ESG-DOE-13404
VOLUME II

PRELIMINARY DESIGN OF
THE CARRISA PLAINS
SOLAR CENTRAL RECEIVER POWER PLANT
VOLUME II — PLANT SPECIFICATIONS

Prepared for the Department of Energy,
San Francisco Operations Office,
under Contract DE-FC03-82SF11674

Rockwell International
Energy Systems Group

PG and E

ARCO Solar Industries

DISCLAIMER

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CONTRACT: DE-FC03-82SF11674

ISSUED: 31 DECEMBER 1983

This report, Preliminary Design of the Carrisa Plains Solar Central Receiver Power Plant, ESG-DOE-13404, consists of three volumes, one of which is further subdivided. These are:

Volume I. Executive Summary
Volume II. Plant Specifications
Volume III. Plant Design
  Book 1. Design Description
  Book 2. Design Drawings
  Book 3. Appendices

Books 1, 2, and 3 in Volume III, Plant Design, are a single document, separated for reasons of format and readability. Book 1, Design Description, contains narrative material, tables, and figures suited to an 8½-in. by 11-in. format. Book 2, Design Drawings, is a 17-in. by 22-in. volume containing material whose readability is benefitted by a larger format. Graphic material cited in Book 1 is referenced as a figure if it appears in Book 1, or as a drawing if it appears in Book 2. Material appearing in Books 2 and 3 is assigned a number in accordance with the section of Book 1 in which it is referenced. Consequently, the numbering in Books 2 and 3 may appear to leave gaps.

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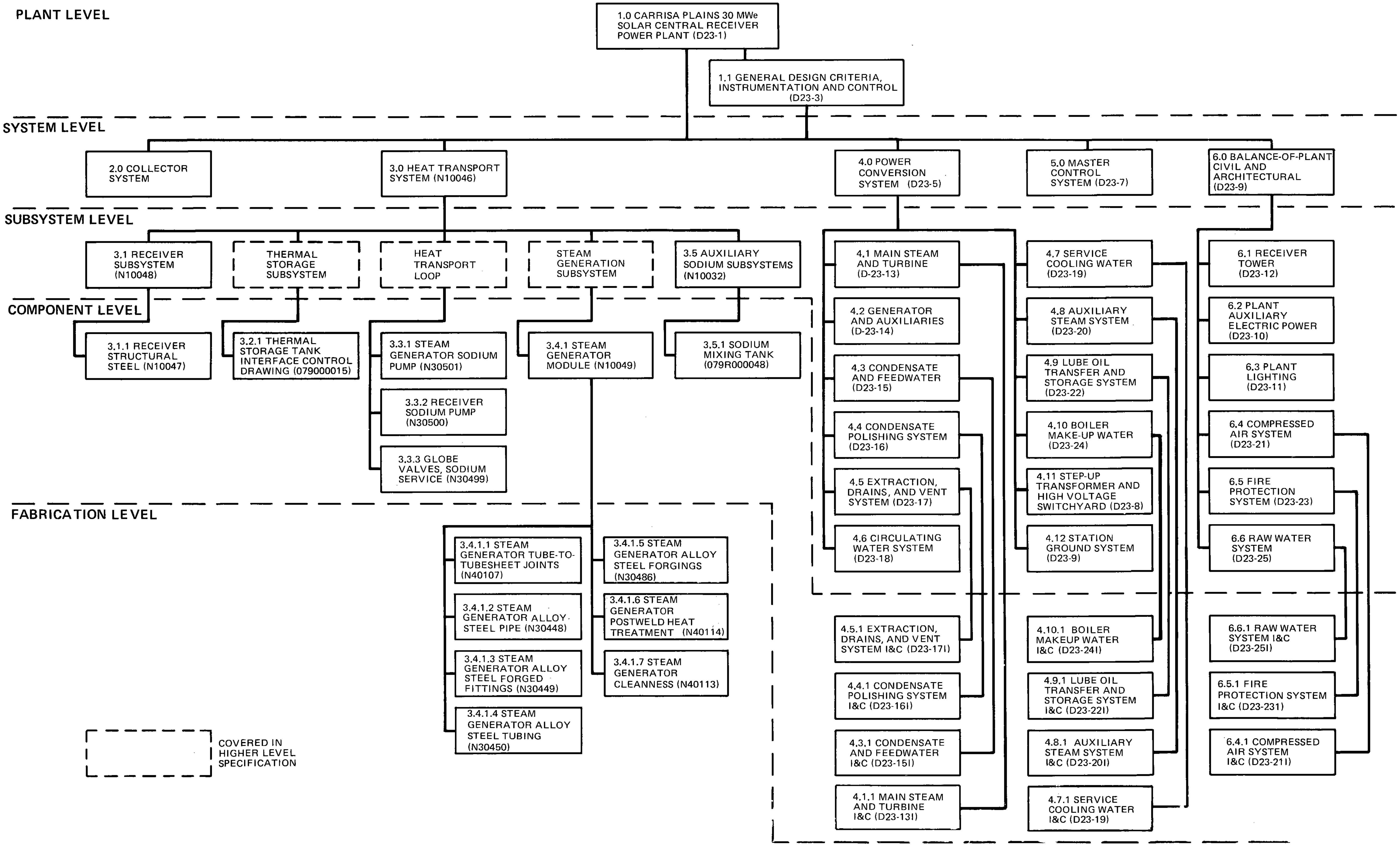
VOLUME II
PLANT SPECIFICATIONS

The specifications and design criteria for all plant systems and subsystems used in developing the preliminary design of Carrisa Plains 30-MWe Solar Plant are contained in this volume. The specifications have been organized according to plant systems and levels. The levels are arranged in tiers. Starting at the top tier and proceeding down, the specification levels are the plant, system, subsystem, components, and fabrication. A tab number, listed in the index, has been assigned each document to facilitate document location.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1.0 CARRISA PLAINS 30 MW SOLAR CENTRAL RECEIVER POWER PLANT
(D23-1)

Engineering
76-370 2/81

DCM No. D23-1 Revision 0
Date December 22, 1982
File No. D23-01700

PACIFIC GAS AND ELECTRIC COMPANY

DESIGN CRITERIA MEMORANDUM

Structure, System, or Component: Solar 30 MW Power Plant

Prepared by: Date Dec. 23 1982

Group Leader/Supervisor Review , M&NE (Discipline) Date Dec 27, 1982

Reviewed by Interfacing Disciplines:

Group Leader/Supervisor A. B. Schuurman Date 1/4/83
Group Leader/Supervisor K. G. Zaharoff Date 1/3/83
Group Leader/Supervisor M. T. Perakis Date 12/23/82

Approved by:

Department Chief: J. V. Rocca Date: 1-5-83

Approved for Project use:

Project Engineer: Date: 1.7.83

Page 2 through 16 attached; describing design inputs. Other attachments as indicated below.

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ARCO Solar Industries, D. Horgan
D.A.Brand

SOLAR 30 MW POWER PLANT

Contents

1.0 Scope

This is the specification of a central receiver solar electric power plant to be located on the Carrizo Plain west of Simmler in San Luis Obispo County, California, in the service territory of Pacific Gas and Electric Company. This document specifies the functional, operating, and safety requirements; provides the technical, economic, and environmental design basis; and sets forth standards to which the plant will be designed. The plant is to be erected complete, on a virgin site; the design will include all plant, site preparation, and auxiliary facilities to the point of interconnection with PGandE's existing transmission lines.

The preliminary portion of design will be done by three organizations:

PGandE:	Engineering Department	San Francisco, CA
ESG:	Rockwell International Energy Systems Group	Canoga Park, CA
ARCO:	ARCO Power Systems	Littleton, CO

2.0 References

2.1 Conceptual Design Report

"Preliminary Design of the Carrizo Plain Solar Central Receiver Power Plant," Energy Systems Group, May 24, 1982.

The conceptual design report does not constitute the specification for the plant to be designed. The contents may be taken as design basis only where this document makes specific reference.

2.2 Standards and Codes

The plant will conform with the most-recent revision or edition of the following codes:

Mechanical

American National Standards Institute (ANSI)

A13.1	Identification of Piping Systems
B31.1	Power Piping
B36.10	Welded and Seamless Wrought Steel Pipe

American Petroleum Institute (API)

API Standard 620 Recommended Rules for Design and Contruction of Large, Welded Low-Pressure Storage Tanks.

American Society of Mechanical Engineers (ASME)

Boiler and Pressure Vessel Code, Section VIII, Div.1
Performance Test Codes
Standard TWDPS
Standard 116

American Society for Nondestructive Testing (ASNT)

SNT-TC-1A Personnel Qualifications and Certification in Nondestructive Testing

American Society for Testing and Materials (ASTM) Pipe Specifications

Instrument Society of American (ISA)

SP-1	Instrumentation Symbols and Identification
RP-7.1	Pneumatic Control Circuit Pressure Test

Electrical

National Electrical Manufacturers Associated(NEMA)

ICS	Industrial Controls and Systems
SG6	Power Switching Equipment

WDI	General Purpose Wiring Devices

American National Standards Institute (ANSI)

C50.10	Requirements for Synchronous Machines
C37.13	Standard for Low-Voltage AC Power Circuit Breakers Used in Enclosures
C37.20	Standard for Switchgear Assemblies Including Metal-Enclosed Bus.
C37.50	Standard for Test Procedures for Low-Voltage AC Power Circuit Breakers Used in Enclosures
C57	General Requirements for Distribution, Power, and Regulating Transformers

<u>Occupational Safety and Health</u>

California Administrative Code, Title 8
California Department of Occupational Safety and Health

2.3 Technical Data

W. H. Yunker, "Standard FFTF Values for the Physical and Thermophysical Properties of Sodium", Westinghouse Electric Corporation, Richland, Washington, IDT 12083 (WHAN-D-3)

"Thermodynamic and Transport Properties of Steam," Fourth Edition, 1977
ASME

M. Sittig, AIChE Monograph #133 Reinhold NY 1956
Sodium, its Mfg, Properties + Uses

3.0 Requirements

3.1 Plant Description

The plant will produce electricity from solar heat. Moveable mirrors ("heliostats") will direct solar radiation to a thermal receiver mounted on a tower. Liquid sodium metal circulating in the receiver will remove the heat and generate steam which will drive a turbine-generator.

The plant will be designed for approximately 30 MW full-load net electrical output. Energy storage, in the form of storage of liquid sodium, will be provided in an amount sufficient for at least one hour of full-power operation.

The plant will be substantially powered by sunlight, but may use fossil fuels or electricity from the grid for auxiliary heat and auxiliary and emergency electric power. More than 75% of the energy used to heat water or generate steam shall be solar heat.

Start-up capability independent of the grid is not required. Emergency power shall be provided independent of the grid sufficient to take the plant systems to shutdown condition.

The plant will be designed for 30 years' lifetime.

3.2 Plant Systems

The plant is divided into the following systems, with the design responsibilities indicated:

Collector System	ARCO
Heat Transfer System	ESG
Power Conversion System	PGandE
Master Control System	PGandE
Balance of Plant	PGandE

3.2.1 Collector System

The collector system is composed of an array of heliostats and supporting power and control elements which interact with the plant master control. The heliostat array reflects solar radiation onto the receiver and provides auxiliary functions for other modes of operation and nonoperational positionings. The collector system is composed of the following subsystems and components:

1. Heliostats, including reflective surface, structural support, drive mechanism, control sensors, pedestals, foundations, and junction boxes.

2. Electromechanical and electrical controllers, including individual heliostat and heliostat field controllers, control system interface electronics, and power supplies.

3. Beam characterization subsystem.

The collector system shall be capable of delivering 116 MW thermal power onto the receiver surface at local noon on the equinoxes.

3.2.2 Heat Transfer System (HTS)

The heat transfer system receives the radiant energy from the collector system into a liquid sodium circuit and delivers it to the power conversion system working fluid (water/steam). It also provides a means of storing thermal energy: as sensible heat in stored sodium. The HTS is divided into the following subsystem: receiver, storage, steam generator, sodium transport, controls, and instrumentation, auxiliary sodium equipment.

The heat transfer system is composed of the following components:

- Sodium-containing piping, tanks, heat exchangers, and pumps.
- Supports for this equipment, to the point of attachment to the first structural member.
- Heat tracing, to the point of (TBD).
- Controls and instumentation to operate the HTS manually.
- Auxiliary Sodium Equipment including all components, packages, and items necessary to accommodate the unique properties of sodium as a heat transport fluid. Included in this category are sodium purification equipment, sodium/water reaction products handling equipment, argon cover gas packages, sodium cleaning and component handling and shipping equipment, and sodium receiving, storage, drain, and mixing tanks. Primary sodium storage will be accommodated by the storage tanks in the storage subsystem.

The HTS shall be sized to deliver 85 MW thermal power to the steam cycle, for waterside temperature range of 436°F-1000°F.

3.2.3 Power Conversion System (PCS)

The power conversion system will be a conventional regenerative Rankine cycle with main steam conditions of 1465 psig, 1000°F from the sodium-heated steam generator. The turbine exhaust pressure should be 2 to 4 in. Hg. absolute pressure. The condenser will be cooled by water recirculated from an evaporative tower. This system is further described in system and subsystem design criteria.

3.2.4 Master Control System (MCS)

A master or supervisory control system will be provided which will enable the plant operator's to control the plant systems according to the operating requirements. Equipment and software which directs functions entirely within one of the plant systems shall be provided as part of that system. The Master Control System comprises the display boards, control boards, and control hardware and software other than that which is part of individual plant systems. This system will include automatic collection of engineering data.

Requirements of this system are the subject of a seprate Design Criteria, D23-3.

3.2.5 Balance of Plant (BOP)

The balance of plant denotes all those site improvements, structures, utilities, and other facilities which may be required to support the other plant systems. Following is a partial catalog of items:

Tower supporting the receiver and related components

Structure for the heat transfer system and power conversion system, with installed turbine generator crane

Switchyard, except switchgear and transformers

Raw water storage and effluent water disposal facilities

Cooling tower basin

Grading, roadways, fencing and landscaping

Structure(s) housing control room, maintenance space, machine shop, warehouse, offices, and personnel support space

Utilities including sanitary system, raw and domestic water supply, communications, and lighting

Yard and buried portions of fire protection system

Weather protection is required only for control room, computer room, local control panels, auxiliary boiler, switchgear, maintenance shops and offices, and temporarily for turbine and generator maintenance.

3.3 The Site and Its Environment

The site description and environmental information contained in the Conceptual Design Report (v. Section 2.1 herein) constitutes the design basis for site and environment.

The Civil design criteria contains design basis seismic and wind loads.

The site is adjacent to State Highway 58. Rail facilities are available to McKittrick, 60 highway miles to the East. The rail line is a "good" line, with a weight limit above 240,000 lb.

The land parcel selected shall be level so that, on a 500-foot rectangular grid, the downward slope of each element is either in a northerly direction with slope less than 1%, or in a southerly direction.

3.3.1 Water

The following is the present estimate of the mineral analysis of ground water at the site. On-site wells will be the source of raw water for the project.

		Design Basis
pH		8.0
Electrical conductivity	mhos/cm	1156.
Calcium ion	mg/l	78.
Magnesium ion	mg/l	20.
Sodium ion	mg/l	142.
Potassium ion	mg/l	.8
Alkalinity	mg/l $CaCo_3$	155.
Sulfate	mg/l	236.
Chloride	mg/l	80.
Nitrate ion	mg/l	97.
Boron	mg/l	.69
Fluoride ion	mg/l	.5
Silica	mg/l	35.
TDS	mg/l	797.
Total hardness	mg/l	274.
Non-carbonate hardness	mg/l	122.
Sodium absorbtion ratio		3.7

3.4 Economic Design Data

In the economic design of the plant, added capital cost is justified provided its annual charges are offset by the combined worth of:

a) increased net annual electric energy production,

b) increased net plant capacity (which earns revenue independent of the corresponding energy production), and

c) reduced annual operating and maintenance cost.

The following values should be used for this project, in place of others which might apply if the design were for a Company-owned project:

- One kW on net plant capacity justifies $895. in capital cost
- One kWh of net annual energy production justifies $1.095 in capital cost
- One dollar in annual OandM saving justifies $16.30 in capital cost
- One dollar in annual saving in auxiliary boiler fuel (because of the positive real escalation rate expected) justifies $32.72 in capital cost
- Projected costs for fossil fuels are equivalent to the following 1982 delivered costs per MM Btu:

Fuel oil (medium sulfur)	$6.12
Distillate oil	7.50
Propane	5.38
Natural gas	4.40

The basis year for capital, fuel, and operating costs is 1982. The assumed capacity factor is 30%.

Note that added capital cost associated with differences in equipment must include installation, sales taxes, and overheads.

3.5 Permits and Licenses

Following are some of the approvals, the requirement of which should be taken into account in the design:

Air Quality. The facility should have only minor potential for emission and can be expected to require no permits. Inclusion of a significant combustion source of auxiliary heat, however, might necessitate a permit. A letter of exemption from the local Air Pollution Control District is advisable.

Water Quality. The facility is expected not to discharge to waters of the U.S. and thus to be free of NPDES requirements. Chemical wastes and cooling tower blowdown discharged to an evaporating pond constitute a water release and must meet the permit and reporting requirements of the Regional Water Quality Control Board. Depending upon their composition, treatment and hold-up time, they may constitute hazardous waste and enter the realm of the Federal RCRA.

Environmental Impact. A report requirement is anticipated.

Fuel Use Act. Auxiliary fuel use will be below the quantity threshold of this act.

California Energy Commission. The plant size is below that requiring CEC action.

San Luis Obispo County Building Permit

3.6 Reliability

The reliability design objective is stated in terms of service demand availability after forced and scheduled outages. The unit is said to be available if it is able to carry load (at least 80% of full load), given the presence of all required external conditions such as sunlight, a dispatch order, or the transmission grid. The plant should have an availability during the service demand period, defined as 6:00 a.m. - 8:00 p.m. daily, of 90%.

The allowance for outage is divided among plant systems as follows:

Collector System	98% (capability above 95% of design value)
Heat Transfer System	97%
Power Conversion System	98%
Master Control System	98%
Structures and Common Utilities	99%

3.7 Safety

3.7.1 Sodium Safety

Sodium systems shall be designed so as to minimize the possibility, in case of equipment failure, of generating sodium aerosols.

As a matter of policy, piping or vessels containing water or steam shall not be routed within 25 ft. of piping or vessels containing sodium, except within 30 ft. of any of the steam generators.

3.7.2 Fire Protection

A water system will be installed providing water to all plant areas including the heliostat field except as stated in Section 3.7.1. Sodium system areas will be provided with supplies of dry extinguishant to be manually applied. Certain plant areas as required will be provided with fixed or portable fire-fighting equipment.

3.8 Operating Requirements

The expected operating mode will be to operate at full load only and to operate for those daily hours allowed by available insolation and storage. However, the PCS shall be capable of automatic operation down to 20% gross electrical output and of steady state manual operation down to 3%.

The plant will receive heat as it is available and store hot sodium up to the capacity of the storage. At the same or at other times, it will draw hot sodium from storage and generate electricity.

The plant shall be managed overnight so as to maximize long-term operating income, considering the following factors:

a) safety of operating personnel and the public,
b) allowable temperature ramp rates for equipment,
c) maintenance of acceptable PCS feedwater chemistry,
d) consumption of auxiliary heat and electricity,
e) net raw water consumption, and
f) any other pertinent considerations.

3.9 Electrical Systems

The main generator will produce electric power at 12 kV, 3 phase, 60 hertz. The generator output will feed through a generator breaker to the main step up transformer to transmit the power through a circuit breaker to the 115 kV SLO-to-Midway transmission line. The connection to the transmission line will be a T connection with disconnect switches in each leg of the T.

The 1,250 Hp cold sodium receiver pump and two 750 Hp boiler feedwater pumps will be supplied from the generator bus at 12 kV voltage. The 12 kV to 480 volts auxiliary transformer for all other plant loads will also be supplied from the generator bus.

The back-up station power will be supplied from the 12 kV Carrizo Plain Substation. A 12 kV/480 volt transformer will supply back-up power for stowing the heliostats, for lighting, for heat tracing, I&C equipment, and for other essential loads during shutdown.

1.1 GENERAL DESIGN CRITERIA, INSTRUMENTATION AND CONTROL (D23-3)

Engineering
76-370 2/81

DCM No. D23-3 Revision 0
Date APRIL 27, 1983
File No. __

PACIFIC GAS AND ELECTRIC COMPANY

30MW SOLAR

DESIGN CRITERIA MEMORANDUM

Structure, System, or Component: INSTRUMENTATION AND CONTROL GENERAL DESIGN CRITERIA

Prepared by: J.M. WALEWSKI / M.T. PERAKIS MTPerakis JMWalewski Date 4/27/83

Group Leader/Supervisor Review A.F. ARIEY, AF Ariey (Discipline) Date 4/29/83

Reviewed by Interfacing Disciplines:

Group Leader/Supervisor J.B. GEGAN JB Gegan Date April 29, 1983

Group Leader/Supervisor M.E. CONLU MEConlu Date 4-29-83

Group Leader/Supervisor K.G. ZAHAROFF Date 5-25-83

A.B. SCHUURMAN ABSchuurman 6-10-'83

Approved by:

Department Chief: J.V. ROCCA JVRocca Date: 6-14-83

Approved for Project use:

Project Engineer: R.E. PRICE REPrice Date: 6.15.83

Page 2 through 12 attached; describing design inputs. Other attachments as indicated below.

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☐ Manager, Steam Generation

Others

30 MW SOLAR
INSTRUMENTATION AND CONTROL
GENERAL DESIGN CRITERIA

Contents:

1.0 Scope

This defines the general instrumentation and control (I&C) requirements for the 30 MW Solar Power Plant as defined by DCM No. D23-1. Specific requirements are contained in the various systems I&C criteria. The major systems included are:

1.1 Collector

1.2 Heat Transport

1.3 Power Conversion

1.4 Balance of Plant

1.5 Master Control System (DCM No. D23-7)

2.0 General Requirements

The design basis for this plant is attended operation at maximum cost-effective availability and power output. Sufficient automatic control equipment shall be provided to permit safe operation with minimum operator participation.

When manual operation is necessary, such control shall be available to permit safe and expeditious start-up, part load, full load, and shutdown operations. Sufficient process data and equipment status information shall be available to allow safe manual operation. All major equipment and processes shall be controlled from the main control room. Initial start of equipment shall be by operator action or in selected instances by automatic logic control. Standby starts of equipment required for continuous operation shall be automatic based upon system needs. See Master Control System Criteria D23-7 for additional information.

Turbine roll and acceleration shall be automatic after program initiation by operator. Rates of acceleration and hold points shall be selected by operator. Turbine shall hold at synchronous speed until decision is made by operator to parallel with system. Load and rate changes shall be initiated by operator. All plant controls shall be capable of following turbine load changes at maximum TBD rates allowed by turbine manufacturer. Controls shall allow each system to operate with the full rangeability that the process is capable of without sacrificing reliability. An important goal shall be to achieve maximum unit availability without undue complexity.

Major equipment shall be controlled from the remote control room. Both local and remote control will not be provided on equipment except for special cases where local control may be required for normal operation. Local control alone shall be provided for less important equipment which does not warrant remote control.

Equipment protection will be provided by separate and independent hardwired systems which can function during all possible modes of operation. Protection cannot be defeated by cutout switches. All protective devices shall be fail safe. This means that the equipment will either trip on device failure, or if it is safe to continue running, the failure will be alarmed only. Power supplies for protective equipment shall be very reliable and independent of other services.

All instrument and control devices shall be replaceable and repairable. Some devices will require loop operation in manual mode to allow their replacement or repair. All devices shall be capable of in place testing. Test features such as pressure test tees, isolation valves, test terminals, etc., shall be provided.

The main control room will contain annunciation for the entire plant. Sequence of events leading to a unit trip will be stored for logging on demand. The plant logger shall print out all status changes of major equipment and all alarm status changes.

Control loops shall be designed with failure modes that will provide for the safest of plant conditions. The mechanical or pneumatic failure mode and the electrical failure mode must be consistent. Controller failure shall result in the final control element either moving to the failed position or remaining in the last position. In most controller failures, the loop will be placed in manual by the control system and that information shall be displayed.

3.0 Functional Requirements

3.1 Automatic Control

Automatic controls will be provided for equipment and processes within the various systems in the plant. Sufficient capability shall be provided to accommodate reasonable future requirements. Redundant control capability will be considered in those cases where plant reliability would be improved.

When the automatic control system is inoperative, the equipment and processes may be controlled manually. Redundant sensors shall be provided in certain critical applications to improve reliability. Loss of one out of two sensors would be displayed for operator action.

Certain selected process variables which are vital for operator information during manual operation will be displayed on dedicated indicators or recorders conveniently located on the main control board.

Total loss of operator interface shall result in a main unit trip and a trip of all equipment running under Master Control System control.

Certain control stations shall be dedicated and capable of manual or automatic operation. Stations shall indicate which mode is being used. On loss of automatic control, the station will go to the manual mode.

Dedicated stations shall have process variable indication in engineering units or percent as applicable, controller output in percent, manual/automatic status, and manual control input device.

Controls shall be capable of safely accommodating all normally expected load changes and rates of change including unit trip, loss of sodium flow, and sudden decrease of solar energy input without operator intervention.

Control loops shall have control constants applied through a centrally located station having controlled access.

3.2 Manual Control

All major equipment and processes shall be capable of manual operation from the main control room. Equipment status and process information shall be available to allow safe manual control.

Manual control of process control loops shall be possible, but the controlability of the process may be such that continued operation in this mode would be undesirable.

3.3 Protection

Equipment protection shall be provided for all equipment. The extent of protection used for each application shall be determined by considerations of equipment replacement time and costs, safety, common failure history, and reliability of protective devices.

All protection shall be dedicated, independent of other controls, hardwired, and designed to be effective regardless of control system status, control mode, and plant status. Cut out switches shall not be provided; and design shall be such that protective features will not inhibit operation during startup, normal operation, and testing. Power supplies shall be dedicated and very reliable. Redundancy of protection instruments and power supplies will be utilized where necessary.

Protection shall be based upon preventing damage to equipment from the most likely causes such as loss of pump suction, bearing deterioration, lack of sufficient pump flow, sudden imbalance, or motor overloading.

3.4 Interlocking

Plant operations which require interlocking with other functions for plant or equipment protection shall have hardwired logic. Means of defeating this logic such as cut out switches shall not be provided.

Each application shall be determined by study of system, subsystem, or equipment operating criteria, safety considerations, potential for damage to plant and equipment, and the relative importance of interrelationships of the various components.

3.5 Annunciation

All plant alarms shall be annunciated in the main control room. Annunciator windows will be used for only the most urgent alarms and will display the appropriate alarm message information as clearly as possible. Several inputs may share a window which has a general message.

Annunciator shall be independent of other data processing systems and shall remain functional regardless of master control system status, plant status, and loss of plant AC power. The annunciator shall have reflash capability, dual lamps, seal in feature, and test and acknowledge push buttons.

Alarm logic shall be positive and such that validity of the alarm shall be verified before the annunciation is performed. Once a valid alarm is accepted, it will remain on until the condition clears and the acknowledge push button is activated.

3.6 Data Logging

Alarms and change of status of equipment and systems shall be logged with time on a 24-hour basis. A return to normal of an alarm condition shall also be logged. The smallest time increment shall be one second.

A sequence of events function shall be provided to record events leading up to a unit trip. The events shall be stored in memory and shall print out in correct time sequence at operator command. The smallest time increment between events shall be four milliseconds.

3.7 Recording

Dedicated multipoint strip chart recorders shall be used to record certain essential process variable data. Charts shall be scaled in proper engineering units to suit the expected operating range, or 0-100%, if that is more appropriate to the measurement. Recorders shall remain functional regardless of plant status, Master Control System status, and loss of other data processing systems.

Trend recording capability shall be provided with inputs operator selectable. The address of the particular inputs on trend shall be conveniently displayed at each recorder location. Charts shall be 0-100%. Most analog signals in the plant shall be available for trending.

3.8 Reliability

Design of control logic shall be such that a single control component failure shall not affect more than one piece of equipment. If the single failure results in the tripping of the main unit, a subsequent loss of additional equipment will normally occur.

If a single control component failure results in an unacceptable level of risk to the plant, system, equipment, or personnel, then such failure shall result in the automatic tripping of the system or equipment as necessary to reduce that risk.

Control components shall be provided which have high reliability and performance over an extended operating life. However, components shall not be expected to perform at optimum levels when subjected to abnormal conditions caused by process leaks, equipment failures, and similar occurrences.

In most cases, replacement of a failed or malfunctioning on line component shall be possible when the affected loop can be operated safely on manual control. Redundant components may be used on certain very vital loops to help maintain automatic operation. The replacement of a failed component shall be possible in a minimum amount of time without undue risk to plant or personnel.

3.9 General Considerations

Positive logic shall be used unless otherwise noted on specific control criteria. An alarm state shall be confirmed upon receipt of a positive or closed contact signal. For control purposes, a closed contact or energized control circuit shall be used to initiate a given command which results in energizing, starting, or pressurizing of systems or components unless otherwise noted.

Commands to start equipment and operate various components shall be based upon a momentary contact closure or energizing with a seal in arrangement, unless noted otherwise.

Commands to stop, deenergize, or depressurize equipment or systems shall be based upon an open contact or deenergized circuit. All equipment protection circuits shall be based upon open contact tripping.

When two full sized components are provided for parallel operation, the standby component shall be capable of automatically starting, when selected for such duty, by closure of a contact or energizing a control circuit. The logic behind that decision shall be based upon system needs or equipment needs. Normally when a standby is started, the other component remains in service until stopped manually or tripped by protective scheme. The standby component remains in service after the start until manually stopped. An exception would be when certain selected equipment is automatically started and stopped by control logic to satisfy particular system requirements.

When status of equipment is displayed by lights, the red light denotes an energized, running, or open condition, while a green light denotes a deenergized, stopped, or closed condition.

The Master Control System equipment and all other control equipment shall be purchased with sufficient documentation to allow installation, testing, proper operation, and repair/maintenance. Documentation shall include all necessary drawings, instructions, parts lists, and specifications.

4.0 Interfaces

The plant controls interface with the system equipment and final control elements in the following systems:

4.1 Heat Transfer

4.2 Power Conversion

4.3 Balance of Plant

The interfaces with the Collector System are the computers used to position heliostats for solar tracking.

Operator interfaces are the control equipment such as switches, control stations, and operator consoles located in the main control room and certain local control stations.

5.0 Instrument Requirements

5.1 General

All control components shall be designed for continuous duty in an industrial environment which may include rain, dust, water vapor, and corrosive elements. They shall be capable of being maintained in serviceable condition for a plant design life of 30 years.

Instrument case type shall be determine by the environment that it will be exposed too. Instrument Data Sheets will specify the environment and the selected case type and materials for each instrument.

Where corrosive elements are expected in the atmosphere, materials which are resistant to those elements shall be selected. Plating of parts is generally not an acceptable substitute for materials having true corrosion resistance in such cases.

Wetted parts shall contain materials which will operate corrosion free and provide long life and reliable performance with due consideration given to the process fluids.

Instruments located in the field shall be mounted to rigid support structures such that vibration is minimized. However, some vibration will be present in most installations and the instrument design must accommodate this without adverse effect to performance or service life.

5.2 Specific

Pressure and temperature ratings of instruments shall exceed the maximum expected process conditions in all cases. The nominal range of an instrument shall be at least 30% higher than the expected high operating point of that instrument. Normal operation should be in the middle third of the range whenever possible.

Electrical instrument loops shall employ 4-20 ma signals for all control data transmissions to final control elements. Pneumatic loops shall employ 3-15 psig signals and will be used in local loops having no interface with the Master Control System.

Modulating control valves shall have pneumatic actuators and will require an electric to pneumatic positioner when used on an electrical control loop. Modulating control valves and on/off control valves shall have local position indicators integrated into the valve design.

Performance requirements for various components shall be designated on data sheets prepared for purchase documents. The specific data relating to ranges, set points, outputs, proof pressures, materials of contruction, and other pertinent information shall also be found in the Data Sheets. System engineer shall review Data Sheets for compliance with various system requirements.

Failure direction (upscale or downscale) shall be determined by analysis of the consequences of instrument failure to the process. The most important consideration shall be to avoid damage to equipment and to maintain safety for personnel in the event of failure.

The maximum temperature rating of all components shall be higher than the highest expected ambient temperature at the mounting location with due consideration for sun heating if applicable.

Electrical circuit boards shall be conformally coated or sprayed to protect against possible atmospheric attack. Circuits shall be immune from radio frequency interference and be able to withstand high voltage surges without damage. Specific requirements will be developed for purchase order documents.

5.3 Maintenance and Testing

Instrument design shall be such that routine maintenance and in place testing can be accomplished easily. Adjustments to electronic instruments shall be made from outside the instrument without sacrificing the dust or vapor proof rating of the case. Modular design to facilitate repair of the vaious components is preferable. Circuit boards designed for easy replacement shall be utilized wherever possible. Terminals for testing electrical instruments shall be accessible.

6.0 Control Boards and Local Panels

The main control board shall be arranged by function wherever possible. Within each section, the controls, indicators, and recorders shall be logically grouped to facilitate operator interfacing. Annunciators for the corresponding systems shall be located above the controls for those systems whenever possible.

Control boards having both bench and vertical sections will have operating controls on the bench section. The vertical parts will be for recorders, indicators, and certain less frequently used switches. Recorders shall be located on the lower third of the vertical section for accessibility. Annunciator windows will be located on the upper third of the vertical parts of the board.

All controls, recorders, and indicators shall be properly identified by nameplates with service designations and instrument numbers. Controls shall be clearly identified as to the position-function relationships.

Local enclosed panels shall be used whenever instruments are to be grouped and need protection from the environment. The panels are to be designed and located to suit the particular circumstances. Instrument panels shall be called out on the specific system I&C criteria if required.

7.0 Instrument Power

The AC power supply for computers and controls in the plant shall be uninterruptible, regulated, and conditioned. The supply shall be reliable, independent of other services, and shall be properly grounded.

The DC power supply for certain critical controls shall be from the station battery.

30 volt DC nominal regulated and conditioned power supplies will furnish power to individual 4-20 ma instruments. The AC supply for DC power supplies shall be uninterruptible.

All power supplies shall have sufficient capacity to handle all continuous loads plus a minimum of 30% extra.

8.0 Codes and Standards

The design and fabrication of all instruments shall comply as a minimum with the latest revisions of the following codes and standards:

8.1 ISA Standard S51.1 (1979) Process Instrument Terminology

8.2 NEMA Standard 250 (1979) Enclosures for Elec. Equipment

8.3 SAMA Standard PMC33.1 (1978) Electromagnetic Susceptibility

8.4 ANSI Standard C37.90a (1974) Surge Withstand Capability

8.5 PGandE Mechanical Design Manual, Section 30.

9.0 Seismic Requirements

Control equipment and enclosures including the attachment to supporting structures shall be designed to resist a static equivalent horizontal force of 0.3 W simultaneously with a static equivalent vertical force of 0.2 W, where W is the weight of the enclosure and equipment. These forces shall be assumed to act in any direction through the center of gravity of the enclosure or equipment. The combination of forces which, in conjunction with deadloads, causes the highest stresses, shall apply.

Equipment need not operate through the seismic disturbance, but should allow a safe shutdown without creating damage or personnel hazards.

10.0 Installation Requirements

Field mounted equipment will be installed in suitable enclosures if environmental protection is required. Outdoor enclosures shall be capable of protecting against rain and dust, as a minimum, and other atmospheric conditions, as required. Enclosures shall be heated when required for humidity control or when maximum thermal stability is required of equipment.

Centrally located electronic control equipment will be installed in environmentally controlled rooms separated from electrical switching equipment. Such rooms shall provide humidity and temperature control of atmosphere. Sufficient cooling will be provided to keep equipment below maximum safe operating temperature.

The main control room which houses the control boards shall provide humidity and temperature control of atmosphere. Heat removal to keep equipment below maximum safe operating temperature is also a requirement.

Locally mounted instruments shall be installed so that they are accessible and readable. Installation at approximately 5 feet above grade or platform is preferred. Line mounting or mounting on equipment is to be avoided. Supports and mounting brackets shall provide rigid support free of excessive vibration.

Instruments shall be located near the equipment or process that they service, with grouping of instruments preferred. Sharing of common supports and enclosures shall be encouraged as far as practical.

Level instruments installed on nonsodium heat exchangers, feedwater heaters, and pressure vessels shall utilize a common standpipe. The standpipe connects to the vessel at two points which allow the standpipe to span the required level range. All level instruments will be mounted on the same standpipe unless it becomes too crowded. A second standpipe can then be utilized. Each instrument must have isolation and blowdown valves and a vent connection to allow testing.

All pressure instruments must be capable of being isolated for testing or replacement. All nonsodium pressure instruments shall also have a test connection between the isolation valve and the instrument. Instruments must be easily removable for replacement or repair.

Field instruments having wiring will require a junction box at the instrument for ease of testing and to help prevent the entrance of water into the instrument case. The junction box in an outside installation shall be below the instrument case. In all cases, a flex conduit shall connect the instrument with the junction box. A common junction box may be used to connect several instruments in the immediate area.

2.0 COLLECTOR SYSTEM

Technical Specification for the Collector System

1. GENERAL

1.1 Scope

This specification establishes the performance, design, fabrication, construction, installation, operation, maintenance and acceptance requirements for the Collector System.

2. DOCUMENTS

The equipment, material, design, installation and checkout procedures, and construction of the Collector System shall comply with all Federal, State, and local standards, regulations, codes, laws, and ordinances which are currently applicable for siting in Simmler, California. These shall include, but are not limited to, the documents itemized below.

National Electrical Manufacturers Association (NEMA)
  Standards

Manual of Steel Construction, 8th Edition, 1974,
  American Institute of Steel Construction

Uniform Building Code - 1976 Edison, Vol. 1 by
  International Conference of Building Officials

National Electrical Code, NFPA 70-1975

ANSI C1-1975, American National Standards Institute

ANSI A58.1-1972, Building Code Requirements for Minimum Design Loads in Buildings and Other Structures

2.2 Other Publications

"Wind Forces on Structures," ASCE Paper No. 3269, Transactions, American Society of Civil Engineers, Vol. 126, Part II, 1961.

3. REQUIREMENTS

3.1 Collector System Definition

The Collector System is composed of an array of heliostats power supply, and control elements which interact with the master control. The heliostat array reflects solar radiation onto the elevated absorber of the receiver system in a manner which satisfies receiver incident heat flux requirements.

The Collector System components are:

a. Heliostats

   (1) Mirror modules

      o Silvered Glass Reflector

      o Mirror Support Panel

   (2) Structural support

   (3) Drive units

   (4) Control sensors

   (5) Pedestal and foundation

   (6) Heliostat cabling

      o Power

      o Signal

(7) Heliostat field wiring

  - o Power
  - o Signal
  - o Grounding

b. Heliostat Controllers

(1) Controller

(2) AC/DC power supplies

(3) Motor control electronics

c. Heliostat Array Controller (HAC)

(1) Master Control System interface including electronics

(2) Main and backup computers

(3) Time base

(4) Beam Characterization System interface including electronics

(5) Software

d. Heliostat Field Controllers (HFC)

(1) Controller

(2) AC/DC power supplies

(3) Heliostat Controller interface including electronics

(5) Software

e. Support Equipment and Procedures

(1) Mirror Canting and recant

(2) Heliostat Track Alignment

(3) Operation and Maintenance Equipment and Manuals

3.1.1 <u>Collector System Diagrams</u>

Figure 1 represents the basic heliostat configuration. Figure 2 shows the collector field control configuration and interfaces, and Figure 3 shows a block diagram of the control system and interfaces.

3.1.2 <u>Interfaces</u>.

3.1.2.1 <u>Collector/Physical Site</u>. The physical arrangement, outer boundaries of the array of heliostats. Roads and site preparation will be supplied.

3.1.2.2 <u>Collector/Receiver System</u>. The Collector System shall concentrate the redirected energy onto the receiver. The receiver is a rectangle 40 ft. high by 50 ft. wide, and the center is 450 feet above ground level.

3.1.2.3 <u>Collector/Plant Power</u>. Uninterruptible power is to be supplied to the Heliostat Array Controller (HAC). Power to the heliostat is to be supplied by the plant substation bus.

3.1.2.4 <u>Heliostat Array Controller (HAC) Interfaces</u>. The collector subsystem interfaces to the Master Control System (MCS) Data Acquisition System, and Receiver System are specified.

3.1.2.5 <u>Collector/Beam Characterization System</u>. The collector subsystem will initiate beam characterization by directing a heliostat to focus on the BCS target. The BCS will be commanded to execute data acquisition and return beam centroid location to the CS. Additional measurements will be made as needed to resolve all tracking error terms. In cases of large errors, the CS will be requested by the BCS to adjust the heliostat alignment to bring the heliostat on target.

3.2 Specification

3.2.1 Performance

In order to attain overall collector field performance, the following requirements have been established for designing and evaluating individual heliostats.

a. Maximum beam pointing error (tracking accuracy) shall be limited to 1.5 mrad standard deviation for each gimbal axis under the following conditions:

   - o Wind - none
   - o Temperature - 0° to 50°C (32°F to 122°F)
   - o Gravity Effects - at all elevation and azimuth angles that could occur in a heliostat field
   - o Azimuth Angles - at all angles except during gimbal lock
   - o Sun Location - at least .26 rad above horizon, anytime of year
   - o Heliostat Location - any position in the field

   Pointing error is defined as the difference between the aim point and measured beam centroid for all of the above conditions for any tracking aim point (on target or at standby).

b. Beam quality shall be such that a minimum of 90% of the reflected energy at target slant range shall fall within the area defined by the theoretical beam shape plus a 1.4 mrad fringe width. Heliostat beam quality shall be met throughout 60 days without realignment. Beam quality requirements are applicable under the following conditions.

- Wind - none
- Temperature - 0° to 50°C (32°F to 122°F)
- Gravity Effects - at all elevation and aximuth angles that could occur in a heliostat field
- Sun Location - at least .26 rad above horizon, anytime of year
- Heliostat Location - any position in the field and any slant range
- Operating Mode - tracking on receiver
- Facet Alignment - as planned
- Theoretical Beam Shape - the theoretical beam contour is the isoflux contour that contains 90% of the total power. This isoflux contour will be increased by 1.4 mrad fringe.

c. Overall structural support shall limit reflective surface static deflections to an effective 1.7 mrad standard deviation for a field of heliostats in a 27 mph wind. Wind deflections of the foundation, pedestal, drive mechanism, torque tube, and mirror support members shall be

included, but not the slope errors due to gravity and temperature effects. Wind slope errors due to gravity and temperature effects. Wind deflection limits apply to the mirror normal (not reflected beam) for each axis fixed in the reflector plane. Both beam quality and beam pointing are affected.
To assure that the net slope errors of a field of heliostats is less than 1.7 mrad, the rms value of the slope errors taken over the entire reflective surfsce of an individual heliostat, computed under the worst conditions of wind and heliostat orientation (but excluding pedestal deflection), shall be limited to 3.6 mrad for a single heliostat. This limit represents a 3-sigma value for the field derived by subtracting pedestal deflection (see 3.2.1.d) from the total surface slope error. (1.7 - .5 = 1.2 mrad std. dev. x 3 = 3.6 mrad 3-sigma).
The conditions under which this requirement applies are:

- o Wind, including gusts - 27 mph (12 m/s) at 33 ft (10m) elevation
- o Temperature - 32° to 122°F (0° to 50°C)
- o Heliostat Location - any position in the field at any time of the year
- o Gravity Effects - not included

- o Mirror Module Waviness - none
- o Facet Alignment Error - none

d. A maximum allowable elastic deflection of 0.5 mrad standard deviation is the limit placed on the foundation design, which must be included in the 1.7 mrad structural support deflection limit for any environmental condition excluding earthquake. Realignment after earthquake is acceptable.

Standard deviation as used in these requirements shall be determined from a sample of at least 20 data points from each individual heliostat tested.

3.2.2 Operation

Operational control requirements are as follows:

a. The Collector Subsystem shall function as appropriate for all steady-state modes of plant operation. This shall include the capability of controlling the number of heliostats in tracking mode so as to vary the redirected flux to the receiver between zero and the maximum achievable level.

b. Drive systems must be capable of positioning a heliostat to stowage, cleaning, or maintenance orientation from any operational orientation within 15 minutes.

c. Elevation and azimuth gimbals drives shall not drift from last commanded position due to environmental loading.

d. Heliostat control shall be by computer with gimbal axis and motor shaft sensors. Control functions shall be accomplished as follows:

Heliostat Array Controller (HAC) shall:

- Initiate operational mode commands to HFC
- Address command to HFC groups or individual HC
- Respond to MCS commands
- Provide data to DAS
- Interface with Beam Characterization System
- Provide time base
- Respond to Receiver System Emergency Commands

Heliostat Field Controller (HFC) shall:

- Determine individual heliostat azimuth and elevation position requirements
- Transmit position requirements to HC
- Transmit status and data to the HAC which interfaces with the MCS and DAS
- Initiate beam safe stowage command upon loss of HAC communication
- Control groups of HCs

Heliostat Controller (HC) shall:

- Control drive motors
- Receive gimbal axis sensor data and check sensor condition
- Provide gimbal axis position data to HFC
- Provide heliostat status to HFC

3.2.3 Safety

Tentative operational safety requirements, pending final resolution, are as follows:

a. The collector field shall be capable of emergency defocusing to standby position upon command within 5.0 seconds.

b. Heat fluxes on tower and normally unirradiated portions of the Receiver System are limited to one (1) heliostat beam at any one location.

c. Beam control strategy and equipment will protect personnel and property within the boundaries of the plant, as well as the surrounding area in the vicinity of the plant, including the definition of safe air space.

3.2.4 Maintainability

The collectors will be designed so that they do not require routine field maintenance, with the exception of periodic washing.

The Collector Subsystem shall be designed to report any subsystem malfunctions at the HAC console and provide fault isolation information on critical components. Critical components are those components that, because of failure, downtime, or effect on overall pilot plant performance, materially affect the CS availability, or the CS safety with respect to the reflected beam in the surrounding air space or on the ground.

3.2.5 Physical Characteristics

The Collector Subsystem detailed design shall be based on the following basic configuration:

a. Reflective surface of approximately 95m^2

b. Reflective surface as follows:

   - o Nominal .060 low iron float glass
   - o Second surface reflector, with a min. specular solar weighted reflectivity of 93%
   - o Chemically deposited silver refelctive surface

c. Reflective surface envelope not to exceed 32 x 32 ft., with an operating exclusion radius of 23 ft.

d. Local override of heliostat controller.

e. Single pedestal from foundation to drives.

f. Metal structure.

g. Environmentally sealed drive and sensor systems.

h. Heliostat focal lengths of 100 to 1100m (325 to 360 ft) shall be allowed by canting of mirror modules.

i. Azimuth and elevation gimbal axis located near centroid of reflective surface.

j. Independent mechanical azimuth and elevation limit switches.

k. Control sensors (encoders) for each gimbal axis.

l. Corrosion protection of all parts.

m. Mirror facet adjustment for recanting.

3.2.6 Environmental Design Conditions

The Collector Subsystem must maintain structural integrity in any applicable combination of the environments.

3.2.6.1 Wind Loading. The natural wind environment specified produces a vibratory response both from the oscillatory nature of the gusts and from periodic vortex shedding. The Collector Subsystem shall be designed to withstand, and/or operate when subjected to, the loads produced by this vibration. The actual loads must be computed taking into account structural configuration and dynamic characteristics, and the velocities of the winds.

In computing the angle between the wind direction and the plane of the heliostat reflective surface, the wind shall be assumed to deviate by up to, plus or minus, 10° from the horizontal.

3.2.6.2 Operational Limits. The Collector Subsystem must meet performance requirements for the following conditions:

Environment	Level
Wind, including gusts	12 m/s maximum (27 mph)
Temperature	a. 32°F to 122°F (0°C to 50°C) operate and meet all performance specifications b. 16°F to 32°F (-9°C to 0°C) operate but with no beam quality requirements

Gravity	All elevation angles

3.2.6.3 Stowage Initiation. The heliostats will continue to track the target with wind speeds up to 16 m/s (35 mph), above which stowage action will be initiated as a result of an externally provided signal. The heliostat must maintain structural integrity in a nonoperational state in a 22 m/s (50 mph) wind in any orientation.

3.2.6.4 Hail. The heliostat, in any orientation, must survive 20 mm (0.75) in diameter, 0.9 specific gravity hail impacting at 20 m/s. (65 ft/s).

3.2.6.5 Lightning. The Collector Subsystem shall have lightning protection consistent with the following guidelines:

Direct Hit - Total destruction of a single heliostat and its controller subjected to a direct lightning strike is acceptable.

Adjacent Strike- Damage to a heliostat adjacent to a direct lightning strike should be minimized within appropriate cost-risk limits.

Controller - The HAC's, HFC's, and HC's adjacent to a direct lightning strike must be protected.

3.2.7 Transportability

Collector Subsystem components or assemblies shall be designed for transportability by highway handling equipment within applicable Federal and State regulations.

3.3 Design and Construction

Commerical design and construction standards shall be employed. Where applicable, the Uniform Building Code (1976 ed.) and the American Institute of Steel Construction's Manual of Steel Construction (8th ed.) shall be used. (ASCE paper no. 3269 and ANSE A53.1-1972, Wind Forces on Structures (ASCE Transactions, Vol. 126, Part II 1961) and/or equivalent applicable test data shall be used for design when determining loading due to winds. For electrical components, the National Electronic Code (ANSI C1), the National Electrical Manufacturers Association (NEMA) and MIL-STD-454 standards for electronic equipment shall be used.

Design and material selection is to be based on a 30-year life.

3.3.1 Materials, Processes, and Parts

To the maximum extent possible, standard materials and processes, and off-the-shelf components shall be used. Wherever possible, commercial specifications shall be employed. All non-commerically available parts shall be defined and documented in deliverable documents. Commercial items shall not be proprietary.

3.3.2 Electrical Transients

The HAC is expected tolerate power transients which are commercially acceptable to the HAC purchased equipment suppliers.

The heliostat field controller (HFC)and heliostat controllers (HC) shall operate through the following power transient conditions:

a. Increasing Transient:

One cycle of the fundamental frequency at 1.7 PU voltage followed by an exponental decay back to the original voltage in 5 cycles.

b. Decreasing Transient:

A voltage drop-out (zero volts) for one cycle maximum of the fundamental frequency.

3.3.3 Electromagnetic Radiation

The Collector Subsystem control wiring shall be designed to minimize susceptibility to electromagnetic interference and to minimize the generation of conducted or radiated interface.

3.3.4 Workmanship

The level of workmanship shall conform to practices defined in the codes, standards, and applicable specifications. Where specific skill levels or certifications are required, current certification status shall be maintained with evidence of the status available for examination. All work shall be finished in a manner that presents no unintended hazard to operating and maintenance personnel, is neat and clean, and presents a uniform appearance.

3.3.6 Interchangeability

Items with a common function shall have a common part number and be interchangeable. Components with similar appearance but different functions shall incorporate protection against inadvertent erroneous installation. All heliostats shall be interchangeable, regardless of their position in the heliostat array.

3.3.7 Safety

The Collector Subsystem shall be designed to minimize safety hazards to operating and service personnel, the public, and equipment. Electrical components shall be insulated and grounded. All components with elevated temperatures shall be insulated against contact with or exposure to personnel. Any moving elements shall be shielded to avoid entanglements, and safety override controls/interlocks shall be provided for servicing.

3.3.8 Human Engineering

The Collector Subsystem shall be designed to facilitate manual operation, adjustment, and maintenance as needed and provide the optimum allocation of functions between personnel and automatic control. The Collector Subsystem design shall provide electrical and electronic packaging which ensures rapid repair and replacement, placarding of hazardous work areas, and equipment for item removal and handling.

3.4 Documentation

3.4.1 Characteristics and Performance

Equipment functions, normal operating characteristics, limiting conditions, test data, and performance curves shall be provided for inclusion in Overall Plant Design Description.

3.4.2 Operating and Maintenance (O&M) Manuals

O&M Manuals shall cover assembly, installation, alignment, adjustment, checking, lubrication, maintenance, and operation of the Collector Subsystem. All O&M Manuals shall include reference to applicable system engineering data and guides to troubleshooting instruments and controls. All phases of Collector Subsystem operation shall be addressed, including startup, normal and synthetic tracking operation, on-line and off-line maintenance, shut-down, contingency operation, and emergency operations.

3.4.3 Construction

Engineering assembly and installation drawings shall be provided to show the equipment construction, including assembly and disassembly procedures. Engineering data, wiring diagrams, and parts lists shall be provided.

3.4.4 Format

Collector system documentation (drawing, specifications, instructions, etc.) shall be compatible with other plant documentation.

3.0 HEAT TRANSPORT SYSTEM
(N10046)

Rockwell International

Energy Systems Group

PREPARED BY
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CARRIZO PLAINS 30-MWe SOLAR POWER PLANT HEAT TRANSPORT SYSTEM SPECIFICATION

APPROVALS
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DESIGN SPECIFICATION FOR
THE CARRIZO PLAINS SOLAR CENTRAL RECEIVER POWER PLANT HEAT TRANSPORT SYSTEM

1. SCOPE This specification establishes the heat transport system design requirements.

2. DOCUMENTS

2.1 Applicable Documents The following documents in effect on January 1, 1983, unless otherwise specified, form a part of this specification to the extent specified in Sections 3, 4, and 5..

Governmental

Federal - to be determined.
State - to be determined.
Local - to be determined.

American National Standards Institute (ANSI)

ANSI B31.1 - Power Piping

National Electric Code

NFPA 70-1978

National Electric Manufacturers Association (NEMA) Standards

American Society of Mechanical Engineers (ASME)

ANSI/ASME BPV-I - Power Boilers
ANSI/ASME BPV-VIII-1 - Pressure Vessels
ASME Steam Tables, 1967 Edition

Government Publications

TID 26666 - Nuclear Systems Materials Handbook

Uniform Building Code - International Conference of Building Officials

OSHA Regulations

OSHA Title 29, Part 1910 - Occupational Safety and Health Standards

Institute of Electrical and Electronic Engineers (IEEE) Codes

National Fire Protection Association (NFPA) National Fire Codes

Human Engineering Design Criteria

MIL-STD-810C
MIL-STD-1472

Design, Construction, and Fabrication Standards

Standards of AISC (American Institute of Steel Construction); Specification for the Design, Fabrication, and Erection for Structural Steel for Buildings; Code of Standard Practice

American Concrete Institute (ACI) - ACI 307-69 - Specification for the Design and Construction of Reinforced Concrete Chimneys; ACI 318-71 - Building Code Requirements for Reinforced Concrete

Standard of TEMA (Tube Exchanger Manufacturer's Association)

American Petroleum Institute (API) - API Standard 620 Recommended Rules for Design and Cosntruction of Large, Welded, Low-Pressure Storage Tanks

ANSI A58.1 - Building Code Requirements for Minimum Design Loads in Buildings and Other Structures

3. REQUIREMENTS

3.1 Plant Design

3.1.1 Function The function of the plant is to produce approximately 30 MWe (net) ±2 MWe electrical power from solar insolation.

3.1.2 Plant Description The Carrizo Plains Solar Power Plant Unit 1 shall be designed to be part of the PGandE grids. The plant site is located at Carrizo Plains, adjacent to Highway 58 in San Luis Obispo County, California.

Prominent features of the plant include an array of heliostats (mirrors) surrounding a tower-mounted receiver. Solar absorber panels in the receiver are illuminated by this field of heliostats. Heat directed to the absorber panels is removed by the circulation of liquid sodium. The sodium transports the heat to a thermal storage tank, and then to steam generators, where superheated steam is produced. The steam is fed to the turbine-generator to produce electricity. The cooler sodium is recirculated to the tower, and the turbine exhaust steam condensed and recirculated to the steam generators.

3.1.3 Principal Systems The plant shall consist of the following systems and subsystems, each of which is defined in terms of its functions and principal components. Each system, subsystem, and component identified shall include all the appurtenances necessary to make it operational such as local instrumentation, insulation, trace heaters, safety equipment, and supporting structure between the component and the foundation.

3.1.3.1 Collector System The function of the Collector System is to reflect insolation incident on the collector field onto the receiver.

The major components of the Collector System are the following:

- Collector field
- Heliostats including pedestals
- Field instrumentation and controls
- Field wiring
- Beam characterization equipment
- Tracking systems

3.1.3.2 Receiver Subsystem The function of the Receiver subsystem is to intercept incident radiant energy from the collector system and to transfer it into the sodium flowing through the receiver in the form of sensible heat.

The major components of the Receiver Subsystem are the following:

- Solar absorber panels
- Accumulator tank
- Surge tank
- Associated manifolds and valves
- Electrical heaters
- Local instrumentation and control elements
- Sodium catch pans
- Flux meters
- Support structures
- Ullage control loops
- Thermal insulation

3.1.3.4 Heat Transport Loop The function of the Heat Transport Subsystem is to transport energy from the receiver to and from the thermal storage and steam generation subsystems.

The major components of the Heat Transport Subsystem are the following:

- Sodium piping
- Sodium pumps
- Valves
- Pipe thermal insulation
- Pipe hangers
- Instrumentation and controls
- Electrical heaters

3.1.3.5 Thermal Storage Subsystem The function of the Thermal Storage Subsystem is to provide a post-insolation heat source and heat sink for the steam generators.

The major components of the Thermal Storage Subsystem are the following:

- Hot storage tank
- Cold storage tank
- Local instrumentation and controls
- Electrical heaters
- Thermal insulation

3.1.3.6 Steam Generation Subsystem The function of the Steam Generation Subsystem is to convert boiler feedwater into superheated steam.

The major components of the Steam Generation Subsystem are the following:

- Once-through steam generators
- Steam relief valves and power vent valves
- Running vent connections
- Attemperator
- Rupture disc assemblies
- Associated piping
- Local instrumentation and controls
- Electrical trace heaters
- Thermal insulation
- Feedwater control valves

3.1.3.7 Sodium Auxiliaries Subsystem The functions of the Sodium Auxiliaries Subsystem are to:

a. Establish and maintain sodium purity.

b. Provide for the loading and disposal of sodium.

c. Provide an inert cover gas over all free sodium surfaces, provide cover gas pressurization to maintain sodium levels and to move sodium from one location to another, and provide venting of gas spaces during fill and drain operations.

d. Provide equipment protection in the event of a sodium spill or sodium water reaction event.

e. Provide for detection of sodium leakage.

f. Provide for routine fill and drain of sodium-containing components.

g. Provide for the shipment of equipment containing residual sodium.

The major components of the Sodium Auxiliaries Subsystem are the following:

- Sodium purification equipment
- Sodium/water reaction products handling equipment
- Argon cover gas supply distribution
- Argon compressor
- Sodium cleaning and component handling and shipping equipment
- Sodium mixing tank
- Sodium drip pans

3.1.3.8 Master Control System The function of the Master Control System is to integrate the operation of independent plant sytems and to monitor, integrate, and report all plant and system parameters necessary to ensure safe operation of the plant.

The major components of the Master Control System are the following:

- Central computer
- Computer peripheral equipment
- Control and display consoles
- Solar, electric power, process and heat control software.

3.1.3.9 Electrical Power Generating System The function of the Electrical Power Generating System is to convert the energy in the steam from the Steam Generation Subsystem.

