modulus, psi, min. @ 130C	200
Aging Requirements	
After air oven test for 168 hours at 150C	
Tensile strength, % of unaged, min.	75
Elongation, % of unaged, min.	60
Ozone Resistance	
After 24 hours at 0.025 to 0.030%	No Cracks
Electrical Characteristics at Room Temperature (15.6C)	
SIC at 80V/mil, maximum	3.0
% power factor at 80V/mil, maximum	1.0
Insulation resistance constant (k), Minimum	50,000
Electrical Characteristics at 90C	
After 24 hours water immersion at 90C	
Dielectric Constant, SIC, 80V/mil, max.	3.0
Power factor, PF%, 80V/mil, max.	1.5
After 26 weeks water immersion at 90C	
Dielectric Constant, SIC, 80V/mil, max.	3.1
Power Factor, PF%, 80V/mil max.	1.5
Stability Factor, (PF at 80-40V/mil) max.	0.2
Mechanical Water Absorption	
7 days at 70C, mg/sq.in., max.	5.0

CABLE

APPENDIX "A" - Part 2

Insulation thicknesses and test voltages as given herein shall be criteria for the conductor sizes shown. Where differences between this specification and IPCEA-S-68-516 occur, this specification shall govern.

VOLTAGE PHASE/PHASE	CONDUCTOR SIZE AWG or MCM	THICKNESS MILS	MM	TEST VOLTAGE KV AC	DC	DC SPARK TEST VOLTAGE KV
0-600v	14-9 AWG	45	1.14	4.0	12.0	16.0
Unshielded	8-2 AWG	60	1.52	5.5	16.5	21.0
	1-4/0 AWG	80	2.03	7.0	21.0	28.0
	225-500 MCM	95	2.41	8.0	24.0	33.5
	525-1000 MCM	110	2.79	10.0	30.0	38.5
601-2000v	14-9 AWG	60	1.52	5.5	16.5	21.0
Unshielded	8-2 AWG	70	1.78	7.0	21.0	24.5
	1-4/0 AWG	90	2.29	8.0	24.0	31.5
	225-500 MCM	105	2.67	9.5	28.5	37.0
	525-1000 MCM	120	3.05	11.5	34.5	42.0
2001-5000 Shielded	8 AWG-1000 MCM	90	2.29	13.0	--	--
5001-8000 Shielded	6AWG-1000 MCM	140	3.56	22.0	45.0	
8001-15,000 Shielded	2AWG-1000 MCM	220	5.46	33.0	80.0	
15,001-25,000 Shielded	1AWG-1000 MCM	345	8.76	49.0	125.0	
25,000-35,000 Shielded	1/0AWG-1000MCM	345	8.76	49.0	125.0	

CABLE

APPENDIX "B"

Part 1

Physical Characteristics of Polyvinyl Chloride Jacket

When tested in accordance with IPCEA specification, the jacket shall meet or exceed the following guaranteed values:

	Guaranteed Value
Physical Requirements - Unaged	
Tensile Strength, psi, minimum	1500
Elongation at Rupture, % minimum	100
Aging Requirements	
Air oven test at 100°C ± 1°C for 5 days	
Tensile strength, % of unaged value	85
Elongation, % of unaged value (minimum)	60
Oil Immersion Requirements	
In ASTM #2 oil at 70°C ± for 4 hours	
Tensile strength, % of unaged value (minimum)	80
Elongation, % of unaged value (minimum)	60
Heat Distortion	
After 1 hour in air over at 121°C±1°C	
% (maximum)	50
Heat Shock	
After 1 hour in air oven at 121°C ± 1°C	No cracks
Cold Bend	
After 20 hours at -35°C ± 1°C	No cracks

Part 2

Physical and Electrical Characteristics of Chlorosulfinated Polyethylene Jacket

When tested in accordance with IPCEAS-19-81 the vulcanized thermoset chlorosulfinated polyethylene jacket shall meet or exceed the following guaranteed values:

Physical Requirements Before Aging	Guaranteed Value
Tensile Strength, min. psi	1800
Tensile Stress at 200% Elongation, min. psi	500
Elongation at Rupture, min. %	300
Set, max. %	30