The major components of the Electrical Power Generating System are the following:

- Turbine-generator set
- Feedwater pumps
- Feedwater heaters
- Water/steam valves and piping
- Condenser
- Cooling tower
- Mechanical and electrical associated equipment
- Condenser cooling water piping and valves
- Condenser cooling water pumps
- The auxiliary boiler

3.1.3.10 Balance-of-Plant System The function of this system is to provide physical and logistics support to the other plant systems and subsystems.

This system includes all subsystems, equipment components, and items not included in the other systems; specifically, the land, site preparation, structures, foundations, permanent tools, fixtures, and fire protection.

The major items and components of the Balance-of-Plant System are the following:

- Site improvements
- Security
- Communications
- Utilities
- Instrument air
- Administrative control building
- Turbine-generator building
- Fire pump building
- Auxiliary boiler
- Maintenance shop and warehouse
- Cooling tower
- Electrical switchyard
- Treated water
- Clean feedwater
- Waste water treatment
- Evaporation pond
- Cranes and handling equipment
- Heliostat cleaning and maintenance equipment
- Receiver maintenance equipment
- Sodium components shipping containers

3.1.4 Plant Diagrams The following plant diagrams show the typical physical and functional relationship of the various systems, subsystems, flow of energy, and the control logic.

The conceptual layout of the plant is shown in Figures 1 and 2. Equipment arrangement and piping layout is shown in Figures 3. The schematic flow diagram is shown in Figure 4 and the P&I diagram for the heat transport system in Figure 5.

3.2. Heat Transport System (HTS) Design and Operating Requirements

3.2.1 HTS Requirements

3.2.1.1 Plant Rating The HTS shall be sized for a plant nominal electrical output of 30 MWe. The ratio of peak solar heat input to peak steam output (solar multiples SM) shall be 1.25. The HTS solar rating shall be based on a design point at vernal equinox noon, with a solar flux of 1000 W/m^2.

3.2.1.2 Arrangement The Heliostat Field and the Central Receiver shall be oriented so that the Central Receiver faces true north.

3.2.1.3 Design Life The design life for facilities and equipment shall be 30 years except when it is more economical to repair or replace than to design for longer life.

3.2.1.4 Thermal Storage The HTS shall have thermal energy storage capability equal to 70 min of full power operation.

3.2.1.5 Heat Transfer Media The heat transport and thermal storage media shall be commercial grade sodium.

3.2.1.6 Plant Cycle Type The plant cycle type shall be the nonreheat cycle.

3.2.1.7 HTS Control The HTS shall be responsive to the plant dispatcher. The design basis for the HTS shall be attended operation.

The HTS shall be designed for automatic operations with operator surveillance.

The HTS shall be designed for manual control for startup, part- and full-power operations, and for shutdown.

The HTS protective system shall be independent of the control system and shall be hardwired and be operable in all operating modes. The protective system shall not be defeated by cutout switches.

Annunciators for the HTS shall be in the control room.

Power and rate changes shall be initiated by the operator.

All steam generator controls shall be capable of following turbine load changes at maximum rates allowed by turbine manufacturer.

3.2.1.8 Availability The annual availability of the plant shall be 0.92 or greater, exclusive of weather outage. Allocation of this availability to individual systems is listed in Appendix 10, Section A-2.

Redundant critical components listed below shall be incorporated into the HTS design:

Steam generators - Three
Receiver pumps - Two
Steam generator pumps - Two
Argon compressors - Two

Argon system over- and under-pressure relieving devices shall be redundant and diverse.

The performance rating of each of the above shall be as listed in Appendix 10, Section A-4 through A-9. The HTS shall be capable of providing 90% of plant electrical output using only two steam generators.

The above-listed components shall be arranged in the plant design to permit operation with any two of the three steam generators and either one of the duplicate components.

3.2.1.9 Operating Cycle The HTS shall be capable of starting up, running, and shutting down on a daily basis.

3.2.1.10 Operating Modes The HTS shall be capable of operating in the following modes:

- Solar startup: Preheating of the receiver and associated components.
- Solar power operations: Provision of heated sodium from the solar receiver at full or part power.
- Solar shutdown: Reduction in power and cessation of solar power operations.
- Solar standby: Long- or short-term maintenance of the receiver and associated components in operational readiness.
- Thermal storage charging: Net accumulation of solar-heated sodium in the hot storage tank.
- Thermal storage discharging: Net accumulation of cooled sodium in the cold storage tank.
- Steam startup: Steam generation startup to a low power level.
- Steam power operations: Provision of steam from the steam generators for electric generation at full or part power.
- Steam shutdown: Reduction in power and cessation of steam power operations.
- Steam standby: Long- or short-term maintenance of the steam generator in operational readiness.

3.2.1.11 Maintainability Equipment shall be designed to satisfy the following maintenance requirements:

1) Adjust or repair the component in place
or
Replace component with a spare
or
Remove, repair, or reinstall the component.

2) Component removal and replacement shall be possible with the minimum removal of other components and parts.

3) All servicing and adjustment points shall be accessible without removal of other components and parts.

4) Components and systems shall be capable of being inspected, tested, calibrated, and adjusted after maintenance.

5) Access shall be provided for personnel and equipment for maintenance and replacement.

3.2.1.12 Environment The HTS shall be capable of startup, run, and/or safe shutdown while subjected to the environmental conditions of insulation, seismic activity, temperature, humidity, wind, dust, rain, snow, ice, hail, and/or lightning as specified below.

The plant shall withstand with minor damage but shall be required to run under the following conditions:

- Insolation: Appendix 10, Section A-2
- Seismic: Appendix 10, Section A-1
- Temperature and Humidity: Appendix 10, Section A-1
- Wind: ANSI A58.1, Section 6
- Dust Devils: Appendix 10, Section A-1
- Precipitation: Appendix 10, Section A-1

The wind design value is 90 mph at 30 ft elevation, with 100-year mean recurrence interval and a local wind vector variation of ±10 degrees from the horizontal. Lightning protection is to be provided.

3.2.1.13 Safety Requirements The HTS shall be designed in accordance with the applicable requirements of "OSHA Title 29, Part 1910 - Occupational Safety and Health Standards" and the Sodium Safety Plan, 079TI000007. Hazardous areas shall be clearly marked.

Provisions and equipment shall be included to prevent, control, and extinguish sodium fires. Catch pans, basins, or berms shall be provided in accordance with the Sodium Safety Plan, 079TI000007.

3.3 HTS Design Requirements This section contains the functional and top-level input and output requirements for the HTS subsystems.

3.3.1 Receiver Subsystem Design Requirements

3.3.1.1 Performance Degradation The Receiver Subsystem components and equipment shall be designed to withstand the environmental conditions specified in Appendix 10, Section A-1, without degradation in performance of more than TBD%.

3.3.1.2 Control The Receiver Subsystem control system shall be designed to respond independently to control signals and commands from the Heat Transport Control System.

3.3.1.3 Absorbed Energy The Receiver Subsystem shall be designed to accept the maximum integrated power and peak flux specified in Appendix 10, Section A-4.

3.3.1.4 Aircraft Warning The Receiver Subsystem design shall incorporate aircraft warning devices as specified in (TBD FAA publication).

3.3.1.5 Drainage The Receiver shall be drainable on operator command.

3.3.1.6 Preheat The Receiver shall be preheated by the heliostats to at least 500°F before filling with sodium.

3.3.1.7 Ullage Gas The ullage gas shall be commercial-grade argon within a closed system using a compressor storage system and recycling of the argon.

3.3.1.8 Temperature and Pressure The receiver shall be designed to accept the static head delivered by the receiver sodium pump as specified in Appendix 10, Section A-6. The design inlet and outlet sodium temperatures shall be as specified in Appendix 10, Section A-4.

3.3.2 Tower Subsystem Design Requirements

3.3.2.1 Structural Design The tower shall be designed to support the receiver and associated equipment for dead load, wind, and seismic conditions. Structural design shall be in accordance with the Uniform Building Code. The ZICS factor in the Code shall be equal to 0.4.

3.3.2.2 Insolation Protection The tower design shall protect personnel and equipment from solar insolation from the heliostat field. Such features shall include insulation or cladding to protect the upper portion of the tower from heliostat spillage.

3.3.3 Heat Transport Loop Design Requirements

3.3.3.1 Function The Heat Transport Loop shall

a. Receive sodium from the cold storage tank and deliver it to the receiver.

b. Receive sodium from the receiver and deliver it to the hot storage tank.

c. Receive sodium from the hot storage tank and deliver it to the steam generators.

d. Receive sodium from the steam generators and deliver it to the cold storage tank.

The sodium conditions for the above are listed in Appendix 10, Section A-6.

3.3.3.2 Sodium Fill During standby, the system shall remain filled except for the receiver subsystem.

3.3.3.3 Drain Requirements The sodium components and piping shall be drainable to the system low point as limited by the valve configuration.

3.3.3.4 Storage Tank Shutoff Valves The storage tank valves shall close against the flow.

3.3.4 Thermal Storage Subsystem Design Requirements

3.3.4.1 Sodium Inlet/Outlet Parameters The thermal storage subsystem shall

a. Accept hot sodium from the receiver and deliver it to the steam generator pumps.

b. Accept cold sodium from the steam generators and deliver it to the receiver pumps.

3.3.4.2 Capacity The energy storage capacity of the thermal storage system shall be as specified in Appendix 10, Section A-7. Each storage tank shall be designed to accomodate the entire plant inventory of sodium at the highest average temperature consistent with the design conditions of Appendix 10, Sections A-4 through A-9.

3.3.4.3 Foundation Requirements Shall be as given in Appendix 10, Section A-7.

3.3.5 Steam Generation Subsystem Design Requirements

3.3.5.1 Steam Generator Type Steam generators shall be AI-MSG units as described in 079R000007.

3.3.5.2 Operating and Design Values The operating and design values for the steam generators is given in Appendix 10, Section A-8.

3.3.5.3 Piping to Steam Generators The steam generators shall be arranged to operate in parallel. Metering of feedwater shall be independent for each steam generator. Sodium metering shall be common to all steam generators.

3.3.5.4 Code The steam generator units shall be designed and Code-stamped to Section VIII,Division 1, of the ASME Boiler and Pressure Vessel Code.

3.3.5.5 Material The steam generators shall be fabricated from 2-1/4% chrome - 1% moly steel.

3.3.5.6 Tube Rupture The steam generator pressure containment boundary shall be designed to accommodate the rupture of a single tube in any one steam generator and the resultant sodium-water reaction.

3.3.5.7 Tube Plugging Provisions shall be made to permit plugging up to 5 tubes per steam generator and still meet the design requirements.

3.3.5.8 Attemperator The subsystem shall be equipped with an attemperator to maintain the temperature of steam to the turbine at 1000°F or lower, as required.

3.3.5.9 Weatherproofing The Steam Generator Subsystem equipment shall be weatherproofed.

3.3.5.10 Foundation Loads The Steam Generator Subsystem design foundation loads shall be as specified in Appendix 10, Section TBD.

3.3.5.11 Thermal Loss The Steam Generator Subsystem components and equipment which operate at elevated temperatures shall be designed to the requirements given in Appendix 10, Section A-8.

3.3.6 Sodium Auxiliaries Subsystem

The Sodium Auxiliary System shall be designed to provide services to those systems containing sodium as follows:

3.3.6.1 Ullage Gas Requirements The Sodium Auxiliary Subsystem shall be designed to accept and process ullage gas from all systems requiring ullage gas over sodium-free surfaces. The design conditions of ullage gas leaving the Sodium Auxiliary Subsystem shall be as specified in Apendix 10, Section A-09.

3.3.6.2 Fill/Drain Requirements The Sodium Auxiliary Subsystem shall be designed to provide for the fill, drain, and venting of all sodium-containing components and equipment in other systems. The Sodium Auxiliary Subsystem shall be designed to interface with the fill/drain vent points of the other systems as specified in Appendix 10, Section A-9.

3.3.6.3 Sodium Receiving Requirements The Sodium Auxiliary Subsystem shall be designed to receive, unload, and prepare liquid sodium for filling the sodium-containing components and equipment of other systems. The design requirements for incoming sodium shall be as specified in Appendix 10, Section A-9. The design requirements for sodium going to other systems shall be as specified in Appendix 10, Section A-9. The design interfaces for connection to other systems shall be as specified in Appendix 10, Section A-9.

3.4 Systems Interfaces This section identifies the operational interfaces between the HTS and the remainder of the plant and between HTS subsystems. For detailed quantitative values of the interfaces refer to the indicated appendices.

3.4.1 Collector Receiver (Appendix 10, Section A-3) The collector shall supply radiant energy to the receiver for all steady-state modes of plant operation as listed in Appendix 10, Section A-3. This shall include the capability of controlling the number of heliostats in tracking mode so as to vary the redirected flux to the receiver between zero and the maximum achievable level with step changes no larger than 10% of the total collector field output. The collector system shall provide for preheat of the receiver and shall normally maintain temperature at 600°F while the receiver is being drained.

The collector system shall be capable of emergency defocusing upon command to reduce peak incident radiation on the receiver.

3.4.2 <u>Collector - Tower (Appendix 10, Section A-3)</u> Heat fluxes on the tower and normally unirradiated portions of the receiver shall be as listed in Appendix 10, Section A-4.

3.4.3 Receiver - Tower (Appendix 10, Section A-5)

A. The tower and receiver support structure shall support the receiver at a midplane elevation given in Appendix 10, Section A-5. The receiver position shall be controlled within tolerances given in Appendix 10, Section A-5 under all environmental conditions during which the receiver is required to be operational.

b. The tower shall provide for personnel access to the receiver for maintenance and repair.

c. The tower shall provide an elevator for personnel and equipment.

d. The Receiver System design load criteria on the tower shall be as specified in Appendix 10, Section A-4.

3.4.4 Receiver - Heat Transport

a. The heat transport loop shall provide liquid sodium to the receiver at flow rates and temperatures as listed in Appendix 10, Section A-6.

b. The receiver shall return liquid sodium to the heat transport system at flow rates and temperatures as listed in Appendix 10, Section A-4.

c. The temperature of sodium leaving the receiver shall be as shown in Appendix 10, Section A-4.

3.4.5 Receiver - Sodium Auxiliaries

a. The sodium auxiliaries subsystems shall provide argon cover gas and venting capability for the accumulator tank and surge tank.

b. The receiver subsystem components and equipment shall interface with the fill/drain venting equipment associated with the sodium auxiliary system as specified in Appendix 10, Section A-9.

3.4.6 Receiver - Balance-of-Plant The Balance-of-Plant shall provide the following to the Receiver Subsystem:

a. Lifting and handling equipment for handling receiver-related equipment.

b. Utilities as listed in Appendix 10, Section TBD.

c. Instrument air for the instrumentation and controls of the receiver subsystem as listed in Appendix 10, Section A-12.

3.4.7 Tower - Heat Transport The tower shall provide support for the heat transport loop piping to and from the receiver and for the piping heaters, electrical and instrumentation wiring. The piping loads are given in Appendix 10, Section A-6.

3.4.8 Tower - Sodium Auxiliaries The tower shall provide support for the sodium auxiliary piping to and from the receiver and for the piping electrical and instrumentation wiring. The load requirements are given in Appendix 10, Section A-9.

3.4.9 Tower - Balance-of-Plant The Balance-of-Plant shall provide a foundation for the tower. The tower loads are given in Appendix 10, Section A-5.

3.4.10 Heat Transport - Thermal Storage

a. The heat transport loop shall provide liquid sodium to the thermal storage system at steady flow rates and at steady temperatures and pressures as listed in Appendix 10, Section A-6.

b. The thermal storage subsystem shall provide liquid sodium to the heat transport loop at steady temperatures and pressures as listed in Appendix 10, Section A-7.

c. The maximum rate of temperature change of sodium from the heat transport loop to the thermal storage system shall be as listed in Appendix 10, Section A-6.

d. The heat transport loop shall be designed to accept cold sodium from the thermal storage systems at the conditions specified in Appendix 10, Sections A-7 and A-8, respectively.

e. The maximum rate of temperature change of sodium from the thermal storage system to the heat transport loop shall be as listed in Appendix 10, Section A-7.

3.4.11 Heat Transport - Steam Generator

a. The heat transport loop shall provide liquid sodium to the steam generator at steady flow rates and at steady temperatures as listed in Appendix 10, Section A-6.

b. The steam generator system shall provide liquid sodium to the heat transport loop at steady flow rates and at steady temperatures as listed in Appendix 10, Section A-8.

c. The maximum rate of temperature change of sodium from the heat transport loop to the steam generator system shall be as listed in Appendix 10, Sectioon A-6.

d. The maximum rate of temperature change of sodium from the steam generator system to the heat transport loop shall be as listed in Appendix 10, Section A-8.

e. The heat transport loop shalal provide individual running vents and syphon breaks for the steam generators.

3.4.12 Heat Transport - Sodium Auxiliaries (Appendix 10, Section A-9

a. The sodium auxiliaries system shall provide argon cover gas, level control, and venting capability for the heat transport loop pumps.

b. The sodium auxiliaries system shall be capable of controlling the plugging temperature of the entire inventory of sodium.

c. The sodium auxiliaries system shall be capable of measuring the plugging temperature of the sodium.

d. The heat transport system components and equipment containing sodium-free surfaces shall be designed to interface with the cover gas handling equipment of the sodium auxiliary system. The design conditions of cover gas entering the heat transport system shall be as specified in Appendix 10, Section A-9.

e. The design conditions of cover gas leaving the heat transport system shall be as specified in Appendix 10, Section A-6.

f. The heat transport system sodium-containing components and equipment shall be designed to interface with the fill/drain venting equipment associated with the sodium auxiliary system as specified in Appendix 10, Section A-9.

3.4.13 Heat Transport - Balance-of-Plant The Balance-of-Plant System shall provide foundations, lighting, fire protection, and instrument air and electrical power to the heat transport system.

3.4.14 Thermal Storage - Sodium Auxiliaries (Appendix 10, Section A-9

a. The sodium auxiliaries system shall provide argon cover gas, pressure control, and venting capability for the hot and cold storage tanks.

b. The Sodium Auxiliary Subsystem shall accept, clean, and return the cleaned sodium to the thermal storage system. The design requirements for clean sodium leaving the sodium auxiliary system shall be as specified in Appendix 10, Section A-9. The design interfaces with the thermal storage system shall be as specified in Appendix 10, Section A-9.

c. The Thermal Storage Subsystem components and equipment containing sodium-feee surfaces shall interface with the ullage gas handling equipment of the Sodium Auxiliary System. The design conditions of ullage gas leaving the Thermal Storage Subsystem shall be as specified in Appendix 10, Section A-7.

3.4.15 Thermal Storage - Balance-of-Plant The Balance-of-Plant System shall provide foundations, lighting, fire protection, and instrument air to the thermal storage system as specified in Appendix 10, Section __.

3.4.16 Steam Generation - Electrical Power Generating System

a. The electrical power generating system shall provide feeedwater to the steam generator system at conditions listed in Appendix 10, Section A-8.

b. The steam generator system shall provide superheated steam to the electrical power generating system at conditions listed in Appendix 10, Section A-8.

3.4.17 Steam Generation - Sodium Auxiliaries (Appendix 10, Section A-9

a. Capability shall be provided for sodium drainage of each of the three steam generator modules individually.

b. The steam generator subsystem sodium-containing components and equipment shall be designed to interface with the fill/drain venting equipment associated with the sodium auxiliary system as specified in Appendix 10, Section A-9. Provisions shall be made to fill and drain the steam generators from the lowest point in the shell.

c. The sodium auxiliary subsystem shall accept, process, and/or store for eventual disposal sodium/water reaction products from the steam generator subsystem. The design conditions for the sodium/water reaction products entering the sodium auxiliary subsystem shall be as specified in Appendix 10, Section A-8.

3.4.18 Steam Generation - Thermal Storage The steam generation subsystem shall return cold sodium to the thermal storage subsystem via the heat transport system at the conditions specified in Appendix 10, Section A-8.

3.4.19 Steam Generation - Balance-of-Plant

a. The Balance-of-Plant shall furnish the utilities to the steam generator subsystem as specified in Appendix 10, Section A-12.

b. The Balance-of-Plant shall furnish instrument air to the steam generator subsystem instrumentation and controls at conditions specified in Appendix 10, Section A TBD.

c. The Steam Generation Subsystem components and equipment shall be supported on foundations that are furnished by the Balance-of-Plant. The design interfaces with these foundations shall be as specified in Appendix 10, Section A TBD.

d. The Balance-of-Plant System shall provide weather protection for the steam generator system.

3.4.20 Sodium Auxiliaries - Balance-of-Plant

a. The Balance-of-Plant shall provide utilities to the sodium auxiliaries subsystem as specified in Appendix 10, Section A-12.

b. The Balance-of-Plant shall furnish instrument air to the instrumentation and controls of the sodium auxiliaries subsystem as specified in Appendix 10, Section TBD.

c. The Balance-of-Plant shall furnish the foundation for the sodium auxiliaries equipment as specified in Appendix 10, Section A-12.

d. The Balance-of-Plant shall furnish buildings or structures to accommodate sodium auxiliaries equipment as specified in Appendix 10, Section TBD.

3.4.21 Master Control - Heat Transport Control Subsystem The master control system shall provide the set points for the operation of the receiver and steam generation subsystems.

The following parameters shall be measured and the measurements supplied to the master control system:

a. Surge and accumulator tank pressure and level

b. Heat flux incident on the receiver

c. Receiver inlet sodium flow

d. Receiver inlet and outlet sodium temperature

e. Steam generator sodium flow

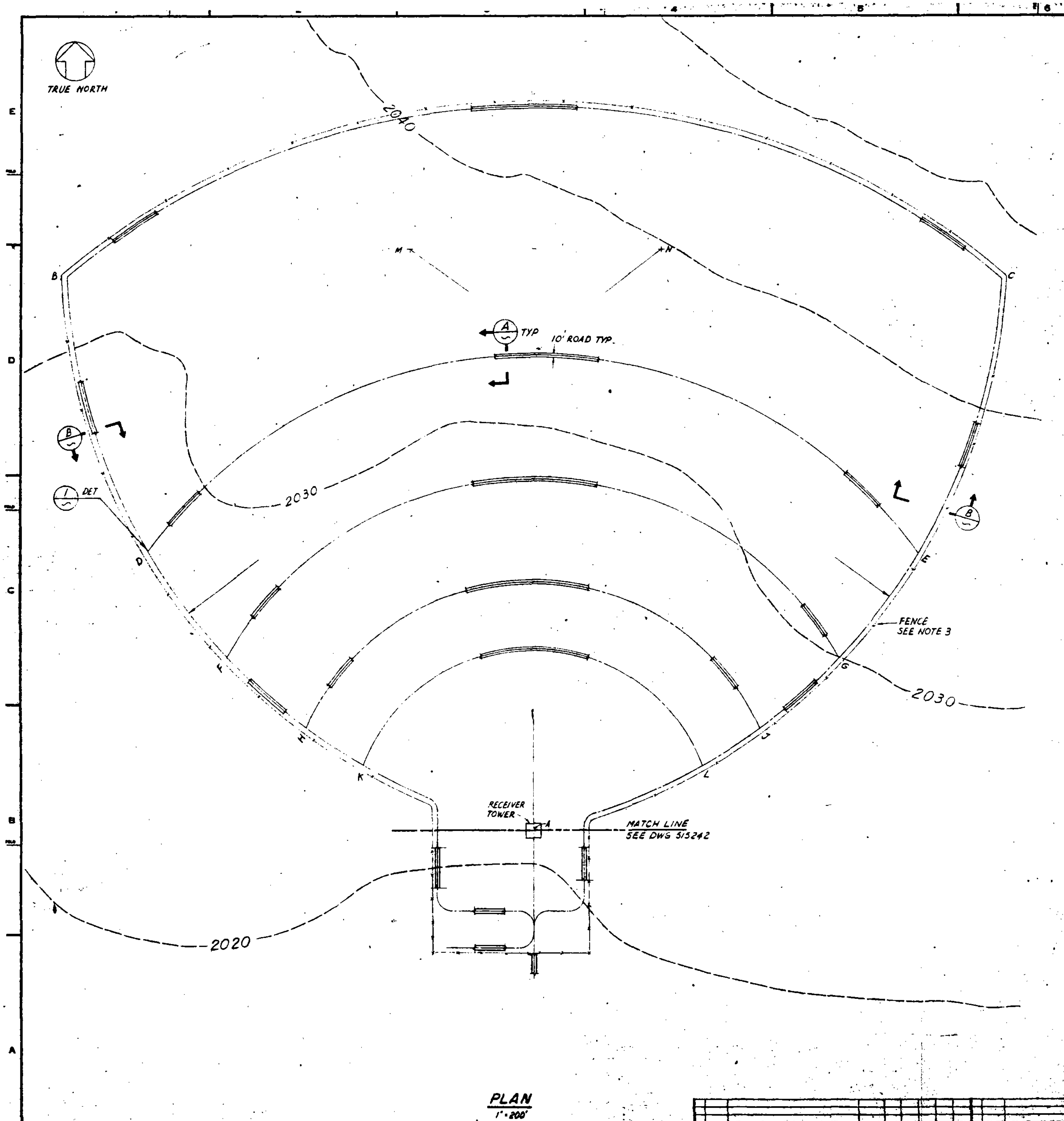
f. Steam generator inlet and outlet sodium temperature

g. Hot storage tank level

h. Cold storage tank level.

The master control system shall provide a power demand signal to the heat transport control subsystem, derived from turbine first-stage steam pressure, trimmed by turbine throttle steam pressure. The heat transport control shall adjust the sodium flow from the hot thermal storage tank to the steam generator system, and the outlet steam temperature from the steam generators, to respond to this demand signal.

The heat transport system shall be designed to independently respond to the control signals and commands from the master control system specified in Appendix 10, Section A-10 and shall be designed to independently respond to a demand for system status from the master control system with the status parameters specified in Appendix 10, Section A-10.



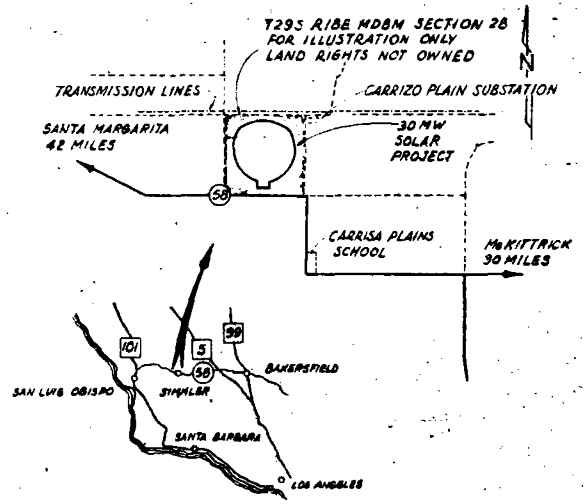
PLAN
1" = 200'

CURVE	RADIUS FROM 'A	CENTRAL ANGLE AT 'A'
BC	3650.00'	80° 4' 50"
DE	2400.00'	108°40'56"
FG	1775.00'	121°29'07"
HJ	1250.00'	131°56'31"
KL	915.00'	138°33'50"

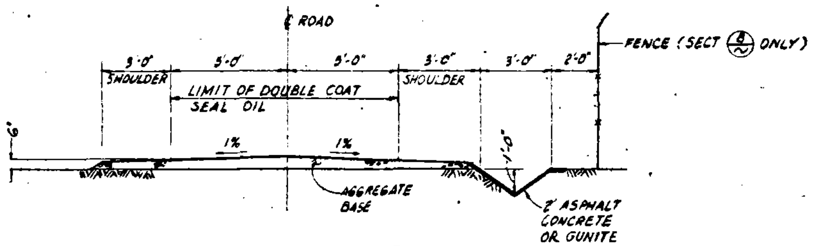
CURVE	RADIUS FROM 'M'	CENTRAL ANGLE AT 'M'
CL	3000.00'	

CURVE	RADIUS FROM 'N'	CENTRAL ANGLE AT 'N'
BK	3000.00'	

COORDINATES		
POINT	N	E
A	10000.0'	10000.0'
B	12779.0'	7634.0'
C	12779.0'	12366.0'
D	11399.0'	8050.0'
E	11399.0'	11950.0'
F	10868.0'	8452.0'
G	10868.0'	11549.0'
H	10509.0'	8858.0'
J	10509.0'	11142.0'
K	10374.0'	9144.0'
L	10324.0'	10856.0'
M	12930.0'	9370.0'
N	12930.0'	10630.0'



KEY PLAN
NTS

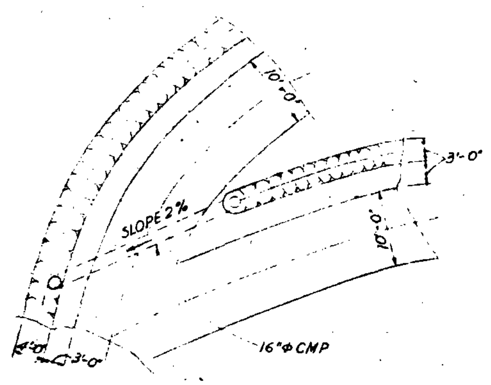


SECTION A
$\frac{3}{8}$" = 1'-0"

SECTION B
SIM EXCEPT V-DITCH = 4'-6" WIDE 1'-6" DEEP

GENERAL NOTES

1. PG&E REFERENCE AXES N10000.0 & E10000.0 COINCIDE WITH TRUE NORTH AND EAST
2. HORIZONTAL & VERTICAL CONTROLS WILL BE ESTABLISHED AFTER SURVEY
3. GRADES SHOWN ARE NATURAL GRADES FROM USGS SHEET LA PANZA NE QUADRANGLE CALIFORNIA
4. NO GRADING IN THE HELIOSTAT AREAS EXCEPT FOR ROADWAYS
5. FENCING AND GATES TO BE ACCORDING TO PG&E STD DWGS 059659 059665 FENCES TO BE 7'-0" HIGH
6. GRADING AND PAVING IN THE TOWER AND POWER PLANT AREAS TO BE ACCORDING TO PG&E STD DWG 041838
7. PG&E DATUM 1000' = USGS ELEV 2020.5'



DETAIL 1
$\frac{1}{8}$" = 1'-0"

REFERENCES
1. PLOT PLAN ____________ 515242

ROCKWELL INTERNATIONAL
APPROVED ☒ APPD W/COMMENT ☐
DISAPPROVED ☐ INFO ONLY ☐
DATE

REVISIONS

ISSUED FOR COST ESTIMATE

6340160

Carrizo Plains Solar
Plant Layout

515840

Figure 1.
N10046
D-2 Page 3-20

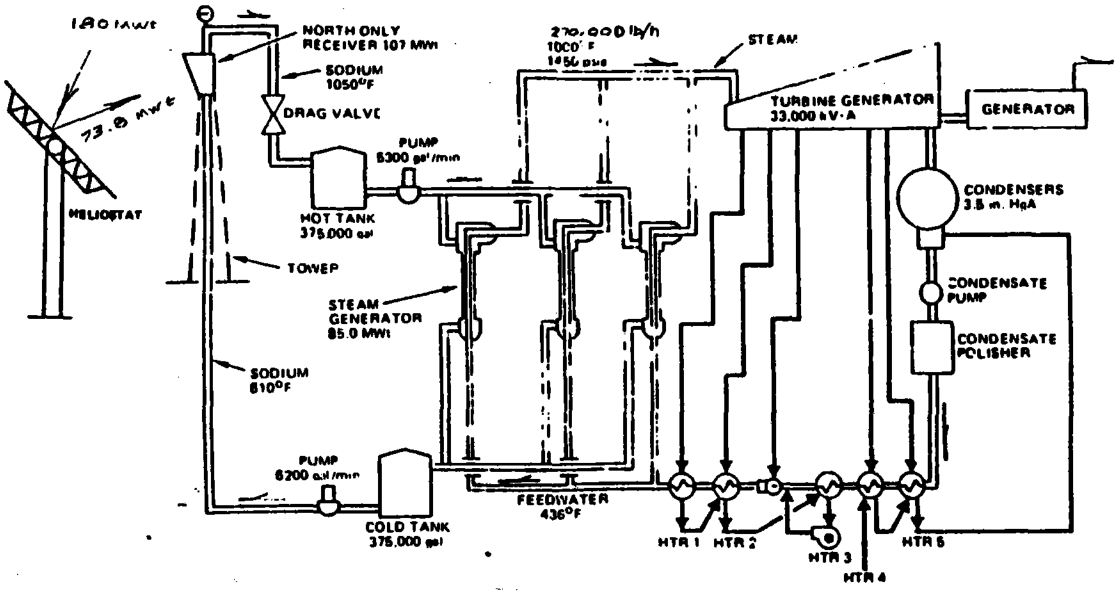


Figure 4. Carrizo Plains Solar Plant Schematic Flow Diagram

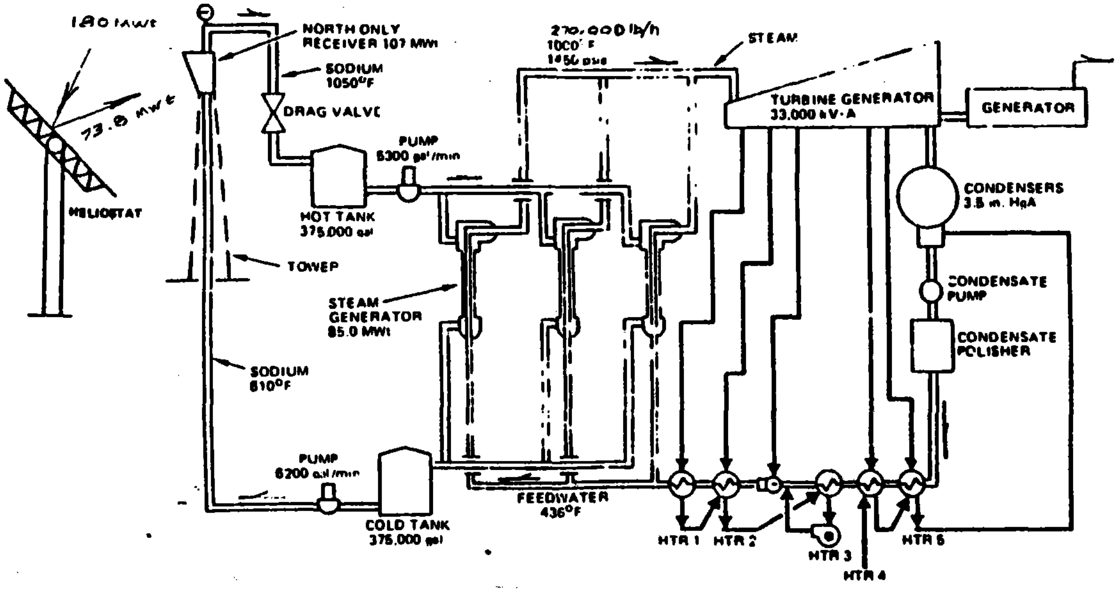
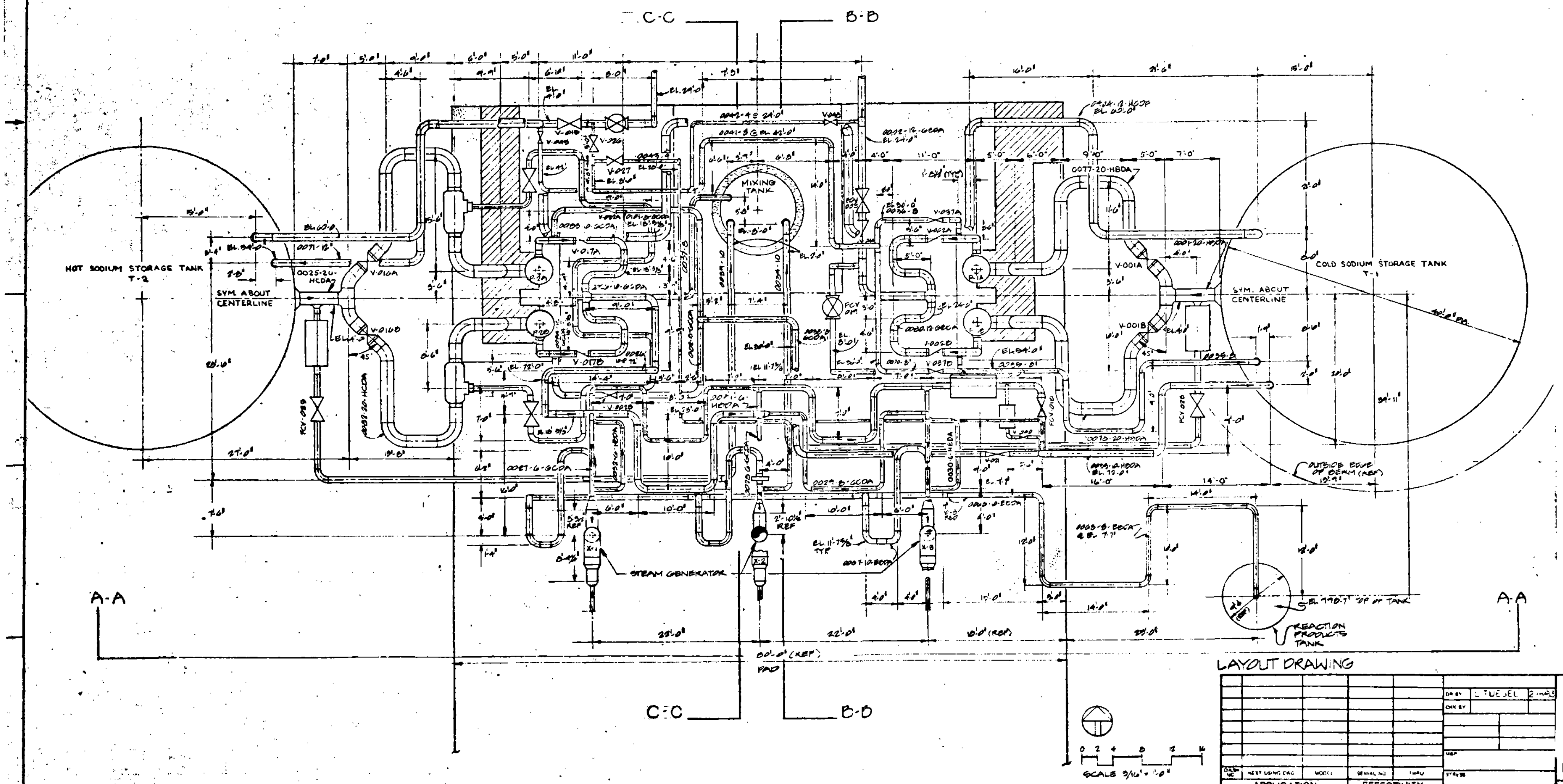


Figure 4. Carrizo Plains Solar Plant Schematic Flow Diagram

REVISIONS			
LTR	DESCRIPTION	DATE	APPROVED

NOTES: UNLESS OTHERWISE SPECIFIED



LAYOUT DRAWING

IN WORK
DOCUMENT NOT RELEASED
DATE 6-83 ISSUE NO 1
FOR INFO ONLY ☐
FOR STORAGE ☒

PACIFIC GAS AND ELECTRIC COMPANY
SOLAR CENTRAL RECEIVER
POWER PLANT
CARRIZO PLAINS – UNIT 1

Figure 3.
N10046
D-2 Page 3-22

11000000

Rockwell International Corporation
Energy Systems Group

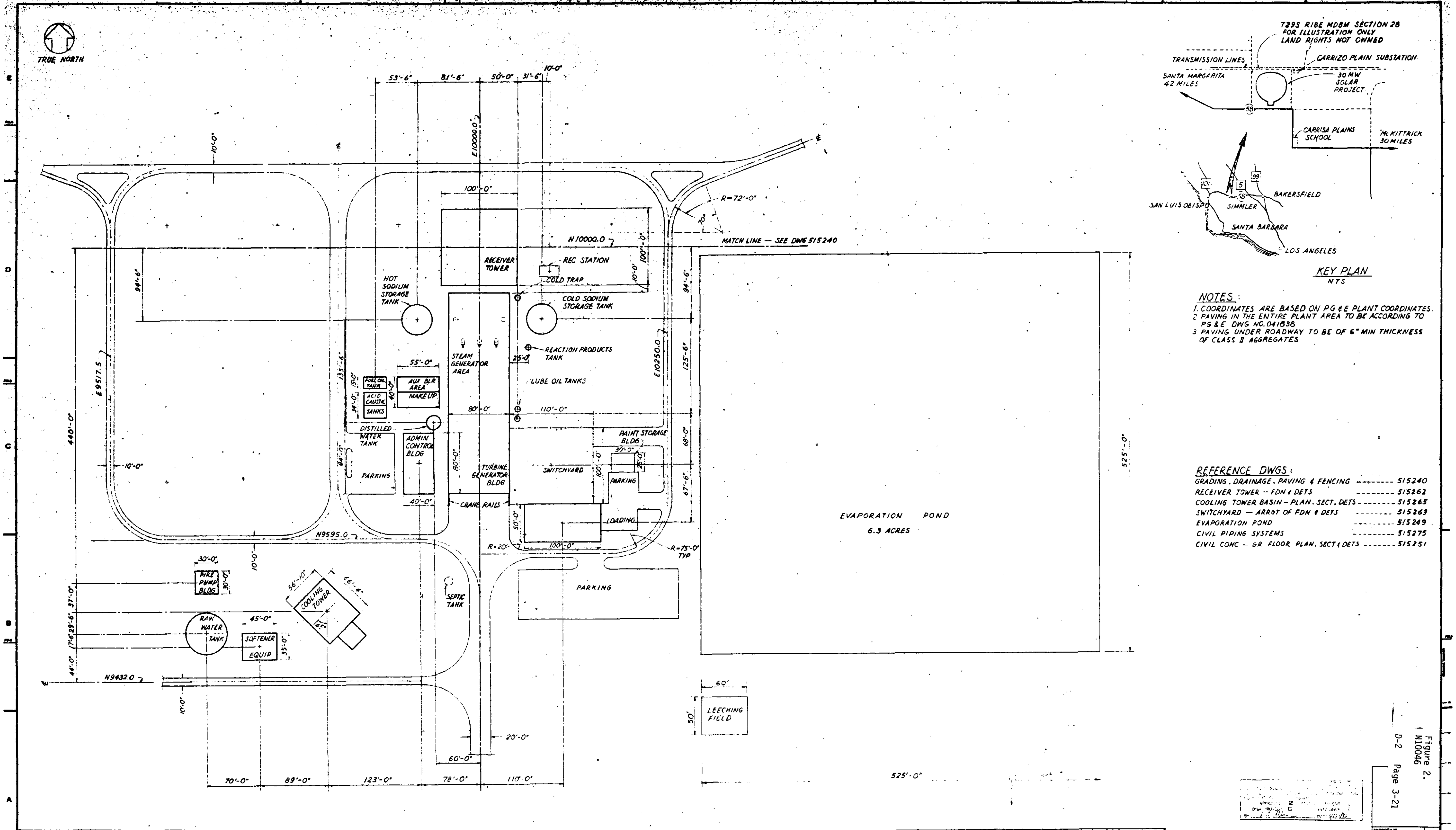
Carrizo Plains Solar Plant
Piping & Equipment Layout-
Plan View

DR BY L TUESEL 2-83
CHK BY

E 0790000II

SCALE 3/16" = 1'
SHEET

APPLICATION
EFFECTIVITY



KEY PLAN
NTS

NOTES:

1. COORDINATES ARE BASED ON PG & E PLANT COORDINATES.
2. PAVING IN THE ENTIRE PLANT AREA TO BE ACCORDING TO PG & E DWG NO. 041838
3. PAVING UNDER ROADWAY TO BE OF 6" MIN THICKNESS OF CLASS II AGGREGATES

REFERENCE DWGS:

GRADING, DRAINAGE, PAVING & FENCING	515240
RECEIVER TOWER — FDN & DETS	515262
COOLING TOWER BASIN — PLAN, SECT, DETS	515265
SWITCHYARD — ARRGT OF FDN & DETS	515269
EVAPORATION POND	515249
CIVIL PIPING SYSTEMS	515275
CIVIL CONC — GR FLOOR PLAN, SECT & DETS	515251

NO.	DATE	DESCRIPTION	DWN	CHKD.	SUPV.	RESP. ENGR.
03	3-11-83	APPVD FOR COST ESTIMATE		GTE		
02	2-4-83	ISSUED FOR COORDINATION	PAm			
01	1-17-83	ISSUED FOR COORDINATION	DRM			

REVISIONS

COORDINATED APPROVAL FOR CONSTRUCTION

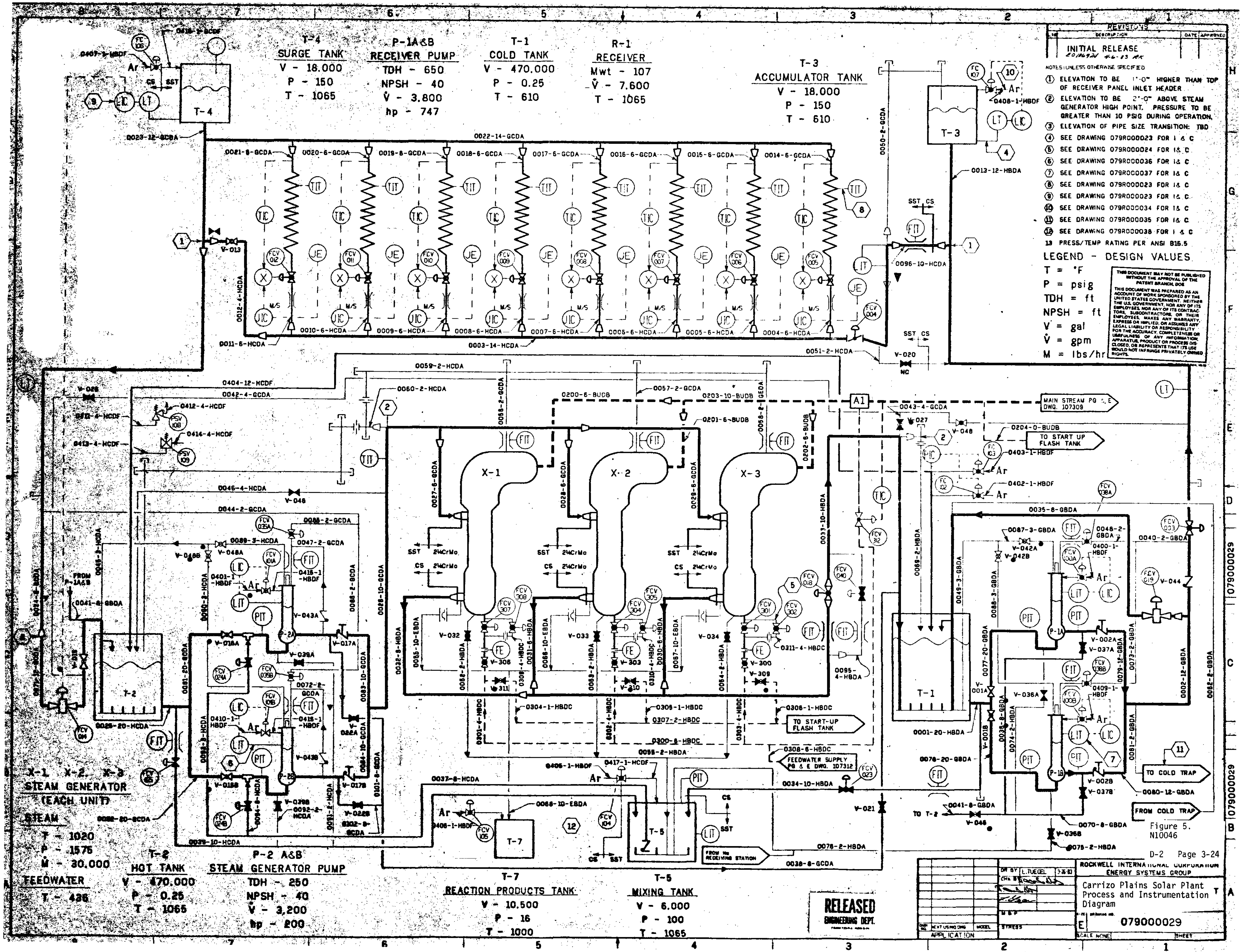
APPROVED ☒ DISAPPROVED ☐

SCALES 1"=40'

Carrizo Plains Solar
Plant - View

SHEET NO 515242 REV. 03

Figure 2.
N10046



REVISIONS

LTR	DESCRIPTION	DATE	APPROVED
	INITIAL RELEASE E0106924 4-6-83 RK		

NOTES: UNLESS OTHERWISE SPECIFIED

① ELEVATION TO BE 1'-0" HIGHER THAN TOP OF RECEIVER PANEL INLET HEADER

② ELEVATION TO BE 2'-0" ABOVE STEAM GENERATOR HIGH POINT. PRESSURE TO BE GREATER THAN 10 PSIG DURING OPERATION.

③ ELEVATION OF PIPE SIZE TRANSITION: TBD

④ SEE DRAWING 079R000023 FOR I & C

⑤ SEE DRAWING 079R000024 FOR I& C

⑥ SEE DRAWING 079R000036 FOR I& C

⑦ SEE DRAWING 079R000037 FOR I& C

⑧ SEE DRAWING 079R000023 FOR I& C

⑨ SEE DRAWING 079R000023 FOR I& C

⑩ SEE DRAWING 079R000034 FOR I& C

⑪ SEE DRAWING 079R000035 FOR I& C

⑫ SEE DRAWING 079R000038 FOR I & C

13 PRESS/TEMP RATING PER ANSI B16.5

LEGEND - DESIGN VALUES

T = °F
P = psig
TDH = ft
NPSH = ft
V = gal
V̇ = gpm
M = lbs/hr

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RELEASED
ENGINEERING DEPT.

Figure 5.
N10046

DR BY L.TUEGEL 3-25-83
CHK BY
M & P
STRESS
NEXT USING DWG MODEL
APPLICATION

ROCKWELL INTERNATIONAL CORPORATION
ENERGY SYSTEMS GROUP

Carrizo Plains Solar Plant
Process and Instrumentation
Diagram

E 079000029

SCALE NONE SHEET

4. QUALITY ASSURANCE

4.1 Verification Methods

It shall be verified that the Plant will perform its function as intended, to the extent feasible during preliminary design. Verification shall be accomplished by one or more of the following methods:

4.1.1 Performance Verification Compliance with performance requirements shall be verified by documented engineering studies and calculations. Calculations shall include estimated performance curves, heat transfer calculations, flow, hydraulic performance, pressures, temperatures, and comparisons with similar systems and equipment.

4.1.2 Physical Characteristics Verification Verification of physical characteristics shall be accomplished by review and evaluation of system/component drawings and specifications. Verifications shall determine compliance with this specification, and applicable drawings and data, with respect to dimensions, component locations, fabrication processes, material selections, and other applicable physical requirements and constraints.

4.1.3 Environmental Requirements Verification Compliance with the environmental requirements shall be demonstrated by analysis and evaluation of drawings, descriptive data, supporting calculations, specifications.

4.1.4 Reliability/Availability Verification Reliability/availability requirements shall be verified by means of calculational analyses using best available failure data. A Failure Modes and Effects Analysis shall be performed and documented.

4.1.5 Maintainability Verification Maintainability requirements shall be verified by maintainability studies, outline assembly drawings, maintenance procedures, and maintenance sequence studies.

4.1.6 Useful Life Verification Useful life of the plant shall be verified by documented analysis of the expected life of systems and components which cannot be replaced economically. These analyses shall include the effects of exposure to the environment, corrosion, erosion, cyclic stresses, creep, mass transport, thermal aging, and seismic events.

4.1.7 Safety Requirements Verification Safety requirements shall be verified by review of plant drawings and specifications against a safety requirements checklist, which shall be prepared using this specification as a basis.

4.2 Requirements Verification Index

The requirements of this specification shall be verified by the methods of 4.1, as tabulated below:

Paragraph	Requirement Title	Verification Method
3.2.1	HTS Requirements	4.1.1, 4.1.2, 4.1.5, 4.1.6, 4.1.7
3.3	HTS Design Requirements	4.1.1, 4.1.2, 4.1.3, 4.1.4, 4.1.7
3.4	Systems Interfaces	4.1.1, 4.1.2

5. NOTES AND DATA

5.1 Solar Terminology

ABSORBER: The portion of the receiver that absorbs radiant energy.

ABSORPTANCE: The ratio of the radiant flux absorbed in a body of material to the radiant flux incident upon it.

ABSORPTIVE COATING: An absorber coating which improves its absorptance of the absorber to sunlight.

APERTURE: The area of the concentrator & receiver, projected normal to the central ray and corrected for shading.

BEAM (LIGHT): A bundle of light rays.

BEAM CHARACTERIZATION: The determination of the spectral power distribution of light reflected by a heliostat.

BLACK BODY: An "ideal" body which would, if it existed, absorb all of the radiation falling upon it independent of wavelength, direction, and temperature. Its reflectance and transmittance would be zero and its absorptance would be 1.0. Since its emittance would also be 1.0, it would emit the maximum possible amount of radiation for that temperature.

BLOCKING: The act of intercepting sunlight reflected from a concentrator before it reaches the receiver. For example, one heliostat may block some of the light reflected from another heliostat and prevent it from reaching the receiver.

CENTRAL RAY: A ray of sunlight directly from the center of the solar disk.

CENTRAL RECEIVER: A solar collector in which the maximum dimension of the receiver (or maximum distance between parts of the receiver subsystem) is small compared to the maximum dimension of the concentrator (or maximum distance between parts of the concentrator subsystem) and in which the receiver is stationary with respect to the earth.

CLOUD COVER: That portion of the sky cover which is attributed to clouds, usually measured in tenths of sky covered.

COLLECTOR (SOLAR): A device which collects and converts solar energy into an alternate form.

COLLECTOR EFFICIENCY: The ratio of the energy collection rate of a solar collector to the radiant power intercepted by it under steady-state conditions.

COLLECTOR, CONCENTRATING: A collector which utilizes lenses, mirrors, or other optical elements to concentrate the radiant energy on an absorber whose surface area is smaller than the geometric aperture of the concentrator.

COLLECTOR TILT ANGLE: The angle between the geometric aperture plane of a flat-plate collector and a horizontal plane.

CONCENTRATION (RATIO): This term has several different commonly used connotations. Here modifiers are used to distinguish between the different commonly accepted meanings. The concentration is the ratio of the flux density at a point on the absorber to the incident normal insolation.

a) Ideal Concentration: The concentration that would exist for a perfectly focused concentrator with no reflection or absoption losses.

b) Average Ideal Concentration: The average of the ideal concentration over the absorber surface.

c) Geometric Concentration: The ratio of the geometric concentrator aperture area to the surface of the absorber.

CONCENTRATOR APERTURE: The unshaded area of the concentrator normal to the central ray from the sun.

CONCENTRATOR (SOLAR): A concentrator is the optical element which concentrates (possibly by focusing) the incident radiation on the receiver.

CREEP: A time-dependent deformation resulting from pressure or thermal stresses or from cycling of these loads.

CREEP-FATIGUE-INTERACTION: When a structural component is subjected to both steady-state and cyclic loading at elevated temperatures, both creep and fatigue conditions are present. Experimental evidence has shown that, in many cases, the presence of both types of loading results in failure much earlier than predicted by considering the creep and fatigue separately. This synergism between creep and fatigue at elevated temperatures is called the creep-fatigue interaction.

ELEVATED TEMPERATURE DESIGN: Structural design in which the service conditions of temperature, stress, and service life require that time-dependent deformation be included in determining strain accumulation and failure conditions. The exact conditions under which time-dependent deformation becomes significant will be different for different alloys.

EMITTANCE: Ratio of the actual radiation emitted by a body to the radiation emitted by a black body at the same temperature.

FLUX DENSITY (OR IRRADIANCE) [W/m^2]: The radiant flux incident per unit area.

FLUX (RADIANT) (OR RADIANT POWER) (WATTS): The time rate of flow of radiant energy.

GEOMETRIC APERTURE: The maximum value of the aperture.

HEAT TRANSPORT SYSTEM: System used to deliver solar energy from the receiver to the point of use.

HELIOSTAT: A reflecting concentrator element which can utilize tracking axes to keep redirected solar radiation fixed on the receiver.

INFRARED RADIATION: Radiation with wavelengths higher than about 0.8 micrometers and less than one millimeter.

INSOLATION (OR SOLAR RADIATION) [W/m^2]: The solar energy incident on a unit surface in unit time.

a) Circumsolar Radiation: When passing through a turbid atmosphere with a large amount of aerosols, there is a broadening of the angular cone through which the sun's rays arrive at the earth's surface. Under turbid sky conditions, a significant amount of the direct insolation is scattered into a cone of roughly ±5° about the central ray. This part of the diffuse insolation is referred to as circumsolar radiation. This component of solar insolation has similar general angular time variations as the direct component. Although it is usable with some types of concentrators, it is not usable by highly concentrating collectors and may contribute to spillage radiation problems.

b) Direct Insolation: The insolation that comes from within the solid angle subtended by the solar disk. (A cone of approximately ±1/4 degree about the central ray.

c) Diffuse Insolation: Any contribution to the insolation that is not direct excluding spectral reflections from other objects.

d) Horizontal Insolation: The insolation on a surface parallel to the surface of the earth.

e) Normal Insolation: The insolation on a surface perpendicular to a central ray from the sun.

f) Total Insolation: The total radiant power per unit area. It includes direct, diffuse, and background radiation.

g) Background Radiation: The contribution that is reflected from objects on the earth.

These terms can be used in combinations such as direct-normal insolation.

IRRADIANCE (OR FLUX DENSITY) [W/m^2]" The radiant flux incident per unit area.

IRRADIATION: (J/m^2) The radiant energy incident per unit area. The product of flux density (irradiance) and its duration.

OPTICAL ELEMENT: Any element that alters the direction or magnitude of an incident ray of sunlight.

POINT-FOCUS COLLECTOR: A solar collector for which the ideal geometric focus is a point for a collimated beam from at least one direction of incidence.

PYRANOMETER: A radiometer used to measure total insolation (both direct and diffuse).

PYRHELIOMETER: A radiometer used to measure the direct normal insolation.

RADIANT POWER (WATTS): The time rate of flow of radiant energy.

RADIATION: The emission and propagation of energy through space or through a material medium in the form of waves (or photons). The radiant energy emitted from a surface by virtue of its temperature is called thermal radiation. For most purposes thermal radiation occurs in the 0.1 to 100 micrometer wavelength interval.

RADIOMETER: An instrument that measures radiation.

RECEIVER: That element of the collector system to which solar radiation is directed and where it is converted to another form of energy.

RECEIVER TOWER: The structure supporting the central receiver.

REFLECTANCE: The ratio of the reflected radiant flux to the incident radiant flux.

Diffuse Reflectance: Refers to the radiation reflected from a surface such that the angle of reflection is not equal to the angle of incidence on a macroscopic scale.

Spectral Reflectance: The reflectance as a function of wavelength.

Specular Reflectance: Refers to the radiation reflected from a surface such that the angle of reflection is equal to the angle of incidence. For use in concentrating collector systems, the geometry of the incident and reflected beams used for the measurement must be specified.

Hemispherical Reflectance: The combination of diffuse plus the spectral reflectance.

Total Hemispherical Reflectance: Refers to hemispherical reflectance integrated over all wavelengths in the solar spectrum.

SELECTIVE SURFACE: A surface for which solar absorptance and the emittance exhibit a different wavelength dependence such as a high absorptance for solar radiation and a low emittance for infrared radiation.

SHADING (OR SHADOWING): The act of casting a shadow across any portion of a concentrator or receiver.

SOLAR CONSTANT: The normal insolation in near earth space. (1353 Watts/m^2).

SOLAR ENERGY: The energy carried by photons in the wavelength interval 0.3 to 2.7 micrometers that originate on the sun.

SOLAR MULTIPLE: The ratio of the design-point absorbed power at the receiver to the power conversion system thermal rating.

SOLAR TIME: The time as reckoned by the apparent position of the sun. Solar noon is the instant at which the sun reaches its zenith.

SPILLAGE (RADIATION): Radiation emanating from the concentrator system but which misses the receiver aperture.

SUN POSITION: The azimuth and elevation angles for specifying the direction antiparallel to the central ray from the sun.

THERMAL STORAGE SYSTEM: Any rechargeable unit capable of storing thermal energy for later use. Examples are: thermal energy storage as sensible heat in rocks, water, oil, etc.; latent heat in phase-change materials; mechanical storage as kinetic energy in flywheels or potential energy in pumped hydro; and chemical storage in secondary batteries.

TRANSMITTANCE: The ratio of the radiant power transmitted by a body to the radiant power incident on it.

a) Specular Transmittance: Only the emergent radiation which is parallel to the incident beam is observed.

b) Hemispherical Transmittance: All the emergent radiation is observed.

c) Visible Transmittance: The transmittance for visible light.

d) Spectral Transmittance: The transmittance as a function of wavelength.

0111F/bes

CARRIZO PLAINS
SOLAR CENTRAL RECEIVER
POWER PLANT

APPENDIX 10
DESIGN DATA SHEETS

Rockwell International
Energy Systems Group

DESIGN DATA SHEET

PREPARED BY	APPROVED BY	TITLE Carrizo Plains Solar Central Receiver Power Plant	NUMBER N10046 D-2
			PAGE 10-2
		WBS NO.	DATE

NEW REV	NO.	ITEM	UNIT	VALUE OPERATING	 DESIGN	TEN-TATIVE	FIRM	REFERENCES AND REMARKS
		A-1 SITE AND ENVIRONMENT						3.2.1
		A-1.1 <u>Site</u>						
		. Elevation above sea level	ft	2000	2000			
		. Area	acres	294	294			Available area 640 acres
		. Soil load bearing capability	lb/ft^2	TBD	4000			
		. Min. Temp. - Outdoors		20°F	10°F			
		. Max. Temp. - Outdoors		100°F	110°F			
		. Min. Temp. - Indoors		62°F	60°F			
		. Max. Temp. - Indoors		78°F	80°F			
		. Wind		30 mph	90 mph			
		. Seismic		DNA				Per UBC Zone IV
		. Snow		DNA				
		. Rain		DNA				
		. Ice		DNA				
		. Hail		DNA				

FORM 706-A REV. 11-82

Rockwell International
Energy Systems Group

DESIGN DATA SHEET

TITLE
Carrizo Plains
Solar Central Receiver
Power Plant

NUMBER N10046 D-2

PAGE 10-3

PREPARED BY

APPROVED BY

WBS NO.

DATE

NEW REV	NO.	ITEM	UNIT	VALUE OPERATING	VALUE DESIGN	TENTATIVE	FIRM	REFERENCES AND REMARKS
		A-1.2 Environmental Conditions						
		Minimum temperature	°F	-10	TBD			
		Maximum temperature	°F	+110	TBD			
		Maximum wind, including gusts	mph	30	90			Ref. height 32.8 ft
		Seismic environment	-	Zone 4	Zone 4			Uniform Building Code
		Seismic horizontal and vertical Accelerations						
		Building & Structures			ZIRCS =			
		Horizontal			0.4			
		Vertical			1			1 Use live floor load as criteria
		Equipment	-					
		Horizontal			0.4 W			
		Vertical			0.27 W			
		Maximum dust devil wind speed	mph	45	45			
		Maximum static snow load	lb/ft^2	2	2			
		Maximum snow deposition rate	in./day	4	4			
		Average annual rainfall	in.	8	25			
		Maximum 24 hr rainfall	in.	DNA	TBD			Plant not required to operate during rain or hailstorm
		Hail maximum diameter	in.	DNA	1			
		Hail ice deposit	in.	1	1			
		Hail specific gravity		0.9	0.9			
		Hail maximum terminal velocity	fps	DNA	75			
				2				

Rockwell International
Energy Systems Group

DESIGN DATA SHEET

TITLE
Carrizo Plains
Solar Central Receiver
Power Plant

NUMBER N10046 D-2

PAGE 10-4

PREPARED BY

APPROVED BY

WBS NO.

DATE

NEW REV	NO.	ITEM	UNIT	VALUE		TENTATIVE	FIRM	REFERENCES AND REMARKS
				OPERATING	DESIGN			
		A-2 PLANT						3.2.2
		Useful life	yrs	30	30		X	
		Operating days/year	d/y	270	366			
		Operating hours (solar)						
		Lifetime	hr	80,850	83,500			+5 -30%
		Yearly		2,695	3,000			
		Daily						
		Equinox	hr	10.5	-			
		Summer solstice	hr	12.5	-			
		Winter solstice	hr	8.5	-			
		Thermal energy (collector)						
		Annual, collected	MWh	456,541	-			
		Daily average, collected	MWh	1,691	-			
		Equinox	MWh	2,637	-			
		Winter solstice	MWh	1,183	-			
		Summer solstice	MWh	2,198	-			
		Plant power level (net)	MWe	30.0	31.5			
		Plant power level (gross)	MWe	32.8	33.4			
		Thermal storage capability	hr	1-1/6 hr at 29.4 MWe	1.25			
		Availability						3.2.4
		Annual	%	92	TBD			
		12:30-6:30, May thru Sept	%	96	96			
		12:30-6:30, Oct thru April	%	89	89			

Rockwell International
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DESIGN DATA SHEET

TITLE	Carrizo Plains Solar Central Receiver Power Plant
NUMBER	N10046 D-2
PAGE	10-5
PREPARED BY	
APPROVED BY	
WBS NO.	
DATE	

NEW REV	NO.	ITEM	UNIT	VALUE		TEN-TATIVE	FIRM	REFERENCES AND REMARKS
				OPERATING	DESIGN			
		A-2 PLANT (Continued)						
		Minimum power production goals						
		June	MWhe	4320				
		July and August	MWhe	4464				
		Maximum power level ramp rate	MWe/min	1	6			
		Power level - one steam generator module out of service	MWt	28.5	34.2			
		Plant Unavailability						
		Allocation	hr/yr		Forced Outage Sched. Outage			Entries are plant unavailability due to outage of the individual system
		Collector			27 -			
		Receiver			6 15			
		Tower			- -			
		Heat transport			24 15			
		Steam generator			3 10			
		Sodium auxiliaries			3 -			
		Elec. power generation			82 35			
		Master control			2 3			
		Balance of plant			- -			
		Totals			147 78			225 hr/yr total

Rockwell International
Energy Systems Group

DESIGN DATA SHEET

TITLE
Carrizo Plains
Solar Central Receiver
Power Plant

NUMBER
N10046 D-2

PAGE 10-6

PREPARED BY

APPROVED BY

WBS NO.

DATE

NEW REV	NO.	ITEM	UNIT	VALUE		TEN-TATIVE	FIRM	REFERENCES AND REMARKS
				OPERATING	DESIGN			
		A-3 COLLECTOR/RECEIVER INTERFACE						Paragraphs 3.2.7.1, 3.2.7.2
		Collector land area	ft^2		6 6			Optimum _____ on 640 acres
		Peak incident receiver flux limit	$\frac{MWt}{m^2}$	-	1.2			
		Spillage			2.5			
		Insolation						
		Design point (March 21, noon)	W/m^2	-	1,000			
		Annual, clear day	$\frac{kWh}{m^2}$	-	3,420			
		Annual, average	$\frac{kWh}{m^2}$	-	2,524			
		Design point power, incident on receiver	MWt	-	116			
		Annual receiver energy	$\frac{MWht}{m^2}$	261,020	261,020			
		Design life	yr	30	35			

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Energy Systems Group

DESIGN DATA SHEET

TITLE	Carrizo Plains Solar Central Receiver Power Plant
NUMBER	N10046 D-2
PAGE	10-7
PREPARED BY	
APPROVED BY	
WBS NO.	
DATE	

NEW REV	NO.	ITEM	UNIT	VALUE		TEN-TATIVE	FIRM	REFERENCES AND REMARKS
				OPERATING	DESIGN			
		A-4 RECEIVER						
		Design life	yr	30	30			
		Midplane elevation	ft	410	410			
		Incident power	MWt	197	197			
		Absorbed power	MWt	116	118			
		Sodium inlet temperature	°F	610	610			
		Sodium outlet temperature	°F	1050	1100			
		Sodium flow	gpm	6200	7400			
		Pressure	psig	0 to 50	150			
		Panel pressure drop	psi	0 to 20	30			
		Maximum peak energy flux	$\frac{MWt}{m^2}$	TBD	1.2			
		Size						
		Aperture size	ft	52W x 40H	52W x 40H			
		Orientation of panel		North	North			Vertical
		Maximum horizontal wind load	psf	5	54			
		Accumulator tank cover gas pressure	psig	50	150			
		Accumulator tank temperature	°F	580	610			
		Surge tank cover gas pressure	psig	5	150			
		Surge tank cover gas temperature	°F	1050	1100			
		Surge tank Na vol/tank vol	gal	9000/ 18,000	9000/ 18,000			
		Accumulator tank Na vol/tank vol	gal	9,000/ 18,000	9,000/ 18,000			
		Energy loss allowance						
		Reflectivity	%		95.0			Percent of full power
		Radiation	%		2.7			Percent of full power
		Convection	%		0.8			Percent of full power

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DESIGN DATA SHEET

PREPARED BY	APPROVED BY	TITLE Carrizo Plains Solar Central Receiver Power Plant	NUMBER N10046 D-2
			PAGE 10-8
		WBS NO.	DATE

NEW REV	NO.	ITEM	UNIT	VALUE		TEN-TATIVE	FIRM	REFERENCES AND REMARKS
				OPERATING	DESIGN			
		A-5 TOWER						Paragraph 3.2.7.4
		Type		Structural steel				
		Height	ft	DNA	355			Interface with receiver base
		Service elevator load capacity	lb		3000			
		Maximum horizontal displacement at interface	in.		10			Operating wind conditions

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NEW REV	NO.	ITEM	UNIT	VALUE OPERATING	VALUE DESIGN	TEN-TATIVE	FIRM	REFERENCES AND REMARKS
		A-6 HEAT TRANSPORT LOOP						Paragraphs 3.2.7.5, 3.2.7.6
		Receiver pump conditions:						
		Sodium flow rate	gpm	0 to 6200	7400			
		Temperature	°F	350 to 610	610			
		Head	ft	650	750			
		Steam generator pump conditions:						
		Sodium flow rate	gpm	0 to 5300	6300			
		Temperature	°F	350 to 1050	1100			
		Head	ft	200	250			
		Receiver pump cover gas pressure	psig	250	300			
		Receiver pump cover gas temperature	°F	610	610			
		Steam generator pump cover gas pressure	psig	250	300			
		Steam generator pump cover gas temperature	°F	350 to 1050	1100			
		Maximum temperature ramps		TBD	TBD			

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NEW REV	NO.	ITEM	UNIT	VALUE OPERATING	 DESIGN	TENTATIVE	FIRM	REFERENCES AND REMARKS
		A-7 THERMAL STORAGE SUBSYSTEM						Paragraph 3.2.7.10
		Energy storage	MWht	99	99			
		Hot tank temperature	°F	750 to 1050	1100			
		Cold tank temperature	°F	350 to 610	610			
		Maximum charge rate	MWt	107	107			
		Hot tank cover gas pressure	psig	0	0.12			
		Cold tank cover gas temperature	°F	610	610			
		Sodium flow to auxiliary system	gpm	10	30			
		Sodium temperature to auxiliary system	°F	610	610			
		Sodium maximum plugging temperature	°F	250	350			
		Minimum operating level	ft	3	2			
		Minimum level alarm	ft	5	3			
		Minimum level trip	ft	2	2			

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NEW REV	NO.	ITEM	UNIT	VALUE		TEN-TATIVE	FIRM	REFERENCES AND REMARKS
				OPERATING	DESIGN			
		A-8 STEAM GENERATION SUBSYSTEM						Paragraph 3.2.7.11
		Number of steam generators	-	3	3			
		Power per steam generator	MWt	28.3	38.2			Each unit to be designed to operate from 10% to 135% of operating rating
		Steam Conditions						
		@ Steam generator outlet						
		Pressure	psig	1515	1590			
		Temperature	°F	1010	1020			
		@ Turbine throttling valve inlet						
		Presssure	psig	1515	1590			
		Temperature	°F	1000	1005			
		Inlet sodium temperature	°F	1050	1065			
		Inlet feedwater temperature	°F	436	450			
		Maximum temperature ramp		TBD				

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NEW REV	NO.	ITEM	UNIT	VALUE		TEN-TATIVE	FIRM	REFERENCES AND REMARKS
				OPERATING	DESIGN			
	A-9	SODIUM AUXILIARIES						Paragraph 3.2.7.14
		Argon manifold supply pressure	psig	250	300			
		Argon purity	%	99.95	-			
		Argon total flow rate	scfm	TBD	TBD			
		Service conditions			TBD			

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NEW REV	NO.	ITEM	UNIT	VALUE		TEN-TATIVE	FIRM	REFERENCES AND REMARKS
				OPERATING	DESIGN			
		A-10 MASTER CONTROL SYSTEM PLANT PROTECTION TRIP SETTINGS						
		Receiver median radiant energy flux high	$\frac{MW}{m^2}$	1.25	1.20			
		Receiver median sodium exit temperature high	°F	1075	1100			
		Receiver sodium exit temperature rate of change high	$\frac{°F}{min}$	TBD	-			

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DESIGN DATA SHEET	TITLE	NUMBER
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NEW REV	NO.	ITEM	UNIT	VALUE		TEN-TATIVE	FIRM	REFERENCES AND REMARKS
				OPERATING	DESIGN			
		PLANT PROTECTION TRIP SETTINGS						
		Receiver						
		Accumulator tank pressure low	psig	TBD	-			
		Accumulator tank level low	ft	TBD	-			
		Hot sodium storage tank level high	ft	TBD	-			
		Receiver exit sodium rate of temperature change high	°F/min	TBD	-			
		Receiver inlet - outlet sodium flow ratio mismatch	-	TBD	-			
		Radiant energy input - sodium heat removal power	-	TBD	-			
		Sodium leak	-	TBD	-			

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NEW REV	NO.	ITEM	UNIT	VALUE		TEN-TATIVE	FIRM	REFERENCES AND REMARKS
				OPERATING	DESIGN			
		PLANT PROTECTION TRIP SETTINGS						
		Steam Generator						
		Hot sodium storage tank sodium outlet temperature high	°F	TBD	-			
		Steam generator outlet steam temperature high	°F	TBD	-			
		Steam generator inlet feedwater temperature low	°F	TBD	-			
		Steam generator sodium side-water side power mismatch	MWt	TBD	-			
		Hot sodium storage tank level low	ft	TBD	-			
		Sodium-water reaction	DNA	TBD				Triggered by rupture disk failure

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NEW REV	NO.	ITEM	UNIT	VALUE OPERATING	VALUE DESIGN	TEN-TATIVE	FIRM	REFERENCES AND REMARKS
		PLANT PROTECTION TRIP SETTINGS						
		Generator						
		TBD		TBD	-			
		Turbine						
		TBD		TBD	-			

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PREPARED BY T. L. Johnson

DATE 10/22/82

DESIGN SPECIFICATION

NUMBER N10048

REV NEW

TYPE Subsystem

TOTAL PAGES 12

E.O. 5-18-83 RK 106296

TITLE

Receiver Subsystem, Solar Central Power Plant, Carrizo Plains, Unit 1

APPROVALS

TL Johnson

Cognizant Engineer

RELEASED

ENGINEERING DEPT.

FORM 723-P-3 NEW 8-74

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FORM N 131-H-1 REV. 2-79

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LIST OF TABLES

SPECIFICATION FOR RECEIVER SUBSYSTEM CARRIZO PLAINS SOLAR THERMAL POWER PLANT

1. SCOPE This specification establishes requirements for the design of the Receiver Subsystem for the 30-MWe Solar Power Plant to be located at Carrizo Plains. This specification includes the absorber panels, surge tank, accumulator tank, manifold piping, interconnecting piping, instrumentation and control, support structure, and interface with the top of the tower. The tower specification is presented in a separate document.

2. DOCUMENTS

2.1 Applicable Documents The following documents, of exact issue shown, form a part of this specification to the extent specified in Sections 3, 4, and 5 of this specification. In the event of a conflict between the documents referenced here and other provisions herein, the specification shall be the superseding requirement.

2.1.1 Rockwell Documents

N10046	Solar Central Receiver Power Plant, Carrizo Plains Unit No. 1
N10047	Specification of Structural Steel Tower - Carrizo Plains Solar Thermal Power Plant
PON DE-PN03-82SF11596	Preliminary Design of the Carrizo Plain Solar Central Receiving Power Plant
079R000029	Heat Transport System P&ID - Solar Central Receiver, 30 MWe

2.1.2 American National Standards Institute (ANSI)

ANSI B31.1-1980 - Power Piping

ANSI A58.1 - Building Code Requirements for Minimum Design Loads in Buildings and Other Structures

2.1.3 National Electric Code

NFPA 70-1978

2.1.4 National Electric Manufacturers Association (NEMA) Standards

2.1.5 American Society of Mechanical Engineers (ASME)

ASME Boiler and Pressure Vessel Code Section VIII, Division 1

2.1.6 State and City Codes and Regulations

Uniform Building Codes, 1982

San Luis Obispo Department of Building and Safety

3. REQUIREMENTS

3.1 Subsystem Description The receiver subsystem is supplied with sodium from the cold leg of the transport loop, absorbs the radiant energy from the collector system, and supplies this energy in the form of heated sodium to the hot leg transport loop. The elements of this system are as follows:

a. Absorber panels (8)
b. Surge tank (1)
c. Accumulator tank (1)
d. Manifold and interconnecting piping and valves
e. Support structure and interface with tower
f. Instrumentation and control
g. Beam Characterization System (BCS) target
h. Cable spreading room

The requirements for the following items which are a part of the receiver subsystem are given in design requirements for structural steel tower.

a. Tower structure and foundation
b. Riser and downcomer piping
c. Elevator
d. Ancillary equipment
e. Cable spreading area

3.1.1 Piping and Instrumentation Diagram Diagrammatic representation of this system is shown on the drawing for heat transfer system P&ID.

3.1.2 Equipment Arrangement The components and equipment of 3.1 shall form a compact arrangement on top of the tower in a manner suitable to their function as shown by the typical arrangement of Figure 1.

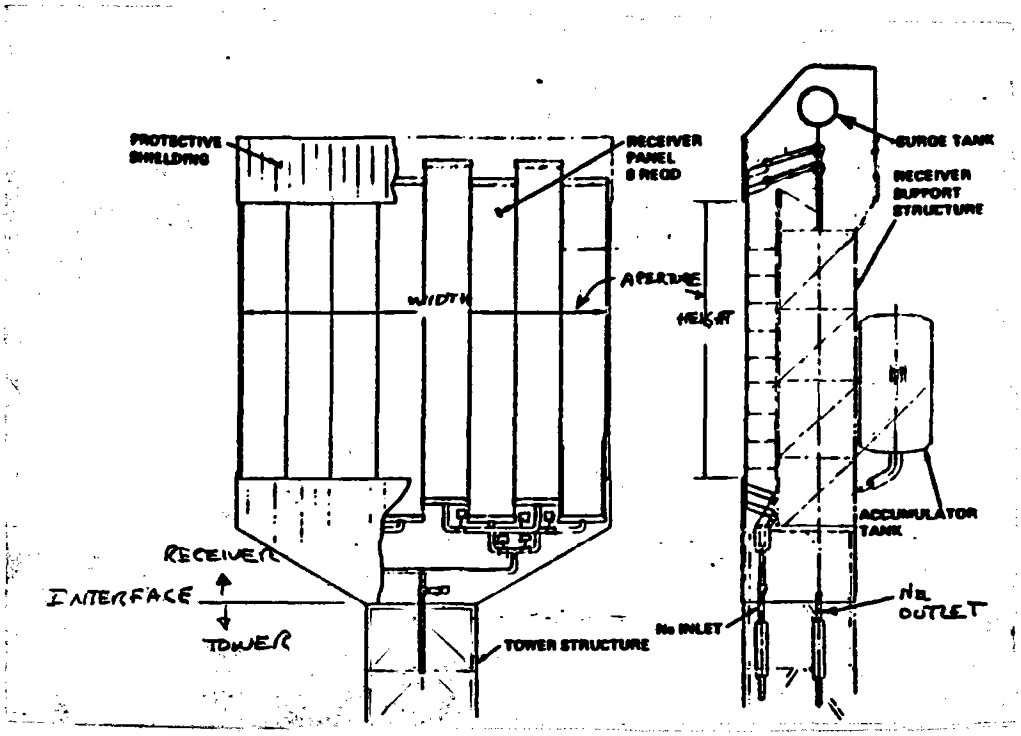

Figure 1. Typical Receiver Subsystem Arrangement

3.1.3 Interface Definitions The items of this document shall be assembled as identified in 3.1.2 and attached to the top of the tower by a suitable arrangement of flanges or other means of securing the receiver structure to the tower. Interface control drawings (ICD) shall be prepared showing all structural, piping, electrical, instrument, and control connections to be interfaced.

3.1.4 Cable Spreading Room The cable spreading shall be located in the tower-to-receiver transition area with about 400 sq ft of floor area and an 8-ft clear ceiling height. This room shall be completely enclosed with insulated metal siding and be atmosphere controlled with an air conditioning unit having humidity control and heating capabilities. An elevator landing shall be provided at this level if possible. The floor shall be designed to support 100 lb per sq ft.

3.1.5 BCS Target The BCS target shall be supplied by others. This item is to be located on the north side of the receiver interface structure. Interface requirements shall be supplied to ESG.

3.2 Performance The receiver shall be designed for the performance values of Table 2.

3.2.1 Design Life The useful life of the receiver subsystem shall be 30 years with normal maintenance as described in 3.2.3. The absorber panels may be designed to a shorter life, if it is shown to be cost-effective over the plant lifetime.

3.2.2 Environment The receiver subsystem shall be designed for the environmental conditions of Table 1. Wind loads shall be determined from ANSI 58.1.

Temperatures within any weather enclosure provided for receiver component shall not exceed 65°C (150°F).

3.2.2.1 Sodium The system shall be filled with commercial-grade sodium. While the initial system oxide concentration is uncertain, after operation, the nominal oxide concentration will be 10 ppm or less by weight.

3.2.3 Maintenance The following criteria shall be used for maintenance of the sodium components.

a. All equipment, piping, and valves shall be accessible for contact maintenance, repair, removal, and replacement. Provision for a movable window washer type hoist shall be made for inspection and maintenance of the front surface of the receiver.

b. All piping shall be arranged to accommodate minimum cutting for removal of any removable equipment.

c. Each absorber subpanel shall be removable without disturbance to the adjacent panels. A hoist shall be provided for panel installation and removal.

d. Maintenance operations shall not be allowed during receiver operation.

3.3 Design The receiver subsystem design parameters are given in Table 2.

3.3.1 Codes and Standards The pressure-containing components of this specification shall be designed to the applicable requirements of ANSI B31.1 and ASME Boiler and Pressure Vessel Code, Section VIII, Division 1. Liquid penetrant examination and helium leak testing of welds per these Codes may be substituted for any radiographic examination of weld requirements. Weld joint factors according to Table UM-12 of Section VIII, Division 1, must be utilized according to the inspection performed.

3.3.2 Receiver

3.3.2.1 Panel Temperatures The nominal panel inlet temperature will be as given in Table 2. During startup, the inlet sodium may be as low as 232°C (450°F). During certain operations, the inlet temperature may be increased to 427°C (800°F).

The nominal mixed mean outlet temperature from all panels will be as given in Table 2. Peak front surface tube metal temperatures shall be determined using the flux distribution of Table 2. The maximum temperature difference between inlet and outlet to a panel shall not exceed 315°C (600°F).

3.3.2.2 Panel Power Gradients The peak-to-minimum power distribution across an end panel shall not exceed 5. The end panels may require flow control orifices for each tube to reduce the edge-to-edge temperature gradients across the panel. For nonedge panels, the peak-to-minimum power distribution on a panel shall not exceed 1.4. For any panel, the tube-to-tube outlet temperature variation shall not exceed 2°F. The panels and headers are required to accommodate such temperature variations.

3.3.2.3 Temperature Difference in Adjacent Panels An outlet temperature difference of up to 111°C (200°F) may exist between tubes in adjacent panels. The panel assembly design must accommodate such temperature differences.

3.3.2.4 Panel Pressure Drop The pressure drop through a panel shall be adequate to minimize flow oscillations between panels. Panel outlet temperature variations due to such oscillations shall not exceed ±10°F. A secondary requirement is to select the panel pressure drop so as to minimize pump head required.

3.3.2.5 Pressure in Loop The maximum design pressure in the panel will be as given in Table 2.

3.3.2.6 Construction The solar receiver will be made of eight panels. Each panel shall be identical in design and construction except for internal orificing, if any. The panels shall be supported by a structure in a side-by-side arrangement for a continuous flat surface. Adjacent panels shall be mounted such that the gaps between the edge of the tubes meet the same requirement as for tubes within the panel surface. The tubes for each panel shall be supported by a mechanical constraint arrangement such as used for the panel tested at the CRTF. The material for construction of pressure-containing parts exposed to sodium shall be as given in Table 2.

3.3.2.7 Panel Tubes Seamless tubes of the size and material of Table 2 shall be used. Weld joints within the tube length are not permitted. The gap between tubes, when the panel is mounted in the support structure, shall be adequate to allow for thermal expansion.

3.3.2.8 Thermal Insulation and Barrier The panel structure shall be protected from any direct heat flux and from excessive temperatures. The subpanel headers and nearby tubing shall be shielded from the collector field energy. If high-temperature insulation is used near the panel edges, such insulation shall abut the edge tubes without causing significant shadowing of the edge tube. Backside heat loss from a panel shall not exceed 3 kWt/m^2. The insulation for the backside of the panels shall be Cerafelt 600.

3.3.2.9 Structural Integrity The panel and its structure shall retain its integrity, neither warping unduly nor opening up gaps through which heat flux can penetrate, for the required lifetime. The out-of-plane variation of any one tube or group of tubes shall not exceed one-half tube diameter.

3.2.2.10 Transients The panel shall be capable of being started up and shut down twice each day for the lifetime (22,000 cycles). At night, the panel shall be drained and shall reach ambient temperature.

The panel and hot leg piping shall be subjected to cold leg temperatures during hold periods of low insulation for a total of 28,000 cycles over the lifetime.

Temperature transient rates are determined primarily by the transit time of sodium through the panel or subsystem.

	Temperature Change, °F			
Condition	Cold Leg	Panel	Hot Leg	Duration (min.)
Dry Preheat	-	Amb.-600	-	10
Fill	450-610	600-610	550-610	4
Power Buildup	-	610-1050	610-1050	5
Cooldown, hold	-	1050-610	1050-610	1
Drain	610-550		610-550	4
		610-Amb.		30

3.3.2.11 Instrumentation Each tube of every panel shall be equipped with thermocouple measurement at the mid-height backside of the solar heated area. In addition, Tubes 1, 25, 51, 75, and 102 shall be equipped with five backside thermocouples equally spaced along its length from bottom to the top of the solar heated area. Each panel shall be equipped with a primary and backup flux sensors with spacing TBD.

All instrumentation shall be accessible for inspection and repair with a minimum of disassembly of the panel or support fixture components. Particular attention should be given to the accessibility of the flux gauges. Flux gauges may require water cooling with an antifreeze additive. Selected thermocouples and flux gauges may be part of the panel control system. Thermocouples shall be mounted so as to minimize response time.

3.3.2.12 Heat Tracing The shielded areas of the receiver panels, including the headers, shall be electrically trace heated to a nominal temperature of 288 ± 56°C (550°F ± 100°F). Sufficient heater capacity shall be available to heat from ambient conditions to the nominal preheat temperature in 2 h.

3.3.3 Receiver System Hot Leg Piping Design This piping connects the panel outlet headers to the downcomer. The surge tank is connected to the receiver outlet piping at the system high points. Sodium pipe size shall be selected such that the flow velocity does not exceed 20 ft/s at the design flow rate. The piping from the surge tank to the downcomer piping at the tower interface shall be the same size as the riser pipe. Immersion thermocouples shall be located in each panel outlet pipe as close to the header as practical. An immersion thermocouple shall also be located in the piping containing the combined flow from all panels.

3.3.3.1 Receiver Hot Leg Temperatures The hot leg piping shall be subjected to the same temperatures and temperature transients as the panel outlet, 3.3.2.1 and 3.3.2.10.

3.3.3.2 Construction The hot leg piping shall be constructed of 316H or 304H stainless steel. Full penetration welded butt joints shall be used for all pipe connections.

3.3.4 Receiver System Cold Leg Piping Design This piping connects the riser to the panel inlet headers. The accumulator tank is connected to this piping system. A flow control valve shall be included for each panel. A flow control valve for the total flow shall also be included. Sodium pipe size shall be selected such that the flow velocity does not exceed 20 ft/s at the design flow rate.

3.3.4.1 Receiver Cold Leg Temperatures The receiver cold leg piping and components shall be subjected to the same temperatures and temperature transients as the panel inlet, 3.3.2.1 and 3.3.2.10.

3.3.4.2 Construction The material for the receiver cold leg piping shall be selected as appropriate for the design conditions. The material must be suitable for interfacing with the panel header material and with the riser material.

3.3.5 Lightning Protection The receiver and tower shall be protected from lightning to prevent damage to receiver subsystem components, equipment, and structure.

3.3.6 Inert Gas Provision shall be made to provide argon cover gas to the surge and accumulator tanks. All sodium-containing piping and tanks shall be filled with argon gas when drained of sodium.

3.3.7 Miscellaneous Requirements Provision shall be made for the following materials and services. Quantities and other requirements for these items shall be identified in the interface documentation, 3.1.4.

a. Electric power
b. Compressed air
c. Cooling fluid for flux sensors
d. Sodium fire fighting equipment

4. QUALITY ASSURANCE

TBD

5. PREPARATION FOR DELIVERY

TBD

6. NOTES AND DATA

TBD

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DESIGN DATA SHEET	TITLE TABLE I ENIRONMENTAL CONDITIONS	NUMBER SCR 30-MWe	
PREPARED BY	APPROVED BY		PAGE
		WBS NO.	DATE

NEW REV	NO.	ITEM	UNIT	VALUE		TEN-TATIVE	FIRM	REFERENCES AND REMARKS
				OPERATING	DESIGN			
		Minimum temperature	°F	-10	-20			
		Maximum temperature	°F	+110	120			
		Maximum wind, including gusts	mph	30	90			Ref. height 32.8 ft
		Seismic environment	-	Zone 4	Zone 4			
		Seismic horizontal and vertical Accelerations						
		Equipment	g	DNA	0.4			
		Civil	g	DNA	0.27			
		Maximum dust devil wind speed	mph	45	45			
		Maximum static snow load	lb/ft^2	2	2			
		Maximum snow deposition rate	in./day	4	4			
		Average annual rainfall	in.	DNA	20			
		Maximum 24 hr rainfall	in.	DNA	4			Plant not required to operate during rain or hailstorm
		Hail maximum diameter	in.	DNA	1			
		Hail ice deposit	in.	DNA	1			
		Hail specific gravity		0.9	0.9			
		Hail maximum terminal velocity	fps	DNA	75			Plant not required to operate during hailstorm

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DESIGN DATA SHEET

TITLE	TABLE 2 Receiver Design, Operation, and Performance Parameters
NUMBER	
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APPROVED BY	
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DATE	

NEW REV	NO.	ITEM	UNIT	VALUE		TENTATIVE	FIRM	REFERENCES AND REMARKS
				OPERATING	DESIGN			
	1	Midplane aperature elevation (1)	ft		410			
	2	Receiver aperature						
		Width (2)	ft		51.70			
		Height	ft		40			
	3	Number of panels			8			
	4	Panel characteristics						
		Width (2)	ft		6.464			
		Height			As req'd			
		Number of tubes			102			
		Tube diameter	in.		0.75			
		Tube wall	in.		0.049			
		Maximum power per panel	MWt		17.3			
		Pressure	psig	50	100			
		Panel outlet temperature	°F	1050 ± 25	1100			
		Panel inlet temperature	°F	610 ± 10	610			
		Material	Type		316 SS			
		Absorbtivity coating (minimum)			0.95			
	5	Surge tank volume	gal		18,000			
		Pressure	psig	10	50			
		Temperature	°F	1050 ± 17	1100			

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TITLE TABLE 2

Receiver Design, Operation, and Performance Parameters

NUMBER

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WBS NO.

DATE

NEW REV	NO.	ITEM	UNIT	VALUE		TEN-TATIVE	FIRM	REFERENCES AND REMARKS
				OPERATING	DESIGN			
	6	Accumulator tank volume	gal		18,000			
		Pressure	psig	50	100			
		Temperature	°F	610 ± 17	610			
	7	Performance						
		Incident power	MWt	116				
		Absorbed power	MWt	107				
		Mixed mean outlet temperature	°F	1050 ± 17				
		Maximum flux	MWt/m2	1.2				
		Average flux	MWt/m2	0.61				
		Flux distribution			See Figures 2 and 3			
		Pump flow	gpm	6200				

(1) Referenced to nominal collector field grade
(2) Nominal gap between tubes of 0.010 in.

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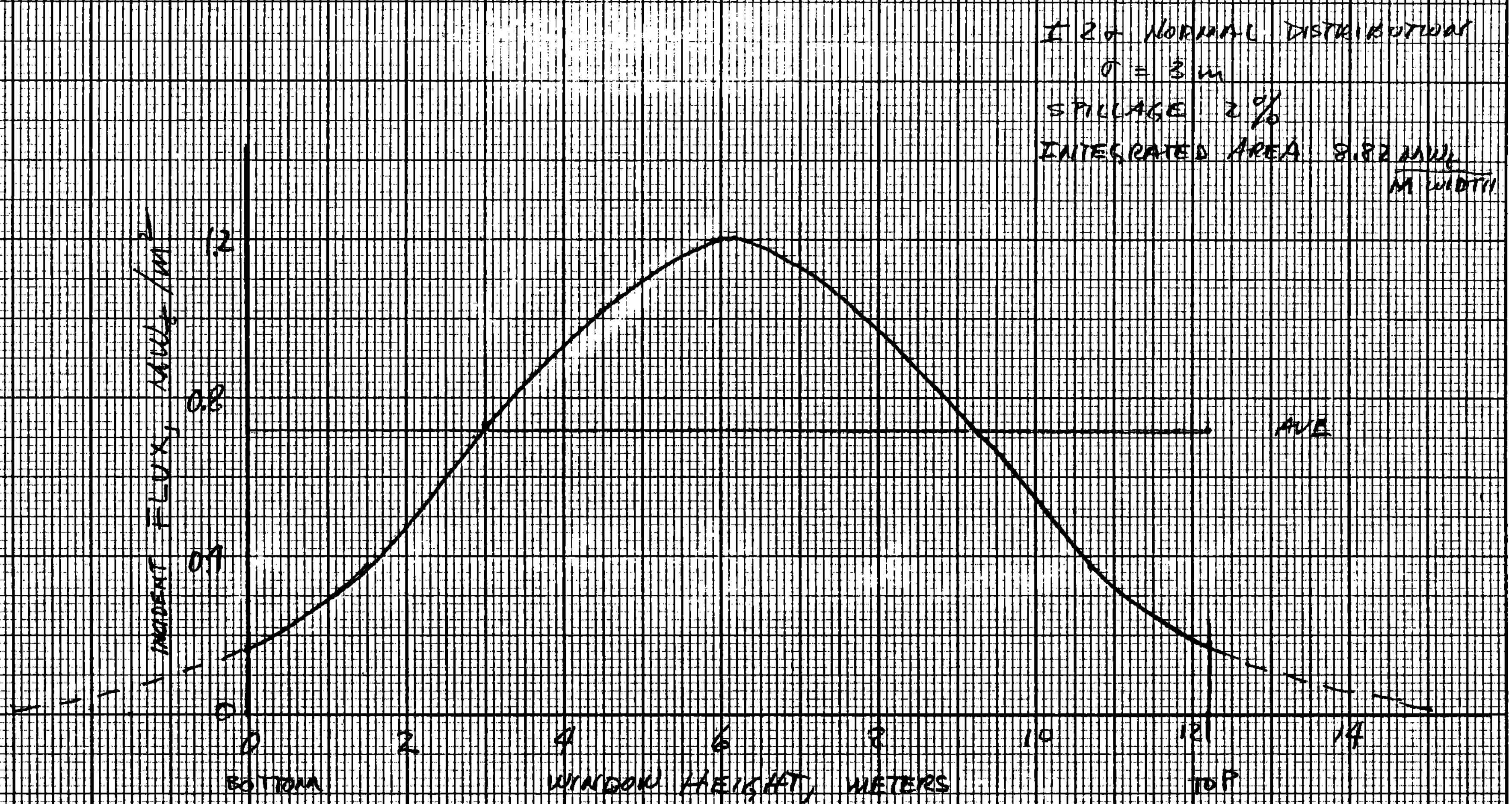
NEW



I 2σ NORMAL DISTRIBUTION
σ = 3 m
SPILLAGE 2%
INTEGRATED AREA 8.82 MWt / M WIDTH

FIGURE 2 REFERENCE VERTICAL FLUX DISTRIBUTION - 30 MWe SOLAR PLANT

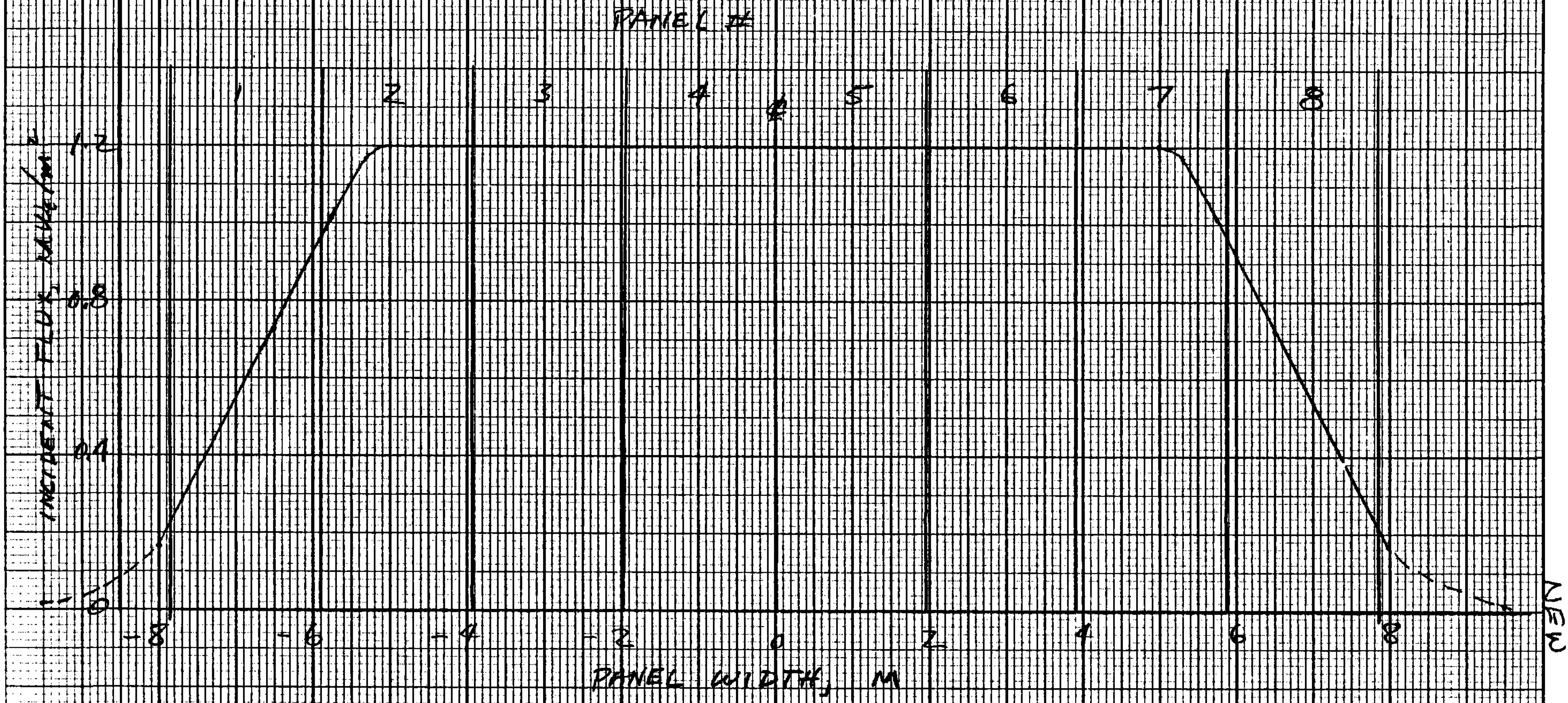


FIGURE 3 REFERENCE LATERAL FLUX DISTRIBUTION - 30 MWe SOLAR PLANT

3.1.1 RECEIVER STRUCTURAL STEEL (N10047)

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Energy Systems Group

PREPARED BY
R. W. Knapp
T. L. Johnson

DATE
01-11-83

DESIGN SPECIFICATION

NUMBER N10047

REV NEW

TYPE Subsystem

TOTAL PAGES 10

E.O. 5-18-83 RK
93305

TITLE
Specification for Structural Steel Tower
Carrizo Plains Solar Thermal Power Plant

APPROVALS

TL Johnson
Cognizant Engineer

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5017C/sjh

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SPECIFICATION FOR STRUCTURAL STEEL TOWER CARRIZO PLAINS SOLAR THERMAL POWER PLANT

1. SCOPE This specification establishes the requirements for the design of a steel tower to support the solar receiver system of the Carrizo Plains solar thermal power plant.

2. DOCUMENTS

2.1 Applicable Documents The following documents of the exact issue shown form a part of this specification to the extent specified in Sections 3, 4, and 5 of this specification. Any apparent conflict between this specification and the requirements of an applicable document shall be brought to the attention of Rockwell International for resolution.

2.1.1 Rockwell Documents

N10046	Design Specification for the Solar Central Receiving Power Plant, Carrizo Plain Unit No. 1
079000047	Receiver Interface Control Drawing

1.2 American Institute of Steel Construction (AISC)

AISC Manual	Manual of Steel Construction; 8th Edition

2.1.3 American Welding Society (AWS)

AWS A 5.1-78	Specification for Carbon Steel Covered Arc Welding Electrodes
AWS A 5.5-69	Specification for Low-Alloy Steel Covered Arc Welding Electrodes
AWS D 1.1-82	Structural Welding Code, Steel

2.1.4 American Society for Testing and Materials (ASTM)

ASTM A 6-77	Specification for General Requirements for Rolled Steel Plates, Shapes, Sheet Piling, and Bars for Structural Use
ASTM A 36-77	Specification for Structural Steel
ASTM A 53-77	Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless

ASTM A 123-73	Specification for Zinc (Hot-Galvanized) Coatings on Products Fabricated from Rolled, Pressed, and Forged Steel Shapes, Plates, Bars, and Strip
ASTM A 307-76	Specification for Carbon Steel Externally Threaded Fasteners
ASTM A 325-76	Specification for High-Strength Bolts for Structural Steel Joints
ASTM A 490-77	Specification for Quenched and Tempered Alloy Steel Bolts for Structural Steel Joints
ASTM A 525-77	Specification for Steel Sheet, Zinc-Coated (Galvanized) by the Hot-Dip Process, General Requirements
ASTM A 569-72	Specification for Steel, Carbon (0.15 maximum percent), Hot-Rolled Sheet and Strip, Commercial Quality

2.1.5 Occupational Safety and Health Act

OSHA-72	Occupational Safety and Health Act

2.1.6 International Conference of Building Officials

UBC-1982	Uniform Building Code

2.1.7 American National Standards Institute (ANSI)

ANSI A58.1	Building Code Requirements for Design Loads in Buildings and Other Structures

3. REQUIREMENTS

3.1 Item Definition The tower shall be a steel structure designed to support the complete Receiver Subsystem. It shall also be required to house auxiliary systems required to support the operations of the Receiver Subsystem.

The tower shall comprise the following items:

a. Columns, girders, bracing, rods

b. Horizontal support framing, service and landing levels including platforms, grating, and handrails

c. Stair and catwalk structure including stringers, treads, grating, handrails, and ladders.

3.1.1 Interface The tower will interface with the following:

a. Concrete foundation at plant grade

b. Receiver at elev. 362 ft; see Drawing 079000047

c. Elevator supports

d. Pipe supports.

3.1.1.1 Tower Platform The tower platform shall be designed to match the mounting structure of the complete receiver subsystem and accept the loads as shown on interface drawing.

3.1.1.2 Elevator Supports A nominal 1.5-ton capacity elevator system shall be supported by the tower. Attachment method will be provided by the elevator supplier.

3.1.1.3 Pipe Supports Pipe supports will be required for piping and conduits. Support framing and loads shall be supplied by others.

3.2 Structure Design The tower shall be designed to completely support the solar receiver subsystem and all its related components. It shall also include a stairwell, ladders and platforms, pipe chase, and provisions for an elevator. The design shall be performed in accordance with Uniform Building Code (U.B.C.). Should any other method be used in the design, it shall be identified to provide a basis for review. Maximum sway limits shall be 12 inches at maximum operating wind. Design parameters are identified in Table I.

3.2.1 Environment The tower will be located outside and will be exposed to the environment shown in Table I. Wind loads will be determined using ANSI A58.1.

3.2.2 Useful Life The useful life of the complete solar power plant including the receiver support tower shall be 30 years.

3.2.3 Connections All connections shall be designed in accordance with AISC Steel Construction Manual.

The Supplier shall design the beam connections for a shear load equal to the maximum web shear (v) shown in Part 2 of the AISC Manual. Diagonal bracing and all back-to-back strut connections shall be designed to carry the full capacity of the members, either compression or tension.

If welding is used for shop or field connections, the welds shall be proportioned to equal the load-carrying capacity of the bolted connections of the preceding paragraphs. The size of fillet welds shall be in accordance with Section 2 of AWS D1.1.

High-strength bolts shall be used for all structural connections between members. Diagonal bracing connections shall be designed as friction joints. All other joints using high-strength bolts shall be designed as bearing-type joints with threads excluded from the shear plane.

Welding may be designed for attaching connection angles to beam webs, except as otherwise noted herein.

Designed welded field connections shall be minimized. Where welded field connections are designed, holes for erection bolts shall be designed to be placed in the end connections and the members to which they are to be attached.

Beams and connections shall not present either a tripping or a head-knocking hazard.

3.2.4 Handrail, Stair Stringer, and Tread Design Handrail and stair stringers and treads shall be designed for bearing-type ASTM A 307 common bolt connections.

Handrailing shall be designed of two lines of pipe, made up with welded connections without fittings. Bends shall be smooth and uniform.

Designed treads shall not have kick plates. Standard supporting clips shall be designed for use at each end of stair treads for mounting to the stair stringers with two 3/8-in.-diameter bolts. All toe plate and angle curbs shall be designed to have neat close joints and shall be butted at corners. The maximum clearance at joints shall be 1/8 in. Exposed ends of stair stringers shall be closed with plates. Requirements as dictated by OSHA shall be adhered to in the design phase of work for all stairs, ladders, catwalks, and platforms.

3.3 Materials Materials to be used in design shall be in accordance with the following:

a. Structural steel shapes, tubing, and plates shall conform to ASTM A 36.

b. Handrail steel pipe and post pipe shall conform to ASTM A 53, Grade B. Handrail shall be 1-1/2-in. nominal inside diameter with 1-1/2-in. extra-strong posts at 8 ft 0 in. maximum.

c. High-strength bolts, nuts, and washers shall be ASTM A 325 or ASTM A 490 with yield strength between 130 ksi and 145 ksi except as noted. The minimum bolt diameter shall be 1 in. for main members and 3/4 in. for bracing and secondary members. Diameters of 7/8 in., 1-1/8 in., and 1-3/8 in. shall not be used. Direct tension indicators, if used, shall be Coronet indicators as manufactured by Cooper-Turner, Inc., or approved equal.

d. Common bolts, nuts, and washers (other than high strength) shall conform to ASTM A 307, Grade A.

e. Grating shall be 1-1/4 in. deep except stair treads and intermediate stair landings which shall be 1 in. deep. Grating shall be of welded construction, rectilinear in pattern, with 3/16-in.-thick bearing bars on 1-3/16-in. centers. Crossbars shall be 3/16 in. thick and have a minimum cross-sectional area of 1/6 in.^2 and shall be twisted and spaced 4 in. on centers.

f. Stair treads shall be the same construction as the floor grating. Standard treads shall not be less than 9-3/4 in. wide. The supplier shall provide special-sized treads where they may occur, or otherwise be necessary due to interferences, notably at the top tread of certain runners.

g. Cast 1-1/4-in. abrasive nosings shall be fastened to all stair treads and to grating at main floors or landings at the head of all descending stair runs.

h. Visible abrasive nosings shall be plain-finish Feralun Type B as distributed by American Abrasive Metals Company, Irvington, New Jersey, or equal, approved by Rockwell.

i. Steel for floor grating and stair treads shall be of welding quality, mild carbon steel conforming to ASTM A-569. Floor plates shall have a symmetrical, checkered, raised diamond pattern.

j. Metal siding for the Control Room enclosure shall be of galvanized factory finish, 1-1/2 in. deep by 22 gage, minimum thickness. Insulation shall be 1-1/2-in.-thick Owens-Corning Fiberglas with a white vinyl membrane inner facing. Roof panels shall be 16-gage minimum, thickness of the same type and pattern as the walls. Roof insulation shall be identical as walls.

3.4 Drawings Design drawings to be submitted shall include conection designs, calculations, and loads imposed on members, necessary dimensions and member sizes needed for shop fabrication. Documents shall be in form of good quality sepia or Xerox copy and be of such quality that reproductions will be legible to the unaided eye.

4. QUALITY ASSURANCE PROVISIONS

4.1 Design Verification A design verification will be performed by Rockwell International to establish that the requirements of Section 3 have been met. This will include:

a. Verification of codes

b. Calculations

c. Drawings

d. Other analyses that were performed.

4.2 Document Certification Following approval by Rockwell International, the supplier shall have the documents signed by a professional engineer registered in the State of California.

5. PREPARATION FOR DELIVERY

5.1 Shipping Sepias shall be shipped rolled (unfolded) inside mailing tubes. Prints shall be folded to 8-1/2 by 11 in. and shipped flat. Other 8-1/2 by 11-in. documents shall also be shipped flat.

5.2 Delivery Data to be delivered or mailed shall be addressed to:

Rockwell International
8900 De Soto Avenue
Canoga Park, California 91304

Attention: ________________
Contract No. ________________

6. NOTES AND DATA

6.1 Documents Documents such as calculations, analysis, charts, tables, and any other data developed for design shall be transmitted to Rockwell International for record and future reference.

5017C/bes

Rockwell International
Energy Systems Group

DESIGN DATA SHEET

TITLE ENVIRONMENTAL REQUIREMENTS
TABLE I

NUMBER SCR 30-MWe

PAGE 8

PREPARED BY

APPROVED BY

WBS NO.

DATE

NEW REV	NO.	ITEM	UNIT	VALUE		TEN-TATIVE	FIRM	REFERENCES AND REMARKS
				OPERATING	DESIGN			
		Minimum temperature	°F	-10	-20			
		Maximum temperature	°F	+110	120			
		Maximum wind, including gusts	mph	30	90			Ref. height 32.8 ft,
		Seismic environment	-	Zone 4	Zone 4			
		Seismic horizontal and vertical Loads						
		Equipment horizontal/vertical	W	TBD	0.4/0.27			
		Civil horizontal/vertical	W	TBD	0.27/0.18			
		Maximum dust devil wind speed	mph	45	45			
		Maximum static snow load	lb/ft^2	2	2			
		Maximum snow deposition rate	in./day	4	4			
		Average annual rainfall	in.	3.5	20			
		Maximum 24 hr rainfall	in.	DNA	3			Plant not required to operate during rain or hailstorm
		Hail maximum diameter	in.	DNA	1			
		Hail ice deposit	in.	DNA	1			
		Hail specific gravity		0.9	0.9			
		Hail maximum terminal velocity	fps	DNA	75			Plant not required to operate during hailstorm
			ft	TBD	TBD			

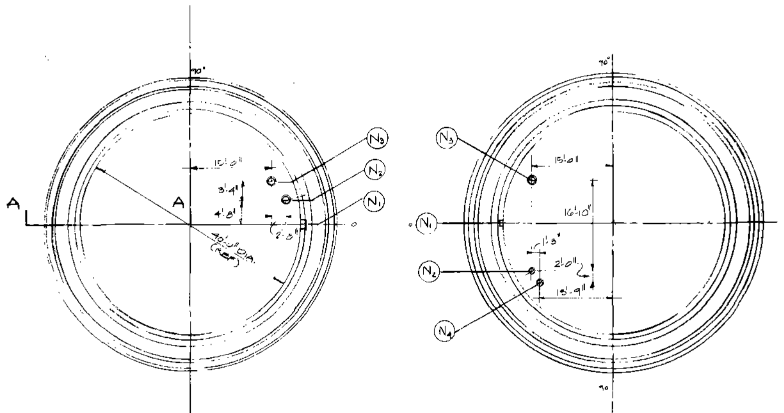
5017C/bes

FORM 706-A REV. 11-82

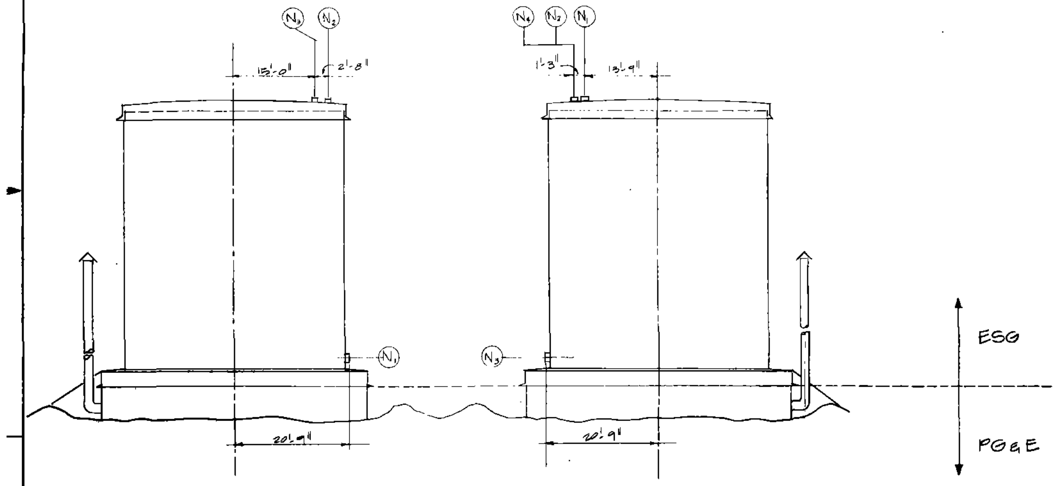
3.2.1 THERMAL STORAGE TANK INTERFACE CONTROL DRAWING
(079000015)

LTR	REVISIONS DESCRIPTION	DATE	APPROVED

NOTES: UNLESS OTHERWISE SPECIFIED



PLAN



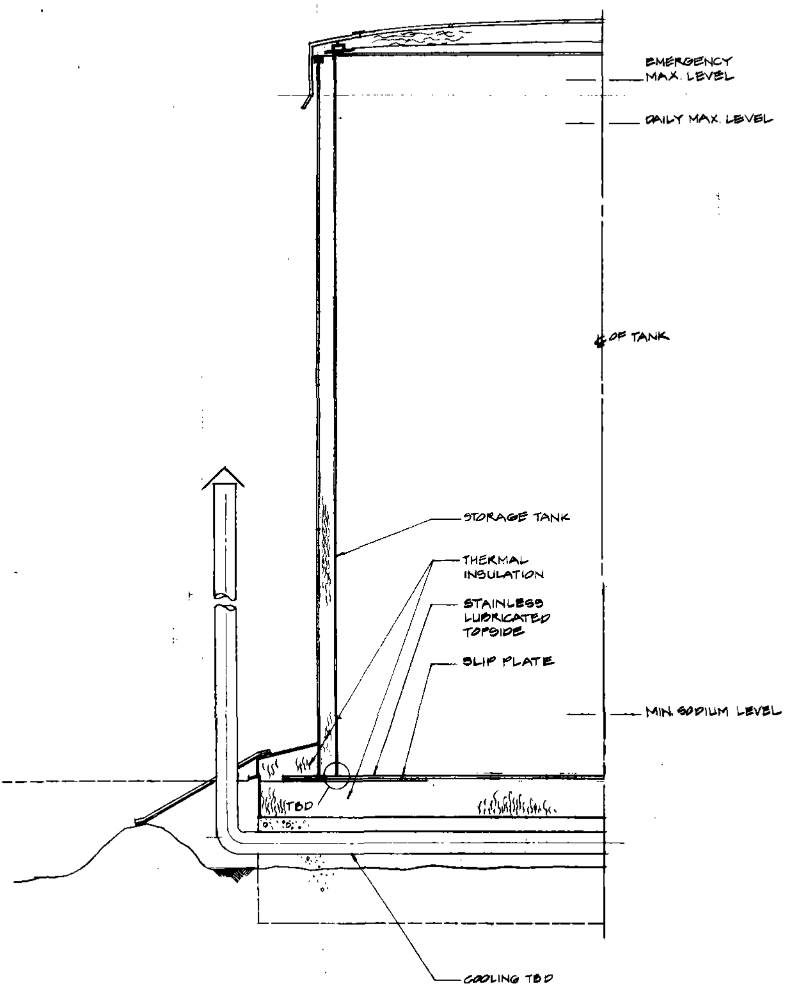
ELEVATION

No.	DESCRIPTION	SIZE	SCHED.	CONN.
N1	PUMP SUCTION	20"	40	BW
N2	HOT SODIUM INLET	12"	40	BW
N3	ARGON EQUALIZATION LINE	12"	40	BW

HOT TANK T-1

No	DESCRIPTION	SIZE	SCHED	CONN
N1	PUMP SUCTION	20"	40	BW
N2	RECIRCULATION TOT-1	8"	40	BW
N3	ARGON EQUALIZATION LINE	12"	40	BW
N4	MAIN OUTLET HDR.	10"	40	BW

COLD TANK T-2



SECTION

DESIGN VALUES

	HOT TANK T-1	COLD TANK T-2
DIAMETER	40 FT.	40 FT.
HEIGHT	50 FT.	50 FT.
TANK VOLUME	470 GAL × 10^3	470 GAL × 10^3
PRESSURE	0.0 PSIG	0.0 PSIG
TEMPERATURE	1050 °F	610 °F
WALL THICKNESS	0.5 IN.	0.5 IN.
MATERIAL	304 SS	M.S.
MIN. LEVEL	3	3
DAILY MAX. LEVEL	41.5	39
EMERG. MAX LEVEL	45	45
MAX. WT.	3.2 × 10^6	3.2 × 10^6
DAILY WT. CHANGE	2.5 × 10^6	2.5 × 10^6
HEAT LOAD		
TL. HEAT LOAD		

RK

IN WORK
DOCUMENT NOT RELEASED
DATE 5/4/83 ISSUE NO. 1
MGR J. [illegible]
FOR INFO ONLY ☐
FOR STORAGE ☒
FORM 723-P-1 REV. 7-78

PACIFIC GAS AND ELECTRIC COMPANY
SOLAR CENTRAL RECEIVER
POWER PLANT
CARRIZO PLAINS – UNIT 1
FORM 723-P-7 NEW 10-82

INTERFACE CONTROL DRAWING

DR BY N.L. CIRLOS
CHK BY
M&P
STRESS

DASH NO. | NEXT USING DWG | MODEL | SERIAL NO. | THRU
APPLICATION | EFFECTIVITY

Rockwell International Corporation
Energy Systems Group

CARRISA PLAINS POWER PLANT
HOT & COLD TANKS
INTERFACE CONTROL DRAWING

SIZE E
DRAWING NO. 079000015
SCALE
SHEET

079000015

3.3.1 STEAM GENERATOR SODIUM PUMP (N30501)

Rockwell International

Energy Systems Group

PREPARED BY
J. O. Pfouts

DATE

PROCUREMENT SPECIFICATION

NUMBER N30501

REV New

TYPE Component

TOTAL PAGES 23

E.O. 105928 5-18-83 RR

TITLE

Carrizo Plains - Unit 1 - Steam Generator Sodium Pump

APPROVALS

L. E. Glasgow
Cognizant Engineer

5026s/emh

FORM N 131-H-6 REV. 2-79

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TABLE OF CONTENTS

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LIST OF FIGURES

SODIUM PUMP FOR A SOLAR POWER PLANT

1. SCOPE

This specification establishes the requirements for the design and construction of a pump for the sodium heat transport system of a solar central receiver power plant.

1.1 Equipment and Services to be Furnished by Supplier

a. Pump shaft, hydraulic and support assemblies, including connections for instrumentation, cooling, lifting, cover gas control, and a thimble for a sodium level sensor.
b. Electric motor drive and speed control equipment, including necessary cooling and monitoring equipment.
c. Pump tank complete with nozzles, saddles, and structural supports required for installation and maintenance.
d. Shaft seal assembly with instrumentation necessary to monitor seal operation.
e. Electrical preheating and thermal insulation for the pump.
f. Instrument sensors.

2. DOCUMENTS

2.1 Applicable Documents _ The following documents of the exact issue shown form a part of this specification to the extent specified herein. In the event of conflict between the documents referenced here or other detail contents of this specification, the detail contents of this specification shall be considered a superceding document. The order of precedence of documents is: (1) procurement specification, (2) ASME Code, (3) ANSI specification, and (4) other specifications.

a. American Society of Mechanical Engineers (ASME)

- ASME Boiler and Pressure Vessel Code, 1980 Edition with Addenda through Winter 1981

ANSI/ASME BPV-VIII-1	Rules for Construction of Pressure Vessels
PTC 8.2-1965 (with 1973 Addenda)	Test Code for CENTRIFUGAL Pumps

b. American National Standards Institute - (ANSI)

ANSI B-1.1-1974	Unified Inch Screw Threads
ANSI/NEMA MG1-1978	Motors and Generators

3. REQUIREMENTS

3.1 Pump Definition — The pump shall be a vertical shaft, free surface, piped suction-type pump with a variable speed electric motor. The pump assembly shall consist of a pump bowl assembly including suction and discharge nozzles, pump tank with free surface liquid level control nozzle, drive shaft including bearings and seals, electrical drive motor and speed control equipment, shaft-to-motor coupling, motor mount, lubrication, purge gas and cooling systems, instrumentation sensors, electrical preheating, thermal insulation for the pump section, provisions for maintaining an inert atmosphere during maintenance, provisions for pressurizing the pump bearing by external means, and provisions for protecting the pump from a sodium overfill. The design shall provide for shipping the pump internals as an assembly.

3.1.1 Pump Diagram — The arrangement of the pump assembly shall be similar to Figure 1.

3.1.2 Interface Definition — The pump assembly will interface with the following systems and elements:

a. Mounting structure that supports the pump assembly.

b. Mounting surfaces for auxiliary equipment, if necessary.

c. Argon gas piping for level control and cover gas.

d. Level control piping for sodium or a mixture of sodium and argon.

e. Sodium piping for pump inlet and discharge nozzles.

f. A connection through which liquid sodium will be supplied from an external source to the sodium pump to pressurize the sodium bearing.

g. Interconnections between the oil system(s) or other auxiliary systems and the sodium pump or the drive motor, if required.

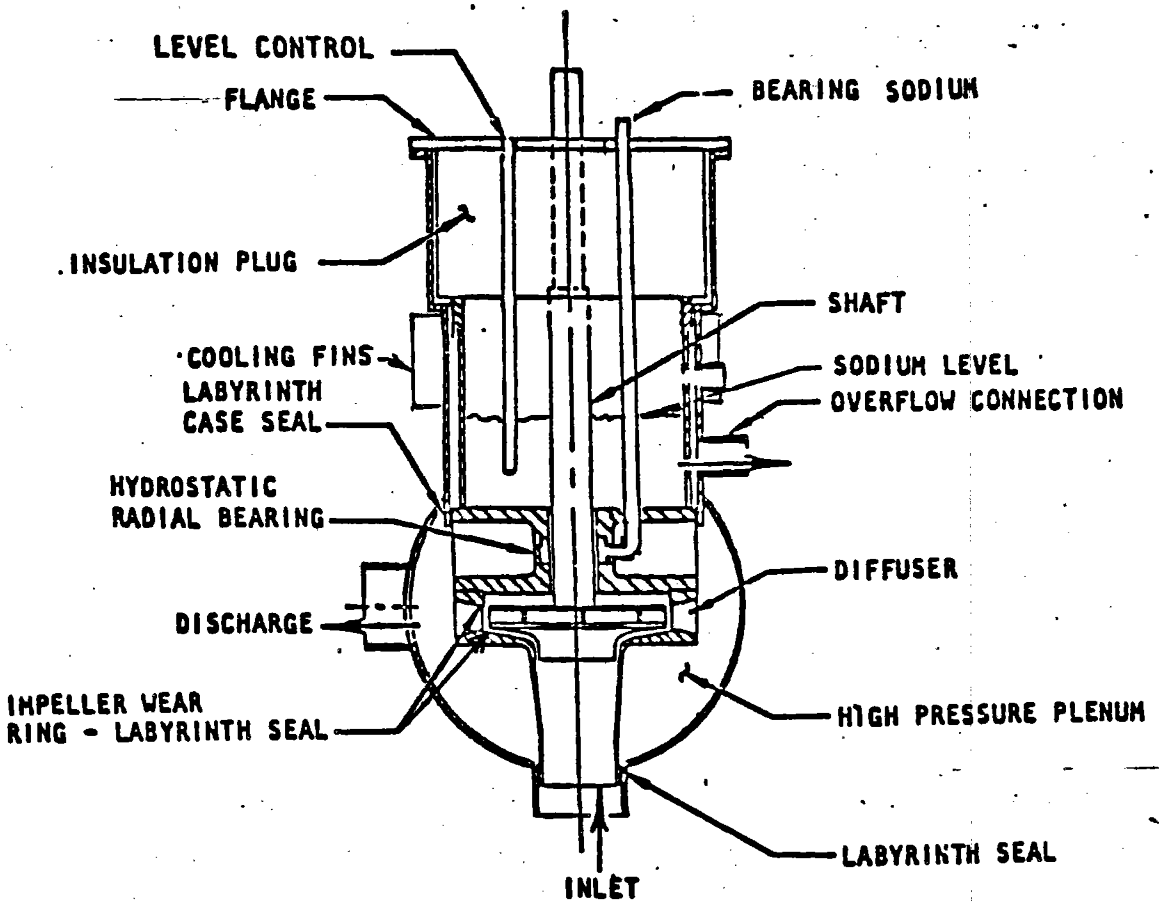

Figure 1. Pump Assembly Arrangement Schematic

h. Drive motor electrical connections.

i. Preheat power connections and other electrical power connections.

j. Instrument connections for data, for alarms, and for controls.

k. Drive motor speed control system.

3.2 Operating Requirements

A summary of the pump operating requirements, Appendix A, which is Design Data Sheet N30500-1.

3.2.1 Performance Characteristics – The pump head vs flow curve required for running speed is defined by the requirements as follows:

a. The pump is required to produce 3200 gpm at a total developed head of 250 feet or more at full speed.

b. The maximum slope of the head vs flow curve at 3200 gpm shall be a 1% increase in head for a 4% decrease in flow, and the slope shall be negative for all points from zero flow to maximum flow.

c. The system static head downstream of the pump is 75 feet.

The pump head vs flow curve is shown in Figure 2. As a goal, the best efficiency point should occur at a flow of 2650 gpm and a head of 180 feet or more. The pump rpm for this point is to be chosen by the pump supplier.

3.2.1.1 Operating Stability – The pump shall be designed to operate stabily in a system that has two of the subject pumps operating in parallel to pump liquid sodium through a steam generator system. The top header of the steam generator system has vents that return sodium and or argon gas to the hot sodium tank. The vents are open at all times. The pump will operate steady state from an output flow rate of 26 gpm at a minimum head of 110 feet to an output flow rate of 3200 gpm at a minimum head of 250 feet. In the event of a failure of one pump, the remaining pump must be capable of operating at a runout condition of 4300 gpm at maximum pump speed. The runout condition will exist for no more than 2 minutes per event and no more than 10 events for the life of the pump.

TBD

Figure 2. Pump Operational Boundaries

3.2.1.2 Pump Inlet Conditions – The pump shall be designed to operate with either of two inlet systems. During normal plant operation, sodium will be drawn into the pump from the hot sodium tank; and during plant start, sodium will be drawn into the pump from the mixing tank.

3.2.1.2.1 Hot Tank Operation – During hot tank operation, the sodium temperature will be in the range from 950°F to 1050°F. For hot tank operation, the pump shall be designed to operate without loss of performance or damage due to cavitation over the entire operating range of 3.2.1.1 at NPSH available at 40 feet. At the runout condition (4300 gpm) some reduction of performance is allowed.

3.2.1.2.2 Mixing Tank Operation – During mixing tank operation, the sodium temperature will be in the range from 600°F to 1050°F. For mixing tank operation, the pump shall be designed to operate without loss of performance or damage due to cavitation over the range from 26 gpm at 100 feet or more developed head to 270 gpm at 110 feet or more developed head with available net positive suction head of 22 feet or less. The maximum rate of change of temperatures of sodium entering the pump is 200°F per hour.

3.2.1.3 Pump-Generated Pressure Pulsations – The fluctuations in sodium pressure due to the interaction between the blades in the impeller and diffuser vanes shall not exceed ±1.8 psi as measured downstream of the discharge nozzle within the steady-state operating region.

3.2.2 Noise Emission – During water testing and plant operation, the airborne noise shall not exceed 85 dba at any distance 10 ft or greater from the pump assembly.

3.2.3 Pump and Vibration – The pump unit shall be designed to minimize mechanical and hydraulic instabilities. It shall be designed to withstand internally or externally (as herein specified) generated operational vibrations or flow-induced pressure oscillations (as herein specified) without causing any damage to or malfunction of the pump unit. During testing and operation, the amplitude of vibrations generated by the pump as measured at the suction nozzle and at the discharge nozzle shall not exceed 0.005 in. at frequencies of 33 Hz or less.

3.2.3.1 Pump mounting – The pump will be mounted on a steel support structure. The stiffness constants for the pump tank support flange are as follows:

Horizontal	East-West	TBD lb/in.
Horizontal	North-South	TBD lb/in.
Vertical		TBD lb/in.
Overturning	East-West	TBD in. lb/radian
Overturning	North-South	TBD in.lb/radian
Torsional about Pump Centerline		TBD in.lb/radian

Requirement to be suggested by pump supplier.

3.2.3.2 Structural Resonance — The pump system's first structural resonance shall be 120% of the pump maximum speed or greater.

3.2.4 Temperature Control — The preheater system shall have the capability to heat the sodium-containing portions of the pump (prior to sodium fill) at a desired uniform preheat average rate of 10°F/hr from a nominal -10° to +350°F with the pump under an argon atmosphere. The preheater system shall also be capable of holding the pump at a temperature of 1100 ± 20°F when the pump is filled to the normal level with sodium. The thermal barrier and the pump insulation shall be designed so the metal parts of the pump which are exposed to operator contact shall not exceed 140°F at the environmental conditions of Appendix A.

3.2.4.1 Sodium Overfill — The pump shall be designed to prevent external spilling of sodium in the event of an accidental sodium overfill. Heaters shall be provided to melt out solidified sodium after an accidental sodium overfill.

3.2.5 Drive Motor and Speed Control — The drive motor shall meet the requirements of ANSI/NEMA MG1-1978. The motor power supply will be 480 volts, 3 phase, 60 Hz.

3.2.5.1 Control Stability – The pump shall maintain a speed within ±0.5% of the set point for at least 6 hours when all other input conditions (hydraulic, thermal, electrical, and mechanical) remain constant. The pumps shall have stable operation over the region specified in 3.2.1 through 3.2.1.2.3.

3.2.5.2 Control Response – The pump speed control shall be capable of increasing or decreasing the pump speed at a rate of not less than 1% per second at any pump operating condition.

3.2.5.3 Control Sensitivity – The pump speed control shall be smooth and continuous and capable of set point changes of 1% or less.

3.2.6 Internal Leakage — No leakage of oil to the liquid sodium shall be permitted. The seal leakage system for the pump shaft lower oil seal shall be capable of draining seal leakage at a rate that is great enough to prevent oil from mixing with the sodium in the pump tank; and, in normal operation, shall not allow the escape of argon cover gas at a rate to exceed 0.0025 scfm. Provision shall be made to collect argon gas so that it may be passed through a sodium knockout drum before it enters the atmosphere. Any reservoirs provided for collection of internal or external oil leakage shall have capacities large enough that draining and disposing of normal oil leakage will not be required more often than once in 2 months.

3.2.6.1 Shaft Sealing System – The shaft seal system shall not permit out-leakage of cover gas and sodium vapor or inleakage of air or oil into the sodium except as defined in 3.2.6. The lower oil seal shall be compatable with bone dry argon gas.

3.2.6.2 Sodium Leakage – No leakage of sodium shall be permitted.

3.2.6.3 Oil System – The combined total oil leakage from the oil system(s) shall not exceed 10 cc/h.

3.2.7 Duty Cycle and Availability – The pump shall be designed to operate for not more than 12 hours on sunny days. The design shall be based on 270 operating days per year and an annual shutdown period of 30 days for maintenance. The pump shall have an availability of 99.8% of required operating hours.

3.2.8 Service Life – The pump structural components shall have a service life of 30 years when operated under the conditions specified in 3.2 and the environments of Appendix A. Service life of the pump seals and instrumentation sensors shall be as given below based upon the maintainability requirements of Section 3.2.9.

a. Elastomer seals shall have a service of 5 years.

b. Inner and other shaft seals shall have a service life of 5 years with a confidence level of 90% or better.

c. Instrumentation sensors shall have a service life of 5 years.

3.2.9 Maintainability

3.2.9.1 Objectives – The pump shall be designed such that the internals, including all rotating parts and all rubbing surfaces may be removed from the pump tank as a unit. The design of the pump shall enable all major inspections and maintenance operations (including all operations that require removing the pump internal assembly from the pump tank) to be performed during the annual shutdown period. Operations that can be performed within a 12-hour period can be planned for an interval of less than 1 year. Provisions shall be made for keeping an inert atmosphere in the pump tank during seal servicing or removal of the pump internals.

3.2.9.2 Sodium Drainability – Provision shall be made for drainability of surfaces wetted (or potentially wetted) with sodium or subject to sodium frost accumulation. Flow through passages shall be provided where possible to facilitate draining and flushing.

3.2.9.3 Sodium Removal – Provisions shall be made to maintain an inert atmosphere over the sodium wetted parts of the pump inner structure during removal from the pump tank and transportation to a cleaning vessel. The design of the inner structural assembly and its parts shall facilitate the removal of sodium and sodium frost both in the assembled condition and following disassembly.

3.2.9.4 Sodium Level Control – The system for controlling sodium level in the pump during normal operation shall be designed to operate with an argon supply pressure of 350 psig. Consumption of argon for level control shall not exceed TBD. The maximum pressure at the pump suction nozzle is 22 psig.

3.2.9.5 Sodium Bearing – The sodium bearing will be pressurized with sodium from sources that are external to the pump. During starts and for a short period after starts, the pressure supplied to the bearing will be in the range from 85 psig to 320 psig. During normal operation, the pressure supplied to the bearing will be pump discharge pressure. The pressure surrounding the bearing will range from 2.4 psig to 22 psig. The bearing sodium supply system in the pump shall provide a location where the sodium velocity is low enough to settle out steel particles with a diameter larger than 50% of the centered bearing clearance.

3.2.9.6 Pump Tank – The pump tank shall be designed for a maximum internal pressure of 330 psig.

3.2.9.7 Convection – The pump internals shall be designed to prevent gas convection that could cause adverse differential thermal expansion.

3.2.9.8 Environment – The pump operating environment will be as shown in Appendix A.

3.2.9.9 Working Fluid – The working fluid will be liquid sodium.

3.3 Pump Construction

3.3.1 Code — Pressure boundary containment shall be constructed in accordance with ANSI/ASME BPV-VIII- 1.

3.3.2 Seismic — Seismic design and analysis of the pump assembly shall be in accordance with the Uniform Building Code, considering a Zone 4 occurrence with ZIKCS = 0.40 and with a vertical load of 0.27 times the dead load.

3.4 Loading — The pump shall be designed for loading in accordance with the Code (3.3.1) Part UG-22.

3.5 Safety — Safety considerations to protect human life and limb shall be part of all pump design and construction detail in accordance with applicable OSHA requirements.

3.6 Lift Points — The pump shall be provided with lift points such as threaded holes, eyebolts, or lugs for lifting components exceeding 50 lb during transport, installation, or maintenance.

3.6.1 Lifting Lug Design Safety Factor — All lifting lugs shall be designed using the more stringent of the following design options:

a. A design safety factor of 5 using the material ultimate strength, or

b. A design safety factor of 3 using the material yield strength.

3.7 Transportability — The components of the pump unit shall be constructed so as to be shipped by conventional modes of transportation to an inland site having all-weather highway access. Each part or subassembly shall be designed such that it can be safely lifted or handled.

3.7.1 Special Handling Requirements The pump internals shall be designed to permit shipping as an assembly after exposure to sodium. The assembly of the pump internals may be shipped from the operating site to a sodium removal site each time it is necessary to remove the internals from the pump tank. The container to be used for such shipment will be the subject of a separate procurement.

3.8 Identification and Marking — Identification marking of parts and components shall be in accordance with the manufacturer's applicable drawing.

3.8.1 Identification Plates — A permanent identification plate shall be attached to the pump assembly and shall include the information as required by Part UG-116 of the Code (3.3.1).

3.9 Interchangeability — All replaceable parts or assemblies having the same part number shall be interchangeable with respect to installation and performance. The replacement of interchangeable parts or modules, as applicable, shall require a minimum of adjustment, realignment, or replacement of mating or adjoining assemblies. Interchangeability requirements shall not apply to permanent assemblies such as welded, potted, encapsulated, or matched detail parts. The design shall make use of parts that will be available on a long-term basis wherever feasible.

3.10 Instrumentation — Design provision for the installation of the instruments required for the pump unit and auxiliary systems shall be made.

All instruments and leads shall be supported so that their natural frequency is at least 1.5 times the pump shaft maximum forcing frequency. Mercury and water shall not be used in any part of the instrumentation.

3.10.1 Instrumentation List — As a minimum, the instruments for the pump unit are to monitor the following parameters:

a. Pump Drive and Shaft Seal

   1) Critical motor temperatures

   2) Bearing metal temperatures

   3) Seal temperature

b. Pump Assembly

   1) A stainless steel thimble shall be provided for an induction type sodium level probe. The dimensions of the thimble are TBD.

2) Internal temperature of:

   a) sodium in pump

   b) cover gas

   c) thermal barrier

   d) floor plate

   e) temperature needed to monitor and control pump heating.

c. Auxiliary Systems

1) External temperature as required to monitor and control pump heating system

2) Bearing lubricant temperature and pressure as required

3) Seal fluid temperatures and pressures as required

4) Sodium level control system measurements as required for monitoring and control

5) Auxiliary fluid tank levels as required.

3.11 Material Requirements – Material selection shall be based upon the construction code requirements, design life, operational and maintenance considerations.

3.11.1 Corrosion Protection – All materials shall be treated to resist corrosion if not inherently corrosion-resistant. All surface finishes shall be compatible with environmental conditions. If susceptible to electrolytic corrosion, dissimilar metals shall not be used in contact. Only nonhalogenated materials shall be selected for static seals. Lubricants selected for shaft seals or upper bearings shall be nonhalogenated types that are compatible with contact materials.

3.12 Fabrication

3.12.1 General Requirements – Fabrication, inspection, and assembly of the components shall be in accordance with fabrication procedures.

3.12.2 Equipment Protection — Extreme care shall be exercised to protect all surfaces from contamination during fabrication, handling, testing, and storage. Precautions necessary to assure such protection shall be incorporated in the detailed component or fabrication procedure. Detailed procedures for cleanness control, in-process cleaning, and final cleaning of all parts, components, and assemblies shall be prepared.

3.12.3 Sensitization — Except for welding and/or heat treatment procedures, austenitic stainless steel shall not be subjected to temperatures over 750°F during fabrication.

3.12.4 Plating — Chemical vapor plating, vacuum vapor disposition, and flame spraying shall not be permitted on materials in contact with sodium or sodium vapor.

3.12.5 Welding — All pressure boundary weld joints shall be full penetration welds. Backing rings, if used, shall be removed. Partial penetration of internal welds in contact with sodium shall be designed to prevent sodium entrapment.

3.12.6 Permissible Types of Welded Joints — Welded joints shall be designed to permit required physical and visual accessibility for welding and nondestructive examination personnel and equipment.

3.12.7 Threaded Fasteners — All screw threads shall conform to ANSI B1.1. Threaded fasteners used internal to the pump barrel and case assembly shall be equipped with positive locking devices to prevent rotation and to trap the head or nut of the fastener in order to prevent escape into the system in the event of failure. Bolted joints shall permit drilling out (accidentally) ruptured bolts or studs and retrapping to a larger size.

3.13 Cleaning — The pump shall be cleaned of rust, scale, oxides, and contaminants using a cleaning agent free of halides or halogens. Precautions shall be taken to maintain a clean, dry contaminant-free surface after cleaning by sealing all openings. The final cleaned surface shall have no rust, scale, or any contamination visible without magnification to a person with normal visual acuity, natural or corrected.

3.14 Testing Requirements

3.14.1 Acceptance Tests

3.14.1.1 Pressure Test — A hydrostatic or pneumatic pressure test of the pump shall be conducted in accordance with the Code (3.3.1) and this specification. Where a hydrostatic test is to be used, the water shall meet the purity requirements of 3.14.2.2.

3.14.2 Performance Tests

3.14.2.1 General Requirements — The pump unit is to be flow tested with water in accordance with ASME PTC 812-1965 with 1973 Addenda.

3.14.2.2 Water Tests — Full-scale tests of the pump unit shall be conducted in water to verify the hydraulic and mechanical performance. Water used for the tests shall meet the requirements of 6.1.

a. Hydrodynamic Performance Tests — These tests shall establish curves of head, required NPSH, efficiency, and power input versus flow over the operating ranges shown in Figure 2.

b. Special Tests — Additional tests are required to generate operating data including, but not limited to, pump vibration, speed control, and sodium level control.

c. Post-Test Pump Draining — After completion of these tests, the pump shall be drained, cleaned, and dried.

4. QUALITY ASSURANCE PROVISIONS

4.1 Quality Control System — A quality control system shall be established and maintained meeting the requirements of Appendix 10 of the Code (see Section 3.3.1).

4.2 Design Verification — It shall be verified that the pump design and maintenance requirements of this specification are met. Verification shall be accomplished by the following methods.

4.2.1 Hydraulic performance requirements will be verified by comparison of the requirements to the test results of the reference pump that is being scaled for this application. If any of the requirements of this specification are not included in the test conditions for which data is available on the reference pump, compliance will be verified in water test. Verification of the requirements will be confirmed in plant operation. The specific requirements to be verified by this method are:

3.2.1
3.2.1.1
3.2.1.2
3.2.1.2.1
3.2.1.2.2
3.2.1.3
3.2.3

4.2.2 Noise emission requirements will be verified in water test and plant operation. The specific requirement to be verified by this method is 3.2.2.

4.2.3 Pump-mounting requirements will be considered verified when the values recommended for stiffness constants allow the requirements of 3.2.3.2 and 3.2.3 to be met. The specific requirement to be verified by this method is 3.2.3.1.

4.2.4 Structural resonance requirements may be verified by modeling the pump shaft, pump tank, pump internal support structure, drive motor system, and pump mount in a multi-bean spring mass model, calculating resonances and reactions by means of ANSYS or an equivalent computer code, and showing that the calculated results meet the requirement. A demonstration shall be made that the computer code used has been used before successfully to predict resonances and reactions of a pump with construction that is similar to the subject pump. The verification will be confirmed in plant operation. The specific requirement to be verified by this method is 3.2.3.2.

4.2.5 Verification of the design of temperature control features (including preheaters, thermal barrier, pump insulation, and anti-convection features) shall be done by means of a mathematical thermal analysis model. Accurate predictions of temperature distributions are not required. The model may be simplified to any degree that will still provide reasonable assurance that excessive convection will not occur and that limiting temperature and heat rates are not exceeded. The limiting temperature includes the 140°F maximum temperature for operator contact and the maximum temperatures for the desired operating life of the shaft seals, seal fluid, and other materials used in the pump topworks. The limiting heat rates include, at least, the cooling capacity of the seal fluid system and the heating capacities of the heating systems. The verification will be con- firmed in plant operation. The specific requirement to be verified by this method is 3.2.4.

4.2.6 The verification methods to be used for some requirements will not be determined until the design concept is established. The specific requirements in this classification at the time of the revision of the specification are:

3.2.4.1
3.2.9.4 3.2.9.7

4.2.7 The verification methods for the design requirements of the pump drive motor and speed control system will be determined by the pump supplier and by the suppliers of the motor and control system. The specific requirements to be verified by these methods are 3.2.5, 3.2.5.1, 3.2.5.2, and 3.2.5.3.

4.2.8 For design purposes, the leakage requirements will be verified by one or more of the following methods:

a. Static seal joints are designed to the Code (3.3.1) or, if "O" ring seals are used, the joints are designed to the "O" ring supplier's recommended practice. All gasket and "O" ring materials shall be shown to be suitable to the temperature and fluid environments in which they are used.

b. Shaft seals are designed to the seal supplier's conventional design practice, and the seal leakages are calculated by the seal supplier's normal method.

c. Shaft seal leakage recovery system has a capacity for 20 times the calculated shaft seal leakage.

d. Gas leakage is calculated by conventional flow analysis at the limiting conditions.

Verification of the leakage requirement will be confirmed in water test and plant operation. The specific requirements to be verified by these methods are 3.2.6 and 3.2.6.3.

4.2.9 The seal system and sodium leakage requirements will be verified by designing the pressure boundary to the Code (3.3.1) and the seismic loading of 3.3.2; and by using a design that provides a pressurized body of liquid oil or seal fluid above the lower shaft seal. The pressure of the body of liquid will be maintained higher than the pressure of the pump cover gas at all times except periods of disassembly. This verification will be confirmed in water test and plant operation. The specific requirements to be verified by these methods are 3.2.6.1 and 3.2.6.2.

4.2.10 In design, the duty cycle and availability requirements will be verified by using the pump supplier's judgment of the availability of the system components. The benefits of a fully developed and proved design together with a fully developed prevention and scheduled maintenance program may be assumed. Overfilling and other human or system-operating failure events need not be considered. The verification will be confirmed in water test and plant operation. The specific requirement to be verified by this method is 3.2.7.

4.2.11 In design, verification of service life will be done by choosing materials for suitable life assuming regular maintenance such as repainting components that are exposed to weather. Parts that are subject to fatigue (such as bearings, flexing parts, and springs) will be verified by a fatigue-life calculation using data for similar materials. The life of rubbing for seals will be verified by experience with the same (or closely similar) materials operating with a PV value as high as, or higher than, the values used in this application and operating in an oil/air or oil/argon (as appropriate) environment. Verification of the life of elastomers can be done with data from the product supplier's experience with similar applications. Verification of the life of instrument sensors and instrument system components can be done with the supplier's experience in similar applications. Service life will be confirmed in water test and plant operation. The specific requirement to be verified by these methods is 3.2.8.

4.2.12 The maintainability objectives can be verified by the following methods:

a. Removal of the internals as a unit can be verified by examination of the design layout or assembly drawing. This requirement can be confirmed during pump assembly.

b. The inspection and maintenance intervals can be verified by examination of the operation and maintenance manual. The requirement will be confirmed in plant operation.

c. Provisions for maintaining an inert atmosphere in the pump tank can be verified by drawings showing the maintenance shaft seal; and interface connections on the tank and the internals for a plastic bag-type removal envelope.

The specific requirements to be verified by these methods are in 3.2.9.1.

4.2.13 Verification of sodium drainability will be by a design layout showing that all major spacers will drain by gravity and that no single undrained pocket will contain more than 3 cc of sodium. This requirement will be confirmed in plant maintenance. The specific requirement to be verified by this method is 3.2.9.2.

4.2.14 The provisions for sodium removal will be verified by the following methods:

a. A design layout that shows connections for a plastic bag system of inerting the pump internals during and after removal from the tank.

b. A design layout showing that there are no gas traps that would prevent sodium removal by immersing the pump internals in a liquid sodium removal agent.

c. Design layout, tool drawings, and load/stress analysis showing that the pump rotor and all parts of the internals will be adequately supported for shipping when the assembly is in the configuration to be used for transfer to a sodium removal facility as indicated in 3.7.1.

The requirements for sodium removal will be confirmed in plant maintenance. The specific requirement to be verified by these methods is 3.2.9.3.

4.2.15 Verification of the sodium-bearing design will be based on bearing loads estimated by the pump supplier's normal method of estimating rotor loads. Design of the bearing will be verified by an analysis showing that the maximum bearing deflection for any steady-state operating point will not exceed 70% of the centered bearing clearance. The analysis of bearing performance will assume that the pressure surrounding the bearing will vary from 2.4 to 22 psi, independently of the pump operating point. Performance of the bearing will be confirmed in water test and plant operation. The specific requirement to be verified by this method is 3.2.9.5.

4.2.16 The pump tank design will be verified by analysis showing that the tank meets the requirements of 3.3.1, 3.3.2, and 3.4 for the required pressure and temperature conditions. The tank design method will be confirmed in plant operation. The specific requirement to be verified by this method is 3.2.9.6.

4.2.17 The environmental requirements will be verified by the use of the required environmental conditions as boundary conditions in the various analyses made for the design of the pump and auxiliary equipment. The specific requirement to be verified by this method is 3.2.9.7.

4.2.18 The working fluid requirement will be verified by drawing callouts for materials that are compatible with sodium for all parts that could be exposed to sodium. The specific requirement to be verified by this method is 3.2.9.8.

5. PREPARATION FOR DELIVERY

5.1 General Requirements

5.1.1 Packaging — The pump components, subassemblies, and parts shall be packaged by sealing all exterior openings with covers, plugs, or caps. The items shall then be wrapped with a waterproof vapor barrier material for shipping.

5.1.2 Cleanness — The pump shall be free of visible dirt, corrosion, and extraneous materials prior to packaging. Packaging materials such as wraps, plugs, caps, and cushioning, shall be clean. Cleanness of the pump shall be maintained in accordance with Section 3.13.

5.1.3 Handling — Pump components over 50 pounds shall have provisions for handling (as specified herein).

5.1.4 Shipping — The pump components shall be designed and constructed to withstand vibration and shock loads during shipping.

5.2 Special Handling

5.3 Shipping Requirements — The supplier shall be responsible for delivery of the pump assembly and associated parts/systems covered by this specification to the delivery point. These responsibilities include routing, shipping instructions, and documentation.

6. NOTES AND DATA

6.1 Water Purity — The water used for testing the pump shall meet the following requirements:

Chloride, ppm maximum	1.0
Fluoride, ppm maximum	0.1
Conductivity, mhos/cm maxmimum	20.0
pH	6.0-8.0
Turbidity, Jackson Candle Units, maximum	1.0

5026s/emh

Rockwell International
Energy Systems Group

DESIGN DATA SHEET

TITLE
Appendix A of Specification
N30501

Pump Requirement Summary

NUMBER N30501-1
PAGE 1
DATE 3/17/83

PREPARED BY
APPROVED BY
WBS NO.

NEW REV	NO.	ITEM	UNIT	VALUE		TEN-TATIVE	FIRM	REFERENCES AND REMARKS
				OPERATING	DESIGN			
	1	Pump Output Flow	gpm	2650	3200			
	2	Total Developed Heat (Minimum)	ft	180	250			
	3	Cover Gas		Argon	Argon			
	4	Cover Gas Pressure	psig	22				Minimum Cover Gas Pressure 1.69 psig
	5	Minimum NPSH Available	ft	45	40 22			At Maximum Speed At Reduced Pump Speed
	6	Working Fluid	-	Sodium	Sodium			
	7	Sodium Temperature	°F	1000	1050			
	8	Preheat Temperature	°F	300	350			
	9	Test Fluid	-	Water				
	10	Water Temperature	°F					
		Maximum		130				
		Minimum			50			
	11	General Environment	-	Outdoor	Outdoor			
	12	Environmental Temperature	°F					
		Maximum		120	130			
		Minimum		-10	-20			

FORM 706-A REV. 11-82

Rockwell International
Energy Systems Group

DESIGN DATA SHEET

TITLE
Appendix A of Specification
N30501
Pump Requirement Summary

NUMBER N30501-1

PAGE 2

DATE 3/17/83

PREPARED BY

APPROVED BY

WBS NO.

<table>
<tr><th rowspan="2">NEW REV</th><th rowspan="2">NO.</th><th rowspan="2">ITEM</th><th rowspan="2">UNIT</th><th colspan="2">VALUE</th><th rowspan="2">TEN-TATIVE</th><th rowspan="2">FIRM</th><th rowspan="2">REFERENCES AND REMARKS</th></tr>
<tr><th>OPERATING</th><th>DESIGN</th></tr>
<tr><td></td><td>13</td><td>Solar Radiation Gain</td><td>w/ft^2</td><td></td><td>100</td><td></td><td></td><td></td></tr>
<tr><td></td><td>14</td><td>Ambient Pressure</td><td>psia</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td></td><td></td><td>Test</td><td></td><td></td><td>14.8</td><td></td><td></td><td></td></tr>
<tr><td></td><td></td><td>Operating</td><td></td><td></td><td>13.6</td><td></td><td></td><td></td></tr>
<tr><td></td><td>15</td><td>Ambient Humidity</td><td>%RH</td><td></td><td></td><td></td><td></td><td></td></tr>
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<tr><td></td><td></td><td>Minimum</td><td></td><td>5</td><td></td><td></td><td></td><td></td></tr>
<tr><td></td><td>16</td><td>Suction Pipe Diameter</td><td>in.</td><td></td><td>20</td><td></td><td></td><td></td></tr>
<tr><td></td><td>17</td><td>Discharge Pipe Diameter</td><td>in.</td><td></td><td>10</td><td></td><td></td><td></td></tr>
</table>

FORM 706-A REV. 11-82

3.3.2 RECEIVER SODIUM PUMP
(N30500)

Rockwell International

Energy Systems Group

PROCUREMENT SPECIFICATION

PREPARED BY J. O. Pfouts

DATE

NUMBER N30500

REV New

TYPE Component

TOTAL PAGES 21

E.O. 5-18-83 RR 105929

TITLE

Carrizo Plains - Unit 1 - Receiver Pump

APPROVALS

L. E. Glasgow

L. E. Glasgow
Cognizant Engineer

0102C/jbv

FORM N 131-H-6 REV. 2-79

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SODIUM PUMP FOR A SOLAR POWER PLANT

1. SCOPE

This specification establishes the requirements for the design and construction of a pump for the sodium heat transport system of a solar central receiver power plant.

1.1 Equipment and Services to be Furnished by Supplier

a. Pump, shaft, hydraulic and support assemblies, including connections for instrumentation, cooling, lifting, and cover gas control.
b. Three phase, 4160 volt induction drive motor equipment, including necessary cooling and monitoring equipment.
c. Pump tank complete with nozzles, saddles, and structural supports required for installation and maintenance.
d. Shaft seal assembly with instrumentation necessary to monitor seal operation.
e. Electrical preheating and thermal insulation for the pump.
f. Instrument sensors. (Except sodium level sensor.)

2. DOCUMENTS

2.1 Applicable Documents - The following documents of the exact issue shown form a part of this specification to the extent specified herein. In the event of conflict between the documents referenced here or other detail contents of this specification, the detail contents of this specification shall be considered a superceding document. The order of precedence of documents is: (1) procurement specification, (2) ASME Code, (3) ANSI specification, and (4) other specifications. Any conflict between invoked codes, standards, and specifications shall be brought to the attention of the owner or owner's designee for resolution.

a. American Society of Mechanical Engineers (ASME)

- ASME Boiler and Pressure Vessel Code, 1980 Edition with Addenda through Winter 1981

ANSI/ASME BPV-VIII-1	Rules for Construction of Pressure Vessels
PTC 8.2-1965 (with 1973 Addenda)	Test Code for CENTRIFUGAL Pumps

b. American National Standards Institute - ANSI)

. ANSI B-1.1-1974	Unified Inch Screw Threads
. ANSI/NEMA MG1-1978	Motors and Generators

3. REQUIREMENTS

3.1 Pump Definition — The pump shall be a vertical shaft, free surface, piped suction-type pump with a fixed speed electric motor. The pump assembly shall consist of a pump bowl assembly including suction and discharge nozzles, pump tank with free surface liquid level control nozzle, drive shaft including bearings and seals, electrical drive motor, shaft-to-motor coupling, motor mount, lubrication, purge gas and cooling systems, instrumentation sensors, electrical preheating, thermal insulation for the pump section, provisions for maintaining an inert atmosphere during maintenance, provisions for pressurizing the pump bearing by external means, and provisions for protecting the pump from a sodium overfill. The design shall provide for shipping the pump internals as an assembly.

3.1.1 Pump Diagram — The arrangement of the pump assembly shall be similar to Figure 1.

3.1.2 Interface Definition — The pump assembly will interface with the following systems and elements:

a. Mounting structure that supports the pump assembly.

b. Mounting surfaces for auxiliary equipment, if necessary.

c. Argon gas piping for level control and cover gas.

d. Level control piping for sodium or a mixture of sodium and argon.

e. Sodium piping for pump inlet and discharge nozzles.

f. A connection through which liquid sodium will be supplied from an external source to the sodium pump to pressurize the sodium bearing.

g. Interconnections between the oil system(s) or other auxiliary systems and the sodium pump or the drive motor, if required.

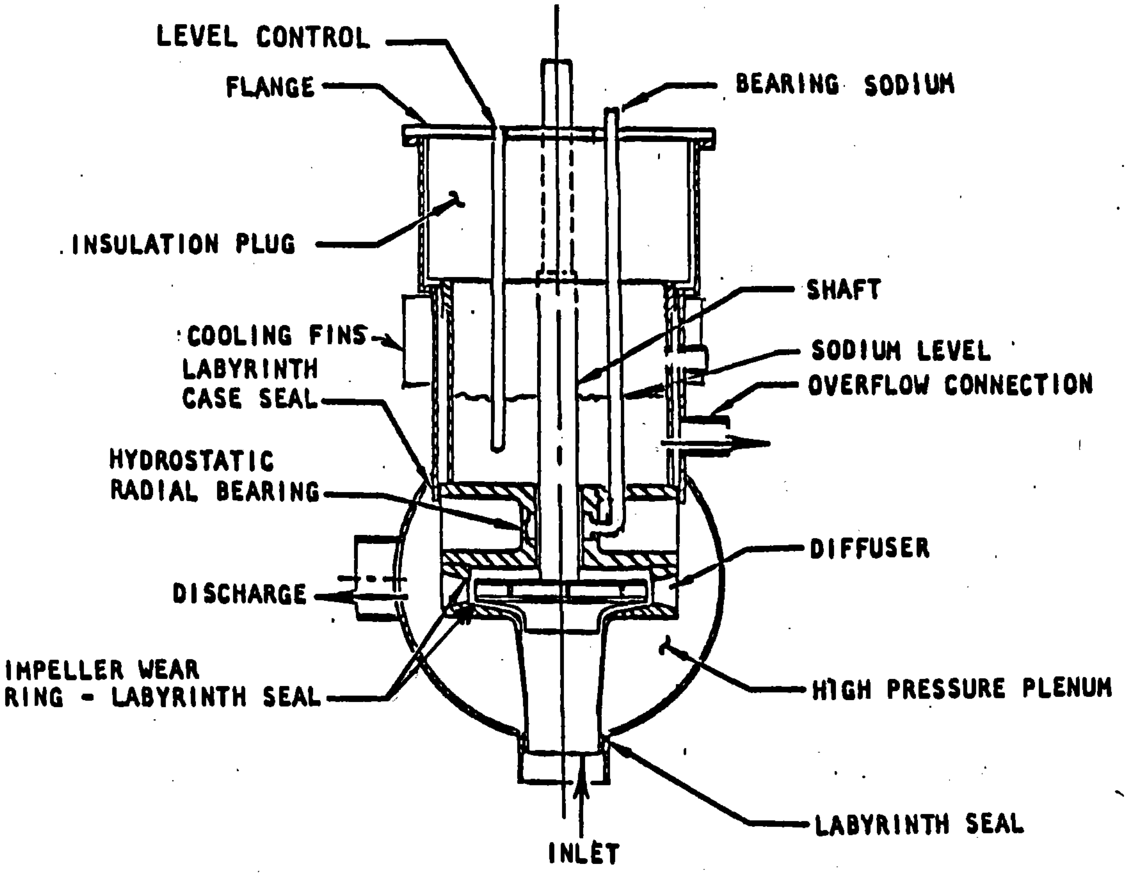

Figure 1. Pump Assembly Arrangement Schematic

h. Drive motor electrical connections.

i. Preheat power connections and other electrical power connections.

j. Instrument connections for data, for alarms, and for controls.

3.2 Operating Requirements

A summary of the pump operating requirements, Appendix A, which is Design Data Sheet N30500-1.

3.2.1 Performance Characteristics — The pump head vs flow curve required for running speed is defined by the requirements as follows:

a. The pump is required to produce 3800 gpm (120% of nominal operating flow) at a total development head of 650 ft or more.

b. The maximum slope of the head vs flow curve at 3800 gpm shall be a 1% increase in head for a 4% decrease in flow, and the slope shall be negative for all points from zero flow to maximum flow.

The pump head vs flow curve is shown in Figure 2. As a goal, the best efficiency point should occur between 1900 gpm (60% of nominal operating flow) and 3167 gpm (100% of nominal operating flow).

3.2.1.1 Operating Stability — The pump shall be designed to operate stably in a system has has two of the subject pumps operating in parallel to pump liquid sodium up a tower to a solar receiver and a pressurized surge tank. During a normal start, both pumps will discharge to a closed check valve. The check valve will open during the starting speed transient at a pump developed head between 240 ft and 440 ft. The pump will operate steady state at flow rates from 316.7 gpm (10% of nominal operating flow) to 3800 gpm (120% of nominal operating flow). In the event of a failure of one pump, the remaining pump must be capable of operating at a runout flow rate of 4700 gpm.

3.2.1.2 Cavitation Performance — The pump shall be designed to operate without loss of performance due to cavitation and without damage due to cavitation over the entire flow range from 316 gpm to 3800 gpm at an available NPSH of 40 ft. At the runout condition (4700 gpm), some reduction of performance due to cavitation is allowed.

TBD

Figure 2. Pump Operational Boundaries

3.2.1.3 Pump-Generated Pressure Pulsations — The fluctuations in sodium pressure due to the interaction between the blades in the impeller and diffuser vanes shall not exceed ±1.8 psi as measured downstream of the discharge nozzle within the steady-state operating region.

3.2.2 Noise Emission — During water testing and plant operation, the airborne noise shall not exceed 85 dba at any distance 10 ft or greater from the pump assembly.

3.2.3 Pump and Vibration — The pump unit shall be designed to minimize mechanical and hydraulic instabilities. It shall be designed to withstand internally or externally (as herein specified) generated operational vibrations or flow-induced pressure oscillations (as herein specified) without causing any damage to or malfunction of the pump unit. During testing and plant operation, the amplitude of vibrations generated by the pump as measured at the suction nozzle and at the discharge nozzle shall not exceed 0.005 in. at frequencies of 33 Hz or less.

3.2.3.1 Pump mounting — The pump will be mounted on a steel support structure. The stiffness constants for the pump tank support are as follows:

Horizontal	East-West	TBD lb/in.
Horizontal	North-South	TBD lb/in.
Vertical		TBD lb/in.
Overturning	East-West	TBD in.lb/radian
Overturning	North-South	TBD in.lb/radian
Torsional about Pump Centerline		TBD in.lb/radian

These requirements to be supported by pump supplier.

3.2.3.2 Structural Resonance — The pump system's first structural resonance shall be 120% of the pump maximum speed or greater.

3.2.4 Temperature Control — The preheater system shall have the capability to heat the sodium-containing portions of the pump (prior to sodium fill) at a desired uniform preheat average rate of 10°F/hr from a nominal -10° to +350°F with the pump under an argon atmosphere. The preheater system shall also be capable of holding the pump at a temperature of 610 ± 20°F when the pump is filled to the normal level with sodium. The thermal barrier and the pump insulation shall be designed so the metal parts of the pump above the mounting flange shall not exceed 140°F at the environmental conditions of Appendix A.

3.2.4.1 Sodium Overfill – The pump shall be designed to prevent external spilling of sodium in the event of an accidental sodium overfill. Heaters shall be provided to melt out solidified sodium after an accidental sodium overfill.

3.2.4.2 Drive Motor – The drive motor shall meet the requirements of ANSI/NEMA MG1-1978 for a 4160 V motor.

3.2.5 Shaft Sealing System – The shaft seal system shall not permit out-leakage of cover gas and sodium vapor or inleakage of air or oil into the sodium except as defined in 3.2.5.1. The lower shaft seal shall be compatible with bone dry argon.

3.2.5.1 Internal Leakage – No leakage of oil to the liquid sodium shall be permitted. The seal leakage system for the pump shaft lower oil seal shall be capable of draining seal leakage at a rate that is great enough to prevent oil from mixing with the sodium in the pump tank; and, in normal operation, shall not allow the escape of argon cover gas at a rate to exceed .0025 scfm. Provision shall be made to collect escaping argon gas so that it may be passed through a sodium knockout drum before it enters the atmosphere. Any reservoirs provided for collection of internal or external oil leakage shall have capacities large enough that draining and disposing of normal oil leakage will not be required more often than once a week.

3.2.5.2 Sodium Leakage – No leakage of sodium shall be permitted.

3.2.5.3 Oil System – The combined total oil leakage from the oil system(s) shall not exceed 16 cc/h.

3.2.6 Duty Cycle and Availability – The pump assembly shall be designed to operate for not more than 14 hours on sunny days. The design shall be based on 270 operating days per year and an annual shutdown period of 30 days for maintenance. The pump shall have an availability of 99.8% of required operating hours.

3.2.7 Service Life – The pump structural components shall have a service life of 30 years when operated under the conditions specified in 3.2 and the environments of Appendix A. Service life of the pump seals and instrumentation sensors shall as given below be based upon the maintainability requirements of Section 3.2.8.

a. Elastomer seals shall have a service of 5 years.

b. Inner and other shaft seals shall have a service life of 5 years with a confidence level of 90% or better.

c. Instrumentation sensors shall have a service life of 5 years.

3.2.8 Maintainability

3.2.8.1 Objectives — The pump shall be designed such that the internals, including all rotating parts and all rubbing surfaces may be removed from the pump tank as a unit. The design of the pump shall enable all major inspections and maintenance operations (including all operations that require removing the pump internal assembly from the pump tank) to be performed during the annual shutdown period. Operations that can be performed within a 10-hour period can be planned for a period of less than 1 year. Provisions shall be made for keeping an inert atmosphere in the pump tank during seal servicing or removal of the pump internals.

3.2.8.2 Sodium Drainability — Provision shall be made for drainability of surfaces wetted (or potentially wetted) with sodium or subject to sodium frost accumulation. Flow through passages shall be provided where possible to facilitate draining and flushing.

3.2.8.3 Sodium Removal — Provisions shall be made to maintain an inert atmosphere over the sodium wetted parts of the pump inner structure during removal from the pump tank and transportation to a cleaning vessel. The design of the inner structural assembly and its parts shall facilitate the removal of sodium and sodium frost both in the assembled condition and following disassembly.

3.2.8.4 Sodium Level Control — The system for controlling sodium level in the pump during normal operation shall be designed to operate with an argon supply pressure of 75 psig. Consumption of argon for level control shall not exceed TBD. The maximum pressure at the pump suction nozzle is 23.7 psig.

3.2.8.5 Sodium Bearing — The sodium bearing will be pressurized with sodium taken from the pump discharge pipe. During normal operation, the pressure available will be pump discharge pressure. This sodium supply will be turned on before the pump is started. During starts, the pressure supplied to the bearing will be a minimum of 85 psig while the pressure surrounding the bearing will be a maximum of

22 psig. As the pump starts, the bearing supply pressure will rise to pump discharge pressure. The bearing sodium supply system in the pump shall provide a location where the sodium velocity is low enough to settle out steel particles with a diameter larger than 50% of the centered bearing clearance.

3.2.8.6 Convection — The pump internals shall be designed to prevent gas convection that could cause adverse differential thermal expansion.

3.2.8.7 Pump Tank — The pump tank shall be designed for a maximum internal pressure of 100 psig.

3.2.9 Environment — The pump operating environment will be as shown in Appendix A.

3.2.10 Working Fluid — The working fluid will be liquid sodium.

3.3 Pump Construction

3.3.1 Code — Pressure boundary containment shall be constructed in accordance with ANSI/ASME BPV-VIII- 1.

3.3.2 Seismic — Seismic design and analysis of the pump assembly shall be in accordance with the Uniform Building Code, considering a Zone 4 occurrence with ZIKCS = 0.40 and with a vertical load of 0.27 times the dead load.

3.4 Loading — The pump shall be designed for loading in accordance with the Code (3.3.1) Part UG-22.

3.5 Safety — Safety considerations to protect human life and limb shall be part of all pump design and construction detail in accordance with applicable OSHA requirements.

3.6 Lift Points — The pump shall be provided with lift points such as threaded holes, eyebolts, or lugs for lifting components exceeding 50 lb during transport, installation, or maintenance.

3.6.1 Lifting Lug Design Safety Factor — All lifting lugs shall be designed using the more stringent of the following design options:

a. A design safety factor of 5 using the material ultimate strength, or

b. A design safety factor of 3 using the material yield strength.

3.7 Transportability – The components of the pump unit shall be constructed so as to be shipped by conventional modes of transportation to an inland site having all-weather highway access. Each part or subassembly shall be designed such that it can be safely lifted or handled.

3.7.1 Special Handling Requirements – The pump internals shall be designed to permit shipping as an assembly after exposure to sodium. The assembly of the pump internals may be shipped from the operating site to a sodium removal site each time it is necessary to remove the internals from the pump tank. The container to be used for such shipment will be the subject of a separate document.

3.8 Identification and Marking – Identification marking of parts and components shall be in accordance with the manufacturer's applicable drawing.

3.8.1 Identification Plates – A permanent identification plate shall be attached to the pump assembly and shall include the information as required by Part UG- 116 of the Code.

3.9 Interchangeability – All replaceable parts or assemblies having the same part number shall be interchangeable with respect to installation and performance. The replacement of interchangeable parts or modules, as applicable, shall require a minimum of adjustment, realignment, or replacement of mating or adjoining assemblies. Interchangeability requirements shall not apply to permanent assemblies such as welded, potted, encapsulated, or matched detail parts. The design shall make use of parts that will be available on a long-term basis wherever feasible.

3.10 Instrumentation – Design provision for the installation of the instruments required for the pump unit and auxiliary systems shall be made.

All instruments and leads shall be supported so that their natural frequency is at least 1.5 times the pump shaft maximum forcing frequency. Mercury and water shall not be used in any part of the instrumentation.

3.10.1 Instrumentation List – As a minimum, the instruments for the pump unit are to monitor the following parameters:

a. Pump Drive and Shaft Seal

1) Critical motor temperatures

2) Bearing metal temperatures

3) Seal temperature

b. Pump Assembly

1) A stainless steel thimble shall be provided for an induction type sodium level probe. The dimensions of the thimble are TBD.

2) Internal temperature of:

a) sodium in pump

b) cover gas

c) thermal barrier

d) floor plate

e) temperature needed to monitor and control pump heating.

c. Auxiliary Systems

1) External temperature as required to monitor and control pump heating system

2) Bearing lubricant temperature and pressure as required

3) Seal fluid temperatures and pressures as required

4) Sodium level control system measurements as required for monitoring and control

5) Auxiliary fluid tank levels as required.

3.11 Material Requirements – Material selection shall be based upon the construction code requirements, design life, operational and maintenance considerations. The pump case and basic structure are to be mild steel. The pump impeller may be stainless steel if necessary for strength. Thermocouples are to be TBD.

3.11.1 Corrosion Protection – All materials shall be treated to resist corrosion if not inherently corrosion-resistant. All surface finishes shall be compatible with environmental conditions. If susceptible to electrolytic corrosion, dissimilar metals shall not be used in contact. Only nonhalogenated materials shall be selected for static seals. Lubricants selected for shaft seals or upper bearings shall be nonhalogenated types that are compatible with contact materials.

3.12 Fabrication

3.12.1 General Requirements – Fabrication, inspection, and assembly of the components shall be in accordance with fabrication procedures.

3.12.2 Sensitization – Except for welding and/or heat treatment procedures, austenitic stainless steel shall not be subjected to temperatures over 750°F during fabrication.

3.12.3 Plating – Chemical vapor plating, flame spraying, or vacuum vapor deposition shall not be permitted on materials in contact with sodium or sodium vapor.

3.12.4 Welding – All pressure boundary weld joints shall be full penetration welds. Backing rings, if used, shall be removed. Partial penetration of internal welds in contact with sodium shall be designed to prevent sodium entrapment.

3.12.5 Permissible Types of Welded Joints – Welded joints shall be designed to permit required physical and visual accessibility for welding and nondestructive examination personnel and equipment.

3.12.6 Threaded Fasteners – All screw threads shall conform to ANSI B1.1. Threaded fasteners used internal to the pump barrel and case assembly shall be equipped with positive locking devices to prevent rotation and to trap the head or nut of the fastener in order to prevent escape into the system in the event of failure. Bolted joints shall permit drilling out (accidentally) ruptured bolts or studs and retrapping to a larger size.

3.13 Cleaning – The pump shall be cleaned of rust, scale, oxides, and contaminants using a cleaning agent free of halides or halogens. Precautions shall be taken to maintain a clean, dry contaminant-free surface after cleaning by sealing all openings. The final cleaned surface shall have no rust, scale, or any contamination visible without magnification to a person with normal visual acuity, natural or corrected.

3.14 Testing Requirements

3.14.1 Acceptance Tests

3.14.1.1 Pressure Test – A hydrostatic or pneumatic pressure test of the pump shall be conducted in accordance with the Code (3.3.1) and this specification. Where a hydrostatic test is to be used, the water shall meet the purity requirements of 6.1.

3.14.2 Performance Tests

3.14.2.1 General Requirements – The pump unit is to be flow tested with water in accordance with ASME PTC 82-1965 (with 1973 addenda).

3.14.2.2 Water Tests – Full-scale tests of the pump unit shall be conducted in water to verify the hydraulic and mechanical performance. Water used for the tests shall meet the requirements of 6.1.

a. Hydrodynamic Performance Tests – These tests shall establish curves of head, required NPSH, efficiency, and power input versus flow over the operating ranges shown in Figure 2.

b. Special Tests – Additional tests are required to generate operating data including, but not limited to, pump vibration, and sodium level control.

c. Post-Test Pump Draining – After completion of these tests, the pump shall be drained, cleaned, and dried.

4. QUALITY ASSURANCE PROVISIONS

4.1 Quality Control System – A quality control system shall be established and maintained meeting the requirements of Appendix 10 of the Code (see Section 3.3.1).

4.2 Design Verification – It shall be verified that the pump design and maintenance requirements of this specification are met. Verification shall be accomplished by the following methods.

4.2.1 Hydraulic performance requirements will be verified by comparison of the requirements to the test results of the reference pump that is being scaled for this application. If any of the requirements of this specification are not included in the test conditions for which data is available on the reference pump, compliance will be verified in water test. Verification of the requirements will be confirmed in plant operation. The specific requirements to be verified by this method are:

3.2.1
3.2.1.1
3.2.1.2
3.2.1.3
3.2.3

4.2.2 Noise emission requirements will be verified in water test and plant operation. The specific requirement to be verified by this method is 3.2.2.

4.2.3 Pump-mounting requirements will be considered verified when the values recommended for stiffness constants allow the requirements of 3.2.3.2 and 3.2.3 to be met. The specific requirement to be verified by this method is 3.2.3.1.

4.2.4 Structural resonance requirements may be verified by modeling the pump shaft, pump tank, pump internal support structure, drive motor system, and pump mount in a multi-bean spring mass model, calculating resonances and reactions by means of ANSYS or an equivalent computer code, and showing that the calculated results meet the requirement. A demonstration shall be made that the computer code used has been used before successfully to predict resonances and reactions of a pump with construction that is similar to the subject pump. The verification will be confirmed in plant operation. The specific requirement to be verified by this method is 3.2.3.2.

4.2.5 Verification of the design of temperature control features (including preheaters, thermal barrier, pump insulation, and anti-convection features) shall be done by means of a mathematical thermal analysis model. Accurate predictions of temperature distributions are not required. The model may be simplified to any degree that will still provide reasonable assurance that excessive convection will not occur and that limiting temperature and heat rates are not exceeded. The limiting temperature includes the 140°F maximum temperature for operator contact and the maximum temperatures for the desired operating life of the shaft seals, seal fluid, and other materials used in the pump topworks. The limiting heat rates include, at least, the cooling capacity of the seal fluid system and the heating capacities of the heating systems. The verification will be confirmed in plant operation. The specific requirement to be verified by this method is 3.2.4.

4.2.6 The verification methods to be used for some requirements will not be determined until the design concept is established. The specific requirements in this classification at the time of the revision of the specification are:

3.2.4.1
3.2.8.4
3.2.8.6

4.2.7 The verification methods for the design requirements of the pump drive motor will be determined by the pump supplier and by the supplier of the motor. The specific requirement to be verified by these methods is 3.2.4.2.

4.2.8 For design purposes, the leakage requirements will be verified by one or more of the following methods:

a. Static seal joints are designed to the Code (3.3.1) or, if "O" ring seals are used, the joints are designed to the "O" ring supplier's recommended practice. All gasket and "O" ring materials shall be shown to be suitable to the temperature and fluid environments in which they are used.

b. Shaft seals are designed to the seal supplier's conventional design practice, and the seal leakages are calculated by the seal supplier's normal method.

c. Shaft seal leakage recovery system has a capacity for 20 times the calculated shaft seal leakage.

d. Gas leakage is calculated by conventional flow analysis at the limiting conditions.

Verification of the leakage requirement will be confirmed in water test and plant operation. The specific requirements to be verified by these methods are 3.2.5.1 and 3.2.5.3.

4.2.9 The seal system and sodium leakage requirements will be verified by designing the pressure boundary to the Code (3.3.1) and the seismic loading of 3.3.2; and by using a design that provides a pressurized body of liquid oil or seal fluid above the lower shaft seal. The pressure of the body of liquid will be maintained higher than the pressure of the pump cover gas at all times except periods of disassembly. This verification will be confirmed in water test and plant operation. The specific requirements to be verified by these methods are 3.2.5 and 3.2.5.2.

4.2.10 In design, the duty cycle and availability requirements will be verified by using the pump supplier's judgment of the availability of the system components. The benefits of a fully developed and proved design together with a fully developed prevention and scheduled maintenance program may be assumed. Overfilling and other human or system-operating failure events need not be considered. The verification will be confirmed in water test and plant operation. The specific requirement to be verified by this method is 3.2.6.

4.2.11 In design, verification of service life will be done by choosing materials for suitable life assuming regular maintenance such as repainting components that are exposed to weather. Parts that are subject to fatigue (such as bearings, flexing parts, and springs) will be verified by a fatigue-life calculation using data for similar materials. The life of rubbing for seals will be verified by experience with the same (or closely similar) materials operating with a PV value as high as, or higher than, the values used in this application and operating in an oil/air or oil/argon (as appropriate) environment. Verification of the life of elastomers can be done with data from the product supplier's experience with similar applications. Verification of the life of instrument sensors and instrument system components can be done with the supplier's experience in similar applications. Service life will be confirmed in water test and plant operation. The specific requirement to be verified by these methods is 3.2.7.

4.2.12 The maintainability objectives can be verified by the following methods:

a. Removal of the internals as a unit can be verified by examination of the design layout or assembly drawing. This requirement can be confirmed during pump assembly.

b. The inspection and maintenance intervals can be verified by examination of the operation and maintenance manual. The requirement will be confirmed in plant operation.

c. Provisions for maintaining an inert atmosphere in the pump tank can be verified by drawings showing the maintenance shaft seal, interface connections on the tank and the internals for a plastic bag-type removal envelope.

The specific requirements to be verified by these methods are in 3.2.8.1.

4.2.13 Verification of sodium drainability will be by a design layout showing that all major spaces will drain by gravity and that no single undrained pocket will contain more than 3 cc of sodium. This requirement will be confirmed in plant maintenance. The specific requirement to be verified by this method is 3.2.8.2.

4.2.14 The provisions for sodium removal will be verified by the following methods:

a. A design layout that shows connections for a plastic bag system of inerting the pump internals during and after removal from the tank.

b. A design layout showing that there are no gas traps that would prevent sodium removal by immersing the pump internals in a liquid removal agent.

c. Design layout, tool drawings, and load/stress analysis showing that the pump rotor and all parts of the internals will be adequately supported for shipping when the assembly is in the configuration to be used for transfer to a sodium removal facility as indicated in 3.7.1.

The requirements for sodium removal will be confirmed in plant maintenance. The specific requirement to be verified by these methods is 3.2.8.3.

4.2.15 Verification of the sodium-bearing design will be based on bearing loads estimated by the pump supplier's normal method of estimating rotor loads. Design of the bearing will be verified by an analysis showing that the maximum bearing deflection for any steady-state operating point will not exceed 70% of the centered bearing clearance. The analysis of bearing performance will assume that the pressure surrounding the bearing will vary from 2.4 to 22 psi, independently of the pump operating point. Performance of the bearing will be confirmed in water test and plant operation. The specific requirement to be verified by this method is 3.2.8.5.

4.2.16 The pump tank design will be verified by analysis showing that the tank meets the requirements of 3.3.1, 3.3.2, and 3.4 for the required pressure and temperature conditions. The tank design method will be confirmed in plant operation. The specific requirement to be verified by this method is 3.2.8.7.

4.2.17 The environmental requirements will be verified by the use of the required environmntal conditions as boundary conditions in the various analyses made for the design of the pump and auxiliary equipment. The specific requirement to be verified by this method is 3.2.9.

4.2.18 The working fluid requirement will be verified by drawing callouts for materials that are compatible with sodium for all parts that could be exposed to sodium. The specific requirement to be verified by this method is 3.2.10.

5. PREPARATION FOR DELIVERY

5.1 General Requirements

5.1.1 Packaging — The pump components, sub-assemblies, and parts shall be packaged by sealing all exterior openings with covers, plugs, or caps. The items shall then be wrapped with a waterproof vapor barrier material for shipping.

5.1.2 Cleanness — The pump shall be free of visible dirt, corrosion, and extraneous materials prior to packaging. Packaging materials such as wraps, plugs, caps, and cushioning, shall be clean. Cleanness of the pump shall be maintained in accordance with Section 3.13.

5.1.3 Handling — Pump components over 50 pounds shall have provisions for handling (as specified herein).

5.1.4 Shipping – The pump components shall be designed and constructed to withstand vibration and shock loads during shipping.

5.2 Special Handling

5.3 Shipping Requirements – The supplier shall be responsible for delivery of the pump assembly and associated parts/systems covered by this specification to the delivery point. These responsibilities include routing, shipping instructions, and documentation.

6. NOTES AND DATA

6.1 Water Purity – The water used for testing the pump shall meet the following requirements:

Chloride, ppm maximum	1.0
Fluoride, ppm maximum	0.1
Conductivity, mhos/cm maximum	20.0
pH	6.0-8.0
Turbidity, Jackson Candle Units, maximum	1.0

Rockwell International
Energy Systems Group

DESIGN DATA SHEET

PREPARED BY

APPROVED BY

TITLE
Appendix A of Specification
N30500
Pump Requirements Summary

WBS NO.

NUMBER N30500-1

PAGE 20

DATE

NEW REV	NO.	ITEM	UNIT	VALUE		TEN-TATIVE	FIRM	REFERENCES AND REMARKS
				OPERATING	DESIGN			
	1	Pump Output Flow	GPM	3100	3800			Minimum flow = zero Minimum operating flow 10% of operating
	2	Total Developed Head	jt	595	650			Maximum head required at zero flow
	3	Cover Gas	-	Argon	Argon			
	4	Cover Gas Pressure	psig	22	24			Minimum cover gas pressure 1.44
	5	Minimum NPSH Available	jt	48	40			Independent of flow
	6	Working Fluid	-	Sodium	Sodium			
	7	Sodium Temperature	^{o}F	610	650			Minimum sodium temperature +307^{o}F
	8	Test Fluid	-	Water	Water			
	9	Water Temperature	^{o}F					
		Maximum			130			Minimum water temperature TBD
		Minimum			100			

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Rockwell International
Energy Systems Group

DESIGN DATA SHEET

PREPARED BY	APPROVED BY	TITLE Appendix A of Specification N30500 Pump Requirement Summary	NUMBER N30500-1
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		WBS NO.	DATE

NEW REV	NO.	ITEM	UNIT	VALUE		TEN-TATIVE	FIRM	REFERENCES AND REMARKS
				OPERATING	DESIGN			
	10	General Environment	-	Outdoor	Outdoor			
	11	Environmental Temperatures	^{o}F					
		Maximum		120	130			
		Minimum		-10	-20			
	12	Solar Radiation Heat Gain (max)	w/ft^2	100	100			
	13	Ambient Pressure	psia					
		Test			14.8			
		Operating			13.6			
	14	Ambient Humidity	%RH					
		Maximum		100				
		Minimum		5				
	15	Suction Pipe Diameter	in.		20			
	16	Discharge Pipe Diameter	in.		12			

FORM 706-A REV. 11-82

bmg

Rockwell International

Energy Systems Group

PROCUREMENT SPECIFICATION

PREPARED BY JL
J. L. Senter, Jr.

DATE
April 15, 1983

NUMBER N30499

REV New

TYPE Component

TOTAL PAGES 18

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TITLE
Valves, Globe, ANSI B16.34 Standard Class, Sodium Service

APPROVALS

Cognizant Engineer

Project Manager

4-22-83
Component Design Engineering
andSpecifications Unit

THIS REPORT MAY NOT BE PUBLISHED WITHOUT THE
APPROVAL OF THE DOE OFFICE OF PATENT COUNSEL

5021s/jjs

FORM N 131-H-6 REV. 2-79

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SPECIFICATION FOR
VALVES, GLOBE, ANSI B16.34 STANDARD CLASS, SODIUM SERVICE

1. SCOPE This specification establishes the requirements for performance, design, fabrication, handling, testing, marking, cleaning, packaging, shipping, and quality assurance of globe valves with actuators for use in high-temperature liquid sodium process lines.

1.1 Classification The valves specified herein shall be in accordance with ANSI B16.34 Standard Class.

1.2 Type The valves specified herein are of the globe type.

2. APPLICABLE DOCUMENTS The following documents are a part of this specification to the extent specified herein. The issue of a document in effect on January 1, 1983, including any amendments also in effect on that date, shall apply unless otherwise specified. Where this specification appears to conflict with the requirements of a reference document, such conflict shall be brought to the attention of Rockwell International for resolution.

American National Standards (ANSI)

ANSI B16.34	Valves--Flanged and Buttwelding End
ANSI B46.1	Surface Texture
ANSI Z1.8	Specification of General Requirements for a Quality Program (ASQC C1)

American Welding Society (AWS)

AWS A5.13	Specification for Solid Surfacing Welding Rods and Electrodes

3. REQUIREMENTS

3.1 General Valves shall be suitable for liquid sodium service and shall be designed, fabricated, and tested to the requirements of ANSI B16.34, Standard Class and the additional requirements of this specification. Each assembly shall include an operator meeting the requirements given in Paragraph 3.4.7.

3.2 Item Definition

3.2.1 Valve Assembly The valve assembly consists of the valve body, bonnet, disk, stem, stem retaining structure, stem seal, support attachment hardware, piping extensions, and valve operator.

3.3 Performance

3.3.1 Functional Performance Functional performance shall conform to the requirements shown in Table I.

3.3.2 Maintainability The valve shall be maintainable without removing it from the pipeline.

3.3.3 Service Life The service life of the valve assembly shall be 30 years.

Valves shall be capable of operation without leakage through the pressure boundary and without impairment of function for the service life or when subjected to the tests of Section 4.

3.3.4 Ambient Environmental Conditions The valve assemblies will be exposed to the conditions stated in Table I.

3.4 Design Design conditions for the valves are given in Table I.

3.4.1 Design Loads

3.4.1.1 Internal and External Pressure The valves shall be designed to withstand the specific internal and external pressures given in Table I.

3.4.1.2 Loading The valve body with extensions shall be designed to be capable of withstanding the loads specified in Table I. The valve stem load shall be assumed to be not less than 600 lb per in. of valve seat circumference.

3.4.1.3 Handling Attachments Valve assemblies weighing 50 lb or more shall have attachments or appurtenances from which the valve assembly can be supported.

3.4.1.4 Shipping Loads The valves shall be constructed to withstand or be isolated from the mechanical loads imposed by the mode of transportation.

3.4.1.5 Mechanical Effects and Hydraulic Shock The valves shall be constructed to withstand mechanical and hydraulic loads generated within the valve as a result of its own operation, without performance degradation.

3.4.2 Body and Bonnet The valve body and bonnet shall be of integral construction with full penetration welds at any required joints. Backing rings shall not be used and weld joint design shall permit nondestructive examination. Bolted body to bonnet flanges with seal welds are permissible. Threaded joints exposed to liquid metal are not permitted. The inlet and outlet ports of the valve body shall be designed to permit welding directly to the valve without distorting the valve body.

3.4.2.1 Valve Disks and Seats Valve disks and seats shall be hardfaced and back seats shall be stress relieved.

3.4.2.2 Valve Cavity Seals Metal O-rings or welding shall be used for valve cavity seals.

3.4.3 Stem Design A nonrotating stem is required. The valve stem shall be protected from rain when the valve is closed. In the areas of contact with frozen sodium, the stem shall have a surface finish of 10 microinches AA or better in accordance with ANSI B46.1.

3.4.3.1 Stem Seals The valve shall be provided with a sodium freeze seal as a primary stem seal.

3.4.3.2 Seal Length The freeze seal length shall be such that liquid sodium does not penetrate beyond 80% of the seal length at design pressure and temperature conditions. The freeze seal shall be designed so that the frozen sodium plug will not obstruct the gas purge port. Natural convection cooling of the freeze stem is required.

3.4.4 Purge Connection The valve shall be provided with a 1/8-in. minimum purge port located between the primary and secondary seals. A 1/8-in. female pipe thread is acceptable.

3.4.5 Differential Thermal Expansion Differential expansion which exists in and between parts of the valve assembly shall not impair the quality or performance of the valve.

3.4.6 Interchangeability All replaceable parts or assemblies having the same part number shall be directly and completely interchangeable.

3.4.7 Operators Requirements for power and/or handwheel operators are specified in Table I.

3.4.7.1 Power Operators Power operators shall be pneumatically operated and shall consist of an assembly of proven design. The open direction stroke shall be limited by a stop. Components shall be sized to provide a minimum actuation force equal to 1-1/4 times the maximum total force required to actuate the valve in the time specified in Table I. The calculated pure sodium shear force for stem freeze seals shall be increased by a factor of 2.

3.4.7.2 Remote Position Indication When required in Table I, valve assemblies shall be equipped with electrical switches for remote indication within 0.060 ± 0.030 in. of the full-open and full-close valve positions. A visual valve position indicator shall be mounted on the valve actuator assembly.

3.4.7.3 Handwheel Rotation Manual valve operators shall be right-hand closing (clockwise rotation).

3.4.7.4 Fail Position The fail position shall be as given in Table I.

3.4.8 Insulation and Heating Valves shall be designed to operate with thermal insulation and electric heaters attached to the valve body and end connections. Insulation and heaters will be furnished and installed by others after delivery. Insulation will extend one inch maximum onto the freeze stem tube from the bonnet. Heating of the valve body by electric heaters is limited to the operating temperature. Valves shall withstand the heating rate specified in Table I.

3.5 Materials The materials used in the construction of the valves shall meet the requirements of ANSI B16.34. Stainless steels shall have 0.04 percent minimum carbon.

3.5.1 Valve Body Materials Materials for use in the valve body shall be as given in Table I.

3.5.2 Other Valve Materials Materials for use for other valve parts shall be selected by the supplier and approved by Rockwell International.

3.5.3 Operator Materials Materials for the valve operator shall be selected by the supplier.

3.5.4 Wear Applications Metal inserts or weld-deposited hard surfacing materials for wear applications in liquid metal or metal vapor environments shall be Stellite[1] 6, 6B, or 156 in contact with Stellite 6, 6B, or 156, or AWS A5.13 Classification RCoCr-A or equivalent alloys.

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[1] Trade name, Cabot Corporation

3.5.5 Contaminants in Marking Materials

3.5.5.1 Marking Materials Used on Stainless Steels and Corrosion-Resistant Alloys Marking materials used for stainless steel and corrosion-resistant alloys shall:

1) Contain less than 300 ppm aggregate of iron, copper, lead, zinc, mercury, and sulfur.

2) Contain less than 200 ppm total halogens (free and chemically combined).

Marking materials may be accepted based on type-qualification or a supplier's certification based on routine quality control test.

3.5.5.2 Marking Materials Used on Carbon and Low-Alloy Steels Marking materials shall be compatible with the base metal and shall provide a distinct, legible mark with good contrast relative to the background of the metal.

3.6 Cleanness The finished item(s) as shipped shall be suitable for installation at the construction site without additional cleaning. Cleaning and inspection for cleanness shall be sequenced into the fabrication process as required to minimize contamination. Dust, debris, and contaminants such as cutting fluids, welding slag, and other processing compounds shall be removed at intervals compatible with the fabrication or assembly operation. Means shall be provided to maintain cleaned surfaces in a clean condition throughout the fabrication and shipping process.

3.7 Identification

3.7.1 Marking Valve bodies shall be identified and marked in accordance with ANSI B16.34. Impression stamping shall not be used on any of the pressure boundary parts of the valve.

3.7.2 Nameplates Valves shall have permanently attached nameplates which are visible after insulation is installed and contain the following information:

1) Name of manufacturer.

2) Manufacturer's drawing or part number.

3) Manufacturer's serial number.

4) Purchase order or contract number.

5) Design temperature ______°F.

6) ANSI B16.34 rating.

7) Valve body material.

8) Valve nominal size and valve type.

9) Year built.

10) Rockwell International numbers.

11) Identification number.

Each valve operator shall be provided with a nameplate which shall contain the following:

1) Manufacturer's name.

2) Contract number.

3) Supply pressure, 100 psig.

4. QUALITY ASSURANCE REQUIREMENTS

4.1 Quality Assurance Program The quality assurance program shall be in accordance with ANSI Z1.8.

4.2 Design Verification Tests shall be conducted on valves of untested design to verify the design operational requirements. Design requirements of valve assemblies other than those verified by testing shall be verified as follows.

4.2.1 Performance Compliance with the performance requirements of rated flow, temperature, pressure, pressure drop, sustained operating conditions, and operator performance shall be verified by comparison with similar designs.

4.2.2 Life Compliance with the life requirements specified in 3.3.3 shall be demonstrated by reference to stress analysis margins, including corrosion allowances, and a comparison with existing valve designs.

4.2.3 Environmental Compliance with the environmental requirements specified in 3.3.4 shall be demonstrated by analysis to verify valve integrity during operation.

4.2.4 Design Features Compliance with the design requirements specified in 3.4 shall be verified by review of applicable drawings, descriptive data, and supporting calculations, and comparison with existing designs.

4.2.4.1 Qualification by Analysis

When the valve is to be qualified by Design Analysis, the following analyses shall be performed:

1) A stress analysis based on the design conditions defined by the pressures, temperatures, and various forces applicable to valve service.

2) A stress analysis to show that the complete valve and operator assembly can withstand the conditions and loads specified in Table I when supported as specified by the supplier.

3) Analysis of hydraulic data from similar valves.

4) Stem seal analysis for the seal configuration as specified in 3.4.3.1 and 3.4.3.2.

4.2.4.2 Qualification by Test The supplier's standard test procedures shall be used to demonstrate that the valves meet the requirements of Section 3.

1) Seat Leakage Test Seat leakage tests shall be conducted with distilled water having a chloride content no greater than 1.0 ppm. The tests shall be performed in accordance with Table I. The valve shall be dried immediately after water testing.

2) Shell Leakage Test A shell leakage test shall be performed on the assembled valve. After at least 2 minutes, no leakage shall occur.

3) Valve Operator Test The valve operator shall be subjected to tests in accordance with Table I. If the operator test is not conducted with the valve filled with sodium, the operating and closing time shall be corrected to the sodium-filled condition.

4.3 Materials Verification Compliance with the materials requirements specified in 3.5 shall be verified by review of materials receival reports and applicable drawings.

4.4 Visual and Dimensional Examination Each fabricated part, including the completed valve, shall be subjected to visual and dimensional examination to verify compliance to applicable drawings and specifications requirements.

4.5 Cleaning and Cleanness Verification Each fabricated part, including the completed valve, shall be examined for cleanness in accordance with 3.6.

5. PREPARATION FOR DELIVERY

5.1 Packaging Preparation for delivery shall provide for individual packaging of valves in sealed moisture-vapor-proof envelopes. The packaging method shall include provisions for the following.

5.1.1 Protection of Surfaces Protection of surfaces during shipping and subsequent handling and storage at the installation site, with particular reference to prevention of damage to machined surfaces and fragile components, parts, or linkages which may require protection against vibration wear, atmospheric corrosion, or improper handling. Parts shall not be exposed to any halogenated materials.

5.1.2 Maintaining Cleanness Provisions for maintaining cleanness in accordance with 3.6 during transfer, shipment, and storage at the job site. Dessicants shall be used as applicable to sustain cleanness during storage.

6. NOTES AND DATA

6.1 Definitions

Bonnet That part of the pressure boundary which is attached to the valve body and allows assembly of the internals.

Freeze Seal An arrangement in which a leak-tight seal can be obtained by freezing sodium between the stem and an extension of the valve bonnet.

Maintainability Those inspection, servicing, testing, and repair characteristics of an item which affect the operating continuity of the facility and the effort required to restore the function of the item to its initial state.

Pressure Boundary Those elements of the valve which form the barrier between the liquid metal contained within the valve interior and the exterior environment. It includes the valve body with nipples, the bonnet, the freeze tube, and secondary seal assembly.

Primary Seal The stem seal nearest to the liquid metal which provides a liquid metal pressure boundary.

Secondary Seal The backup seal for the primary seal.

TABLE I
VALVE REQUIREMENTS
(Sheet 1 of 4)

	Item		Reqm't			Ref. Para.	Note
GENERAL	1. Tag No.						
	2. Service						
	3. Line No./Vessel No.						
	4. Line Size/Sched. No.						
BODY	5. Type of Body					1.2	
	6. Body Size	Port Size					
	7. Guiding	No. of Ports					
	8. End Conn. & Rating						
	9. Body Material					3.5	
	10. Packing Material					3.4.3	
	11. Lubricator	Isolating Valve					
	12. Bonnet Type						
	13. Trim Form						
	14. Trim Material	Seat/Plug					
		Shaft Mtl.					
	15. Required Seat Tightness						
	16. Max. Allow., Sound Level dBA						
ACTUATOR	17. Model No. & Size						
	18. Type of Actuator					3.4.7	
	19. Close at	Open at					
	20. Flow Action to						
	21. Fail Position					3.4.7.4	
	22. Handwheel & Location					3.4.7.3	
POSIT.	23. Mfr. & Model No.						
	24. Filt. Reg.	Gages Bypass					
	25. Input Signal						
	26. Output Signal						
	27. Air Supply Pressure						

TABLE I
VALVE REQUIREMENTS
(Sheet 2 of 4)

	Item		Reqm't		Ref. Para.	Note
TRANSDUCER	28. Make & Model No.					
	29. Input Signal					
	30. Output Signal					
OPTIONS	31.					
	32.					
	33.					
SERVICE	34. Flow Units					
	35. Fluid				3.1	
	36. Quant. Max.	C_v				
	37. Quant. Oper.	C_v				
	38. Valve C_v	Valve F_L				
	39. Norm. Inlet Press	ΔP			3.4.1.1	
	40. Max. Inlet Press.				3.4.1.1	
	41. Max. Shut Off ΔP				3.4.1.1	
	42. Temp. Max.	Operating				
	43. Oper. sp. gr.	Mol. Wt				
	44. Oper. Visc.	% Flash				
	45. % Superheat	% Solids				
	46. Vapor Press.	Crit. Press.				
	47. Predicted Sound Level dBA					
OTHER	48. Manufacturer					
	49. Model No.					
	50. Stem Seal				3.4.3	
	51. Valve & Stem Attitude					
	52. Elec. Htg of Body		50F to TBD F		3.4.8	
	53. Heatup Rate				3.4.8	
	54. Max. Rate of Temp. Change					

TABLE I
VALVE REQUIREMENTS
(Sheet 3 of 4)

Item		Reqm't	Ref. Para.	Note
OTHER	55. Operating Temp. Min.			
	56. Valve Body Loads:		3.4.1.2	
	Axial			
	Shear			
	Moment			
	57. Insulation Required		3.4.8	
	58. Ext. Atm. Air Temp.	10F to TBD F	3.3.4	
	59. Ambient Relative Humidity	5% to 100%	3.3.4	
	60. Stroke Cycles, dry			
	61. Stroke Cycles, wet			
	62. Cavitation Conditions:			
	gpm			
	Inlet psi			
	Outlet psi			
	Temperature, F			
	C_v			
	63. Seismic Loading			
	64. Body Corrosion Allowance			
	65. Operator Power Required		3.4.7	
	66. Operator Response Time		3.4.7.1	
	67. Valve Position (NO or NC)			
	68. Design Life		3.3.3	
	69. Instrumentation		3.4.7.2	
	71. Auxiliary Equipment			

TABLE I

VALVE REQUIREMENTS

(Sheet 4 of 4)

Item	Reqm't	Ref. Para.	Note
72. Test Requirements		4.2	
Seat Allowable Leakage	60 cc water/hr at 50 psid	4.2.4.2	
Shell Leakage Test		4.2.4.2	
Operator Max. Activation			
Pressure		4.2.4.2	

NOTES:

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3.4.1 STEAM GENERATOR MODULE
(N10049)

Rockwell International

Energy Systems Group

PREPARED BY
A. Carnazzola
D. K. Nelson

DATE

DESIGN SPECIFICATION

NUMBER N10049

REV New

TYPE Design

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TITLE
Steam Generator Module, Solar Central Receiver Power Plant,
Carrizo Plains, Unit No. 1

APPROVALS

Cognizant Engineer

Project Engineer

Quality Assurance

Materials & Producibility

THIS REPORT MAY NOT BE PUBLISHED WITHOUT THE APPROVAL OF THE DOE OFFICE OF PATENT COUNSEL

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FORM N 131-H-1 REV. 2-79

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STEAM GENERATOR MODULE
SOLAR CENTRAL RECEIVER POWER PLANT
CARRIZO PLAINS, UNIT NO. 1

1. SCOPE This specification establishes the requirements for the construction (materials, design, fabrication, examination, inspection, testing, and stamping) of the Carrizo Plains Solar Central Receiver Power Plant sodium-heated steam generator modules.

2. DOCUMENTS

2.1 Applicable Documents The following documents form a part of this specification to the extent specified in Sections 3, 4, and 5 of this specification. Any apparent conflict between this specification and the requirements of an applicable document shall be brought to the attention of the Program Office for resolution.

American Society of Mechanical Engineers (ASME)

ASME Boiler and Pressure Vessel Code

ANSI/ASME BPV-VIII-1	Pressure Vessels
ANSI/ASME BPV-V	Nondestructive Examination

Rockwell International

N40113	Cleanness, Steam Generator, Solar Central Receiver Power Plant
N30448	Pipe, Alloy Steel 2.25 Cr - 1.00 Mo, Seamless
N30449	Forged Fittings, Alloy Steel, 2.25 Cr - 1.00 Mo
N30450	Tubing, Alloy Steel 2.25 Cr - 1 Mo, Seamless
N30486	Forgings, Alloy Steel, 2.25 Cr - 1.00 Mo

American National Standards Institute (ANSI)

ANSI A58.1	Building Code Requirements for Minimum Design Loads in Buildings and Other Structures

International Conference of Building Officials

Uniform Building Code

Tubular Exchanger Manufacturers Association, Inc. (TEMA)

Standards of Tubular Exchanger Manufacturers Association

3. REQUIREMENTS

3.1 Item Definition The steam generator modules (module) shall function as a once-through evaporator/superheater in a modular type of steam generator utilizing liquid sodium as the heat source. The module shall consist of tubes, tube supports, tubesheets, nozzles, shell and shell support ring.

The module will be of hockystick configuration installed with the long part of the body vertical and the short part of the body horizontal, with the bend at the top (see Figure 1). Water/steam enters at the bottom and flows up through the tubes countercurrent to the down-flowing sodium in the shell.

The tube-to-tubesheet joint shall be designed so that the tubes do not penetrate the tubesheet and the joint is of a butt weld configuration. The tubesheet shall be an integral part of the shell.

A support ring shall be provided on the shell exterior for attachment to ther support structure.

Support for thermal insulation shall be provided on the exterior surface of the shell. (The insulation is not part of this specification.)

3.1.1 Steam Generator Subsystem The modules will become integral parts of the steam generator subsystem where heat from the sodium is used to convert water to high-pressure steam. The subsystem consists of three identical modules.

3.1.2 Interface Definition The physical interfaces of the module end connections (see Figure 1) are as follows:

Sodium inlet and outlet
Feedwater inlet
Steam outlet
Sodium drains
Running sodium vent
Rupture disk line

3.2 Performance

3.2.1 Powered Operation The module shall be designed so that the steam generator can operate at steady state within an operating range of 10% to 100% of rated power full load. The normal 100% operating conditions are listed in Table I. The surface area shall be based on providing sufficient surface area to account for a water side fouling factor of 3,300 Btu/hr-ft^2-F and an outage of five tubes. Each module shall have sufficient heat transfer area such that operation at 135% of rated full load is achievable. The operating conditions at 135% load are listed in Table I.

3.2.2 Availability The module availability, exclusive of climate unavailability and planned outages, shall be 0.96.

3.2.2.1 Maintainability Provisions shall be made for sodium removal. The module shall be designed so that any tube can be plugged. Tube leaks in the module will require repair by cutting the steamhead such that access can be made to the tubes. Leaking tubes will be plugged and the steamhead rewelded in place. The module design shall be such that any tube can be plugged during fabrication or while shut down at the Carrizo Plains site. The design shall permit tube plugging either with the module horizontal, as during fabrication, or vertical, as installed in the steam generator subsystem. Up to 3 plugged tubes will be permitted as a fabrication acceptance criterion. The analysis shall consider that 5 tubes are plugged at the end of life. The analysis shall consider the end-of-life number to include a group of 5 adjacent tubes located to produce the most severe effect on structural design.

3.2.3 Useful Life The module shall be designed for a useful life of 30 years. The designated operating life for each operating condition shall be as follows:

Nominal operating conditions	84,000 hr
Cold startup	30 cycles
Normal startup and shutdown	20,000 cycles
System trips	4 cycles

3.2.4 Environment

3.2.4.1 Atmospheric The module will be exposed to the following atmospheric conditions as appropriate:

a. During fabrication and shipment

Composition	Air
Temperature	10 to 120°F
Pressure	28 in. Hg to 32 in. Hg
Relative Humidity	0% to 100%

b. During storage, installation, and operation at the Carrizo Plain site:

Composition	Air
Temperature	10 to 120°F
Pressure	18 in. Hg to 32 in. Hg
Relative Humidity	0% to 100%

3.2.4.2 Working Fluid The module will have high temperature sodium on the shell side and high-pressure feedwater and steam on the tube side. The feedwater chemistry will be in accordance with Table II. The composition of the sodium will be in accordance with Table III.

3.2.4.3 Testing and Inspection Vacuum, air, or inert gas may be used internal to the modules during testing and inspection. Inert gas with a dew point of -40°F, or lower, may be used internal to the module argon entering from the sodium pipes and nitrogen entering from the water lines. The module may be exposed to nitrogen gas and sodium/air reaction products in the event of a sodium fire.

3.3 Codes and Standards

3.3.1 ASME Code The module shall be constructed (refer to 1.) and stamped as a pressure vessel in accordance with the requirements of ANSI/ASME BPV-VIII-1.

3.4 Structural Design

3.4.1 Loadings The loadings to be considered in designing the module shall include:

a. Internal and external design pressure

b. Weight of the module and normal contents under operating or test conditions

c. Superimposed static reactions from weight of attached equipment, such as piping and insulation

d. The attachment of internals and module supports

e. Cyclic and dynamic reactions due to pressure or thermal variations, and mechanical loadings

f. Wind and seismic reactions

g. Impact reactions; and

h. Temperature gradients and differential thermal expansion.

3.4.1.1 Design Pressure Design pressures shall be as follows:

a. Sodium side - 120 psig for sodium-to-air boundary
- 1575 psig for sodium-to-steam/water boundary
b. Steam outlet - 1590 psia

3.4.1.2 Design Temperature Design temperatures shall be as follows:

a.	Sodium inlet nozzle	1065°F
b.	Sodium outlet nozzle	620°F
c.	Feedwater inlet nozzle	436°F
d.	Steam outlet nozzle	1015°F

3.4.1.3 Wind The module shall be designed for winds with a maximum speed, including gusts of 90 mph. Loads resulting from 30-mph wind velocity shall be combined with all other loads defined in 3.4.1. Loads resulting from 90-mph wind gusts shall be considered to occur with the module on a standby condition and shall not be combined with other loads.

Wind velocity profile varies geometrically with height to the 0.15 power where the reference height is taken as 10 m (30 ft) and shall be determined according to the model shown for calculation of wind speed as a function of elevation.

$$V_H = V_1 \left(\frac{H}{H_1}\right)^C$$

where

V_H = mean wind velocity at height H
V_1 = reference wind velocity
H_1 = reference height (assume 10 meters)
C = 0.15

Wind loads shall be determined in accordance with ANSI A58.1.

3.4.1.4 Seismic Seismic loads shall be the loading derived by the method described in the Uniform Building Code considering a Zone 4 seismic occurrence with ZIKCS = 0.40.

3.5 Tube Support Arrangement The tube support arrangement shall, as a minimum, comply with the requirements of TEMA Standards Class "R", Paragraph R-4.

3.6 Corrosion and Scaling Allowances Corrosion, chemical cleaning, and scaling allowances have been established as follows:

a.	Sodium side	0.004 in. for corrosion based on oxygen content of 1 to 15 ppm by weight

b.	steam side	0.010 in. for corrosion, chemical cleaning, and scaling in the heat transfer tubing and weld nipples, and 0.0065 in. elsewhere.

The corrosion and scaling allowances shall be considered as material physically removed from the tube wall. Unnecessary dead spaces or crevices shall be avoided.

3.6.1 Wastage Baffles Wastage-resistant material shall be placed between the tube bundle and shell wall in the tube-tubesheet joint region to protect the shell against wastage in the event of a tube leak.

3.7 Fouling Cleaning allowance and fouling on the sodium side shall be considered to be negligible. For the water side only, the thermal/hydraulic design shall be based on a fouling coefficient of 5,000 Btu/hr-ft^{2}F.

3.8 Sodium Flow Sodium cross flow within the main section of the shell shall be avoided to minimize induced tube vibrations and tube wear. The maximum allowable sodium velocity parallel to the tube axes shall be 13 fps. The allowable velocity component perpendicular (cross flow) to the tube axes shall be 10 fps average, and 15 fps maximum.

3.9 Steam Tube Materials Degradation Allowances In evaluating steam tube wall thickness requirements, the following materials degradation allowances shall be used:

a.	Corrosion and erosion	0.0087 in.
b.	Wall thinning due to tube bending	0.001 in.
c.	Reduction in allowable stress due to sodium decarburization	$\Delta S = -25\%$

3.10 Materials

3.10.1 ASME Code Boundary Materials Material subject to stress due to pressure shall conform to the requirements of ANSI/ASME BPV-VIII-1. Specifications applicable to such material are:

a.	Main shell	ASME SA-335, Grade P22 as supplemented by N30448
b.	Tubesheet	ASME SA-336, Class F22, as supplemented by N30486
c.	Tubing	ASME SA-213, Grade T22, as supplemented by N30450
d.	Fittings	ASME SA-182, Grade F22, as supplemented by N30449

e. Welding material 2-1/4 Cr - 1 Mo steel, ASME SFA specifications or identical AWS specifications.

3.10.2 Module Internals Material welded to pressure boundary shall conform to the requirements of ANSI/ASME BPV-VIII-1.

3.11 Fabrication The fabrication of the module shall be in accordance with the requirements for pressure vessels fabricated by welding Part UW of ANSI/ASME BPV-VIII-1 and the following subparagraphs.

3.11.1 Fabrication Prodedure Fabrication and assembly of the module parts shall be in accordance with detailed procedures. Procedures shall be prepared for the following processes; heat treating, welding, cleaning, and nondestructive examination.

3.11.2 Precautions Care shall be exercised to protect all heat transfer surfaces from rusting and physical damage during fabrication, handling, testing, and storage operations.

3.11.2.1 Welding Precautions shall be taken to control spatter, smoke, and fumes produced by welding operations. Anti-spatter compounds shall not be used unless specified in an approved procedure.

3.11.3 Assembly Care shall be exercised in the handling of tubes in order that their original quality will not be degraded. During insertion of the tubes through the tube supports, care shall be exercised to minimize scratching or gouging the tube surfaces. The holes in the tube supports shall have a 125-microinch surface finish and rounded corners.

3.11.4 Lubricants A lubricant may be used during machining, fabrication, and assembly operations if it can be completely removed after the operation. Lubricants shall not be used on threaded fasteners which will be in a sodium environment. Lubricants used for fasteners not in contact with sodium shall be compatible with the materials which they may contact. The tests necessary to establish the compatibility of the lubricant shall be determined, and a test procedure shall be prepared prior to testing of lubricant.

3.11.5 Threaded Fasteners Threaded fasteners shall be preloaded solely by torque using a calibrated wrench. Installation and torque application shall be in accordance with written procedures.

3.11.6 Identification and Marking Components, parts, and assemblies shall be marked to identify them with the quality control records. The markings shall be permanently applied. If any markings are destroyed or permanently concealed by fabrication operations, the quality control records of the higher assembly shall include identification of the part or assembly affected.

3.11.6.1 <u>Permanent Marking</u> Permanent marking shall be applied by die stamping.

3.11.6.2 <u>Temporary Marking</u> Temporary marking may be by any of the following methods:

a. Rubber stamp, rubber roller, or wheel using nonacidic ink
b. Felt tip marking pen
c. Removable tape or tag attached with removable tape
d. Removable tag
e. Electrochemical etching.

All temporary marking shall be removed prior to a fabrication operation which renders them inaccessible for cleaning or removal.

3.11.6.3 <u>Nameplate</u> A nameplate for the module to be U-stamped shall be installed on a standoff in an accessible location to permit reading after insulation is applied. Portions of the standoff, welded directly to the vessel, shall be 2.25 Cr - 1.00 Mo ferritic steel alloy. The nameplate shall be made of a corrosion-resistant material compatible with the surface to which it is attached. Nameplate markings shall be in accordance with Paragraph UG-116 of ANSI/ASME BPV-VIII-1.

3.11.7 <u>Cleanness</u> Fabrication shall be conducted so as to permit cleaning and inspection for cleanness, and to minimize contamination. During those stages when internal or crevice-containing surfaces are being created that are no longer accessible for cleaning or inspection, appropriate action shall be taken to prevent condensation of water in the inaccessible areas. Shop dust, debris, and contaminants such as welding slag and processing compounds shall be removed as compatible with the fabricationor assembly operation. Final cleaned surfaces shall be maintained in a clean condition up to and including their assembly into the components.

Cleanness shall be in accordance with N40113. The applicable class of cleanness shall be as specified on engineering drawings.

3.12 <u>Transportability</u> The mode of transportation to be used in shipping the module shall be by truck.

The normally expected transportation load conditions will be as follows:

Shipment Mode	Vertical	Longitudinal	Lateral
Truck	±1.0	±3.0	±2.0

The primary stresses resulting from the transportation and handling loadings shall not exceed the Code values at room temperature. Means shall be provided for recording and verifying actual load conditions during transport of the module.

4. QUALITY ASSURANCE

4.1 Quality Control System A documented quality control system in accordance with Appendix 10 of ANSI/ASME BPV-VIII-1 shall be planned, implemented, and maintained.

4.2 Design Verification The adequacy of the module design shall be verified by design review. Design review shall consist of reviewing the design, checking the analyses, and assessing the results against the design and functional requirements of Section 3. In those cases where the adequacy of similar previously proven design has been verified by testing, the testing shall be identified. The applicability of previously proven designs, with respect to meeting pertinent requirements of Section 3, shall be verified and shall demonstrate the adequacy of performance under the conditions specified in Section 3.

4.3 Quality Verification Nondestructive examinations and inspection shall be performed in accordance with ANSI/ASME BPV-VIII-1. All pressure boundary welds shall be fully radiographed and shall be liquid penetrant or magnetic particle examined. Examinations and inspection shall show that the fabricated module conforms with the requirements of this specification and applicable engineering drawings.

4.3.1 Liquid Penetrant Examination Liquid penetrant examination shall be performed with an organic solvent removable penetrant using a contrast dye method. The penetrant inspection materials shall be removed from surfaces so that there is no evidence of them by inspecting the parts with the unaided eye.

4.3.2 Overcheck As a minimum, the following overcheck shall be performed:

a. Verify material thickness, at receival, of pressure boundary material that is not subsequently machined.

b. Verify material thickness of all machined pressure boundary material after completion of machining operations.

4.3.3 Pressure Tests A hydrostatic or pneumatic pressure test of the tube side of the completed module shall be conducted in accordance with Paragraph UG-99 or UG-100 of ANSI/ASME BPV-VIII-1. A pneumatic pressure test shall be conducted on the shell side in accordance with Paragraph UG-100 of ANSI/ASME BPV-VIII-1. If the tube side is hydrostatically tested with water, the requirements of N40113, Paragraph 3.2.2, Grade II shall apply as a minimum.

Instruments used to monitor and record pressure and temperature shall be calibrated for an overall system accuracy of ±2% in the range of the test.

5. PREPARATION FOR DELIVERY

5.1 Preservation and Packaging

5.1.1 Sealing All exterior openings shall be sealed. Sealing devices and methods shall be capable of maintaining tight seals during handling, shipment, and outside storage for at least 1 year prior to installation in the plant.

5.1.2 Corrosion Protection Prior to shipment, the unit shall be filled with an inert gas (either argon or nitrogen with a dew point of -40°F, or lower) on both the shell side and the tube side. This level may be achieved either by evacuation and backfill or by a series of purges. Pressure of the inert gas shall be 4 psig minimum. A source of inert gas shall be provided to maintain pressure during shipment. Instrumentation shall be provided to measure the inert gas pressure during shipment.

5.1.3 Protection of Instrumentation Projecting instrument leads shall be mechanically supported, if necessary, and shall be protected against possible damage during handling, shipping, and storage. The ends of the leads shall be bagged in plastic and desiccant shall be placed within the plastic to minimize accumulation of moisture.

5.2 Shipping Fixtures Shipping fixtures shall be provided to support the unit securely during shipment. Shipping orientation shall be horizontal with the bend of the "hockey stick" vertical. Points of support shall be determined by stress analysis.

5.3 Shipping Loads Instrumentation shall be provided to measure and record vertical, longitudinal, and lateral accelerations during shipment.

6. NOTES AND DATA (Not applicable)

TABLE I

STEAM GENERATOR MODULE OPERATING CONDITIONS

	100%	135%
Duty, MWt	28.3	38.3
Sodium inlet temperature, °F	1050	1050
Steam outlet temperature, °F	1000	1000
Water/steam flow rate, lb/h	0.898×10^5	1.214×10^5
Steam outlet pressure, psia	1515	1515
Sodium inlet pressure, psia	100	100

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TABLE II
FEEDWATER CHEMISTRY

	Expected Purity Level During Preheat/Startup Operation	Maximum Impurity Level During Steady-State Operation	Best Purity Level Expected During Steady State Operation
Total dissolved solids	150 ppb	100 ppb max.	50 ppb
Silica, SiO_2	20 ppb	20 ppb max.	10 ppb
Iron	100 ppb	10 ppb max.	10 ppb
Copper	5 ppb	2 ppb max.	2 ppb
Dissolved oxygen	10 ppb	7 ppb max.	5 ppb
Free caustic	-	Zero	Zero
pH	8.5 - 9.2	8.5 - 9.2	8.5 - 9.2
Percent of operating period expected	Less than 1.0%	10%	89%

TABLE III
SODIUM CHEMISTRY

Oxygen	10 ppm (maximum)
Hydrogen	0.8 ppm (maximum)
Plugging Temperature	350°F

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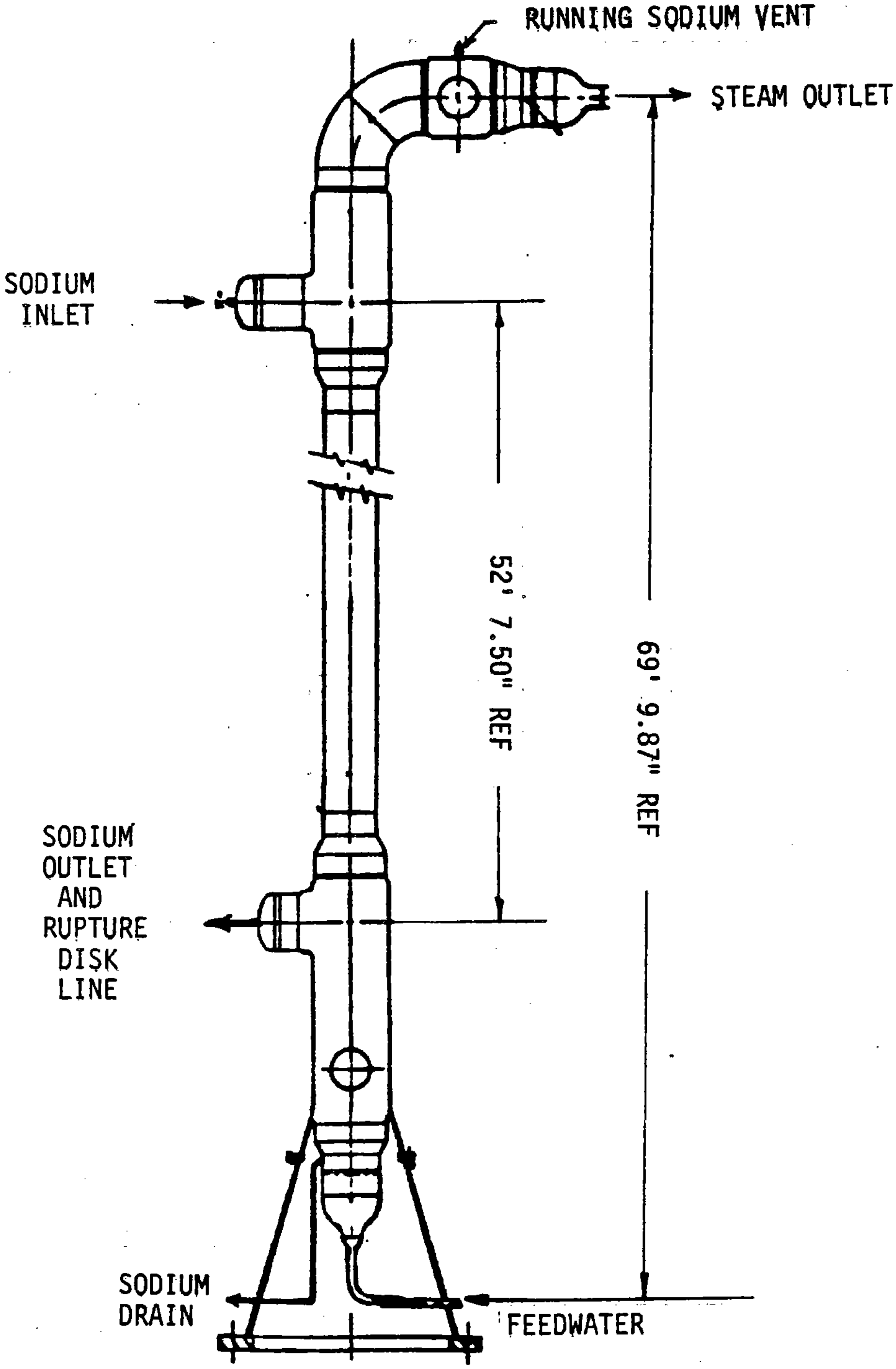

Figure 1. Steam Generator Unit Configuration and Physical Interfaces

3.4.1.1 STEAM GENERATOR TUBE-TO-TUBESHEET WELD JOINTS (N40107)

Rockwell International

Energy Systems Group

MANUFACTURING PROCESS SPECIFICATION

PREPARED BY
MP MICKLICH

DATE
FEBRUARY 11, 1983

NUMBER
N40107

REV
A

TYPE
WELDING

TOTAL PAGES 16

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TITLE
WELDING, TUBE-TO-TUBESHEET JOINTS, STEAM GENERATOR,
SOLAR CENTRAL RECEIVER POWER PLANT (SCRPP)

APPROVALS

Cognizant Engineer

Materials & Producibility

3-9-83
Component Engineering Design & Specifications

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FORM N131-H-7 REV. 2-79

SUMMARY OF CHANGES

This Summary of Changes identifies the pages which have been affected by Revision A . The outside margins have been marked to identify where changes, deletions, or additions from the previous issue have been made.

Pages affected are: 2, 3 and 5.

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LIST OF TABLES

SPECIFICATION FOR
WELDING, TUBE-TO-TUBESHEET JOINTS,
STEAM GENERATOR, SOLAR CENTRAL RECEIVER POWER PLANT (SCRPP)

1.0 SCOPE

This specification establishes the requirements for fabrication and examination of the tube-to-tubesheet welds for the SCRPP Steam Generator.

2.0 DOCUMENTS

2.1 Applicable Documents

The following documents form a part of this specification to the extent specified in Sections 3 and 4 of this specification. Any apparent conflict between this specification and the requirements of an applicable document shall be brought to the attention of the Project Office for resolution.

American Society of Mechanical Engineers (ASME)

ASME Boiler and Pressure Vessel Code

ANSI/ASME BPV-VIII-1	Pressure Vessels
ANSI/ASME BPV-V	Nondestructive Examination
ANSI/ASME BPV-IX	Welding and Brazing Qualifications

Rockwell International

N30450	Tubing, Alloy Steel 2.25 Cr-1.00 Mo, Seamless
N30486	Forgings, Alloy Steel, 2.25 Cr-1.00 Mo
N40113	Cleanness, Steam Generator, Solar Central Receiver Power Plant

N40114	Postweld Heat Treatment, SCRPP, Steam Generator Modules

3.0 REQUIREMENTS

3.1 Construction

Tube-to-tubesheet joints shall be designed, fabricated and examined according to the rules of ANSI/ASME BPV-VIII-1, and the additional requirements of this specification.

3.2 Material

3.2.1 Tubesheet

Tubesheet shall be in accordance with N30486.

3.2.2 Tubing

Tubing shall be in accordance with N30450.

3.2.3 Inert Gas

Inert gases used during the welding proceess shall be technical grade or better and shall be traceable to a standard or specification.

3.3 Cleanness

At the time of welding, the inside and outside surfaces of all joints to be welded shall meet the cleanness requirements of N40113, Class "A", for a distance of at least 1/2 inch on each side of the joint.

3.4 Production Test Welds

At least one successful test weld shall be made on test hardware prior to production welding whenever:

a. There is a change of operator.

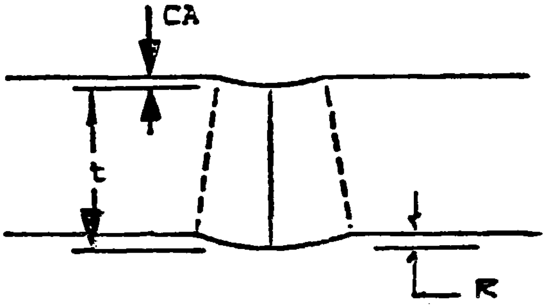
b. The tube material is changed to a different lot or heat number.

c. There is a start of a shift.

d. There has been a change of equipment in the power circuit, weld head, cables, or control units.

Test welds shall be sectioned to permit ready access to the inside and outside weld surface. The weld shall comply with the dimensional and visual acceptance criteria of 3.5 and 4.3.2.

3.5 <u>Procedure, Performance, and Production Test Weld Geometry</u>
The acceptable limits of concavity, underfill, convexity, reinforcement, wall thickness and offset for procedure and performance qualification, and production test welds shall be as follows:



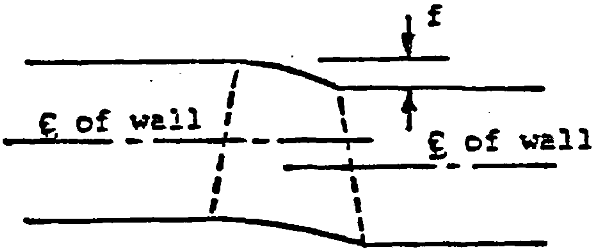


TABLE I TUBE-TO-TUBESHEET WELD ACCEPTANCE CRITERIA

		Tube-to-Tubesheet Weld
Concavity or Underfill	CA(inch)	0.010
Offset	f(inch)	0.005 max.
Wall Weld Thickness	t(inch)	0.097 min.
Convexity Reinforcement	R(inch)	0.030 max.

3.6 Manual Weld Touch-up
Manual welding as required to correct minor imperfections or reinforcement of the weld may be performed after the machine weld cycle. Such manual touch-up welding shall be covered by written procedures.

3.7 Weld Map and Identifying Symbols
In addition to the requirements of ANSI/ASME BPV-VIII-1, the following requirements shall apply.

3.7.1 Weld Map
The record shall include a weld map of the component which shows for each weld joint, or portion thereof, the number of the welding procedure used and the welding machine operator identification symbol.

3.7.2 Identifying Symbols
Each qualified welding machine operator shall be assigned an identifying number, letter, or symbol which shall be used to identify the work of the welding machine operator.

3.8 Heat Treatment

3.8.1 Weld Preheat
The tube-to-tubesheet joint shall be preheated to 430 ±75F. The temperature shall be monitored by one thermocouple contacting the tube, 1/4 inch from the weld joint.

3.8.2 Postweld Heat Treatment
Postweld heat treatment shall be accomplished in conjunction with the final PWHT of the containment welds in accordance with ANSI/ASME BPV-VIII-1 as supplemented by Specification N40114.

3.8.3 Protective Atmosphere
Purging with protective atmosphere shall be applied during preheat, weld, and cooldown.

3.9 Welding Qualifications
Qualification of welding procedures and performance of welding machine operators shall be in accordance with ANSI/ASME BPV-VIII-1 and the following supplemental requirements. These requirements shall be met for all existing and new procedures and their qualification, all existing and new performance qualifications, and all requalifications.

3.9.1 Test Position
Test welds for procedure and performance qualification shall be made on test assemblies oriented in the 5G position.

3.9.2 Procedure

3.9.2.1 Procedure Content

Prior to any production welding, written welding procedures shall be prepared and qualified. All welding used in qualifying a welding procedure shall be performed in accordance with the procedure. The procedures shall be in sufficient detail to ensure that compliance can be verified. The procedure shall include information as required by ANSI/ASME BPV-IX and the following:

a. Reference to the engineering drawing showing joint design, including tolerances.

b. Preheat method and preheat temperature, and method of measuring the temperature.

c. Method of establishing the arc and controlling current.

d. Method for controlling arc length or voltage, and welding speed.

e. Tungsten angle (axial and lead) and offset.

f. Detailed current slope control.

g. Method of location and alignment of welding electrode with tubes and tubesheet.

h. Method and extent of controlling fitup including use of fixtures if used before welding.

i. Method and frequency of cleaning.

j. Nominal electrode size and material type, gas cup part or tool number.

k. Gas type and flow (cover and backup, or purge).

l. Postweld heat treatment for qualification welds.

3.9.2.2 Essential Variables

The welding procedure shall be set up as a new procedure and shall be completely requalified when any of the changes referred to in ANSI/ASME BPV-IX, or listed below, are made in the procedure. Changes other than these may be made in a procedure without the necessity for requalification, provided the procedure is amended to show these changes.

a. An increase or decrease of specified wall thickness or specified diameter which exceeds the drawing tolerances.

b. A decrease in the size of the ligament between tube holes.

c. A change in the tubesheet nipple length beyond the range specified in the approved welding procedure.

d. A change in the electrode-to-work distance beyond the range qualified when both limits of the range of electrode-to-work distance are used during qualification, or an increase or decrease of 0.003 inch in the specified arc length when only the specified arc length was used during qualification.

e. A change from an inert gas or a mixture of inert gases to a shielding gas containing noninert gases, e.g., oxygen. This includes any deliberate change in the mixture of noninert gases.

f. A change in the nominal diameter of the electrode.

3.9.2.3 Test Assembly for Procedure Qualification
The procedure qualification shall be made on test assemblies which simulate the conditions to be used in production with respect to the minimum tube spacing, and the essential variables of 3.9.2.2.

3.9.2.4 Number of Welds
The minimum total number of tube-to-tubesheet welds in the procedure qualification test assemblies shall be 13. The 13 welds shall be made consecutively.

3.9.2.5 Tubesheet Thickness
The test assembly tubesheet thickness, including nipple length, shall be a minimum of 7 inches. Edges of the tubesheet holes in the test assembly shall not be closer than 1 inch from any edge of the test assembly.

3.9.2.6 Types of Tests Required
The following tests shall be used in the qualification of welding procedures:

a. Nondestructive examination by visual, liquid penetrant, and radiographic methods in accordance with 4.3.1, 4.3.2, 4.3.4, and 4.3.3. The consideration specified in the NOTE of 4.3.3.c shall not apply.

b. Sectioning and metallographic examination of weld joints and adjacent areas to test for bond and soundness of the weld (4.2.3).

c. Tension and bend testing of welded joints (4.2.1 and 4.2.2).

3.9.3 Performance Qualification

Performance qualification tests shall be made to determine the ability of welding machine operators to make sound welds. The welding machine operator shall qualify using a welding machine which will be used to make production welds; he shall be required to set up the machine with regard to adjustments permitted by this qualified welding procedure which affect the welding characteristics. Any welding machine operator who welds acceptable procedure qualification tests shall be considered qualified for the welding procedure used. Each welding machine operator shall pass the radiographic tests prescribed for procedure qualification except that only one assembly with a minimum of three joints shall be required. Records of performance qualifications and welding machine operator identification stamps shall be according to 3.7.

3.9.3.1 Renewal of Operator Qualification

Requalification of a welding machine operator is required when 90 or more days have elapsed since he last produced acceptable welds using the specific welding procedure specification for which he was qualified.

3.9.4 Welding Machine Qualification

Each welding machine shall have its capabilities demonstrated by welding acceptable test assemblies. Any welding machine used to weld acceptable procedure or welding operator qualification test assemblies shall be considered qualified to use for production welding.

4.0 QUALITY ASSURANCE

4.1 Weld Examinations

Examinations shall be performed in accordance with the requirements of ANSI/ASME BPV-VIII-1 and the following.

4.1.1 Time of Examination Welds

Radiographic and liquid penetrant shall be performed on welds in the final surface condition after weld cooldown.

4.1.2 Examination of Production Welds
All completed welds shall be examined and tested in accordance with 4.3.

4.2 Destructive Examination and Tests for Qualification Welds

4.2.1 Tension Tests
Following nondestructive examination, two joints in each assembly shall be tested in tension. The specimens shall be removed from the assembly by mechanically cutting the tubesheet to provide a cylinder which has the same inside and outside diameter as the tube. The specimen shall include the tube, tube-to-tubesheet weld, and the tubesheet.

The specimen shall be tested in tension to the requirements of QW-150 of ANSI/ASME BPV-IX.

4.2.2 Bend Tests
Following radiography, one joint in each assembly shall be face- and root-bend tested in accordance with QW-160 of ANSI/ASME BPV-IX. Specimen requirements are similar to tension specimens but shall be in accordance with QW-160 of ANSI/ASME BPV-IX.

4.2.3 Metallographic Examination
Following radiography, tension, and bend tests, the assembly shall be sectioned longitudinally through each remaining tube. The four faces of each tube exposed by sectioning shall be polished and etched with a suitable etchant and shall be visually examined under a microscope starting at 10X magnification. Any cross section which contains any of the following relevant defects shall be cause for rejection of the test assembly:

a. Weld irregularities that violate the allowable weld thickness or allowable weld shape.

b. Excessive oxidation indicating loss of control of welding gas.

c. Any type of crack, or zone of incomplete fusion or penetration.

d. Porosity shall be evaluated in accordance with 4.3.3.1.

4.3 Nondestructive Examinations

The following examinations shall be performed in the order listed.

4.3.1 Visual Examination of Weld Joint Preparation

Weld joint edges and adjacent surfaces shall be examined for:

a. Proper edge preparation, dimensions, and finish.

b. Alignment and fitup of the pieces being welded. An alignment bar may be used when the weld joint is not readily visible.

c. Verification of correct materials by check of records.

d. Verification of cleanness requirements (refer to 3.3).

4.3.2 Postweld Visual Examination of Welded Joint

Mechanical dressing or cleaning with liquid reagents shall not be performed prior to submittal for final postweld visual examination. Weld joints and adjacent surfaces, including heat affected zones, which have any of the following visually observable defects or areas of nonconformance shall be unacceptable:

a. Lack of penetration.

b. Excessive concavity.

c. Excessive reinforcement.

d. Cracks.

4.3.3 Radiographic Examination

Radiographic examination of each weld shall be performed to the procedural requirements of Article 2 of ANSI/ASME BPV-V and the following:

a. Geometric unsharpness shall be 0.001 inch or less.

b. No. 5 penetrameters shall be positioned on the source side, and the 2T holes shall be imaged.

c. Exposure technique shall be as given in Exposure Arrangement E of the Nonmandatory Appendix in Article 2 of ANSI/ASME BPV-V. Exposures shall be normal to the film plane and 45 degrees on each side.

NOTE: This requirement recognizes that 100 percent weld coverage of each tube may not be attained.

d. The area of interest for film density control shall be the fusion zone and 2T on each side of the fusion zone.

4.3.3.1 Radiographic Acceptance Criteria

All inclusions shall be evaluated as porosity. The maximum single defect allowed shall be 0.030 inches. If more than one defect is detected the maximum size allowed shall be 0.020 inches. The total area of porosity shall not exceed 0.002 square inches. Elongated porosity which has a length greater than 0.030 inches shall be unacceptable. Any groups of porosity in line shall be unacceptable when the aggregate length is greater than "T" in a length of 4T, except when the distance between the successive imperfections exceeds 6L where "L" is the length of the longest imperfection in the group. Any type of crack, incomplete fusion or penetration shall be cause for rejection.

4.3.4 Liquid Penetrant Examination

Liquid penetrant examination of welds shall be in accordance with Appendix 8 of ANSI/ASME BPV-VIII-1. The liquid penetrant examination shall be applied to all external weld surfaces and adjacent base metal for a distance of 1/2 inch on each side of the completed weld on the outside surface. Any type of crack and surface porosity exceeding the limits of 4.3.3.1 shall be cause for rejection.

4.4 Inert Gas

Inert gas shall be monitored as required to assure compliance with 3.2.2.

4.5 Gas Dew Point

Each bottle of bottled gas shall be analyzed for dew point prior to use.

4.6 Finished Weld Geometry

The finished weld geometry for procedure and performance qualification, and production test welds shall be inspected for compliance with 3.5.

5.0 PREPARATION FOR DELIVERY

(Not applicable)

6.0 NOTES AND DATA

6.1 Weld Symbols

Weld symbols appearing on the drawing and in the weld procedures shall be interpreted in accordance with AWS A2.4.

6.2 Weld Terms

Welding terms and definitions shall be as defined in AWS A3.0.

6.3 Definitions

Test Weld A weld made at the start of a work shift, or change of operator, to demonstrate that weld preparation, materials, welding machine, and welding process are adequate to produce welds of a quality consistent with the weld qualification requirements.

Qualification Weld A weld made to be tested during procedure or performance qualification in accordance with 3.9.

Production Weld A weld made on a deliverable steam generator assembly.

3.4.1.2 STEAM GENERATOR SEAMLESS ALLOY STEEL PIPE

(N30448)

Rockwell International

Energy Systems Group

PROCUREMENT SPECIFICATION

PREPARED BY A. CARNAZZOLA	NUMBER N30448		REV New
	TYPE MATERIAL		
DATE JANUARY 24, 1983	TOTAL PAGES 4	E.O. 2/2/83 RR 106278	

TITLE

PIPE, ALLOY STEEL 2.25 Cr - 1.00 Mo, SEAMLESS

APPROVALS

Materials & Producibility

W. E. Nagel

Quality Assurance

1-28-83

Technical Support

1-27-83

Cognizant Engineer

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SPECIFICATION FOR

PIPE, ALLOY STEEL 2.25 Cr - 1.00 Mo, SEAMLESS

1.0 SCOPE

ASME SA-335 as supplemented by this specification establishes the requirements for seamless pipe of alloy steel 2.25 chromium-1.00 Molybdenum for use in steam generator shells. The pipe is intended for high temperature service containment of liquid sodium.

2.0 DOCUMENTS

2.1 Applicable Documents

The following documents form a part of this specification to the extent specified in Sections 3, 4, and 5 of this specification. Any apparent conflict between this specification and the requirements of an applicable document shall be brought to the attention of Rockwell International for resolution.

American Society of Mechanical Engineers (ASME)

ASME Boiler and Pressure Vessel Code

ASME SE-655	Specification for Special Requirements for Pipe and Tubing for Nuclear and Other Special Applications
ASME SA-335	Specification for Seamless Ferritic Alloy Steel Pipe for High-Temperature Service

American Society for Testing and Materials (ASTM)

ASTM E 45	Recommended Practice for Determining the Inclusion Content of Steel

3.0 REQUIREMENTS

3.1 Pipe

The alloy steel shall be seamless pipe and shall conform to the requirements of ASME SA-335, Grade P22.

3.2 Process

The steel shall be made by the electric-furnace process. The process shall include vacuum degassing, or vacuum arc remelting, or electroslag remelting in accordance with Paragraph 5.1 of ASME SA-335.

3.3 Manufacture

The pipe shall be hot finished, Paragraph 5.1.2 of ASME SA-335.

3.4 Heat Treatment

The pipe shall be full annealed at 1725 ±25F and furnace cooled to 600 F, Paragraph 5.3.1 of ASME SA-335.

3.5 Finish

Repair by welding, Paragraph 12.6 of ASME SA-335 shall not be permitted.

4.0 QUALITY ASSURANCE

4.1 Product Analysis

A product analysis shall be performed in accordance with Supplementary Requirement S1 of ASME SA-335.

4.2 Flattening Test

An end crop shall be obtained from both ends of each length of pipe. These end crops shall be used for the flattening test, Supplementary Requirement S3 of ASME SA-335.

4.3 Metal Structure and Etching Test

The metal structure and etching test, Supplementary Requirement S4 of ASME SA-335 shall be applicable. The etching test shall be performed on transverse sections selected from both ends of each pipe length.

4.4 Microstructure Test

The requirements of Paragraph S6 of ASME SA-335 shall be applicable. The photomicrographs shall demonstrate metal cleanness to ASTM E-45, Plate I (Heavy Series), (A, B, C, D), No. 2 or better. Each length of pipe shall be considered a separate lot.

4.5 Ultrasonic Examination

All pipes shall be ultrasonically examined in accordance with ASME SA-655, Paragraph 17.2.1(c).

4.6 Magnetic Particle or Liquid Penetrant Examination

All accessible surfaces shall be magnetic particle or liquid penetrant examined in accordance with ASME SA-655, Paragraph 14.RW or 15.RX, as applicable.

5.0 PREPARATION FOR DELIVERY

5.1 Packaging

The pipe shall be packaged dry and free from coatings such as rust inhibitors etc. The pipe shall be packaged in such a manner to assure acceptance by common or other carriers for safe transportation at the lowest rate to the point of delivery. The packaging shall assure that the pipe will not be damaged, during handling and shipping, to result in unacceptable surface defects upon arrival at the point of delivery.

5.2 Marking

In addition to the requirements of ASME SA-335, each length of pipe shall be identified with ESG Specification Number N30448 and revision letter. The marking shall be legible and permanent. Stamping, when used, shall be done with round-nosed interrupted-dot die stamps.

6.0 NOTES AND DATA

6.1 Data Submittal Requirements

Time of submittal and number of copies shall be as specified in the purchase order.

6.1.1 Test Results

A certified test and examination report of actual results shall be submitted. The report shall include the heat number, ESG Specification Number N30448 and revision letter, and the following:

Heat and product analysis for all elements specified.

Results of mechanical properties.

Results of flattening test, metal structure and etching tests.

Conformance to heat treating requirements.

Results of Microstructure Test.

Nondestructive test results.

Hydrostatic test results.

3.4.1.3 STEAM GENERATOR ALLOY STEEL FORGED FITTINGS

(N30449)

Rockwell International

Energy Systems Group

PREPARED BY
A. CARNAZZOLA

DATE
JANUARY 24, 1983

PROCUREMENT SPECIFICATION

NUMBER
N30449

REV
New

TYPE
MATERIAL

TOTAL PAGES 4

E.O. 2/2/83 RK
106278

TITLE
FORGED FITTINGS, ALLOY STEEL, 2.25 Cr - 1.00 Mo

APPROVALS

Materials & Producibility

W. E. Nagel
Quality Assurance

1-28-83
Technical Support

1-27-83
Cognizant Engineer

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APPROVAL OF THE DOE OFFICE OF PATENT COUN

SPECIFICATION FOR

FORGED FITTINGS, ALLOY STEEL, 2.25 Cr - 1.00 Mo

1.0 SCOPE

ASME SA-182 as supplemented by this specification establishes the requirements for forgings of alloy steel 2.25 chromium-1.00 molybdenum for use in steam generator fittings. These include tees, reducers, crosses and outlet headers. The fittings are intended for high temperature service containment of liquid sodium.

2.0 DOCUMENTS

2.1 Applicable Documents

The following documents form a part of this specification to the extent specified in Sections 3, 4, and 5 of this specification. Any apparent conflict between this specification and the requirements of an applicable document shall be brought to the attention of Rockwell International for resolution.

American Society of Mechanical Engineers (ASME)

ASME Boiler and Pressure Vessel Code

ASME SA-182	Specification for Forged or Rolled Alloy-Steel Pipe Flanges, Forged Fittings, and Valves and Parts for High-Temperature Service
ASME SA-655	Specification for Special Requirements for Pipe and Tubing for Nuclear and Other Special Applications

3.0 REQUIREMENTS

3.1 Forgings

The alloy steel forgings shall conform to the requirements of ASME SA-182, Grade F22.

3.2 Process

The steel shall be made by the electric-furnace process. The process shall include vacuum degassing, or vacuum arc remelting, or electroslag remelting in accordance with Paragraph 4.1 of ASME SA-182.

3.3 Heat Treatment

The forgings shall be annealed at 1700 ±25F and furnace cooled to 600 F, Paragraph 5.1 of ASME SA-182.

3.4 Repair by Welding

Repair by welding, Paragraph 12 of ASME SA-182, shall not be permitted.

4.0 QUALITY ASSURANCE

4.1 Product Analysis

A product analysis shall be performed in accordance with Supplementary Requirement S2 of ASME SA-182.

4.2 Ultrasonic Examination

All forgings shall be ultrasonically examined in accordance with ASME SA-655, Paragraph 17.2.1(c).

4.3 Magnetic Particle or Liquid Penetrant Examination

All accessible surfaces shall be magnetic particle or liquid penetrant examined in accordance with Supplementary Requirements S4 or S5 of ASME SA-182 as applicable. Only indications with major dimensions greater than 1/16 inch shall be considered relevant. The following relevant indications shall be unacceptable:

a. any linear indications greater than 1/16 inch long for material less than 5/8 inch thick, greater than 1/8 inch long for material from 5/8 inch thick to under 2 inches thick, and 3/16 inch long for material 2 inches thick and greater;

b. rounded indications with dimensions greater than 1/8 inch for thicknesses less than 5/8 inch and greater than 3/16 inch for thicknesses 5/8 inch and greater;

c. four or more indications in a line separated by 1/16 inch or less edge to edge;

d. ten or more indications in any 6 square inches of area whose major dimension is no more than 6 inches with the dimensions taken in the most unfavorable location relative to the indications being evaluated.

4.4 Hydrostatic Test

A hydrostatic test shall be performed in accordance with Supplementary Requirement S6 of ASME SA-182. The test pressure shall be 180^{+10}_{-0} psig.

4.5 Metallurgical Cleanness

Inclusion rating of the material shall be performed in accordance with ASTM E 45. The photomicrographs shall demonstrate metal cleanness to ASTM E 45, Plate I (Heavy Series), (A, B, C, D), No. 2 or better.

5.0 PREPARATION FOR DELIVERY

5.1 Packaging

The forgings shall be packaged dry and free from coatings such as rust inhibitors etc. The forgings shall be packaged in such a manner to assure acceptance by common or other carriers for safe transportation at the lowest rate to the point of delivery. The package shall be marked as specified in 5.2. The packaging shall assure that the forgings arrive at the point of delivery free from surface imperfections.

5.2 Marking

In addition to the requirements of ASME SA-182, each forging shall be identified with ESG Specification Number N30449 and the revision letter. The marking shall be legible and permanent. Stamping,when used, shall be done with round-nosed interrupted-dot die stamps. The outside of the package shall be stenciled with this same information and the ESG Purchase Order Number.

6.0 NOTES AND DATA

6.1 Data Submittal Requirements

Time of submittal and number of copies shall be as specified in the purchase order.

6.1.1 Test Results

A certified test and examination report of actual results shall be submitted. The report shall include the heat number, ESG specification number N30449 and revision letter, and the following:

Heat and product analysis for all elements specified.

Results of mechanical properties.

Conformance to heat treating requirements.

Nondestructive test results.

Hydrostatic test results.

3.4.1.4 STEAM GENERATOR ALLOY STEEL TUBING (N30450)

Rockwell International

Energy Systems Group

PREPARED BY
A. CARNAZZOLA

DATE
JANUARY 24, 1983

PROCUREMENT SPECIFICATION

NUMBER
N30450

REV
New

TYPE
MATERIAL

TOTAL PAGES
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E.O. 2/2/83 RK
106278

TITLE

TUBING, ALLOY STEEL 2.25 Cr - 1 Mo, SEAMLESS

APPROVALS

Materials & Producibility	W. E. Nagel Quality Assurance	1-28-83 Technical Support
1-27-83 Cognizant Engineer		

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SPECIFICATION FOR

TUBING, ALLOY STEEL 2.25 Cr - 1.00 Mo, SEAMLESS

1.0 SCOPE

ASME SA-213 as supplemented by this specification establishes the requirements for cold drawn seamless tubes of alloy steel 2.25 chromium-1.00 Molybdenum for use in a high temperature sodium-heated steam generator.

2.0 DOCUMENTS

2.1 Applicable Documents

The following documents form a part of this specification to the extent specified in Sections 3, 4, and 5 of this specification. Any apparent conflict between this specification and the requirements of an applicable document shall be brought to the attention of Rockwell International for resolution.

American Society of Mechanical Engineers (ASME)

ASME SA-213	Specification for Seamless Ferritic and Austenitic Alloy-Steel Boiler, Superheater and Heat-Exchanger Tubes
ASME SA-655	Specification for Special Requirements for Pipe and Tubing for Nuclear and Other Special Applications

3.0 REQUIREMENTS

3.1 Tubing

The ferritic alloy steel tubing shall conform to the requirements of ASME SA-213, Grade T22.

3.2 Process

The steel shall be made by the electric-furnace process. The process shall include vacuum degassing, or vacuum arc remelting, or electroslag remelting in accordance with Paragraph 5.1 of ASME SA-213.

3.3 Manufacture

The tubing shall be manufactured by the seamless process and shall be cold-drawn, Paragraph 6.1 of ASME SA-213.

3.4 Heat Treatment

The tubing shall be full annealed at 1650 to 1750F for 15 to 30 minutes, cooled in the furnace to 1225F. Hold at 1225F for 80 to 100 minutes, then cool, Paragraph 7.1 of ASME SA-213. Prior to heat treatment, any lubricant shall be removed from the tubing.

4.0 QUALITY ASSURANCE

4.1 Alloy Identification Test

Immediately prior to packaging, each finished tube shall be tested to verify that the tube is Grade T22, ASME SA-213. This test may be performed by a magnetic permeability or eddy current analysis of the tubing by comparison to a known standard.

4.2 Mechanical Tests

Mechanical tests, including the hydrostatic test, shall be as specified in ASME SA-213.

4.3 Ultrasonic Examination

All tubes shall be ultrasonically examined in accordance with ASME SA-655, Paragraph 17.2.1(c).

4.4 Cleanliness Verification

Prior to final packaging, the cleanliness of the tubing shall be verified by blowing white felt plugs through each length using clean, dry air. When examined, the plugs shall show no particles visible to the unaided eye. Discoloration of the plug shall not be cause for rejection of the tubing.

4.5 Examination of Product

The tubing shall be carefully examined to determine compliance with surface condition, finish and workmanship. Compliance with applicable dimensions and tolerances shall be verified on all tubes.

5.0 PREPARATION FOR DELIVERY

5.1 Packaging

Each tube shall be capped and packaged dry and free from coatings such as rust inhibitors etc. The tubes shall be packaged in such a manner to assure acceptance by common or other carriers for safe transportation at the lowest rate to the point of delivery. The packaging shall preclude rust on the tubing and shall assure that the tubing arrives free from surface imperfections at the point of delivery.

5.2 Marking

Each bale of tubes shall be identified with a tag securely attached to the bundle. The tag shall be marked with at least the following information. The marking shall be legible and permanent.

SA-213, Grade T22

Heat Number

Tubing Size

ESG Specification Number N30450 and revision letter

ESG Purchase Order Number

The outside of the container shall be stenciled with the same information except for the heat number. No identification markings shall be placed on the tubes.

6.0 NOTES AND DATA

6.1 Data Submittal Requirements

Time of submittal and number of copies shall be as specified in the purchase order.

6.1.1 Test Results

A certified test and examination report of actual results shall be submitted. The report shall include the heat number, ESG Specification Number N30450 and revision letter, and the following:

Heat and product analysis for all elements specified.

Results of mechanical properties.

Conformance to heat treating requirements.

Nondestructive test results.

6.1.2 Packaging Method

A detailed description of the methods and procedures to be used by the supplier for packaging the tubes shall be submitted.

3.4.1.5 STEAM GENERATOR ALLOY STEEL FORGINGS (N30486)

Rockwell International

Energy Systems Group

PREPARED BY
A. CARNAZZOLA

DATE
JANUARY 24, 1983

PROCUREMENT SPECIFICATION

NUMBER
N30486

REV
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MATERIAL

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106278

TITLE

FORGINGS, ALLOY STEEL, 2.25 Cr - 1.00 Mo

APPROVALS

Materials & Producibility

W. E. Nagel
Quality Assurance

1-28-83
Technical Support

1-27-83
Cognizant Engineer

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FORM N 131-H-6 REV. 2-79

SPECIFICATION FOR

FORGINGS, ALLOY STEEL 2.25 Cr - 1.00 Mo

1.0 SCOPE

ASME SA-336 as supplemented by this specification establishes the requirements for cylindrical forgings of alloy steel 2.25 chromium - 1.00 molybdenum. The forgings are intended for tubesheets in high temperature liquid sodium.

2.0 DOCUMENTS

2.1 Applicable Documents

The following documents form a part of this specification to the extent specified in Sections 3, 4, and 5 of this specification. Any apparent conflict between this specification and the requirements of an applicable document shall be brought to the attention of Rockwell International for resolution.

American Society of Mechanical Engineers (ASME)

ASME SE-336	Specification for Steel Forgings, Alloy, for Pressure and High-Temperature Parts
ASME SA-654	Specification for Special Requirements for Forgings and Bars for Nuclear and Other Special Applications

American Society for Testing and Materials (ASTM)

ASTM E 45	Recommended Practice for Determining the Inclusion Content of Steel

3.0 REQUIREMENTS

3.1 Forgings

The alloy steel cylindrical forgings shall conform to the requirements of ASME SA-336, Grade P22a and the following.

3.2 Process

The steel shall be made by the electric-furnace process. The process shall include vacuum degassing, or vacuum arc remelting, or electroslag remelting.

3.3 Heat Treatment

The forgings shall be annealed at 1700 ±25F. The time at temperature shall be one hour minimum and an additional hour per inch of thickness over one inch. Cool at a rate of less than 100 F per hour to 600 F, then air cool.

3.4 Repair by Welding

Repair by welding, when permitted by Rockwell International, shall be performed in accordance with written procedures.

4.0 QUALITY ASSURANCE

4.1 Metallurgical Cleanness

Specimens for metallographic inclusion rating shall be selected from prolongations of each forging as follows:

a. One specimen from the center.

b. Four specimens, 90 degrees apart, at approximately mid-radius.

c. Four specimens, 90 degrees apart, near the edge.

Inclusion rating of the material shall be performed in accordance with ASTM E 45, Method D, except that the rating of the worst field for each specimen shall be the rating reported for that specimen. The acceptance criteria per Plate III shall be as follows:

	Inclusion Rating (Max)
Series	Type A, B, C, or D
Thin	1-1/2
Heavy	1

4.2 Ultrasonic Examination

All forgings shall be ultrasonically examined by the straight beam method in accordance with ASME SA-654, Paragraph 21.RZ using flat bottom hole calibration with the following requirements:

First 1-1/2 inch below each face surface	3/64 inch (Hole diameter)
Remainder	1/4 inch (Hole diameter)

5.0 PREPARATION FOR DELIVERY

5.1 Packaging

The forgings shall be packaged dry and free from coatings such as rust inhibitors etc. The forgings shall be packaged to assure acceptance by common or other carriers for safe transportation at the lowest rate to the point of delivery. The packaging shall assure that the forgings will arrive at the point of delivery free from surface imperfections.

5.2 Marking

In addition to the requirements of ASME SA-336, each forging shall be identified with ESG Specification Number N30486 and revision letter and part number as defined on ESG drawings, if any. The marking shall be legible and permanent. Stamping, when used, shall be done with round-nosed interrupted-dot die stamps. The outside of the package shall be stenciled with this same information and the ESG Purchase Order Number.

6.0 NOTES AND DATA

6.1 Data Submittal Requirements

Time of submittal and number of copies shall be as specified in the purchase order.

6.1.1 Test Results

A certified test and examination report of actual results shall be submitted. The report shall include the heat number, ESG Specification Number N30486 and revision letter, and the following:

Heat and product analysis for all elements specified.

Results of mechanical properties.

Conformance to heat treating requirements.

Nondestructive test results.

Metallurgical cleanness.

6.1.2 Welding Procedure

If the supplier peforms any repair by welding, a detailed description of the welding procedure and nondestructive examinations to be used by the supplier shall be submitted.

3.4.1.6 STEAM GENERATOR POSTWELD HEAT TREATMENT

(N40114)

Rockwell International

Energy Systems Group

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TITLE
POSTWELD HEAT TREATMENT, SCRPP,
STEAM GENERATOR MODULES

APPROVALS

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3-9-83
Component Design Engineering & Specifications

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SPECIFICATION FOR POSTWELD HEAT TREATMENT, SCRPP, STEAM GENERATOR MODULES

1. SCOPE This specification supplements the ASME Boiler and Pressure Vessel Code Section VIII, Division 1, for postweld heat treatment of 2.25 chromium - 1.00 molybdenum alloy steel for use in steam generator modules of a Solar Central Receiver Power Plant (SCRPP).

2. DOCUMENTS

2.1 Applicable Documents The following documents form a part of this specification to the extent specified in Sections 3 and 4 of this specification. Any apparent conflict between this specification and the requirements of an applicable document shall be brought to the attention of the Project Office for resolution.

American Society of Mechanical Engineers (ASME)

ASME Boiler and Pressure Vessel Code

ANSI/ASME BPV-VIII-1	Pressure Vessels

Rockwell International

N40113	Cleanness, Steam Generator, Solar Central Receiver Power Plant

3. REQUIREMENTS

3.1 Materials This specification is limited to the postweld heat treatment of alloy steel 2.25 chromium - 1.00 molybdenum. The weldment thickness range shall be up to and including 2 inches.

3.2 Postweld Heat Treatment Postweld heat treatment shall be performed in accordance with ANSI/ASME BPV-VIII-1, Paragraph UW-40 and UCS-56. The postweld heat treatment temperature shall be 1310 ±50F. The minimum holding time at temperature shall be 1 hr or 1 hr per inch of weld thickness whichever is greater. The temperature differential across a change in cross-sectional area shall not exceed 50F. For the heating zone in the shell, the temperature gradient shall not exceed the values shown in Figure 1 for temperatures above 500F. The heating zone shall be defined as that region extending 2.5 $\sqrt{RT}$ (where "R" is the inside shell radius and "T" is shell thickness) on either side of (1) the weld or welds being heat treated, and (2) any shell regions adjacent to the weld or welds being heated which involve a change in geometry. The temperature gradient outside of the heating zone shall not exceed 400F per linear foot for temperatures above 500F. The temperature gradient for the tubing shall not exceed 250F per linear foot for temperatures above 500F.

3.2.1 Accumulative Time at Temperature Upon completion of fabrication, it shall be certified that no portion of the pressure boundary material has been exposed to an accumulated time at temperature in excess of 125 percent of the production material test specimens and the weld materials test specimens. The accumulated time at temperature of the material shall consider those temperatures between 1150-1249F as well as the time at heat treat temperatures.

3.3 Cleaning Weldments and all surrounding material in the area to be postweld heat treated shall be cleaned to the requirements of Specification N40113.

3.4 Time-Temperature Measurements Temperature measurements shall be made at a sufficient number of locations on the part to ensure that the temperature gradients do not exceed the limits specified in this specification.

3.4.1 Temperature Control Temperature sensing and recording equipment shall be used to assure that specified temperatures are maintained. The temperature measuring system shall be accurate to within ±10F of the actual temperature.

3.5 Protective Atmosphere for Sodium and Water Surfaces Sodium or water surfaces which will not be subsequently cleaned of heat treatment oxide shall not be heated above 700F without a protective atmosphere. The protective atmosphere shall meet the requirements of Table I. Surfaces may be protected from oxidation during heat treatment by coating with an approved* high temperature scale inhibitor. Internal threaded surfaces may be protected against oxidation during heat treatment by inserting an approved* bolt which has been coated with an approved* parting material.

3.6 Postweld Heat Treatment Procedure The postweld heat treating procedure shall be approved prior to heat treatment and shall include the following:

a. Description of cleaning methods used prior to heat treatment including all materials which are used in contact with the items, how and where they are used, and their general chemical makeup. Surface protection and parting materials shall be described by trade generic names. Details shall be included to describe their chemical makeup, method of application, reaction with the part, and post heat treat cleaning method required.

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*Approval based on approval of the details specified in the heat treatment procedure.

b. The method being employed to support the item during heat treatment. Describe all materials which will contact the part. A sketch or diagram is preferred.

c. Equipment to be used.

d. The heating method used.

e. The protective atmosphere used, including purity, flow rates, distribution, and other parameters necessary to describe its effectiveness.

f. A diagram showing the location and attachment method for temperature sensing elements (thermocouples), atmosphere sensing device type and location (as applicable), and (for localized heating), the amount, size and location of heating elements and the insulation used.

g. Heating rates.

h. Cooling rates.

i. Holding time at heat treat temperature and method used to determine start and finish of holding time.

j. Method used to monitor heating and cooling rates.

k. Method used to monitor controlled atmospheres.

l. Quality assurance provisions employed.

4. QUALITY ASSURANCE PROVISIONS

4.1 Acceptance Criteria Quality assurance requirements and acceptance criteria are an integral part of Section 3. As a minimum, these requirements shall be specified in the material processing procedure prepared for heat treatment operations.

4.2 Postweld Heat Treatment Records Postweld heat treatment records shall include the following:

a. Measurement locations and data. The data shall show time versus temperature measurements for heating, holding, and cooling and protective atmosphere purity (when applicable).

b. Heat treat charts, identified to the part and welds being heat treated, date that the heat treat was performed, and equipment used. Data shall be verified by the responsible inspection organization.

4.3 Computation of Time at Temperature The accumulated time at temperature, for the temperature range between 1150-1250F, shall be computed as follows:

Temperature Range	Time at Temperature	Equivalent Time at 1275 ±25F
1150-1199F	1 hr	1/3 hr
1200-1249F	1 hr	1/2 hr

It is not necessary to consider the time at temperatures below 1250F for material which is exposed to the heat treating temperatures (1310 ±50F) during a normal heat treat cycle. The time at temperature in the heat treating temperature range (1310 ±50F) shall be directly additive.

5. PREPARATION FOR DELIVERY Not applicable.

6. NOTES AND DATA Not applicable.

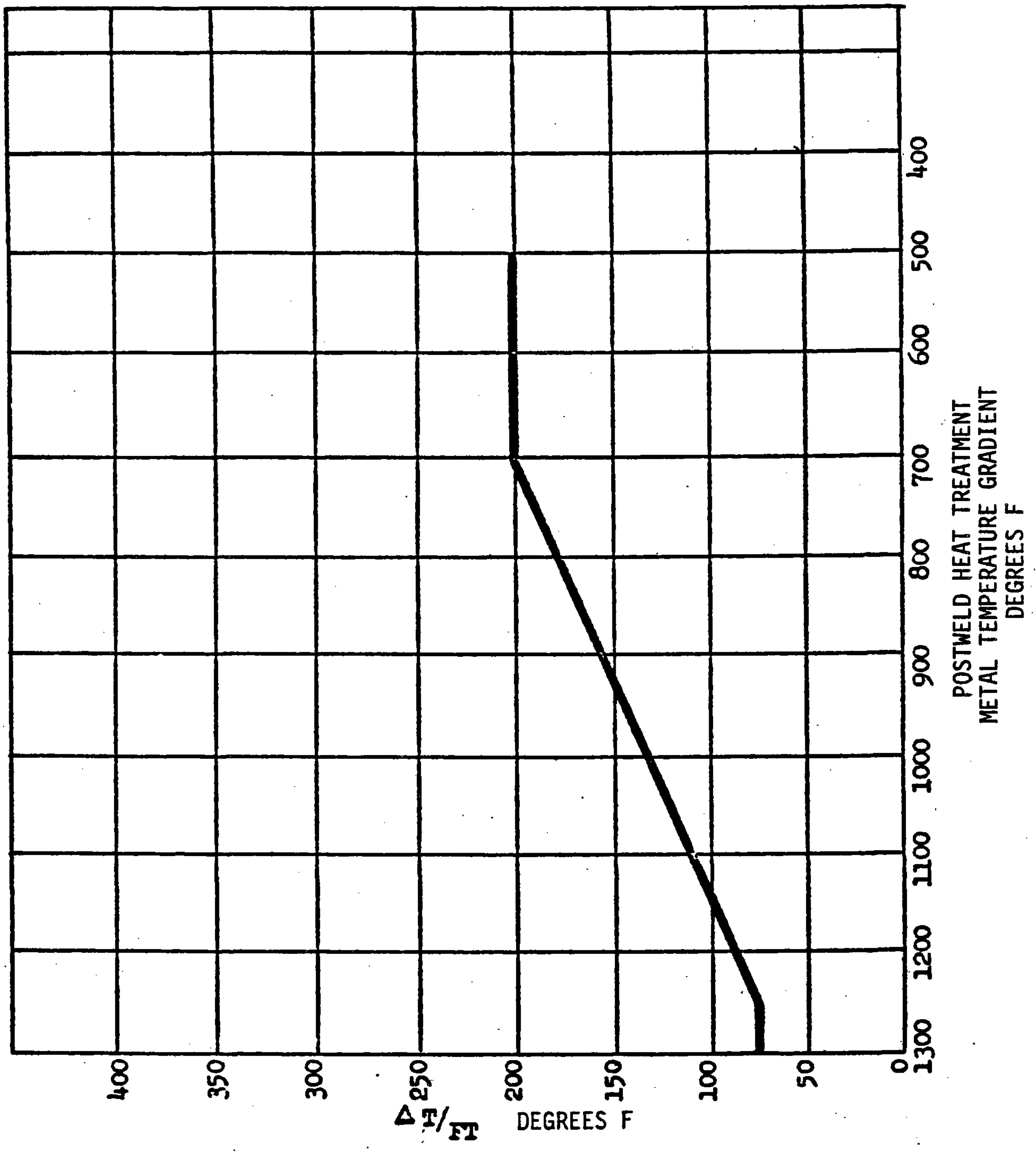

Figure 1 Postweld Heat Treatment

TABLE I

PROTECTIVE ATMOSPHERE REQUIREMENTS

Atmosphere	Purity
Argon	<200 ppm O_2, or dewpoint drier than -40F
Argon plus 2 to 4% hydrogen	<200 ppm O_2, or dewpoint drier than -40F
Nitrogen plus 2 to 4% hydrogen	<200 ppm O_2, or dewpoint drier than -40F
Others as called out in an approved procedure	Equivalent to above. Atmosphere shall be neutral and shall not cause carburization or decarburization.
Any of the above when nickel alloys are subjected to the heat treatment	Dissociated ammonia is prohibited. Titanium or its alloys shall not contact the part. Total sulfur content shall be <5 gm/100 ft^3.

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3.4.1.7 STEAM GENERATOR CLEANNESS (N40113)

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Energy Systems Group

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Technical Support

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SPECIFICATION FOR CLEANNESS, STEAM GENERATOR, SOLAR CENTRAL RECEIVER POWER PLANT

1.0 SCOPE

This specification establishes the engineering requirements for the in-process cleanness and storage of ferritic steel alloys and nickel-iron-chromium alloy materials and parts for use in the fabrication and assembly of a Solar Central Receiver Power Plant.

1.1 Classification

Three classes of cleanness are established by this specification.

Class A - as defined in 3.1.1

Class B - as defined in 3.1.2

Class C - as defined in 3.1.3.

2.0 DOCUMENTS

2.1 Applicable Documents

The following documents form a part of this specification to the extent specified in Sections 3 and 4 of this specification. Any apparent conflict between this specification and the requirements of an applicable document shall be brought to the attention of the Project Office for resolution.

Department of Defense

MIL-STD-889	Dissimilar Metals

American Society for Testing and Materials (ASTM)

ASTM D 512	Chloride Ion in Water, Test Methods for
ASTM D 1125	Electrical Conductivity and Resistivity of Water, Tests for
ASTM D 1179	Fluoride Ion in Water, Test Methods for
ASTM D 1246	Iodide and Bromide in Water Test Methods for

ASTM D 1293	pH of Water, Test Methods for
ASTM D 1888	Particulate and Dissolved Matter, Solids, or Residue in Water, Test Methods for

3.0 REQUIREMENTS

3.1 Cleanness

3.1.1 Class A Cleanness

Surfaces having Class A cleanness shall be free of extraneous material, such as dirt, rust, grease, oil, salt, acid, alkali, moisture, corrosion products, oxides (not including thin temper films), mineral residues, hydrocarbons, paint, grit (imbedded or loose), chips, scale, weld spatter and fluxes.

3.1.2 Class B Cleanness

Surfaces having Class B cleanness shall be free of extraneous material, such as heavy oxides, mineral residues, loose scale or grit, grease, oil, paint, chips, weld spatter and fluxes. Tightly adherent scale is permissible.

3.1.3 Class C Cleanness

Surfaces having Class C cleanness shall be free of gross extraneous material, and a light oil film is permissible.

3.2 Materials

3.2.1 Cleaning Agents

All cleaning agents shall be new and of technical grade quality or better.

3.2.1.1 Halides

The total halide content of cleaning agents, when diluted to the concentration to be used, shall not exceed 30 ppm for Class A cleanness.

3.2.1.2 Silicates

The silicate concentration in cleaning agents, when diluted to the concentration to be used, shall not exceed 20 ppm.

3.2.2 Water

Water shall be in accordance with the following:

Property	Requirements	
	Grade I	Grade II
Particulate and dissolved matter (max. ppm)	10	800
Chloride ion (max. ppm)	1.0	25
Conductivity (max. micromhos/cm at 25C)	2.5	---
pH range	5.5 to 8.0	5.5 to 8.0

3.2.3 Solvents Other Than Water

3.2.3.1 Class A Cleanness

The nonvolatile residue of solvents used in a Class A cleaning process or a Class A cleanness verification shall not exceed 30 ppm. (0.003 g/100 ml).

3.2.3.2 Class B Cleanness

Solvents used in a Class B cleaning process shall be free of particles and suspended matter as determined by visual examination in accordance with 4.1.

3.2.4 Drying Gases

3.2.4.1 Class A Cleanness

Air or gas to be used for forced drying following a Class A cleaning shall be passed through a dryer/absorber unit to remove moisture, oil vapor, and halides. The dew point of the drying air or gas shall be -40F maximum. The temperature of the air or gas shall not exceed 500F. Water pumped bottle gas need not be passed through a dryer/absorber, provided that the gas meets the dew point requirement.

3.2.5 Cloths

3.2.5.1 Class A Cleanness

Cloths used for drying the final rinse liquid from Class A cleaned surfaces, or for wipe-inspections of Class A cleaned surfaces, shall be white, clean, and dry.

3.2.6 Mechanical Cleaning Materials.

3.2.6.1 Brushes
Austenitic or mild steel wire brushes which are new or have been used only on chrome-moly ferritic steels shall be used on chrome-moly ferritic steels. Austenitic stainless steel brushes which are new or have been used only on nickel-iron-chromium alloys shall be used on nickel-iron-chromium alloys.

3.2.6.2 Blast Cleaning
Metallic grit used in blast cleaning operations shall not be electrolytically dissimilar, as defined in MIL-STD-889, with the metallic substrate being cleaned. The abrasive materials shall be new or have been used only on same base alloys.

3.2.6.3 Abrasive Cleaning
Aluminium oxide abrasives shall be used for grinding and silicon-carbide for hand dressing. Rubber bonded grinding wheels shall not be used.

3.3 Cleaning Procedures

The individual operations of a cleaning procedure shall use any of the materials specified in 3.2. Time and temperature of the stages of cleaning shall be controlled to assure effective cleaning without injuring the surface finish, the properties, or the metallurgical structure of the materials being cleaned. Surfaces shall be kept moist between stages of cleaning and final rinsing, wherever possible.

3.3.1 Baths
The baths shall be made up of materials meeting the requirements of 3.2. Grade II water as defined in 3.2.2 shall be used for making up cleaning baths. The bath shall be renewed when concentrations exceed the limits established in 3.2, the concentration of the cleaning agent has decreased to impair cleaning, or other applicable criteria, such as the pH of the bath or the build up of insoluble residue.

3.3.2 Intermediate Rinses
Grade II water or solvent as specified in 3.2 shall be used.

3.3.3 Final Rinses

3.3.3.1 Water
If water is used as a final rinse for Class A cleanness, Grade I water in accordance with 3.2.2 shall be used. Final rinsing for

Class A cleanness shall be of sufficient duration and quality such that the last part of the effluent rinse water shall contain no foreign matter visible with the unaided eye. The last part of the effluent rinse water shall meet the following requirements: (1) an electrical conductivity no greater than 10.0 micromhos per centimeter at 25C (not less than 100,000 ohms specific resistivity); (2) a pH value between 5.5 and 8.0; or (3) a particulate and dissolved matter concentration no greater than 12 ppm.

3.3.3.2 Solvents

The chloride content of the solvents used shall not exceed 1.0 ppm for Class A and 25 ppm for Class B cleanness.

3.4 Prohibited Materials

3.4.1 Halogenated Solvents

Halogenated solvents may be used only where no crevices or inaccessible areas exist and where thorough rinsing and removal can be assured.

3.4.2 Caustics

Caustic compounds shall not be used.

3.5 Safety

When chemicals and materials that are hazardous to health are to be used in cleaning, provisions for care in handling, storing, and mixing such cleaning materials shall be incorporated into the cleaning procedures. Suitable safety equipment and protective clothing shall be used.

3.6 Handling and Storage

Handling shall be performed in a manner to maintain cleanness. Class A cleaned surfaces shall be handled with clean gloves. Exposures to a general shop area atmosphere shall be minimized by temporarily terminating dirt-producing operations or by using temporary seals or covers. Contamination shall be minimized by cleaning the area, terminating work temporarily, or other appropriate procedures. Material shall be stored in a manner to prevent contamination by liquid spillage.

3.7 Preparation and Review

Detailed material process procedures shall be prepared. The procedure shall include, but not be limited to the following:

> The specific handling, storage, machining and processing of materials and operations.

The cleanness class for which procedure is written.

The specific criteria to be applied to evaluate the cleanness attained.

The inspection and process control methods to be employed.

Whether component proof flushing is required, and if so, the detailed flushing procedure.

The specific cleaning processes to be employed.

The detailed steps in the complete cleaning procedure, including times and temperatures in solutions, rinsing steps, drying methods, and metal removal.

Base metal or metals to be cleaned.

Precautions to be taken during and after assembly to maintain cleanness.

Technical description of all cleaning materials to be used for cleaning, rinsing, and drying.

Equipment to be used, such as cleaning tanks, spray systems, air compressors, filters, and sand-blasting units. The items shall be described in pertinent technical terms, e.g., type, size, materials of construction, capacity, and power requirements, if any.

4.0 QUALITY ASSURANCE

4.1 Visual Examination

Visual inspections shall be performed to determine compliance with 3.1.1, 3.1.2, and 3.1.3; to evaluate the adequacy of intermediate and final rinsing by examination of both the rinsed surface and rinse water; to determine the completeness of drying by examination of a surface for moisture. Visual inspections shall be made by direct observation with the unaided eye (20/20 or corrected thereto) with lighting that is adequate to distinguish any unacceptable conditions or cleanness as defined in this specification. In cases where cleanness cannot be adequately determined by the unaided eye, the surface shall be inspected by wiping with a clean white cloth, either dry or moistened with alcohol or acetone (but not saturated). Appearance of extraneous material collected on the cloth shall be cause for rejection. Discoloration shall be evaluated based on the nature of the stain and the material of the surface being inspected. Supplementary devices and techniques may be used to determine the absence or presence of contamination. Rinse solutions shall be examined for foreign matter by looking at the surface for floating material, then looking through a test tube or beaker of the solution toward a light source, to detect any suspended foreign material.

4.2 Nonvolatile Residue

The nonvolatile residue of solvents shall be determined to verify compliance with 3.2.3.1. The following method shall be used: Evaporate 100 milliliters of the sample in a tared platinum crucible or other suitable dish using a water bath or steam bath. Dry the dish and residue for 30 minutes in an oven at 220 ±4F. Cool in a dessicator and weigh. The increase in weight over that of the empty dish shall be reported as the amount of nonvolatile residue.

4.2.1 Halide Content

The halide content of cleaning agents and solvents other than water shall be determined to verify compliance with 3.2.1.1, 3.2.3.1 and 3.2.3.2. The halide content may be determined in accordance with the following ASTM tests: chloride - ASTM D 512; fluoride - ASTM D 1179; iodide and bromide - ASTM D 1246. If other analytical methods are used, they shall be specified in the procedure.

4.3 Silicate Content

The silicate concentration in cleaning agents shall be determined to verify compliance with 3.2.1.2. The analytical method used to determine silicate content shall be specified in the procedure.

4.4 Water Purity

The water purity shall be determined to verify compliance with 3.2.2. Particulate and dissolved matter shall be determined in accordance with ASTM D 1888, conductivity in accordance with ASTM D 1125, pH in accordance with ASTM D 1293, and chloride ion in accordance with ASTM D 512.

4.5 Process Control and Materials Verification

All cleaning operations shall be reviewed and surveillance maintained. Process control criteria shall be established for all detailed cleaning procedures. Inspection and testing shall be to the minimum consistent with level necessary to assure compliance with the requirements of Section 3.

5.0 PREPARATION FOR DELIVERY

5.1 Packaging

Clean, covered or sealed, containers or other packaging materials and methods shall be used as necessary to satisfy the requirements of Section 3 and to prevent deterioration and damage during shipping. Rust preventive or organic material shall not be applied to any internal surfaces.

6.0 NOTES AND DATA

(Not applicable)

3.5 AUXILIARY SODIUM SUBSYSTEMS (N10032)

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Specification

Auxiliary System

Carrizo Plains Solar Power Plant (CPSPP)

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TABLES

FIGURES

1.0 SCOPE

This specification establishes the requirements for the design, fabrication, and installation of the Auxiliary System of the Carrizo Plains Solar Power Plant (CPSPP).

2.0 DOCUMENTS

2.1 APPLICABLE DOCUMENTS

The following documents of the exact shown form a part of this specification to the extent specified herein. Any conflict that may appear between this specification and the applicable documents shall be brought to the attention of the Program Office for resolution.

American Society of Mechanical Engineers (ASME) - ASME Boiler and Pressure Vessel Code, 1980 edition, including Addenda through Winter 1982

Section VIII (Div. 1)	Pressure Vessel
Section IX	Welding Qualification

American Institute of Steel Construction (AISC) - Manual of Steel Construction, Eighth Edition, 1980

American Welding Society (AWS)

AWS D1.1-75	Structural Welding Code

American National Standards Institute (ANSI)

ANSI C1-1981	National Electric Code
ANSI B31.1-1980	Power Piping Code

National Electrical Manufacturers Association (NEMA)

NEMA Standards

3.0 REQUIREMENTS

3.1 SYSTEM DEFINITIONS

The auxiliary system comprises of facilities which are used to support plant operation and to provide plant safety and maintenance. The facilities are defined in the following subparagraphs.

3.1.1 Sodium Purification System

The sodium purification system, which consists of cold traps and a plugging temperature indicator (PTI). The PTI is used to monitor sodium purity and the cold traps are used to lower contaminants in sodium.

3.1.2 Argon Cover Gas System

The argon cover gas system provides argon as an inert cover gas to the ullage spaces in vessels, tanks, pumps, and other Na components at specified pressures and flow rates. It serves to control Na levls and facilitates Na filling and draining.

3.1.3 Sodium Receiving Station

The receiving station consists of heaters, filters, drum handling equipment, piping, and valves for receiving sodium shipments and loading Na into the CPSPP system.

3.1.4 Sodium-Water Reaction Product System

The sodium-water reaction product system consists of a reaction product tank for receiving reaction products from the steam generators due to tube failure which would result in Na water reaction. The system includes the tank, a flare stack, and an inert gas purging system to prevent fire.

3.1.5 Safety and Maintenance Equipment

Safety equipment is provided for fire prevention and control and waste handling. They include drip pans in major sodium component or tank areas to prevent the spread of sodium fire, upon spill, and storage of sodium fire smothering material for fire fighting. The equipment includes facility for packing and shipping sodium components or waste for disposal or repair.

3.2 ENVIRONMENTAL REQUIREMENTS

Normal ambient conditions to which the auxiliary system facilities will be exposed are shown in Table 3-1.

TABLE 3-1

ENVIRONMENTAL REQUIREMENTS

Minimum temperature, °C (°F)	-23 (-10)
Maximum temperature, °C (°F)	45 (110)
Maximum operating wind (including gusts),[a] m/s (mph)	13.3 (30)
Maximum survival wind (including gusts),[a] m/s (mph)	40 (90)
Seismic environment	Zone 4
Survival earthquake horizontal and vertical acceleration, g	0.4 (equipment) 0.25 (civil)
Maximum dust devil wind speed, m/s (mph)	18 (45)
Maximum static snow load, Pa (lb/ft^2)	96 (2)
Maximum snow deposition weight, m/day (in./day)	0.2 (4)
Average annual rainfall, mm (in.)	88 (3.5)
Maximum 24-h rainfall, mm (in.)	TBD (TBD)[b]
Hail maximum diameter, mm (in.)	25 (1)
Hail ice deposit, mm (in.)	25 (1)
Hail specific gravity	0.9
Hail maximum terminal velocity, m/s (fps)	23 (75)

[a] At a reference height of 10 m (32.8 ft)

[b] To be developed from further site monitoring

3.3 DESIGN REQUIREMENTS

The design requirements of the auxiliary system facilities shall be as specified in Table 3-2. The operating conditions shall be as specified in the following subparagraphs.

3.3.1 Sodium Purification System (SPS)

3.3.1.1 Diagram

The schematic flow diagram of the SPS shall be as shown in Figure 3-1.

3.3.1.2 Operating Conditions

The SPS shall remove impurities in sodium by cold trapping. The SPS shall have the capability of reducing plugging temperature of sodium during plant startup to below 300°F in TBD days. The principal source of the contaminant to be removed at startup is oxygen from component metal surface. The design oxygen burden is 4×10^{-4} lb/ft. The SPS shall have the capability of maintaining Na plugging temperature below 300°F during normal operation. The principal contaminant during normal operation is hydrogen evolved from the corrosion of 2-1/4 Cr - 1 Mo steel of the steam generators. The design hydrogen burden is 1.7×10^{-7} lb/ft^2-hr. There is a total of TBD ft^2 heat transfer surface areas in the steam generators. The total sodium inventory in the heat transfer system is 325,000 lb.

The maximum inlet temperature of the SPS is 650°F.

3.3.1.3 Interfaces

The SPS shall interface with the receiver loop at the receiver pump discharge and the cold tank.

TABLE 3-2

AUXILIARY SYSTEM MAJOR COMPONENT
Structural Design Requirements

		Design Conditions		
Facility or Component	Code	Temperature (°F)	Pressure (psig)	Material
1. Na Purification System				
Cold Trap	ASME Section VIII Div. 1	650	300	CS
Plugging Temperature Indicator	ASME Section VIII Div. 1	650	300	SS
Piping	ANSI B31.1	650	300	SS
Valves	ANSI B16.4	650	300	SS
2. Argon Cover Gas System				
Piping	ANSI B31.1	Ambient	150	CS
Valves (Regulators)	ANSI B16.4	Ambient	150	CS
Heat Exchanger	ASME Section VIII Div. 1	250	-14.7	CS
Vacuum Tank Surge Tank	ASME Section VIII Div. 1	250	150	CS
Freeze Vents	ASME Section VIII Div. 1	300	15	SS
Argon Compressor	-	-	150	-
3. Na Receiving Station				
Drum Heater				
Filters	ASME Section VIII Div. 1	400	50	SS
Platform	AISC	Ambient	-	CS
Piping	ANSI B31.1	400	100	SS
Valve	ANSI B16.4	400	150	SS
4. Na-H_2O Reaction Product System				
Reaction Product Tank	ASME Section VIII Div. 1	1,050	16	CS
Flare Stake	AISC	1,050	16	CS

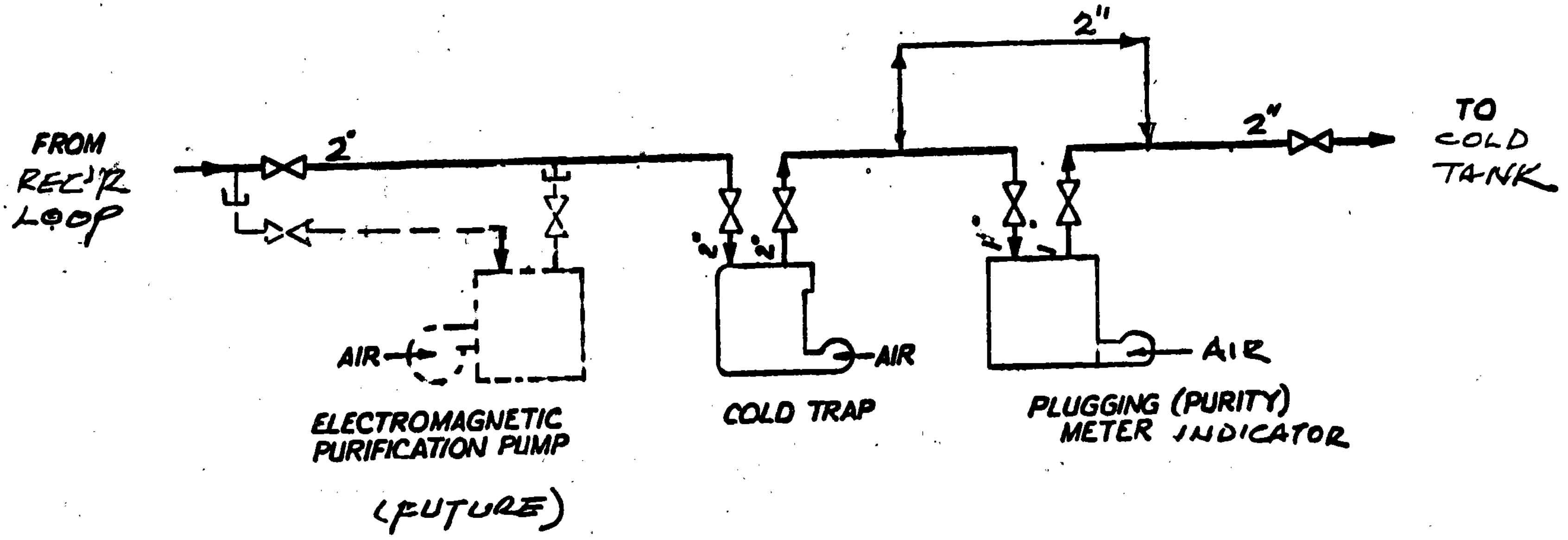


FIGURE 3-1 SODIUM PURIFICATION SYSTEM

3.3.1.4 Sodium Circulation

The SPS will operate when the receiver loop is in operation. The receiver pump head shall be utilized for forced circulating of sodium through the SPS. The pump head available at the interface is 550 ft, and the hydrostatic head in the cold tank is 40 ft with a cover gas pressure of 5-in. Hg.

3.3.1.5 Cold Trap

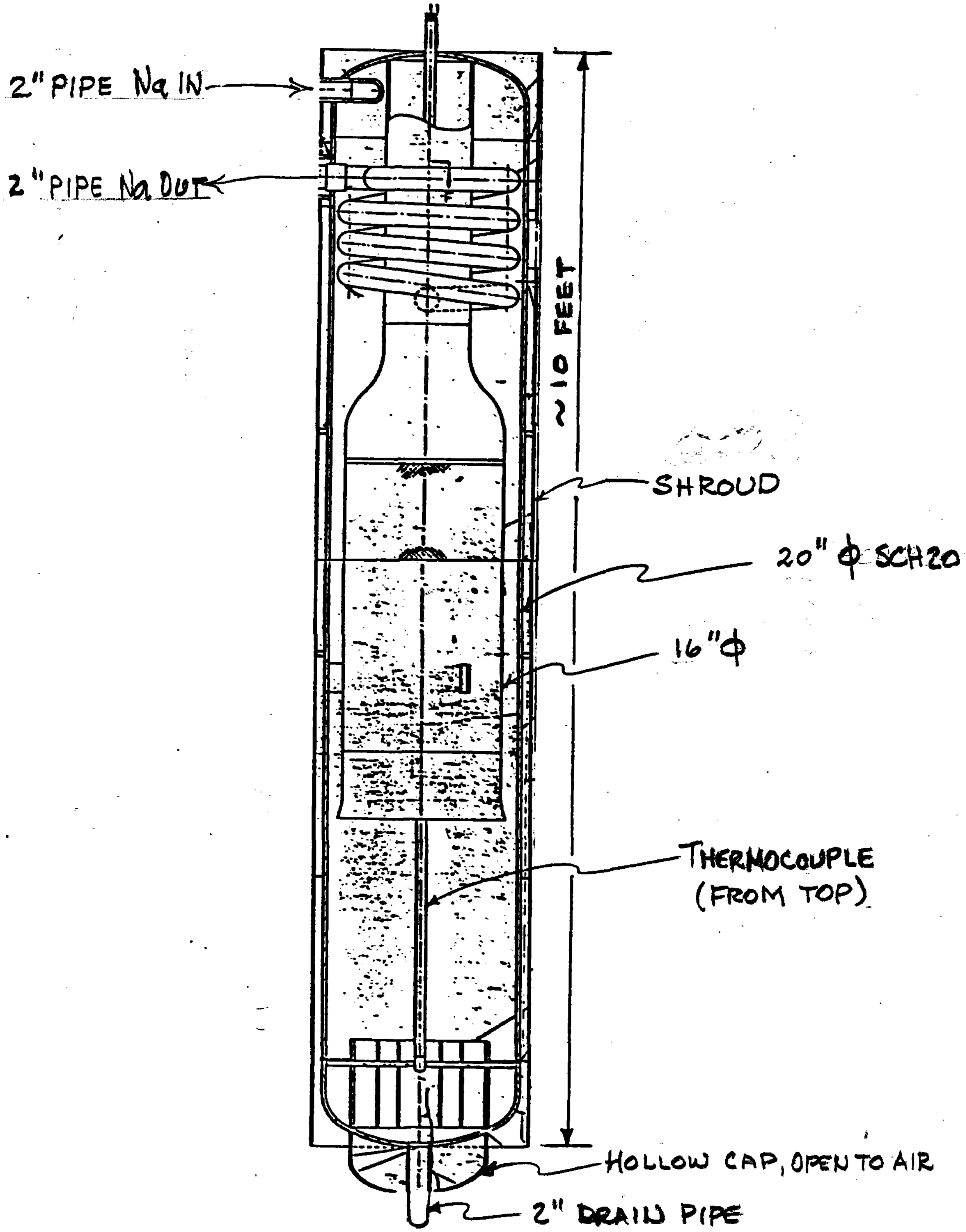
The cold trap shall be an air-cooled and packless type. The layout of the cold trap is shown in Figure 3-2. The economizer is provided to minimize the heat load on the blower which shall have the capability of providing cooling air to lower the temperature of the crystallization zone of the cold trap to 225°F. The cold trap shall include electric heaters for remelting sodium, structure support for the cold trap, thermocouples for monitoring and control of temperatures, insulation clips for the installation of thermal insulation which would reduce the exposed surface temperature to below 140°F.

3.3.1.6 Plugging Temperature Indicator

The plugging temperature indicator (PTI) consists of a cooler-economizer, orifice plate, the clearing device, thermocouples, heater, and blower. Sodium circulates at the rate of 1/4 gpm flowing through the orifice and is cooled by the blower. As the temperature reaches the solubility limits of the dissolved impurities, precipitation will occur at the orifice and reduce the flow rate. The temperature at which the flow first sustained reduction is referred to as the plugging temperature which, in turn, indicates the purity level of the sodium.

The PTI shall be designed and fabricated in accordance with ASME Code Section VIII Division 1. The material of construction shall be Type 304 or 316 stainless steel. The PTI shall include an electromagnetic flowmeter to determine flow losses.

FIGURE 3-2
PACKLESS COLD TRAP



3.3.2 Argon Cover Gas System

The argon gas system provides an inert atmosphere to all ullage space in the sodium heat transfer system and to components for level control and to facilitate draining. The cover gas vented from the components shall be interconnected so as to conserve the argon gas. A vacuum (operates below atmospheric pressure) shall be provided to receive vented argon from the components. Compressors shall be provided to restore the argon to the supply header pressure for reuse.

An argon storage facility consisting of bottle racks shall be provided to supply the plant for a minimum period of 15 days under normal operating conditions. A standby quantity shall be provided to purge the sodium water reaction product tank when necessary.

3.3.2.1 Diagram

The schematic flow diagram of the argon system shall be as shown in Figure 3-3.

3.3.2.2 Design Conditions

Structural design conditions of the argon system and its components are given in Table 3-2.

3.3.2.3 Interface

The interfaces of the argon and other plant systems shall be at component or tank nozzles. The argon system shall provide all valves and freeze vents wherever they are required.

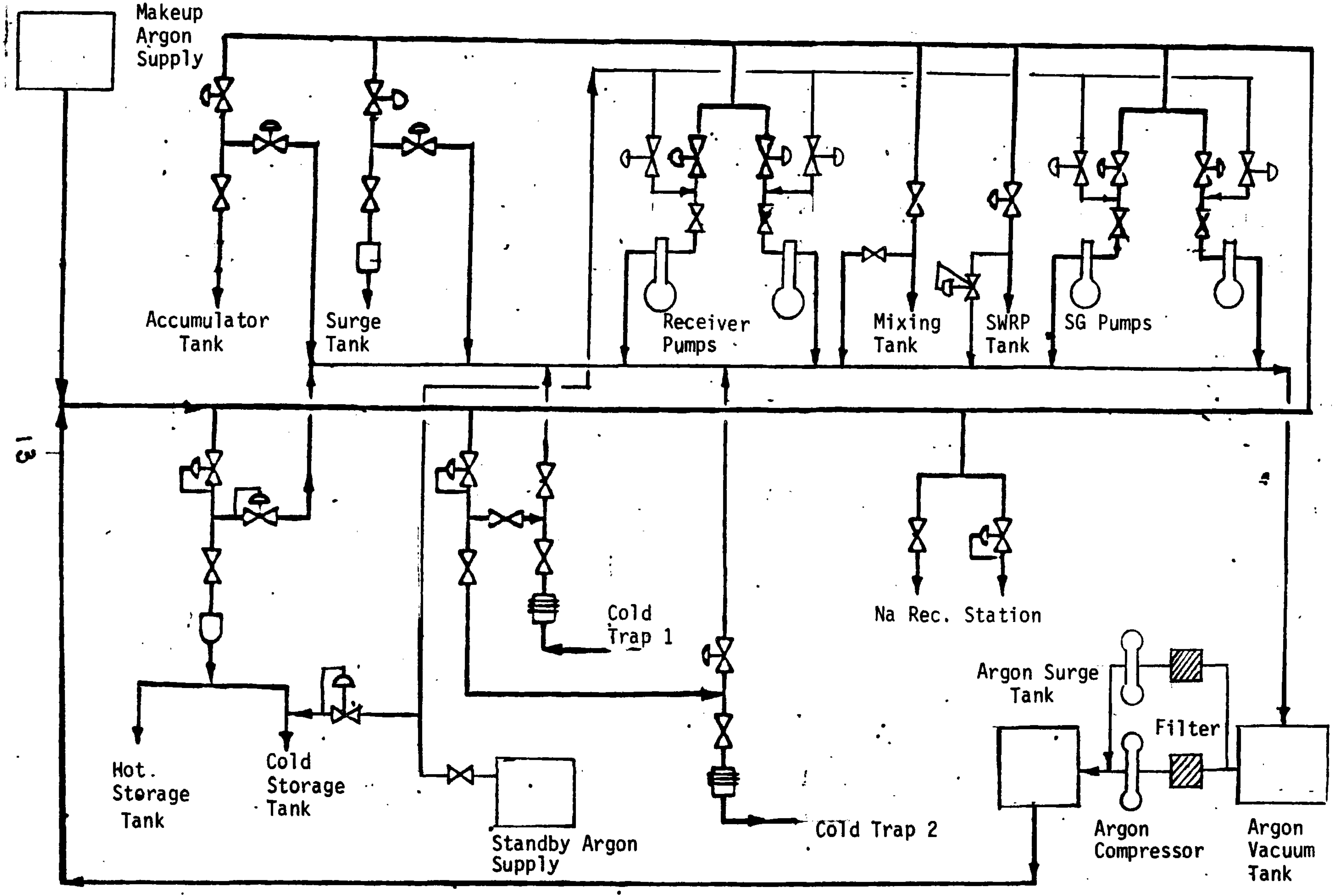


FIG. 3-3 ARGON COVER GAS SYSTEM

3.3.3 Sodium Receiving System

The sodium receiving system (SRS) is a facility for unloading sodium on site into the mixing tank of the CPSPP heat transfer system. The SRS shall include the following major components:

- Na tank trailer oil heater (to be rented)
- Sodium filters (2)
- Na drum unloading station
- Na drum electrical heater
- Piping and valves.

3.3.3.1 Item Diagram

The SRS flow diagram shall be as shown in Figure 3-4.

3.3.3.2 Na Tank Car Trailer Oil Heater

The oil heater provides hot oil which will circulate through the channels of the tank car to melt sodium in the tank car. The trailer truck capacity is 10,000 gallons. The heater shall have the capacity of 1.5×10^6 Btu/hr. The oil heater is a commercially available unit consisting of oil storage vessel, oil pump, an oil heater, and flexible hoses for circulation of oil through the channels on the tank car. The oiler should be obtained on a rental basis.

3.3.3.3 Sodium Filters

The filters shall remove particulate impurities from sodium. The filter elements shall be stainless steel mesh with porous metal backup. The filter efficiency shall be 98% normal for particle size larger than 0.10μ. Two filters are required for a total rated flow capacity of 50 gpm.

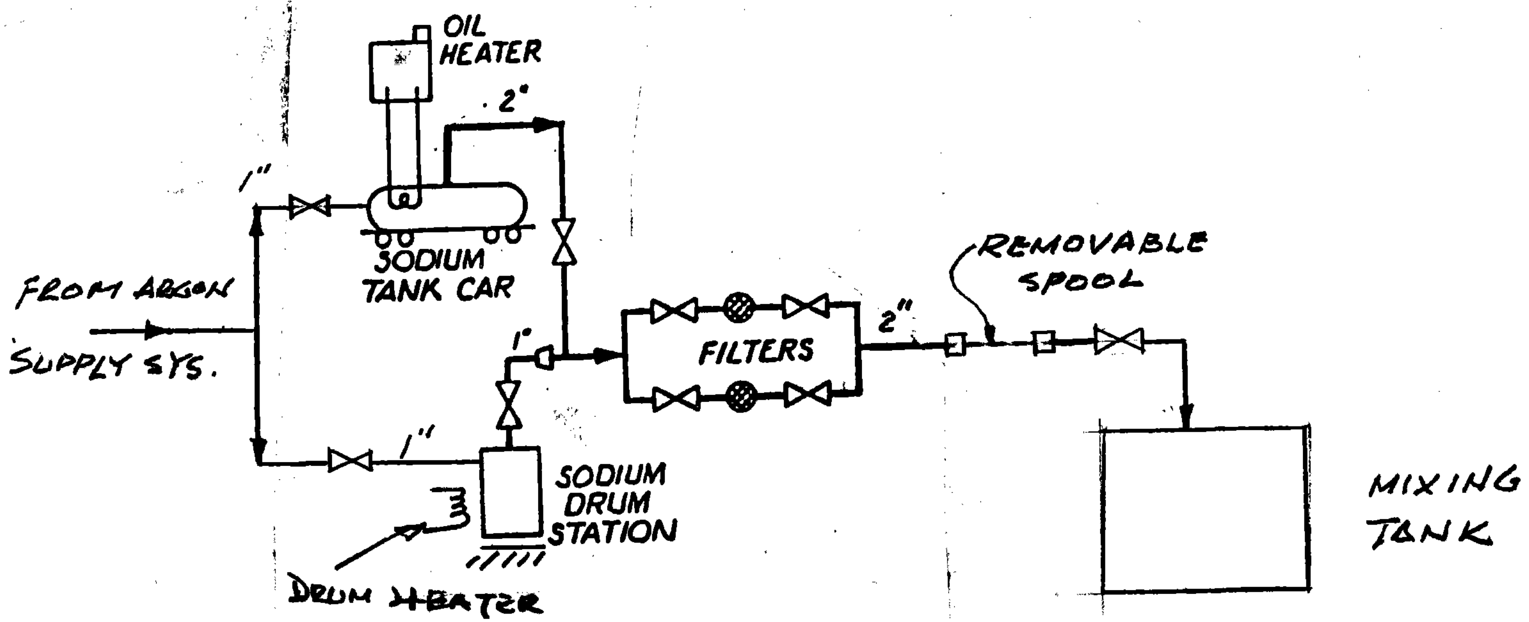


FIGURE 3-4 SODIUM RECEIVING SYSTEM.

3.3.3.4 Drum Unloading Station

The drum unloading station shall consist of:

- A platform capable of supporting the weight of a 55-gallon drum with sodium
- A 12-kW clamshell-type electric heater
- Piping and valves for transfering sodium to the mixing tank.

3.3.4 Sodium Water Reaction Product System (SWRPS)

The function of the system is to reduce pressures in the main sodium heat transfer system, to contain liquid and solid reaction products, and to vent safely the gaseous products resulting from a major tube rupture in the steam generators.

3.3.4.1 Item Diagram and Major Components

The diagram for the SWRPS shall be as shown in Figure 3-5. The major components of the system are:

- Reaction product tank with tangential entry nozzle
- Relief stack with spark-type igniters
- Atmospheric seal rupture disc to contain an inert atmosphere in the SWRPS and exclude air under standby conditions
- Purge vent to allow inert gas purging of SWRPS and to prevent overpressure.

3.3.4.2 Reaction Product Tank

The reaction product tank shall be a vertical, cylindrical tank, capable of accepting 10,050 gallons of liquid and solid sodium reaction products. The volume includes an ullage space for gaseous-solid separation. The inlet nozzle shall be tangential to the tank and the exhaust stack to be at the center of the tank.

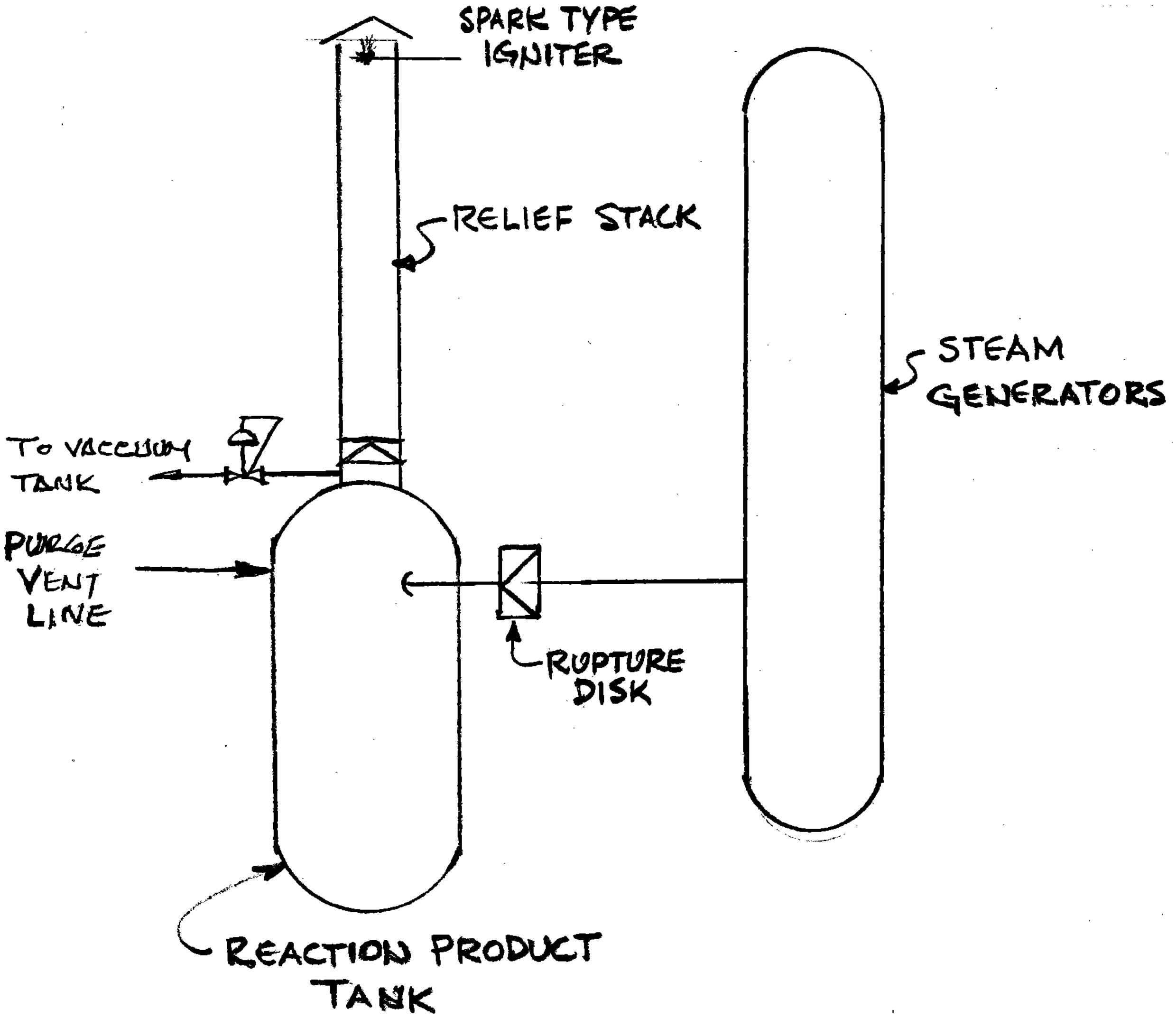


FIGURE 3-5 SODIUM WATER REACTION PRODUCT SYSTEM

3.3.4.3 Relief Stack

Effluent from sodium-water reaction in the steam generator consists of a mixture of argon, hydrogen, and possible water vapor laden with sodium oxide and hydroxide. The stack is to safely release the hydrogen to the atmosphere during relieving. The height of the stack shall be above adjacent structure.

3.3.4.4 Igniters

Two windproof, spark-type igniters shall be provided at the top of the stack to burn hydrogen.

3.3.4.5 Purge Vent

A 2-inch purge vent line with a pressure relief valve shall be provided which shall bypass the atmosphere seal rupture disc. It is used to protect the rupture disk from the relief system overpressure.

3.3.5 Safety and Maintenance Equipment

Safety equipment shall be provided for controlling and extinguishing sodium fire. Maintenance equipment shall be provided for packaging of sodium waste and sodium component for offsite cleaning and/or repair or disposal.

3.3.5 Floor Lining

Steel floor lining (TBD in. thick) shall be provided under major sodium components and large piping. The perimeters of the lining shall have steel curbs with sufficient height to contain 1-1/2 times the quantity of sodium in the components above.

3.3.5.2 Sodium Fire Extinguisher

Met-L-X powder extinguishers shall be provided for extinction of sodium fire. Calcium carbonate in drums shall be provided for packing sodium lines on vertical surfaces of pipe or components. The Met-L-X shall be 150-lb size, movable, on wheels. The numbers and location for Met-L-X powder extinguisher and $CaCO_3$ drums shall be TBD.

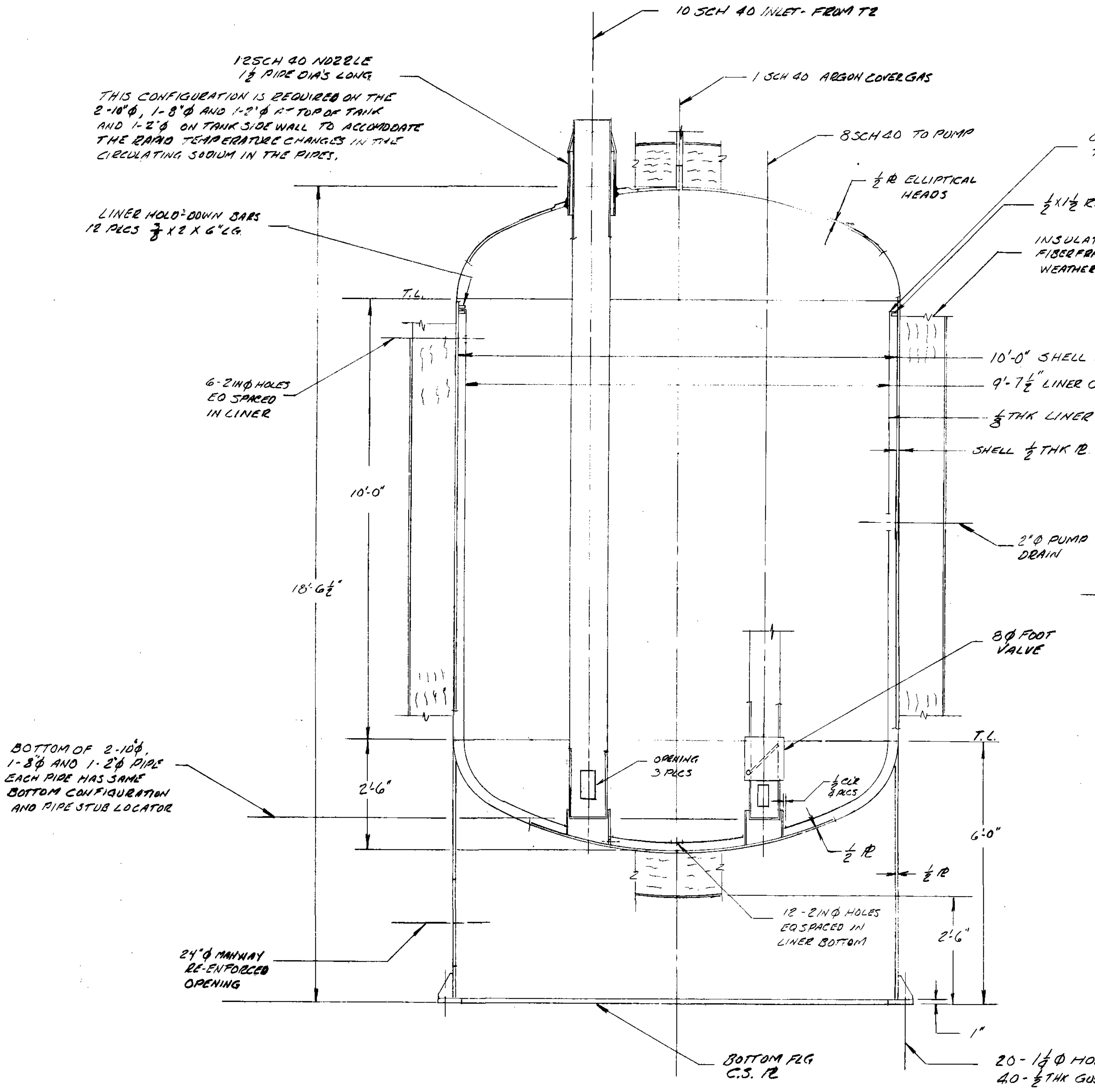
3.3.5.3 Sodium Component and Waste Packaging and Shipping Equipment

Sodium components requiring repair or disposal shall be shipped off site for processing. Metal containers and equipment shall be provided for packaging of sodium components and 55 drums for sodium waste. Packaging equipment to be provided is TBD.

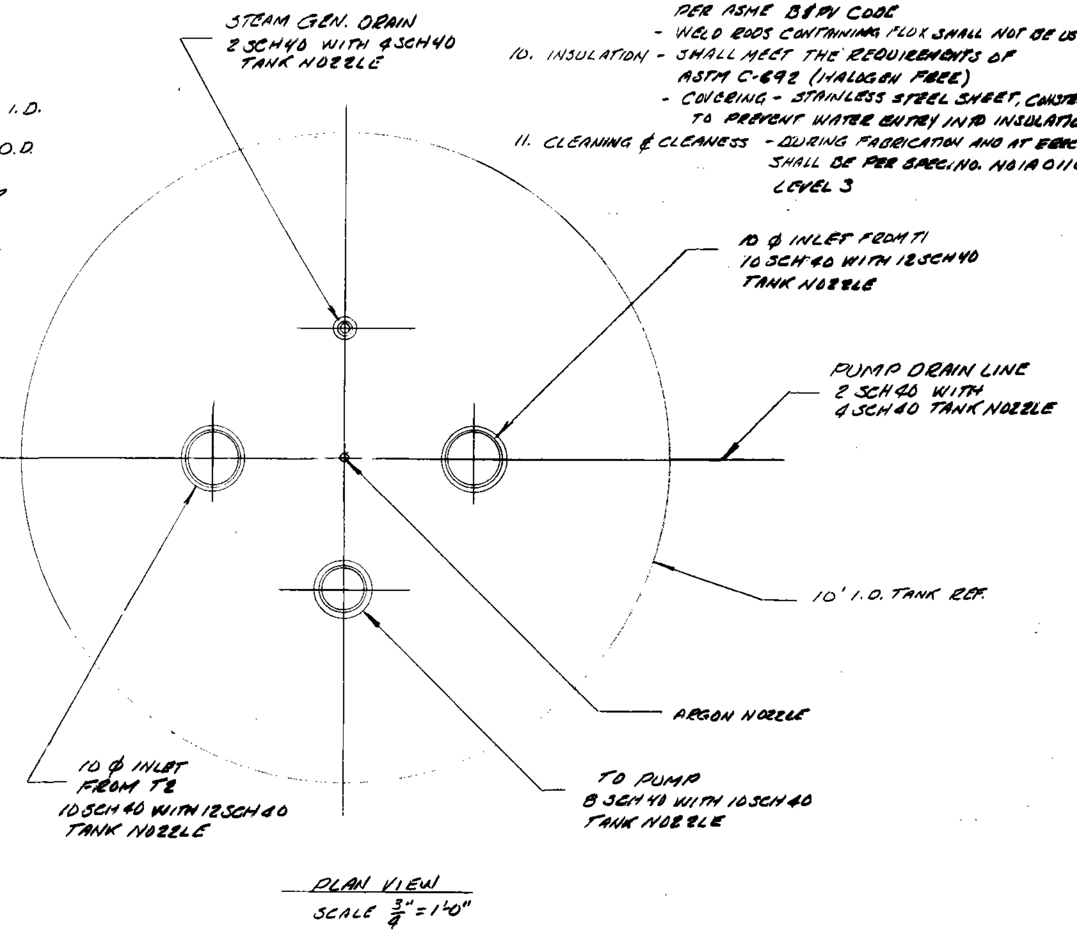
3.5.1 SODIUM MIXING TANK
(079R000048)

REVISIONS

LTR	DESCRIPTION	DATE	APPROVED



ELEVATION
SCALE ¾"=1'-0"



PLAN VIEW
SCALE ¾"=1'-0"

NOTES: UNLESS OTHERWISE SPECIFIED ON THIS DRAWING

1. SERVICE - LIQUID SODIUM
2. CAPACITY - 6000 GAL 'ACTIVE'
3. DESIGN TEMP - 1000°F
4. DESIGN PRESS. - 100 PSIG AT TOP OF SHELL
5. CORR. ALL. - 0
6. SEISMIC REQ. - .4G H, .267G V.
7. DESIGN RULES - DESIGN AND CONSTRUCT TO THE REQ OF ASME B&PV CODE, SECTION VIII, - CODE STAMP REQ.
8. MATERIAL - SHELL PLATES - 304 ST STL. ASME SA-240, [illegible]
   - PIPE AND NOZZLES - SEAMLESS PIPE, ASME SA-312 TP304
   - BOTTOM FLANGE - ASTM A-36
9. WELDING - CONTAINMENT WELDS - FULL PENETRATION WELDS PER ASME B&PV CODE
   - WELD RODS CONTAINING FLUX SHALL NOT BE USED
10. INSULATION - SHALL MEET THE REQUIREMENTS OF ASTM C-692 (HALOGEN FREE)
   - COVERING - STAINLESS STEEL SHEET, CONSTRUCTED TO PREVENT WATER ENTRY INTO INSULATION
11. CLEANING & CLEANESS - DURING FABRICATION AND AT ERECTION SHALL BE PER SPEC. NO. N01A 011001, LEVEL 3
12. INSPECTION - 100% X-RAY OF ALL CONTAINMENT WELDS
   - LEAK TEST - ALL CONT. WELDS SHALL BE BUBBLE LEAK TESTED USING THE VACUUM BOX TECHNIQUE DESCRIBED IN SECTION V, PARA T-1033 OF THE ASME B&PV CODE, 1980 EDITION
   - LIQUID PENETRANT EXAMINE ALL CONTAINMENT WELDS PER APPENDIX VIII OF SECTION VIII OF THE ASME B&PV CODE, 1980 EDITION

DESIGN LAYOUT

IN WORK
DOCUMENT NOT RELEASED
DATE 4-1-83 ISSUE NO. 1 RK
MGR. J. Doming
FOR INFO ONLY ☐
FOR STORAGE ☑
FORM 723-P-1 REV. 7-76

DR BY J. L. McElwee 3-25-83
CHK BY —
J. Doming 3/29/83
M & P —
STRESS —

Rockwell International Corporation
Energy Systems Group

SODIUM MIXING TANK, T-5
CARRIZO PLAINS POWER PLANT

SIZE D
DRAWING NO. 079R000048
SCALE ¾"=1'-0"
SHEET

FORM N94-R-16 REV. 3-80

DIETERICH-POST CLEARPRINT 1020-8

4.0 POWER CONVERSION SYSTEM (D23-5)

Engineering
76-370 2/81

DCM No. D23-5 Revision 0
Date March 14, 1983
File No. D23-01700

PACIFIC GAS AND ELECTRIC COMPANY

30 MW SOLAR PROJECT

DESIGN CRITERIA MEMORANDUM

Structure, System, or Component: Power Conversion System

Prepared by: Richard E. Price RPrice Date 3-14-83

Group Leader/Supervisor Review , M&NE (Discipline) Date 3.14.83

Reviewed by Interfacing Disciplines:

Group Leader/Supervisor J. B. GEGAN JBGegan Date 3-14-83

Group Leader/Supervisor A. B. Schuurman ABSchuurman Date 3-17-'83

Group Leader/Supervisor K. G. Zaharoff KGZaharoff Date 3-18-83

Approved by:
M. E. Conlu M. E. Conlu 3-15-83
M. T. Perakis MT Perakis 3-15-83

Department Chief: J. V. Rocca JVRocca Date: 3-22-83

Approved for Project use:

Project Engineer: Date: March 22, '83

Page 2 through 6 attached; describing design inputs. Other attachments as indicated below.

cc:

☒ Approving Discipline Chief(s)

☒ Chief, Engineering Quality Control C. E. Ralston

☐ Project Engineer

☐ Discipline Group Leader(s)/Supervisor(s)

☐ Manager, Steam Generation

Others

Design Criteria
Power Conversion System

1. Scope

This system document is part of a set of design criteria for a solar central receiver power plant. It supplements a general plant document D23-1, plant civil criteria D23-2, and plant IandC criteria D23-3, and it is supplemented by individual design criteria documents covering subsystems and other plant systems. This document sets out those design basis, standards, and functional requirements specific to the Power Conversion System. It specifies, directly or by reference to other documents, the design requirements at the interfaces of the Power Conversion System.

2.0 Codes and Standards

These are supplied by the Plant Design Criteria D23-1.

3.1 System Description

The PCS is a heat engine working between a liquid-sodium-heated steam generator and moist air as a heat sink. It is a steam Rankine cycle without reheat, using five stages of feedwater heating and cooled by a forced-draft evaporative cooling tower. Control, which can be roughly described as manual control and attended automatic control, is fully described in separate design criteria documents.

The PCS is organized according to the following subsystems:

- Main Steam and Turbine
- Generator and Auxiliaries
- Condensate and Feedwater
- Condensate Polishing
- Extractions and Drains
- Circulating Water
- Service Cooling Water

- Auxiliary Steam
- Lube Oil
- Fire Protection
- Boiler Makeup Water

The PCS is supported by the following Balance-of-Plant Systems:

- Fire Protection System
- Raw Water System
- Plant Electric Power System
- DC Power System
- Compressed Air System

Some design basis data is provided in Table I.

TABLE I

Main Steam Conditions (turbine inlet)	1465 psia, 1000°F
Feedwater Temperature	435°F
Configuration	Nonreheat; Five Heaters
Steam Generator Duty	85 MW_{th}
Cooling System	2.4" Hg Turbine Exhaust 30,000 ft^2 Condenser Area 12° Tower Approach 16.6°F Water Temperature Range

3.2 Design Guidelines

The PCS operating requirements include daily cycling between power operation and shutdown. The design life of the plant is 10,000 such cycles. Unless heat can be expended to maintain steam flow and system temperatures between operating periods, the condensate and feedwater piping system must withstand daily thermal cycling. To this end, system joints should be welded; flanged joints should be specified only where a specific analysis identifies a benefit that exceeds the risk of leaks. Purchase specifications for pumps, valves, and instruments must strictly and unmistakably call for suitability for cycling duty.

4. Operating Requirements

Plant requirements will be met by providing three operating conditions of the power conversion system:

Power operation at full or part load. The system will be capable of attended automatic operation down to 10 percent of design capability and manual operation down to 1 percent. The maximum rate of load change should be between 2 and 20 percent per minute. In addition, the plant must be capable of trip from full load.

Standby. Steam generators are stopped off from the turbine. The feedwater system maintains a level in the steam generators. The auxiliary steam system is supplied from the steam generators with steam at pressure of at least 200 psia. Turbine seals are functioning, the condensate vacuum held, and the circ. water system operating.

Shutdown. Power conversion subsystems secured except, as required,

- Turbine-Generator on turning gear
- Lube Oil System for turning gear operation
- Service Cooling Water System for lube oil and other accessories such as air compressors
- PC Control System

The system shall be capable, in concert with the HTS, of moving from shutdown to standby, from standby to power operation, and the reverse.

On-line instrumentation shall be provided, wherever satisfactory equipment is available, for determination of feedwater purity.

5. Reliability and Maintainability

The plant criteria specify the high figure of 98 percent availability during the summer service demand period, which is 8:00 a.m. - 6:00 p.m. between May 1 and October 31. The PCS shall be designed, therefore, with careful attention to reliability and maintainability. Choices of equipment size and providing of spares should be done with this in mind. The value of energy produced is compared with incremental plant cost in the plant criteria. Maintenance which can be performed between 6:00 p.m. and 8:00 a.m. is without any revenue penalty.

Equipment layout and piping routing shall make full provision for maintenance access, equipment removal clearance, and laydown areas.

6. Interfaces

The PCS design interfaces with the Heat Transfer System (HTS) are between the attemperator and the turbine and at the inlet nozzle of the feedwater control valve. In all operating states, feedwater sent to the steam generators shall be within 175^{o}F of the minimum sodium temperature in the steam generator.

Feedwater purity shall conform to the description in the following table.

TABLE II - FEEDWATER CHEMISTRY

	Expected Purity Level During Preheat/Starup Operation	Maximum Impurity Level During Steady State Operation	Best Purity Level Expected During Steady State Operation
Total Dissolved Solids	150 ppb	100 ppb Max	50 ppb
Silice, SiO_2	20 ppb	20 ppb Max	10 ppb
Iron	100 ppb	10 ppb Max	10 ppb
Copper	5 ppb	2 ppb Max	2 ppb
Dissolved Oxygen	10 ppb	7 ppb Max	5 ppb
Free Caustic	-	Zero	Zero
ph	8.5 - 9.2	8.5 - 9.2	8.5 - 9.2
Percent of Operating Period Expected	Less than 1.0 percent	10 percent	89 percent

Control interfaces are described in the IandC Criteria, D23-3.

7. Personnel

The system will be designed for operation by two shifts of personnel. Maintenance may extend to three shifts. Operation of equipment required for normal start-up and shutdown shall be possible from the control room.

4.1 MAIN STEAM AND TURBINE
(D23-13)

Engineering
76-370 2/81

DCM No. D23-13 Revision 0
Date January 25, 1983
File No. ________

PACIFIC GAS AND ELECTRIC COMPANY

DESIGN CRITERIA MEMORANDUM

Structure, System, or Component: Solar Power Plant, Main Steam and Turbine

Prepared by: J. B. Gegan JBGegan Date 1-25-83

Group Leader/Supervisor Review ______, M&NE Date ______
A. F. Ariey (Discipline)

Reviewed by Interfacing Disciplines:

Group Leader/Supervisor A. B. Schuurman Date [illegible]

Group Leader/Supervisor ENX. K. G. Zaharoff Date 3-16-83

Group Leader/Supervisor M. T. Perakis MTPerakis Date 3-25-83

M. E. Conlu

Approved by:

Department Chief: J. V. Rocca JVRocca Date: 3-30-83

Approved for Project use:

Project Engineer: R. E. Price REPrice Date: 4.1.83

Page 2 through _____ attached; describing design inputs. Other attachments as indicated below.

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☐ Chief, Engineering Quality Control C. E. Ralston

☐ Project Engineer R. E. Price

☐ Discipline Group Leader(s)/Supervisor(s) A. F. Ariey
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☐ Manager, Steam Generation W. H. Barr

Others I. F. Hall
J. B. Gegan
Dept. File

DESIGN CRITERIA D23-13

MAIN STEAM AND TURBINE

30 MW SOLAR PROJECT

GM 6340160

Contents

DESIGN CRITERIA D23-13

MAIN STEAM AND TURBINE

30 MW SOLAR PROJECT

GM 6340160

1.0 Basic Function

The function of the main steam and turbine system will be to conduct the high-pressure, high-temperature steam from the sodium-heated steam generator outlet connections to the main turbine. The function of the turbine-generator is to convert a portion of the heat energy in the steam into mechanical energy in the rotating T-G shaft and finally into the electrical energy that flows from the generator.

The turbine cannot convert into power all of the heat that is added to the feedwater in the steam generators. Most of the heat supplied by the steam generators is lost in the condenser to the cooling water. To reduce the heat loss in the condenser and, hence, increase the turbine's efficiency in converting the heat energy to power, portions of the steam flowing through the turbine are extracted and used to heat the feedwater in the feedwater heaters. This is a regenerative cycle.

The main steam system may also supply steam to other systems:

- Auxiliary steam system.
- T-G bypass system.
- Turbine gland sealing system.

The generator shall be designed to operate successfully in parallel with the PGandE system.

2.0 Rating and Capacity

2.1 Turbine

- 33 MWe (gross), 30 MWe (net)
- 1,450 psig, 1,000°F main steam inlet
- 2.4" HgA uncontrolled exhaust pressure
- 5 uncontrolled extraction points for feedwater heating
- Nonreheat

2.2 Generator

- The MVA rating of the generator shall equal or exceed the maximum capability of the turbine.
- Generator cooling may be by air or hydrogen.
- A generator design criteria will be written by the Electrical Engineering Department.

2.3 The Main Steam Line

The three steam generators will be headered together without individual steam stop valves. A single steam temperature attemperator will be installed in the header. Safety valves will be installed dowstream of the attemperator. The attemperator and safety valves will be in Rockwell's scope of supply. A power actuated valve will be installed at the branch connection for the bypass to the condenser, close to the turbine stop valve. The valves at the branch connection and in the branch connection will be globe type valves for tight shutoff. These valves are in the PGandE scope of supply. There will be no boiler stop valves upstream of these valves.

The main steam piping design pressure is determined as follows:

T-G inlet operating pressure	1,450 psig
Main steam piping pressure drop	50 psi
S.G. operating pressure	1,500 psig
Five percent margin for safety valves	75 psi
Main steam piping design pressure	1,575 psig

The main steam piping design temperature shall be:

From S.G. outlet to attemperator: 1,025°F

(Ref. pg 2-43, Proposal to DOE.)

From attemperator to turbine: 1,010°F

(10°F margin over the operating temperature.)

The main steam piping design flow:

S.G. design 28.3 MWt, each (pg. 2-41, Proposal to DOE) or 289.8×10^6 Btu/hr, total of three.

Steam at 1,515 psia, 1,000°F	1,490 Btu/lb
Feedwater at 1,800 psia, 436°F	416 Btu/lb
Heat added	1,074 Btu/lb

Steam Generated (Design Flow) $$\frac{289.8 \times 10^6 \text{ Btu/hr}}{1{,}074 \text{ Btu/lb}} = 269{,}800 \text{ lbs/hr}$$

The main steam pipe and valve ratings shall be determined by the rules in the latest edition of ANSI B31.1, Power Piping, and ANSI B16.34, Valves.

A corrosion allowance of 0.065 inches shall be included in the pipe wall thickness calculation.

A stress reduction factor will be included in the pipe wall thickness calculation due to the cycles loading (over 10,000 cycles in the 30-year life of the plant).

3.0 Codes and Standards

3.1 The steam generators will be constructed in accordance with Section VIII, Division 1 of the ASME Boiler and Pressure Vessel Code (reference pg. 2-42, Proposal to DOE) since they are unfired steam boilers (see B and PV Code, Section 1, Preamble).

3.2 The main steam piping system shall be designed, fabricated, erected, examined, and tested to the ANSI B31.1 standard and all standards referred to in B31.1. The valves shall comply with ANSI B16.34, Steel Butt-Welding End Valves.

3.3 The recommended practices for the prevention of water damage to steam turbines, ASME Standard TWDPS-1, shall be followed.

3.2 The turbine-generator and its installation shall comply with the following codes and standards:

3.2.1	ASME PTC 6	Performance Test Code for Steam Turbines.
	TWDPS-1	Recommended Practices for the Prevention of Water Damage to Steam Turbines.

		Std. No. 116	Recommended Practices for the Design of Steam Steam Turbine-Generator Lube Oil Systems.
		ASME	Steam Tables.
3.2.2	ANSI	B31.1	Power Piping and All Standards and Codes Referred to in B31.1.
		C50.10	General Requirements for Sychronous Machines.
		C50.13	Requirements for Cylindrical Rotor Synchronous Generators.
		C84.1	Voltage Rating for Electrical Power Systems and Equipment.
3.2.3	ASTM	A472	Standard Test Method for Heat Stability of Steam Turbine Shafts and Rotor Forgings.
		A418	Standard Method of Ultrasonic Inspection of Turbine and Generator Steel Rotor Forgings.

3.2.4	IEEE Std. 122	Specification for Speed Governing of Steam Turbines for Generators 500 kW and Larger.
3.2.5	PGE Eng. Std. No. 95	Fire Protection.
3.2.6	CAL-OSHA	Safety Requirements, Noise, Temperature, Access to Operating Valves, Insulation Materials.

4.0 Design Conditions of Operation

4.1 The main steam source will consist of three sodium heated, once through, forced flow steam generators connected to a main steam header.

4.2 The heat source for the sodium system will be solar; therefore, the plant will cycle from no load to full load daily. The condenser vacuum will be broken on shutdown to conserve the energy required to generate shaft sealing steam. The piping system and turbine-generator will be designed for a 30-year life under daily cycling conditions. Unit load will be controlled by variable inlet pressure to the turbine.

4.3 Except for start-ups, shutdowns, and curtailments, the plant will operate at full load. The unit shall be capable of part load operation down to 20 percent of maximum guarantee. The expected operation, however, will be at full load. The unit will not normally be dispatched.

4.4 The steam cycle design must include procedures for feedwater heating, deaeration, and steam temperature-turbine metal temperature matching within allowable limits during the daily start-ups.

4.5 The main steam piping flexibility analysis must allow for any combination of steam generators to be in or out of service with design provisions that will allow for the differential expansion.

4.6 The main steam design pressure and temperature and the condenser design vacuum are covered in paragraph 2, "Ratings and Capacity."

4.7 The turbine-generator and the main steam piping will be outdoors.

4.8 The exhaust flow will be vertically down into the surface condenser.

4.9 The condenser-turbine connection will be an ~~rubber~~ expansion joint.

JBG
2-24-83

4.10 The generator gas cooling medium will be service cooling water--(not cycle condensate due to the back pressure--temperature, or circulating water due to its corrosiveness).

4.11 The gland steam condenser cooling water will be cycle condensate.

4.12 The main steam piping insulation thickness and jacketing will be determined by an economic analysis and a limitation on the insulation surface temperature for personnel protection.

4.13 The steam generator-piping system will be boiled dry with hot sodium on the shell side of the steam generators daily for overnight hot shutdown.

5.0 Design Loads

The main steam piping system will be designed for the loads described in the ANSI B31.1, paragraph 101.

The seismic loading to be applied to the piping and supports will be those specified in the plant ~~seismic~~ civil design criteria.

ABS 3/29

Thermal expansion and contraction shall be provided for by pipe bends, elbows, offsets, or changes in direction. Expansion joints shall not be used in the main steam line. Due consideration will be given to the 10,000 cycles to be experienced over the 30-year life of the plant.

The turbine-generator will have an expansion joint connection to the condenser and will, therefore, apply a vacuum loading on the turbine pedestal.

The maximum nozzle loadings on the steam generators will be specified in the Rockwell steam generator design criteria.

The maximum nozzle loadings (main steam and extraction) shall be determined from the turbine manufacturers.

Safety valve reaction nozzle loads shall be calculated per the ANSI B31.1 code.

6.0 Environmental Conditions

The main steam piping and turbine-generator will be installed in an open structure. The site characteristics are:

Elevation	Approximately 2,000 feet
Minimum Temperature	0°F
Maximum Temperature	110°F
Nominal Ambient Temperature	55°F
Design Dry Bulb Temperature	106°F
Design Wet Bulb Temperature	72°F
Average Annual Rainfall	8.8 inches
Seismic Zone	4

The turbine will be shutdown each evening, with the exhaust vacuum broken and the turbine rotor exposed to air. The turbine-generator specification will describe this possible corrosive condition and require the bidder's comments.

7.0 Interface Requirements (See paragraph 3.)

Besides the steam generators and the turbine, the main steam pipe will interface with the auxiliary steam system and the turbine bypass system, described in the start-up Design Criteria, and provide backup steam to the turbine gland steam regulator. The connection to the bypass system will be provided with a motor operated valve.

The plant electric power output is set by the operator and establishes the position of the turbine control valves. The main power index for the balance of plant is main steam flow.

The turbine will also interface with the circulating water system in the condenser. The turbine power output and heat rate will depend on the condenser vacuum which is a function of the ambient wet bulb temperature and the cooling tower and condenser performance. (Design Criteria D23-18.)

The turbine will interface with the feedwater system through the extraction steam lines and the feedwater heaters. The feedwater heater shell pressures will vary with load on the turbine and the final feedwater temperature to the steam generators will drop as turbine load decreases. (Design Criterias D23-15 and 17.)

The generator gas coolers (air or hydrogen) and lube oil coolers will interface with the service cooling water system, Design Criteria D23-19.

The interface between the generator and the in-plant electrical system and the transmission system will be covered in the Electrical Engineering Department's design criteria.

The turbine-generator and its lube oil system will interface with the fire system, Design Criteria D23-23.

8.0 Material Requirements

Main Steam System:

- Pipe--Seamless alloy steel, ASTM-A335-P22.
- Fittings--2-1/2 inches and larger, butt-welding, ASTM, A234, GR WP22.
- Fittings--2 inches and under, ASTM, A182, GR F22. Socket-weld or butt-weld to be determined by piping engineer.
- Valves--butt-weld, ASTM, A182 F22, ASTM, A217, WC9.

Pipe bends may be used (five pipe diameters minimum bend radius), within the limitations and specifications of ANSI B31.1.

All thermal insulation shall be asbestos free.

The turbine lube oil system piping, fittings, valves, strainer bodies, and all other containment boundary parts shall be steel. Cast iron or wrought iron shall not be used.

9.0 Layout and Arrangement

There will be three sodium heated steam generators that will be headered into a main steam header that will serve a single turbine-generator unit. Any combination of steam generation can be in service without operating difficulties. If a steam generator must be removed from service for maintenance, its feedwater and steam connections will be cut and closed with welded caps.

Adequately sized drains with remotely operated valves shall be installed at all main steam line low points, ref. ASME TWDPS-1.

The main steam line shall be double valved at the turbine inlet end with a motor operated stop valve supplied by PGandE and the turbine manufacturer supplied stop valve. Remote operated drain valves shall be installed just ahead of the first stop valve and between the motor operated stop valve and the turbine stop valve.

All drains on the main steam line and turbine shall be double valved; manually operated root valve and remote operated drain valve.

All remotely operated drain valves shall have position indication in the control room.

If temperature control spray attemperators are used in the main steam line, provisions of ASME TWDPS-1 should be followed to prevent water entering the turbine.

10.0 Instrumentation and Control

Refer also to the Instrumentation and Controls Design Criteria, D23-13 I&C.

The turbine shall have provisions for an ASME Performance Test.

Steam sample connections with condensers shall be furnished.

Safety valves and power actuated relief valves will be installed in the main steam line.

A spray-attemperator for main steam temperature control will be installed in the main steam line.

The turbine shall be provided with an electrohydraulic control system with automatic speed and load ramping capability.

The turbine shall automatically trip under the following conditions:

- Low-bearing oil pressure
- Low condenser vacuum
- Thrust bearing failure
- Manual button
- Overspeed
- Generator electrical trouble

Thermocouples shall be embedded in all journal bearings' metal, in the front and rear thrust bearing shoes, in the turbine casing metal for the purpose of controlled starting, and installed to measure oil cooler oil temperature in and out.

11.0 Access Requirements for Security

Not applicable.

12.0 Reliability

The plant design availability (exclusive of sunshine) is 0.9 (ref. page 2-24, Volume I of Technical Proposal to DOE).

There will be only one main steam line and one turbine.

The main steam line should not cause any unit downtime due to failure over the life of the plant. The main steam line reliability will be enhanced by:

- An all-welded piping system, no flanges.
- Not permitting welding backing rings.
- Radiograph all welds in pipe over 2 inches nominal pipe size.

The main turbine will experience failures causing outages. The turbine reliability will be increased by:

- Automating the start-up ramp.
- Using full arc admission.
- Blowing out the main steam line to remove debris after erection and before initial turbine roll.
- Following the ASME "Recommended Practices for the Prevention of Water Damage to Steam Turbines" No. TWDPS-1.
- Specifying the cyclic nature of the operation in the turbine specification and requesting that the manufacturers describe the design features used to accommodate this mode of operation.

13.0 System Reliability Effects on Unit Availability

The main steam system and turbine generator systems directly effect the plant availability since there is no redundancy and the plant cannot operate without either. A main steam leak cannot be tolerated long. A main steam line break can be catastrophic.

14.0 Examinations, Inspections, and Testing

The main steam piping will be subject to examination, inspection, and testing as required by B31.1, Chapter VI. Shop fabricated piping shall be subject to purchaser inspection and acceptance. Erected main steam piping shall be hydrostatically tested in the presence of the insurance inspector in accordance with the ASME, Boiler and Pressure Vessel Code, Section I, paragraph 99.

Field inspection procedures will be established and followed to confirm the proper alloy specification for the main steam piping, fittings, and valves.

The turbine-generator tests and inspection requirements are very extensive and too lengthy to include in this document. The specification must be approved by the following departments to assure completeness:

- Mechanical and Nuclear Engineering
- Electrical Engineering
- Engineering Quality Control

The turbine-generator shall be given an ASME Performance Test to check the guaranteed heat rate and capability.

15.0 Maintenance

15.1 Main Steam Line

In-service inspection and maintenance of the main steam pipe should not be required; therefore, accessibility of the entire length is not required. Instrumentation root valves and thermocouple wells should be accessible with temporary scaffolding. The attemperator and operating valves will require permanent platform accessibility for operation and maintenance. Refer to PGandE Mechanical Design Standard, Drawing No. 047308.

15.2 Turbine-Generator

An overhead crane capable of handling the heaviest piece after erection will be required. The crane height shall be adequate to lift any piece over the remainder of the unit. The crane run shall be sufficient to pull the generator rotor and to lower it to the ground elevation.

The turbine shall be an outdoor design. ~~with a moveable maintenance shelter provided.~~ During overhaul a temporary shelter will be provided. PES [illegible]

Sufficient lay-down area will be provided to overhaul the unit.

A minimum of 3'-0" wide clearance area shall be provided around the turbine-generator.

16.0 Personnel Requirements

The Solar Plant manpower requirements are shown on page 2-64, Volume 1 of the Technical Proposal to the DOE.

The fabrication and erection phase of the main steam piping system will require qualified welders, nondestructive examinations (NDE) personnel, and inspectors as described in the B31.1 code, Chapter VI.

17.0 Shipping

The main steam system material shall be protected from excessive corrosion in shipment and damage to machined weld-ends due to mishandling. Pipe and valve ends and other openings shall be covered. Exposed valve stems shall be covered.

The turbine specification shall require the manufacturer to describe the preservation and protection procedures to be used for shipment and storage. Shipment of equipment and components from supplier's shop to the jobsite without specific release by PGandE's inspector will not be permitted.

18.0 Fire Protection

See also the Fire Protection Design Criteria D23-23.

Main steam piping under turbine lube oil or hydraulic oil piping is a source of fire from leaking oil onto the hot pipe surface. The lube or hydraulic oil pressure piping shall be guarded in these areas and the steam piping insulation covered by a drained metal jacket or a noncombustible covering which is impervious to hot oil that will prevent the oil from soaking through the insulation material. Fire detection alarms and an automatic water spray (FOG) system shall be provided.

If the T-G stop valve actuator uses combustible hydraulic oil, it shall be protected by an automatic water spray "FOG" system.

The turbine-generator fire protection shall meet the requirements of PGandE, Department of Engineering Standard No. 95, Section 4.

19.0 Handling and Storage

The method of storage of the main steam piping material shall be such as to assure that only material of the proper specification is installed.

The pipe and valves shall be protected against corrosion or damage. Weld end machining shall be protected. All openings shall be covered. Care shall be used in handling to prevent loss of thickness of the pipe wall and prevent gouges or pitting.

4.1.1 MAIN STEAM AND TURBINE INSTRUMENTATION AND CONTROL

(D23-13I)

Engineering
76-370 2/81

DCM No. D23 - 13I Revision 0
Date MAY 4, 1983
File No.

PACIFIC GAS AND ELECTRIC COMPANY

30 MW SOLAR

DESIGN CRITERIA MEMORANDUM

Structure, System, or Component: INSTRUMENTS AND CONTROLS MAIN STEAM AND TURBINE

Prepared by: J.M. WALEWSKI / M.T. PERAKIS M Perakis Date 5/4/83

Group Leader/Supervisor Review A.F. ARIEY A F Ariey (Discipline) Date 5/12/83

Reviewed by Interfacing Disciplines:

Group Leader/Supervisor J.B. GEGAN Date

Group Leader/Supervisor M.E. CONLU MEConlu Date 5-12-83

Group Leader/Supervisor K.G. ZAHAROFF Date 6-17-83

A.B. SCHUURMAN 6-12-83

Approved by:

Department Chief: J.V. ROCCA J V Rocca Date: 6-21-83

Approved for Project use:

Project Engineer: R.E. PRICE R E Price Date: June 21 1983

Page 2 through 20 attached; describing design inputs. Other attachments as indicated below.

cc:

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☒ Project Engineer R.E. PRICE

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M.T. PERAKIS K.B. ZAHAROFF

☐ Manager, Steam Generation

Others

30 MW SOLAR
MAIN STEAM AND TURBINE SYSTEM INSTRUMENTATION AND CONTROL DESIGN CRITERIA

Reference Documents:

Main Steam and Turbine System - System Design Criteria, DCM No. D23-13
Instrumentation and Control - General Design Criteria, DCM No. D23-3
Master Control System - Design Criteria, DCM No. D23-7

1.0 Scope

This criteria will define the Instrumentation and Control (I&C) requirements for the Main Steam and Turbine System which includes control of:

1.1 Mechanical Equipment

- 1.1.1 Main turbine
- 1.1.2 Turning gear
- 1.1.3 Auxiliary lube oil pump
- 1.1.4 Emergency lube oil pump

1.2 Valves –

- 1.2.1 Main steam stop valve
- 1.2.2 Main steam bypass valves (2)
- 1.2.3 Main steam drain valves (TBD)
- 1.2.4 Gland seal steam regulator

1.3 Miscellaneous Equipment

- 1.3.1 Main turbine lube oil reservoir
- 1.3.2 Main turbine lube oil coolers
- 1.3.3 Main steam header

2.0 Control System Interface

2.1 Condensate and Feedwater System

- 2.1.1 Main steam flow and pressure determines feedwater flow.
- 2.1.2 High condenser pressure trips turbine.

2.1.3 Lack of circulating water prevents main steam bypass operation.

2.1.4 Main steam temperature determines attemperating water flow.

2.2 Service Cooling Water System

2.2.1 Turbine lube oil temperature determines service cooling water flow through the turbine lube oil coolers.

2.3 Heat Transfer System

2.3.1 Loss of sodium flow to steam generators trips turbine.

3.0 Operating Requirements

3.1 Main Steam System

The Master Control System provides the necessary control functions to supply main steam at correct flow, pressure, and temperature to suit the particular operating conditions. When the turbine is not operating, the main steam is isolated from the turbine by closing of the main steam stop valve. During the nonoperating and a portion of the daily start-up periods, the main steam line drain valves are kept open.

Turbine bypass system conducts excess steam to the condenser under certain start-up and shutdown operations. The operating mode of the plant determines the pressure set point used to control this system. The system also provides a main steam line cleanup functions during each daily start-up period.

3.2 Turbine

Steam flow to turbine is based upon satisfying the generator load conditions. A generator load set point is established by the operator and the control system permits the required steam flow to pass to satisfy this condition.

Turbine lube oil and hydraulic oil supply is furnished by an auxiliary oil pump during start-up. When main turbine reaches operating speed, a shaft driven pump furnishes all oil needs and the auxiliary pump can be shutdown. On loss of oil pressure, the auxiliary pump automatically starts. An emergency oil pump will start on a lower pressure if the auxiliary pump fails.

Turbine oil temperature is established by controlling the flow of serving cooling water through the main turbine oil coolers.

Main turbine gland seal system pressure is controlled to maintain adequate seals. Seals prevent the entry of air at points where the turbine shaft is exposed.

Turbine turning gear provides the means of rotating the turbine when it is shutdown after a period of operation. Operation is automatic when turbine speed is reduced to zero.

4.0 Mechanical Equipment Process Control and Protection

4.1 Main Turbine

The main turbine drives the generator which produces electrical power.

4.1.1 Controls

4.1.1.1 Remote Automatic, Master Control System

The operator initiates the turbine roll program by selecting a speed and a rate of acceleration. The control system brings the turbine up to that speed and holds until the next speed and acceleration inputs are supplied by the operator. When rated speed is reached, the parallel program may be initiated. Load control is operator selected.

4.1.1.2 Remote Automatic, Dedicated

None

4.1.1.3 Local Automatic

None

4.1.1.4 Remote Manual, Master Control System

Manual operation through the Master Control System enables the operator to roll, control speed, parallel, and load the main turbine.

4.1.1.5 Remote Manual, Dedicated

Manual operation to the same degree as in the Master Control System.

4.1.1.6 Local Manual

Turbine speed and load can be controlled through the turbine auxiliary governor and/governor handwheels.

4.1.2 Trips and Interlocks

All trips and interlocks are hardwired and dedicated.

4.1.2.1 Trips (all SER)

a. Turbine oil pressure low

b. Condenser pressure high

c. Condenser pressure high (mechanical) must be reset at the turbine

d. Thrust bearing failure

e. Overspeed

f. Backup overspeed

g. Sodium to steam generators flow low

h. Turbine metal-steam temperature ΔT high

i. Manual

j. Total loss of computer-operator interface

4.1.2.2 Interlocks

a. Turbine is prevented from rolling until condenser pressure is below established maximum.

b. Turbine prevented from rolling until oil pressure is above established minimum.

c. Turbine prevented from rolling until turbine metal-steam temperature ΔT is below established maximum.

4.1.3 Control Valves (furnished with turbine)

4.1.3.1 Turbine Stop Valve

The turbine stop valve closes to stop steam flow to turbine when any trip signal is initiated. This is an on-off, hydraulically actuated, fail closed valve.

4.1.3.2 Turbine Flow Control Valve

The turbine flow control valve operates to control the flow of steam to the turbine in order to provide the desired speed or load. This is a modulating, hydraulically operated, fail closed valve. The positioning signal comes from the master control system.

4.1.3.3 Gland Steam Regulator

The gland steam regulator is a modulating, pneumatically operated, fail closed valve. Control is by dedicated hardware.

4.1.4 Indication

4.1.4.1 Local

a. Turbine speed

b. Turbine stop valve position

c. Turbine lube oil pressure

d. Turbine hydraulic oil pressure

e. Turbine hydraulic oil sight flow (each bearing)

f. Turbine bearing oil temperature (each bearing)

4.1.4.2 Remote, Master Control System Inputs

a. Turbine speed

b. Turbine stop valve position

c. Turbine bearing metal temperature (each bearing)

d. Turbine metal temperature

e. Turbine steam admission temperature

f. Turbine steam admission pressure

g. Turbine control valve position

h. Turbine metal-steam temperature ΔT

4.1.4.3 Remote, Dedicated

a. Turbine speed

b. Turbine stop valve position, open/closed

c. Turbine control valve position

d. Turbine eccentricity

4.1.5 Test Points

a. Turbine exhaust pressures

b. Turbine extraction pressures (all points)

c. Turbine extraction temperatures (all points)

d. Turbine admission pressure

e. Turbine admission temperature

4.1.6 Recording

a. Turbine bearing vibration (at each bearing)

4.1.7 Alarms

4.1.7.1 Local

None

4.1.7.2 Remote, Master Control System

a. Turbine bearing metal temperature high

b. Turbine lube oil supply pressure low

c. Turbine hydraulic oil supply pressure low (SER)

d. Turbine thrust bearing failure trip (SER)

e. Turbine overspeed trip (SER)

f. Turbine emergency oil pump start

g. Turbine bearing vibration high (SER)

h. Turbine vacuum trip (SER)

4.1.7.3 Remote, Annunciator

a. Turbine trip

4.2 Turning Gear

The turning gear is used to rotate the turbine at low speed while it is cooling down following a period of operation. The rotation is intended to help prevent warping of the shaft and the possible damage resulting from that condition.

4.2.1 Controls

4.2.1.1 Remote Automatic, Master Control System

None

4.2.1.2 Remote Automatic, Dedicated

None

4.2.1.3 Local Automatic

The turning gear will start and engage when turbine speed reaches zero. When the turbine rolls, the turning gear will disengage and shutdown.

4.2.1.4 Remote Manual, Master Control System

None

4.2.1.5 Remote Manual, Dedicated

None

4.2.1.6 Local Manual

The turning gear may be manually started and engaged provided turbine speed is zero.

4.2.2 Trips and Interlocks

4.2.2.1 Trips

a. Turbine lube oil pressure low

b. Overcurrent

4.2.2.2 Interlocks

a. Turning gear cannot start if turbine speed is greater than zero.

b. Turning gear cannot start if lube oil pressure is low.

4.2.3 Control Valves

None

4.2.4 Indication

4.2.4.1 Local

a. Turning gear running/not running

b. Turning gear engaged/not engaged

4.2.4.2 Remote, Master Control System Inputs

a. Turning gear running/not running

b. Turning gear engaged/not engaged

4.2.4.3 Remote, Dedicated

None

4.2.5 Test Points

None

4.2.6 Recording

None

4.2.7 Alarms

4.2.7.1 Local

None

4.2.7.2 Remote, Master Control System

a. Turning gear not running/not engaged (while turbine is stopped)

4.3 Turbine Auxiliary Oil Pump

Turbine auxiliary oil pump supplies lube oil and hydraulic oil prior to turbine running at rated speed.

4.3.1 Controls

4.3.1.1 Remote Automatic, Master Control System

None

4.3.1.2 Remote Automatic, Dedicated

The auxiliary oil pump starts on decrease of oil supply pressure. Pump continues to run until manually stopped.

4.3.1.3 Local Automatic

None

4.3.1.4 Remote Manual, Master Control System

None

4.3.1.5 Remote Manual, Dedicated

Manual start and stop control switch is located in control room.

4.3.1.6 Local Manual

None

4.3.2 Trips and Interlocks

4.3.2.1 Trips

a. Overcurrent (SER)

4.3.2.2 Interlocks

None

4.3.3 Control Valves

None

4.3.4 Indication

4.3.4.1 Local

a. Turbine auxiliary oil pump discharge pressure

b. Auxiliary oil pump running/not running

4.3.4.2 Remote, Master Control System Inputs

a. Auxiliary oil pump running/not running

b. Auxiliary oil pump overcurrent trip

4.3.4.3 Remote, Dedicated

a. Auxiliary oil pump running/not running

4.3.5 Test Points

None

4.3.6 Recording

None

4.3.7 Alarms

4.3.7.1 Local

None

4.3.7.2 Remote, Master Control System

a. Auxiliary oil pump overcurrent trip

4.4 Turbine Emergency Oil Pump

The turbine emergency oil pump supplies lube oil and hydraulic oil to turbine on loss of auxiliary oil pump.

4.4.1 Controls

4.4.1.1 Remote Automatic, Master Control System

None

4.4.1.2 Remote Automatic, Dedicated

The emergency oil pump starts on decrease of oil supply pressure below the point where the auxiliary oil pump would normally start. Pump continues to run until pressure is restored and it is manually stopped.

4.4.1.3 Local Automatic

None

4.4.1.4 Remote Manual, Master Control System

None

4.4.1.5 Remote Manual, Dedicated

Manual start and stop control switch is located in control room.

4.4.1.6 Local Manual

None

4.4.2 Trips and Interlocks

4.4.2.1 Trips

a. Overcurrent

4.4.2.2 Interlocks

None

4.4.3 Control Valves

None

4.4.4 Indication

4.4.4.1 Local

a. Turbine emergency oil pump discharge pressure

4.4.4.2 Remote, Master Control System Inputs

a. Emergency oil pump running/not running

b. Emergency oil pump overcurrent trip

4.4.4.3 Remote, Dedicated

a. Emergency oil pump running/not running

4.4.5 Test Points

None

4.4.6 Recording

None

4.4.7 Alarms

4.4.7.1 Local

None

4.4.7.2 Remote, Master Control System

a. Emergency oil pump overcurrent trip

4.4.7.3 Remote, Annunciator

None

5.0 Vessels and Miscellaneous Equipment

5.1 Main Turbine Lube Oil Reservoir

The main turbine lube oil reservoir provides a sump of cool and clean oil for the main shaft driven oil pump, the auxiliary oil pump, and the emergency oil pump.

5.1.1 Controls

5.1.1.1 Remote Automatic, Master Control System

None

5.1.1.2 Remote Automatic, Dedicated

None

5.1.1.3 Local Automatic

None

5.1.1.4 Remote Manual, Master Control System

None

5.1.1.5 Remote Manual, Dedicated

None

5.1.1.6 Local Manual

Manual valves are used to fill and drain the oil reservoir.

5.1.2 Trips and Interlocks

None

5.1.3 Control Valves

None

5.1.4 Indication

5.1.4.1 Local

a. Turbine lube oil reservoir level

5.1.4.2 Remote, Master Control System Inputs

None

5.1.4.3 Remote, Dedicated

None

5.1.5 Test Points

None

5.1.6 Recording

None

5.1.7 Alarms

5.1.7.1 Local

None

5.1.7.2 Remote, Master Control System

a. Turbine lube oil reservoir level high

b. Turbine lube oil reservoir level low

5.1.7.3 Remote, Annunciator

None

5.2 Main Turbine Lube Oil Coolers

The main turbine lube oil coolers provide cooling for the lube and hydraulic oil systems.

5.2.1 Controls

5.2.1.1 Remote Automatic, Master Control System

The temperature of the oil leaving the coolers is controlled by means of service cooling water flow valve modulation.

5.2.1.2 Remote Automatic, Dedicated

None

5.2.1.3 Local Automatic

None

5.2.1.4 Remote Manual, Master Control System

The service cooling water control valve may be positioned manually through the Master Control System.

5.2.1.5 Remote Manual, Dedicated

None

5.2.1.6 Local Manual

The cooler in service is manually chosen by means of a manual selector valve at the coolers.

5.2.2 Trips and Interlocks

None

5.2.3 Control Valves

See DCM No. D23-19-I.

5.2.4 Indication

5.2.4.1 Local

a. Lube oil cooler oil entering temperatures

b. Lube oil cooler oil leaving temperature

5.2.4.2 Remote, Master Control System Inputs

a. Lube oil cooler oil entering temperature

b. Lube oil cooler oil leaving temperature

5.2.4.3 Remote, Dedicated

None

5.2.5 Test Points

None

5.2.6 Recording

None

5.2.7 Alarms

5.2.7.1 Local

None

5.2.7.2 Remote, Master Control System

a. Lube oil cooler oil leaving temperature high

5.2.7.3 Remote, Annunciator

None

5.3 Main Steam Header

The main steam header is used to conduct steam from the steam generators to the turbine. A bypass is provided to allow startup flow to condenser or to dump excess steam to condenser. An attemperator provides a means of controlling temperature of main steam. Drain valves remove condensate from the header. A stop valve isolates the main steam header from the turbine.

5.3.1 Controls

5.3.1.1 Remote Automatic, Master Control System

a. Turbine bypass responds to the pressure set point in the control system by opening the turbine bypass valve, passing steam to the condenser, and keeping main steam pressure at the desired control point.

b. The attemperator maintains the desired set point of main steam temperature by modulating the attemperating water control valve (see DCM No. D23-15-I).

c. The main steam header drain valves are used to remove condensate. They open on any trip of turbine and remain open until after turbine roll.

5.3.1.2 Remote Automatic, Dedicated

None

5.3.1.3 Local Automatic

None

5.3.1.4 Remote Manual, Master Control System

a. Turbine bypass control valve may be positioned manually from the control room. A turbine bypass isolation valve is provided ahead of the control valve and is operated manually.

b. The attemperator control valve may be positioned manually from the control room. An attemperating water isolation valve is provided ahead of the control valve and is operated manually (see DCM No. D23-15-I).

c. The main steam header drain valves may be opened manually from the control room.

d. The main steam stop valve is closed whenever main steam must be isolated from the turbine.

5.2.1.5 Remote Manual, Dedicated

None

5.2.1.6 Local Manual

None

5.3.2 Trips and Interlocks

5.3.2.1 Trips

a. The turbine bypass valve will be tripped closed on loss of both circulating water pumps.

5.3.2.2 Interlocks

a. The turbine bypass valve cannot be opened unless circulating water flow is established through the main condenser.

5.3.3 Control Valves

5.3.3.1 Turbine Bypass Control Valve

The turbine bypass control valve is a modulating valve with a pneumatic actuator. The valve maintains main steam pressure as established by the operating mode of the plant.

a) Rise in pressure opens the valve, pressure decrease closes valve.

b) Valve will be fail close, air to open.

c) Manual/auto control through the Master Control System.

d) Valve will have a positioner.

5.3.3.2 Turbine Bypass Isolation Valve

The turbine bypass isolation valve is an on/off valve with an electric motor actuator. The valve isolates main steam from the condenser.

a) Manual operation through the Master Control System.

b) Valve will fail as is.

c) Valve will have open/closed position switches.

5.3.3.3 Main Steam Attemperator

See DCM No. D23-15-I.

5.3.3.4 Main Steam Drain Control Valves

1. The main steam drain control valves are on/off valves with pneumatic actuators. The valves drain condensate from the main steam line.

   a. Manual/auto operation through the Master Control System.

   b. Valves fail open.

   c. Valves have open/closed position switches.

   d. Valves will have solenoid valves.

5.3.4 Indication

5.3.4.1 Local

None

5.3.4.2 Remote, Master Control System Inputs

a. Main steam before attemperator temperature

b. Main steam after attemperator temperature

c. Main steam flow

d. Main steam at flow section pressure

e. Main steam before bypass temperature

f. Main steam before bypass pressure

g. Turbine bypass isolation valve open/closed position

h. Main steam drain valves open/closed position

5.3.4.3 Remote, Dedicated

a. Main steam before bypass pressure

b. Main steam before bypass temperature

c. Main steam flow

5.3.5 Test Points

None

5.3.6 Recording

None

5.3.7 Alarms

5.3.7.1 Local

None

5.3.7.2 Remote, Master Control System

a. Main steam temperature low

b. Main steam temperature high

c. Main steam drain valve failure

5.3.7.3 Remote, Annunciator

None

6.0 Analysis

6.1 Indication

6.1.1 Local

a. Main steam specific conductivity

b. Main steam cation conductivity

c. Main steam pH

6.1.2 Remote, Master Control System Inputs

a. Main steam specific conductivity

b. Main steam cation conductivity

c. Main steam pH

6.1.3 Remote, Dedicated

None

6.2 Alarms

6.2.1 Local

None

6.2.2 Remote, Master Control System

a. Main steam specific conductivity high

b. Main steam cation conductivity high

6.2.3 Remote, Annunciator

None

6.3 Recording

None

4.2 GENERATOR AND AUXILIARIES
(D23-14)

Engineering
76-370 2/81

DCM No. D23-14 Revision 1
Date April 21, 1983
File No. D23-50070

PACIFIC GAS AND ELECTRIC COMPANY

DESIGN CRITERIA MEMORANDUM

Structure, System, or Component: Generator and Auxiliaries Carrisa Plains 30 MW Solar Project

Prepared by: D. B. Mills DBMills Date 4-21-83

Group Leader/Supervisor Review KGZ EE (Discipline) Date 4-25-83

Reviewed by Interfacing Disciplines:

Group Leader/Supervisor JBG Date 4-25-83

Group Leader/Supervisor ABS Date 5-3-83

Group Leader/Supervisor MTP MJ Ruakis Date 5-9-83

Approved by:

Department Chief: J M Colwell JRH/JWC Date: 5/18/83

Approved for Project use:

Project Engineer: REP REPrice Date: 5-19-83

Page 2 through 9 attached; describing design inputs. Other attachments as indicated below.

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☒ Chief, Engineering Quality Control CER

☒ Project Engineer REP

☒ Discipline Group Leader(s)/Supervisor(s) KGZ

☒ Manager, Steam Generation

Others Files

Main Generator and Auxiliary Equipment
Carrisa Plains 30 MW Solar Project

1.0 BASIC FUNCTION

The main generation and auxiliaries system converts mechanical energy from the steam turbine to electrical power and delivers the power to the main step up transformer. The following components make up the subsystem:

Main Generator
Exciter
Voltage Regulator
Neutral Transformer
Generator Bus
Generator Circuit Breaker
Fire Protection

2.0 RATINGS AND DESIGN CONDITIONS

2.1 The main generator nominal output will be 35.5 MVA, 0.9 power factor, but the full load capability must equal the maximum expected turbine output. The generator will operate at 3600 rpm with electrical output of 12 KV, 3 phase, wye connected. An outdoor, totally enclosed housing will be used with water cooled heat exchangers for cooling the recirculating air. Generator winding insulation will be Class B or Class F, but at Class B temperature rise.

Twelve current transformers rated 2000/5 amp, relaying accuracy, will be provided by the generator supplier. Two current transformers will be installed on each phase at the neutral and high voltage ends for connection to relaying and metering equipment. At least 12 resistance temperature detectors will be provided in the stator windings for temperature indication.

2.2 The exciter will be a static system with power transformer and rectifiers or a shaft driven alternator with rotating rectifiers, commonly called brushless. A generator field breaker is not required provided the excitation system is capable of removing excitation quickly and dissipating the field stored energy.

2.3 The voltage regulator controls exciter current flow to the generator rotating field. This directly regulates generated voltage and power factor. In automatic mode the regulator will maintain generator terminal voltage to within 1/2 percent of set point voltage. Motor drives will be provided on the automatic and manual mode voltage adjusters for remote setting of voltage levels from the control room. Provisions will be made for addition of a Power System Stabilizer if required.

2.4 The generator neutral transformer is a 12 KV to 120/240 volt, 5 KVA, dry type transformer with primary winding connected from the generator neutral to ground. A suitable loading resistor across the transformer secondary limits fault current and neutral voltage rise when ground faults develop in the generator or connected equipment. Resistance will equal to 1.06/C, where C is the combined capacitance in microfarads of the generator and transformer windings plus interconnecting cables. Voltage developed across the resistor during a ground fault is used for protective relaying. Transformer and loading resistor will be housed in a metal enclosure.

2.5 The bus connection from the generator terminals to the generator circuit breaker will be a section of cable bus, rated for maximum generator rated MVA at 95% voltage. 15 KV insulated cable will be used, braced and supported to withstand fault currents of 15,000 amperes. Basic insulation level will be 110 KV. The bus will be enclosed in a dust and water tight metal enclosure with one set of taps provided for potential transformer connections. Bus connections from the generator breaker to the step up transformer will be made with open aluminum tubing through an air break disconnect switch rated 2,000 amps. The station power cables will be connected to the conductors between the disconnect switch and step up transformer.

2.6 An outdoor circuit breaker will be installed at the end of the cable bus for separating the generator from the step up transformer and the transmission system when the generator is shut down. During startup, synchronizing and connection with system will be performed with this breaker. A 15 KV, oil circuit breaker will be used with a current rating of 2,000 amperes and a fault interrupting capability of 500 MVA.

3.0 CODES AND STANDARDS

All equipment, components and systems will comply with all state of California and federal codes, standards and safety requirements. In addition, design, manufacture and testing will be in accordance with latest revisions of the standards listed below:

3.1 Generator:

ANSI C50.10 - General Requirements for Synchronous Machines

ANSI C50.13 - Requirements for Cylindrical Rotor Synchronous Machines

IEEE 115 - Test Procedures for Synchronous Machines

NEMA LA-1 - Surge Arrestors

NEMA SM-12 - Air Cooled Synchronous Generators for Steam Turbine Drive

3.2 Generator Circuit Breaker:

ANSI C37.04 - High Voltage AC Breaker Ratings

ANSI C37.09 - Test Procedure

ANSI C37.010 - Application Guide

4.0 DESIGN LOADS

4.1 All equipment will be designed and installed to comply with the seismic loading criteria established by Section 4 of the Civil and Architectural Design Criteria, DCM No. D23-2.

4.2 Usual industry standards for the effects of snow, ice and wind loading on the outdoor equipment will be acceptable.

5.0 OPERATING AND ENVIRONMENTAL CONDITIONS

5.1 Plant will be located in a semi-arid region at elevation 2,000 ft. Average seasonal rainfall is 3.5 inches and temperature extremes are -10 to +110 degrees F.

5.2 All equipment will be installed outdoors with the exception of the generator voltage regulator and exciter control and/or power equipment.

5.3 Normal operations require plant startup and shut down daily. Plant may also be shut down several days at a time during periods of cloudy weather. This mode of operation should be taken into consideration in the generator design.

5.4 Generator bearing design may be altered or oil jacking pumps provided to suit the frequent startup requirement. Special provisions will also be required to minimize moisture condensation that will tend to develop in the generator housing during shut down. In addition to the electric heaters that are normally installed, fans for circulating air within the housing or insulating coatings on the inside of the housing shell may be required.

6.0 INTERFACE REQUIREMENTS

6.1 Functional and physical interfaces are shown in the following table:

Interfaces - Main Generator and Auxiliary Equipment

	Main Generator	Exciter	Voltage Regulator	Generator Breaker
Steam Turbine	X			
Lube Oil System	X			
Service Water System	X			
Generator		X	X	X
Exciter	X		X	
Voltage Regulator	X	X		
Generator Breaker	X			
Generator Bus	X			X
Relay Protection	X	X		X
Alarm System	X	X		X

	Main Generator	Exciter	Voltage Regulator	Generator Breaker
Operator Controls		X	X	X
Station AC Power	X	X	X	X
Station DC Power		X	X	X
Emergency Trip	X	X		X
Master Control			X	

6.2 Operation Interfaces:

6.2.1 Operator control interfaces are the voltage regulator transfer switch, auto and manual voltage adjust controls, generator excitation switch and the generator breaker control switch.

6.2.2 The monitoring meter and indicator interfaces are generator volts, amps, megawatts, megavars; field volts and amps; generator neutral voltage, stator and bearing temperatures; generator and bearing cooling water flow indicators.

7.0 LAYOUT AND ARRANGEMENT

7.1 The generator will be coupled to the turbine and mounted on the turbine generator pedestal, 20 feet above ground elevation. The turbine deck will provide a working and lay-down area at the same level.

7.2 The generator terminal box will be at the bottom of the generator, below deck level. The generator bus will run under the turbine deck to the generator circuit breaker in the switchyard.

8.0 INSTRUMENTATION, CONTROL AND PROTECTION

8.1 Control Room Indications:

8.1.1 Generator voltmeter; ammeters (3); wattmeter; varmeter; stator temperature indicator; kilowatt hour meter; generator neutral voltmeter.

8.1.2 Generator field voltmeter; field ammeter.

8.2 Local Indication and Alarm Devices:

8.2.1 Generator bearing temperature indicators.

8.2.2 Generator bearing temperature alarm devices.

8.2.3 Generator housing air temperature alarm.

8.2.4 Generator cooling water flowmeter and alarm.

8.3 Controls in Control Room:

8.3.1 Generator excitation switch.

8.3.2 Generator regulator voltage control.

8.3.3 Generator manual voltage control.

8.3.4 Voltage regulator transfer switch.

8.3.5 Generator circuit breaker control switch.

8.4 Protective Relays and Devices:

8.4.1 Generator relays - Differential; Overcurrent; Phase Unbalance; Neutral Overvoltage; Reverse Power; Underfrequency; Overfrequency Stator Temperature.

8.4.2 Generator bearing overtemperature trip devices.

9.0 GENERATOR FIRE PROTECTION

9.1 Carbon dioxide fire protection equipment will be provided for extinguishing generator winding fires.

9.2 Bearing lube oil fire protection equipment will be included with the lube oil system.

Engineering
76-370 2/81

DCM No. D23-15 Revision 0
Date January 25, 1983
File No. D23 — 44000

PACIFIC GAS AND ELECTRIC COMPANY

DESIGN CRITERIA MEMORANDUM

Structure, System, or Component: Solar Power Plant, Condensate and Feedwater System

Prepared by: J. B. Gegan JB Gegan Date 2-11-83

Group Leader/Supervisor Review M&NE (Discipline) Date 2/15/83
A. F. Ariey

Reviewed by Interfacing Disciplines:

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Group Leader/Supervisor M. T. Perakis M G Perakis Date 2-23-83

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DESIGN CRITERIA D23-15

CONDENSATE AND FEEDWATER SYSTEM

30 MW SOLAR PROJECT

GM 6340160

Contents

DESIGN CRITERIA D23-15

CONDENSATE AND FEEDWATER SYSTEM

30 MW SOLAR PROJECT

GM 6340160

1.0 Basic Function

The function of the condensate/feedwater system will be to pump the condensate from the condenser hotwell through the low-pressure feedwater heaters, the deaerating heater, raise the pressure with the boiler feedwater pumps, then through the high-pressure feedwater heaters to the inlet connections of the sodium heated steam generators. The system will also be used for recirculation during startup to clean and heat the feedwater.

The preliminary design condition at the condenser hotwell is 2.4 inches Hg. absolute, 107.3°F at full-load conditions.

The conditions at the steam generator inlet are preliminarily set at 1,580 psia and 435.9°F from the (GE heat balance).

1,465 psia	Turbine inlet
50 psi	Main steam line pressure drop
65 psi	Steam generator pressure drop (including elevation difference)
1,580 psia	TOTAL

The feedwater heaters will heat the feedwater/condensate with extraction steam from the main turbine. The deaerating heater will remove the dissolved oxygen in the feedwater as well as heat it to its saturation temperature.

2.0 Rating and Capacity

The design main condensate flow from the condenser hotwell to the deaerating heater and the design feedwater flow from the deaerating heater to the inlet of the steam generators shall be determined from the heat balance of the turbine manufacturer and cycle finally chosen.

Pipe sizing will be determined by an economic evaluation of erected pipe costs versus pumping power costs. Preliminary sizing shall follow Mechanical Design Standard 047306.

The pipe and valve ratings for the feedwater/condensate system shall be determined by the rules in the latest edition of ANSI B31.1. A corrosion/erosion allowance shall be included in the pipe wall and feedwater heater shell calculations. The allowances will be determined by the piping engineer and system engineer when the specifications are written.

The design pressure of the closed feedwater heaters shall be determined as follows:

- Shell Side--Maximum expected load (VWO) heat balance turbine nozzle pressure (before extraction piping friction pressure loss), plus 10 percent and rounded to the next higher 10 psi. In no case shall the design pressure be less than 15 psig. Also, all shells shall be designed for full vacuum.

- Tube Side--Pump shutoff head, plus 20 percent (due to variations from predicted values). The high-pressure heaters, tube side, design shall also comply with ANSI B31.1, paragraph 122.1.3 and ASME BPVC, Section I, paragraph 58.3.3.

The design temperature of the feedwater heaters, both shell and tube side, shall be determined per HEI Standard for Closed Feedwater Heaters, Third Edition, paragraph 3.3.

The deaerating heater design pressure and temperature shall be determined as above for the closed feedwater heaters. The deaerating feedwater heater shall be the tray type for better deaeration over the load range. The design oxygen content of the leaving condensate shall not exceed 7 PPB. The storage tank shall be sized for at least five minutes of feedwater pump operation at the pump design flow.

The steam generator feed pump design head and capacity will conform with ASME BPVC, Section I, paragraph 61.5 requirements.

All pump capacity calculations for the system will include a 5 percent wear margin.

The condenser hotwell shall be sized for at least a five-minute storage capacity for the condensate pumps at pump design flow.

3.0 Codes and Standards

The condensate and feedwater system piping shall comply with ANSI B31.1 and the material and dimensional standards referred to in ANSI B31.1.

The erected system shall meet the requirements of the State of California, Administrative Code, Title 8, Industrial Relations, Chapter 1, CAL/OSHA, and Chapter 4, Subchapter 7, General Industry Safety Orders.

All feedwater heaters, both shell and tube side, shall be designed and constructed to the ASME BPVC, Section VIII, Division 1.

All closed feedwater heaters shall comply with HEI Standards for Closed Feedwater Heaters.

Pump tests shall comply in general with the Hydraulic Institute Standards with some exceptions as may be advisable (see EPRI CS-1512), as determined by the system engineer.

Recommended practices for the prevention of water damage to the turbine, ASME STANDARD TWDPS-1, shall be followed.

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4.0 Design Conditions (Also refer to Sections 1 and 2.)

The condensate and feedwater piping system shall include provisions to accommodate daily start-up and shutdown of the unit. The start-up system will include heat exchangers, pumps, piping, valves, etc., as required to bring the feedwater temperature and purity to the required conditions to feed to the steam generators as defined in the "Start-up Requirements" Design Criteria.

The plant will cycle from no load to full load daily. The condensate and feedwater piping system will be designed with proper flexibility to meet this condition. The steam generator feed pumps shall be specifically designed for daily start-up and shutdown.

A full-flow, condensate polishing system will be included in the condensate system as described in Design Criteria D23-16.

There will be three sodium heated, once through, steam generators. The feedwater system shall be designed to meet the ASME BPVC and ANSI B31.1 requirements for this arrangement. The three steam generators will be headered together on the steam outlet ends without individual stop valves. Each steam generator shall have an individual feedwater flow control valve, flow measuring nozzle with small bypass valves, and nozzle for flow control down to one percent of full flow.

The condensate pumps and all valves on the suction side of the condensate pump shall have water seals on the shaft glands to prevent in-leakage of air. The condensate pumps shall have mechanical seals.

Where required, the condensate and feedwater piping heat insulation thickness will be determined by economic analysis and considerations of personnel safety.

5.0 Design Loads

The condensate and feedwater piping will be designed for the loads described in ANSI B31.1.

The seismic loading will be specified in the Civil Engineering Design Criteria D23-2.

Where expansion joints are used in the piping system, anchor or control rods shall be used to absorb the static thrust from the pipe internal pressure.

6.0 Environmental Conditions

The turbine-generator will be installed without a permanent building protecting it from the weather. The condensate and feedwater system will, in part, be installed in locations protected from the weather by overhead floors and curtain walls. The feedwater heaters and the deaerating heater will be installed outdoors.

7.0 Interface Requirements

The condensate/feedwater system will interface with:

- The condenser (included in the Circulating Water System Design Criteria, D23-18M)
- The steam generator/feedwater piping interface requirements are specified in the ASME BPVC, Section I, paragraph PG-58.3.5, Figure PG-58.3.2
- The steam-generator feedwater make-up system
- The extraction drains, which will enter the condensate system either in the deaerator or condenser
- The condensate polishing system
- The auxiliary steam system for heating and deaerating at start-up
- The attemperating water source for main steam temperature control sprays
- The feedwater pumps will be electric motor driven. An evaluation should be done to determine benefits, control capability, and costs of variable speed drives.

8.0 Material Requirements

Piping material shall be carbon steel and shall conform to the requirements of ANSI B31.1.

Thermal insulation shall be asbestos free.

Feedwater heater tubing material shall be stainless steel. The choice of stainless steel over copper alloys is based on:

- Desirability of removing copper from the cycle which will enable the feedwater to be maintained at a higher pH to minimize corrosion of the steel materials
- Prevent copper from plating out in the steam generators
- More resistant to inlet end erosion
- Daily shutdowns could allow air to enter the wet feedwater heater shells and corrode the copper tubes
- Price differential is minimal

The deaerating heater trays should be 300 series stainless steel. The feedwater heater tubes may be either welded or seamless.

9.0 Layout and Arrangement

There will be:

- Two 100 percent feed pumps, motor driven
- Two 100 percent condensate pumps, motor driven
- Single string of horizontal feedwater heaters
- A deaerator at the feed pump suction
- A condensate polisher at the condensate pump discharge
- A gland sealing steam condenser
- A hydrazine and ammonia chemical injection system for oxygen scavenging and pH control

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- No steam jet air ejector
- There will be no in-the-condenser-neck feedwater heaters
- Total number of feedwater heaters, five at this time

The condensate pumps will be vertical, can type with sufficient length to provide NPSH to the pumps with the hotwell water level at the bottom of the hotwell plus piping losses plus a 25 percent margin.

The deaerater heater should be located as nearly directly over the feed pumps as possible in order to shorten the suction pipe length to the pumps. The height of the deaerating heater water level above the feed pumps centerline shall be, as a minimum, equal to the NPSH requirements of the pump at design flow plus the suction pipe friction head loss (in feet) plus the pump entrance loss plus a margin of 100 percent.

The deaerator pressure will be pegged with auxiliary steam.

The feedwater heaters should be located close to the turbine to reduce extraction line pressure drop. The vertical location of the feedwater heaters (their centerline elevation) should, as much as possible, accommodate the shell side cascading drains (especially at low loads). The closed feedwater heaters will have individual bypasses on the tube side. The feedwater heater specifications should include the possibility of operation with a bypassed heater for the designer's consideration, f~~or possib~~le ~~steam~~ (high steam inlet velocities in the next higher heater.)

Recommended practices for the prevention of water damage to the turbine, ASME STANDARD TWDPS-1, shall be followed

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Provisions should be made to keep the standby feed pumps warm with an orificed back-flow line bypassing the pump discharge check valve.

Makeup to the condensate/feedwater system will be from a distilled water tank into the condenser hotwell. Makeup and reject will be controlled by the hotwell level.

10.0 <u>Instrumentation and Control</u> (Refer to the Instrumentation and Control Design Criteria D23-15-I.)

Steam generator feedwater control may be by flow control valve or variable speed drive motors on the feed pumps. An economic evaluation should be performed. Turbine inlet steam pressure will be controlled by the feed pump discharge flow.

Boiler feed pumps' and condensate pumps' minimum flow requirements shall be assured by control systems as designed by the Instrumentation and Control Group. Each pump's recirculation system should be independent of the other pump.

Lowering of the water level in the deaerating heater storage tank below the normal range due to insufficient flow into the heater becomes critical to the feed pump operation as the NPSH margin is reduced. The deaerator level control scheme should start the standby condensate pump on low level. Consideration should be given to unit load runback should the level continue to drop and at an extreme low level, the feed pumps should be tripped, which will trip the main unit.

The feedwater pumps and their drive motors should be provided with bearing metal thermocouples on all bearings including the thrust bearing.

11.0 Access Requirements for Security

Not applicable.

12.0 Reliability

There will be two 100 percent feed pumps and two 100 percent condensate pumps. The feedwater heaters shall have feedwater bypass piping with valving so that they can be removed from service without shutting down the unit.

The use of stainless steel tubing in the feedwater heaters will reduce corrosion and erosion damage.

13.0 System Reliability Effect on Unit Availability

The feed pump and condensate pump control systems will be designed to automatically bring in the standby, full-flow pump upon failure of the operating pump and will cause no loss of capacity of the main unit.

If a tube leak is detected in an operating feedwater heater, it can be valved out of service and the feedwater heater bypassed. Conditions may vary between turbine manufacturers, but it is expected that maximum guaranteed load can be carried on the unit with any single feedwater heater out of service.

Loss of the deaerating heater will cause a complete shutdown. Any plant upset which results in the operating water level in the deaerating heater storage tank dropping to an extreme low level will trip the feed pump and the main unit. See paragraph 10 for the design features to be included to minimize the possibility of the unit trip from this cause.

14.0 Examination, Inspection, and Testing

The piping will be subject to examination, inspection, and testing as required by ANSI B31.1.

Feedwater heaters, pumps, and shop-fabricated pipe will be subject to purchaser's inspection and acceptance before shipment to the site.

Feedwater heaters, shell and tube side, shall be inspected and tested per the ASME Pressure Vessel Code. Performance testing of the feedwater heaters shall be performed at the site after erection.

The feed pumps and condensate pumps will have witnessed performance tests. An NPSH test shall be included using a 1 percent head reduction. The head capacity curves must rise continuously from high capacity to shutoff, preferably not less than 120 percent from design flow to shutoff. No inflection points are acceptable.

Lay down
area
a consideration

15.0 Maintenance

Feedwater heaters and pumps shall be installed with sufficient clearance to allow convenient and proper maintenance. Space shall be reserved to remove tube bundles or shells. Lifting beams and trolly beams should be provided for removal of heater shells or bundles, heater channel covers, feed pump upper case or barrel inner element.

The vertical condensate pump will require head room for removal of the pump from the can and a means to handle the pumping element.

If the feedwater heater channels have manholes for a man to enter for maintenance, the feedwater shutoff valves must be double valved with a telltale vent between them. Refer to California Administrative Code, Title 8, Subchapter 7, paragraph 3312.

Valves will require permanent platform accessibility for operation and maintenance.

Condenser retubing space shall be reserved.

16.0 Personnel Requirements

This system will not require personnel with special skills beyond that which is normally required for power plant operation and maintenance.

17.0 Shipping

Equipment openings shall be covered or plugged. Flange facings and machined surfaces shall be protected. Hydrostatic testing water shall be completely drained.

18.0 Fire Protection

No special requirements.

19.0 Storage

The feed pumps should be stored indoors if possible; otherwise, they should be covered in a heated space to prevent corrosion from dew. The feed pump motors should be stored in an enclosed area with the space heaters energized.

Feedwater heaters may be stored outdoors with periodic inspection and touch-up of the primer paint when corrosion occurs.

The internals of the deaerating heater should be inspected upon arrival at the site for dirt and debris.

Storage requirements of the pumps should be obtained from the manufacturers. The condensate pump may require special treatment to prevent bowing of the shaft. Parts installed in the pumps to prevent the shaft from turning during shipment must be removed.

20.0 Health and Safety of the Public

The State of California Administrative Code, Title 8, Chapter 4, Subchapter 7, General Industry Safety Orders must be complied with.

21.0 Materials and Fabrication

This subject is covered in paragraph 8.

The turbine and generator and all accessories shall be stored indoors in a heated space if possible. If not stored indoors, they shall be covered and space heaters provided.

20.0 Health and Safety of the Public

The main steam piping system will be protected from overpressure by the steam generator safety valves.

21.0 Materials and Fabrication

Materials are covered in paragraph 8.

Fabrication of the main steam piping system shall comply with the requirements of ANSI B31.1, Chapter V.

The main steam piping system shall be of all welded construction as far as practical.

4.3.1 CONDENSATE AND FEEDWATER INSTRUMENTATION AND CONTROL

(D23-151)

Engineering
76-370 2/81

DCM No. D23-15-I Revision 0
Date 5/13/83
File No. D23-44000

PACIFIC GAS AND ELECTRIC COMPANY

30MW SOLAR

DESIGN CRITERIA MEMORANDUM

Structure, System, or Component: CONDENSATE AND FEEDWATER SYSTEM

Prepared by: J.M. WALEWSKI / M.T. PERAKIS MTPerakis Date 5/16/83

Group Leader/Supervisor Review A.F. ARIEY AFAriey (Discipline) Date 5/23/83

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30 MW SOLAR
CONDENSATE AND FEEDWATER SYSTEM INSTRUMENTATION AND CONTROL DESIGN CRITERIA

Reference Documents:

Condensate and Feedwater System - System Design Criteria, DCM No. D23-15
Master Control System - Design Criteria, DCM No. D23-7
Instrumentation and Control - General Design Criteria, DCM No. D23-3
Deaerators - Performance Test Code - ASME PTC 12.3-1977

1.0 Scope

These criteria will define the Instrumentation and Control (I&C) requirements for the Condensate and Feedwater System.

The Condensate and Feedwater System includes the following components:

1.1 Mechanical Equipment to be Controlled

1.1.1 Condensate Pumps Nos. 1 and 2 Page 4

1.1.2 Feedwater Pumps Nos. 1 and 2 Page 8

1.2 Valves to be Controlled

1.2.1 Main Condenser Make-up Level Control Valve Page 12

1.2.2 Condensate Rejection Level Control Valve Page 11

1.2.3 Condensate Return Tank Level Control Valve Page 15

1.2.4 Deaerator Heater Level Control Valve Page 16

1.2.5 Feedwater Pumps Recirculation Flow Control Valves (2) Page 9

1.2.6 Steam Generator Feedwater Flow Control Valves (6) Page 25

1.2.7 Steam Generator Main Feedwater Isolation Valves (3) Page 26

1.2.8 Steam Generator Feedwater Header Isolation Valve Page 26

1.2.9 Start-up Recirculation Feedwater Steam Generator Isolation Valves (3) Page 27

1.2.10 Main Condenser Vacuum Breaker Page 13

1.2.11 Main Steam Attemperator Water Spray Temperature Control Valve Page 27

1.2.12 Main Steam Attemperator Water Spray Isolation Valve Page 27

1.2.13 Auxiliary Steam Attemperator Water Spray Temperature Control Valve Page 28

2.0 Control System Interfaces

2.1 The Condensate and Feedwater System provides water to the steam generators in sufficient flow and pressure to meet turbine demand. Main steam pressure set point is satisfied by the correct feedwater flow rate.

2.2 Feedwater temperature out of limits will cause a steam generator trip.

2.3 Main steam attemperating water valve receives a signal based upon main steam temperature.

2.4 Auxiliary steam attemperating water valve receives a signal based upon auxiliary steam temperature.

2.5 Condenser high pressure trips turbine.

3.0 Overall Operating Requirements

3.1 Initial start-up of condensate and feedwater pumps is manual by operator from Master Control System. Pumps will not start unless sufficient water level is provided on suction.

3.2 Main condenser level will be maintained automatically by Condenser Make-up and Condensate Reject Systems. Rejection only functions while Condensate System is pressurized.

3.3 Condensate recirculation to condenser occurs from a point after FW heater no. 4 and provides:

a. High condensate flows for daily clean-up

b. Minimum flows to satisfy condensate pump and gland steam condenser minimum flow requirements based upon a flow set point.

3.4 The feedwater recirculation lines shall be available to provide protection for the feedwater pumps. The recirculation valves will provide a minimum of 20% of rated flow or the pump manufacturer's minimum flow recommendation.

4.0 Mechanical Equipment Process Control and Protection

4.1 Condensate Pumps Nos. 1 and 2

The primary function of the condensate pumps is to supply the condensate water flow to the gland steam condenser and Feedwater System. The condensate pumps are provided with the minimum flow protection.

4.1.1 Controls

4.1.1.1 Remote Automatic, Master Control System

The initial startup of the first condensate pump will be manual from the Master Control System. However, a second standby pump will start automatically if any of the following events occurs:

a. Main condenser level high

b. Running pump trips

c. Deaerator level low

4.1.1.2 Remote Automatic, Dedicated

None

4.1.1.3 Local Automatic

The condensate standby pump will start on:

None

4.1.1.4 Remote Manual, Master Control System

The condensate pumps will be manually started and stopped from the Master Control System. A manual shutdown is required after the second pump auto start (see Section 4.1.1.1).

4.1.1.5 Remote Manual, Dedicated

None

4.1.1.6 Local Manual

None

4.1.2 Trips and Interlocks

4.1.2.1 The pumps will have the following protective trips:

a. Main condenser low level to provide NPSH protection (one for each pump)

b. Motor upper bearing vibration high

c. Motor lower bearing vibration high

d. Motor upper bearing temperature high

e. Motor lower bearing temperature high

f. Motor overcurrent

4.1.2.2 Low flow protection is provided by automatic recirculation back to the distilled water tank using the condensate recirculation valve (see Section 6.1.9).

4.1.2.3 Maintenance

The maintenance of one condensate pump can be accomplished without affecting the operation of the system as long as the running pump does not fail.

4.1.3 Control Valves

None

4.1.4 Indication

4.1.4.1 Local

a. Condensate Pumps Discharge Pressure (2)

b. Condensate Pumps Differential Pressure (2)

c. Condensate Pumps Suction Pressure

d. Condensate Pumps Suction Temperature

e. Condensate Pumps Motor Bearing Temperature (4)

f. Condensate Pumps Motor Bearing Vibration (4)

4.1.4.2 Remote, Master Control System

a. Condensate Pumps Discharge Header Flow

b. Status of Condensate Pump No. 1, Running and Not Running

c. Status of Condensate Pump No. 2, Running and Not Running

d. Condensate Pumps Motor Bearings Temperature (4)

e. Condensate Pumps Motor Bearings Vibration (4)

4.1.4.3 Remote, Dedicated

a. Condensate Header Flow

4.1.5 Test Points

a. Condensate Pump No. 1, Suction Pressure Before and After Strainer (2)

b. Condensate Pump No. 2, Suction Pressure Before and After Strainer (2)

c. Condensate Pump, Discharge Header Analysis Test Point

4.1.6 Recording

None

4.1.7 Alarms

4.1.7.1 Local

None

4.1.7.2 Remote, Master Control System

a. Condensate Pump No. 1, Differential Pressure High

b. Condensate Pump No. 2, Differential Pressure High

c. Main Condenser Low Level Condensate Pump No. 1 Trip

d. Main Condenser Low Level Condensate Pump No. 2 Trip

e. Condensate Pump No. 1 Standby Start Initiated by the Master Control System

f. Condensate Pump No. 2 Standby Start Initiated by the Master Control System

g. Motor Upper Bearing Vibration High Trip (2)

h. Motor Upper Bearing Vibration High (2)

i. Motor Lower Bearing Vibration High Trip (2)

j. Motor Lower Bearing Vibration High (2)

k. Motor Upper Bearing Temperature High Trip (2)

l. Motor Upper Bearing Temperature High (2)

m. Motor Lower Bearing Temperature High Trip (2)

n. Motor Lower Bearing Temperature High (2)

o. Motor Overcurrent Trip (2)

p. Vibration Monitor Malfunction

q. Condensate Header Flow Low

4.1.7.3 Remote, Annunciator

a. Condensate Pumps Trip

4.2 Feedwater Pumps Numbers 1 and 2

The function of feedwater pumps is to pump feedwater from the deaerator storage tank through the feedwater heaters nos. 2 and 1 to the steam generator. One pump is required for normal operation.

4.2.1 Controls

4.2.1.1 Remote Automatic, Master Control System

The initial startup of the feedwater pump will be manual from the Master Control System. However, a second standby pump will start automatically if the running pump tripped.

4.2.1.2 Remote Automatic, Dedicated

None

4.2.1.3 Local Automatic

None

4.2.1.4 Remote Manual, Master Control System

The feedwater pumps will be manually started and stopped from the Master Control System. A manual shutdown is required after the second pump auto start (see Section 4.2.1.1).

4.2.1.5 Remote Manual, Dedicated

None

4.2.1.6 Local Manual

None

4.2.2 Trips and Interlocks

4.2.2.1 Each pump will have the following protective trips:

a. Deaerator Low Low Level (to prevent low NPSH for pumps)

b. Pump Bearings, Vibration High (2)

c. Motor Bearings, Vibration High (2)

d. Pump Bearings, Temperature High (2)

e. Motor Bearings, Temperature High (2)

f. Pump Overcurrent

4.2.2.2 Maintenance

The maintenance of one feedwater pump can be accomplished without affecting the operation of the system as long as the running pump does not fail.

4.2.3 Control Valves

4.2.3.1 Feedwater Pumps Recirculation Flow Control Valves (2)

The valves are located in feedwater pump recirculation lines. The pump recirculation is used to maintain the minimum continuous flow requirements. Recirculation flow is set by flow orifices located in the recirculation pipe.

The decrease in feedwater pump suction flow will open the valve. The increase in feedwater pump suction flow will close the valve.

a. The open/closed flow control valve operates on suction flow with no interlocks.

b. The valve is fail open/air to close. This will provide minimum flow across the pump. The valve has a pneumatic actuator, a solenoid valve, and open/closed position switches.

c. The feedwater pump recirculation valve will be manual/auto controlled from the Master Control System.

d. The maintenance of the control valve and related equipment can be accomplished as long as running pump does not fail.

4.2.4 Indication

4.2.4.1 Local

a. Feedwater Pumps Suction Pressure (2)

b. Feedwater Pumps Discharge Pressure (2)

c. Feedwater Pump and Motor Bearings Temperature (8)

d. Feedwater Pump and Motor Bearings Vibration (8)

4.2.4.2 Remote, Master Control System

a. Status of Feedwater Pump No. 1 (On and Off)

b. Status of Feedwater Pump No. 2 (On and Off)

c. Status of Feedwater Pump Recirculation Flow Valve No. 1 (Open and Closed)

d. Status of Feedwater Pump Recirculation Flow Valve No. 2 (Open and Closed)

e. Feedwater Pump Suction Flow (2)

f. Feedwater Pump and Motor Bearings Temperature (8)

g. Feedwater Pump and Motor Bearings Vibration (8)

4.2.4.3 Remote, Dedicated

a. Feedwater Pump Suction Flow (2)

4.2.5 Test Points

None

4.2.6 Recording

None

4.2.7 Alarms

4.2.7.1 Local

None

4.2.7.2 Remote, Master Control System

a. Feedwater Pump No. 1, Discharge Pressure High

b. Feedwater Pump No. 2, Discharge Pressure High

c. Feedwater Pump No. 1, Flow Below Minimum

d. Feedwater Pump No. 2, Flow Below Minimum

e. Low Lube Oil Pressure

f. Pump and Motor Bearings, Vibration High Trip (4)

g. Pump and Motor Bearings, Vibration High (4)

h. Pump and Motor Bearings, Temperature High Trip (4)

i. Pump and Motor Bearings, No. 2, Temperature High (4)

j. Pump Overcurrent Trip (2)

k. Pump Vibration Monitor Malfunction

4.2.6.3 Remote, Annunciator

a. Feedwater Pumps Trip

5.0 Vessels Process Control and Protection

5.1 Main Condenser and Hotwell

The main condenser and its hotwell will provide low backpressure for the turbine. The hotwell receives make-up water from the distilled water tank and supplies deaerated water to the condensate pumps suction. The hotwell acts as a storage tank and maintains an operating water level to provide a sufficient suction head for the condensate pumps.

5.1.1 Controls

See Section 5.1.3.

5.1.2 Trips and Interlocks

5.1.2.1 The main condenser will have the following turbine protection trip:

a. Main condenser high pressure to protect turbine blade from windage

b. Main condenser high level to protect turbine from flooding.

5.1.2.2 The main condenser will not have any interlocks.

5.1.3 Control Valves

5.1.3.1 Condensate Rejection Level Control Valve

The condensate rejection level control valve is located after the gland steam seal condenser and is modulated for the removal of the excess of condensate from the main condenser back to distilled water tank.

The valve opens when water level increases. The valve closes when water level decreases. The valve has no interlocks.

a. The modulating level control valve operates on a level signal from the main condenser. The valve is interlocked with the condensate pumps numbers 1 and 2. If both pumps shut down, valve shall close.

b. The valve is fail open/air to close. This will protect the turbine from flooding. The valve has a pneumatic actuator and a positioner.

c. The condensate rejection control valve will be manual/auto controlled from the Master Control System. The controller will have a proportional plus integral control and will be direct acting.

d. The valve is provided with a bypass line and a manual valve. The manual valve can be used to control in emergency situations. However, under normal circumstances, the maintenance of the control valve and related equipment will require system shutdown.

5.1.3.2 Main Condenser Make-up Level Control Valve

The main condenser make-up level control valve is located near the main condenser and is modulated to maintain an operating level of the main condenser hotwell by allowing make-up water from the distilled water tank.

The valve opens when water level decreases. The valve closes when water level increases.

a. The modulating level control valve operates on a level signal from the main condenser. The valve has no interlocks.

b. The valve is fail closed/air to open. This will protect the main condenser from flooding. The valve has a pneumatic actuator and a positioner.

c. The main condenser make-up level valve will be manual/auto controlled from the Master Control System. The controller will have a proportional plus integral control and will be reverse acting.

d. The maintenance of the valve and related equipment is possible by using the bypass. The bypass can be used to control in emergency conditions. However, under normal circumstances, maintenance of the control valve and related equipment will require a system shutdown.

5.1.3.3 Main Condenser Vacuum Breaker

The main condenser vacuum breaker will be on/off valve, which will be opened manually (after time delay) when turbine trip device is actuated.

a. The valve is interlocked to prevent it from opening until after a turbine trip and time delay.

b. The valve is fail closed/air to open. This will protect turbine blade from windage. The valve has a pneumatic actuator, a solenoid valve, and open/closed position switches.

c. The valve will be manually controlled from the Master Control System.

d. The maintenance of the condenser vacuum breaker will require plant shutdown. The vacuum breaker will have a manual bypass valve to allow breaking condenser vacuum during an automatic valve failure.

5.1.4 Indication

5.1.4.1 Local

a. Main Condenser Hotwell Level

b. Main Condenser Pressure (Manometer)

5.1.4.2 Remote, Master Control System

a. Main Condenser Level

b. Main Condenser Pressure

c. Status of Vacuum Breaker - Open and Closed

5.1.4.3 Remote, Dedicated

a. Hotwell Level

b. Condenser Pressure

5.1.5 Test Points

a. Main Condenser Pressure

5.1.6 Recording

None

5.1.7 Alarms

5.1.5.1 Local

None

5.1.5.2 Remote, Master Control System

a. Main Condenser Pressure High

b. Main Condenser Level Low

c. Main Condenser Level High

5.1.5.3 Remote, Annunciator

Window Description: "Main Condenser Trouble"

a. Main Condenser Low Level

b. Main Condenser High Level

c. Main Condenser High Pressure

5.1.5.4 Sequence of Events Requirements

a. Main Condenser High Pressure Trip

b. Main Condenser Low Level Condensate Pump Trip

5.2 Miscellaneous Condensate Return Tank

The miscellaneous condensate return tank receives the condensate from the gland steam condenser and various open drains from the other systems.

5.2.1 Controls

See Section 5.2.3.

5.2.2 Trips and Interlocks

None

5.2.3 Control Valves

5.2.3.1 Condensate Return Tank Level Control Valve

The valve is located on the downstream side of the condensate return tank and is modulated to maintain the condensate return tank level.

The valve opens on increase in the condensate return tank level. The valve closes on decrease in the condensate return tank level.

a. The modulating level control valve operates on a level control signal from the condensate return tank. The valve has no interlocks.

b. The valve is fail closed/air to open. This will protect the vacuum in main condenser. The valve is equipped with a pneumatic actuator and a positioner.

c. The condensate return tank valve will be local controlled with a pneumatic controller. The controller will have a proportional plus integral control and will be direct acting.

d. The maintenance of the control valve and related equipment will require system shutdown.

5.2.4 Indication

5.2.4.1 Local

a. Miscellaneous Condenser Return Tank Level

5.2.4.2 Remote, Master Control System

None

5.2.5 Test Points

None

5.2.6 Recording

None

5.2.7 Alarms

5.2.7.1 Local

None

5.2.7.2 Remote, Master Control System

a. Condensate Return Tank Level High

b. Condensate Return Tank Level Low

5.2.7.3 Remote, Annunciator

None

5.3 Deaerator Heater and Storage Tank

The deaerator heater receives the condensate and drains from the feedwater heaters and extraction steam from the Extraction Steam System. The heated and deaerated water is collected in the storage tank for the feedwater pump suction. Also, the deaerator heater receives flash steam from the flash tank during start-up and pegging steam (at low loads) from the Auxiliary Steam System.

5.3.1 Controls

a. For control valves, see Section 5.3.3.

b. Standby start of a condensate pump will occur on deaerator storage tank level low. This is a local automatic dedicated system.

5.3.2 Trips and Interlocks

Refer to Section 4.2.2.1 (feedwater pump trip).

5.3.3 Control Valves

5.3.3.1 Deaerator Heater Level Control Valve

The valve modulates condensate flow to deaerator to maintain required level in the storage tank.

Decrease in level opens valve; increase in level closes valve.

a. The modulating valve operates on a level signal from the deaerator storage tank. The valve has no interlock.

b. The valve is be fail closed/air to open. The valve is equipped with a pneumatic actuator and a positioner.

c. The valve is manual/auto controlled from the Master Control System. The controller will have a proportional plus integral control and will be reverse acting.

d. The maintenance of the valve and related equipment will require system shutdown.

5.3.3.2 Deaerator Condensate Flow Isolation Valve

#2

The valve is located upstream of the deaerator level control valve and is intended to shut off all condensate flow to deaerator during condensate recirculation clean-up mode.

a. This on/off control valve operates on a remote signal. The valve has no interlocks.

b. The valve is fail closed/air to open. The valve is equipped with a pneumatic actuator and a solenoid valve.

c. The valve will be manual/auto controlled from the Master Control System.

d. The maintenance of the control valve and related equipment will not require system shutdown.

5.3.4 Indication

5.3.4.1 Local

a. Deaerator Heater Storage Tank Level

b. Deaerator Heater Storage Tank Pressure

5.3.4.2 Remote, Master Control System

a. Deaerator Tank Level

b. Deaerator Tank Pressure

5.3.4.3 Remote, Dedicated

a. Deaerator Storage Tank Level

b. Deaerator Storage Tank Pressure

5.3.5 Test Points

None

5.3.6 Recording

None

5.3.7 Alarms

5.3.7.1 Local

None

5.3.7.2 Remote, Master Control System

a. Deaerator Heater Storage Tank Level High

b. Deaerator Heater Storage Tank Level Low

c. Deaerator Storage Tank Pressure High

5.3.7.3 Remote, Annuciator

Window Description: "Deaerator Heater Trouble"

a. Deaerator Heater Storage Tank Level Low

b. Deaerator Heater Storage Tank Level High

5.4 Flash Tank

The flash tank is used during the start-up mode to recover heat from the feedwater by flashing it into steam and using that steam in the deaerator.

5.4.1 Controls

See Section 5.4.3.

5.4.2 Trips and Interlocks

None

5.4.3 Control Valves

5.4.3.1 Flash Tank Level Control Valve

The valve is located in the drain line from the flash tank after the start-up heat exchanger (drains to condenser). It modulates to control level in the flash tank.

a. The modulating level control valve operates on flash tank level signal. The valve has no interlocks.

b. The valve is fail closed/air to open. This prevents steam from blow through the start-up heat exchanger and condenser. The valve will have a pneumatic actuator and a positioner.

c. The valve will be manual/auto controlled from the Master Control System. The controller will have a proportional plus integral control and will be direct acting.

d. The maintenance of the valve and related equipment will require flash tank system shutdown.

5.4.3.2 Flash Tank Feedwater Flow Control Valve

The valve is located in the feedwater to flash tank line and controls the flow to the flash tank. Flow rate is set by the particular mode during start-up operations.

a. The modulating flow control valve operates on flow set point. The valve has no interlock.

b. The valve is fail closed/air to open. This is to prevent flow into flash tank under the wrong conditions. The valve will have a pneumatic actuator and a positioner.

c. The valve will be manual/auto controlled from the Master Control System. The controller will have a proportional plus integral control and will be direct acting.

d. The maintenance of the valve and related equipment will require system shutdown.

5.4.3.3 Flash Tank Feedwater Flow Isolation Valve

The valve is located ahead of the feedwater to flash tank flow control valve. It is intended to prevent flow into flash tank when not required.

a. The on/off control valve operates on a remote signal.

b. The valve is fail as is. The valve is equipped with an electric actuator, the travel switches, and a local position indication.

c. The valve will be manual/auto controlled from the Master Control System. The flash tank operating mode determines the valve position.

d. The maintenance of the control valve and related equipment will require system shutdown.

5.4.3.4 Flash Tank Steam Pressure Control Valve

This valve is located in the line from flash tank to main condenser. The primary function is to pass excess steam to the condenser in order to hold flash tank pressure at a given set point.

a. The modulating valve operates on a remote signal. The valve has no interlocks.

b. The valve is fail open/air to close. This is to prevent overpresssuring of the flash tank. The valve is equipped with a pneumatic actuator and a positioner.

c. The valve will be manual/auto controlled from the Master Control System. The controller will have a proportional plus integral control and will be reverse acting.

d. The maintenance of the valve and related equipment will require flash tank system shutdown.

5.4.4 Indications

5.4.4.1 Local

None

5.4.4.2 Remote, Master Control System

a. Flash Tank Level

b. Flash Tank Pressure

c. Flash Tank Feedwater Isolation Valve Position (Open or Closed)

5.4.4.3 Remote, Dedicated

None

5.4.5 Test Points

None

5.4.6 Recording

None.

5.4.7 Alarms

5.4.7.1 Local

None

5.4.7.2 Remote, Master Control System

a. Flash Tank Pressure High

b. Flash Tank Level High

5.4.7.3 Remote, Annunciator

None

5.5 Startup Feedwater Heater

The startup feedwater heater is used to help raise the feedwater temperature to match (within $150^{\circ}F$) the temperature at the cold end of the steam generator.

5.5.1 Control

See Section 5.5.3.

5.5.2 Trips and Interlocks

None

5.5.3 Control Valves

5.5.3.1 Start-up Feedwater Heater Inlet Flow Control Valve

The valve is located on the feedwater inlet to the start-up heater.

a. The on-off control valve operates on a remote signal in response to plant mode requirements.

b. The valve is fail as is. The valve is equipped with an electric actuator, open/closed position switches, the travel switches, and a local position indication.

c. The valve will be manual/auto controlled from the Master Control System.

d. The maintenance of the control valve and related equipment will require system shutdown.

5.5.3.2 Start-up Feedwater Heater Level Control Valve

The valve is located in the drains from feedwater heater to flash tank. It modulates to control level in feedwater heater.

a. The modulating level control valve operates on a feedwater heater level signal. The valve has no interlocks.

b. The valve is fail open/air to close. This will prevent flooding of feedwater heater. The valve is equipped with a pneumatic actuator and a positioner.

c. The valve will be manual/auto controlled from the Master Control System. The controller will have a proportional plus integral control and will be reverse acting.

d. The maintenance of the control valve and related equipment will require system shutdown.

5.5.3.3 Startup Feedwater Heater High Level Control Valve

The valve is located in the drains from feedwater heater to condenser. It modulates to control level in feedwater heater whenever normal level valve is unable to do so.

a. The modulating level control valve operates on a feedwater heater level signal. The valve has no interlocks.

b. The valve is fail open/air to close. This will prevent flooding of feedwater heater. The valve is equipped with a pneumatic actuator and a positioner.

c. The valve will be auto controlled from a local dedicated controller. The controller will have a proportional plus integral control and will be reverse acting.

5.5.4 Indication

5.5.4.1 Local

a. Start-up feedwater heater level indicator

5.5.4.2 Remote, Master Control System

a. Start-up feedwater heater level

5.5.4.3 Remote, Dedicated

None

5.5.5 Test Points

None

5.5.6 Recording

None

5.5.7 Alarms

5.5.7.1 Local

None

5.5.7.2 Remote, Master Control System

a. Start-up feedwater heater level high

5.5.7.3 Remote, Annunciator

None

5.6 Start-up Heat Exchanger

The startup heat exchanger is used to recover heat from the flash tank drains during startup mode of plant operation.

5.6.1 Control

See Section 5.6.3.

5.6.2 Trips and Interlocks

None

5.6.3 Control Valves

5.6.3.1 Start-up Heat Exchanger Inlet Control Valve

This valve is used to control flow through the start-up heat exchanger during flash tank operation. The valve is manually positioned either fully open or throttled as the system conditions dictate.

a. The modulating flow control valve operates an open loop by the operator command. The valve has no interlocks.

b. The valve is fail open/air to close. The valve is equipped with a pneumatic actuator and a positioner.

c. The valve is manually controlled from the Master Control System.

d. The maintenance of the control valve and related equipment will require system shutdown.

5.6.3.2 Startup Heat Exchanger Bypass Control Valve

The valve is used to bypass flow around the start-up heat exchanger for normal system operation. During start-up phase, the valve will either be fully closed or throttled as system conditions dictate.

a. The modulating flow control valve operates on open loop by the operator command.

b. The valve is fail open/air to close. The valve is equipped with a pneumatic operator and a positioner.

c. The valve is manually controlled from the Master Control System.

d. The maintenance of the control valve and related equipment will require system shutdown.

5.6.4 Indication

5.6.4.1 Local

None

5.6.4.2 Remote, Master Control System

a. Condensate temperature entering startup heat exchanger

b. Condensate temperature leaving startup heat exchanger

5.6.4.3 Remote, Dedicated

None

5.6.5 Test Points

None

5.6.6 Recording

None

5.6.7 Alarms

None

6.0 Miscellaneous Instruments

6.1 Local

6.1.1 Steam Generator Feedwater Flow Control Valves (6)

The six valves used to control feedwater to steam generators are located just upstream of the steam generators on the Feedwater System. Three valves control minimum flows (up to 10%) and three valves control normal flows (10% - 100%). All valves are modulated in response to feedwater demand signals in the Master Control System.

a. The modulating flow control valve operates on feedwater demand signal generated from the steam flow and turbine throttle pressure.

b. The valve is fail closed/air to open. This is to prevent possible damage from cold water entering steam generators and excessive water carryover to main steam line. The valve is equipped with a pneumatic actuator and a positioner.

c. The valves will be manual/auto controlled from the Master Control System. The controller will have a proportional plus integral control and will be direct acting.

d. The maintenance of the valves and related equipments will require system shutdown.

6.1.2 Steam Generator Main Feedwater Isolation Valves (3)

The valves are located in each feedwater line to steam generators.

a. The open/closed flow control valve operates on a remote signal. The valve has no interlocks.

b. The valve is fail as is. The valve is equipped with an electric actuator, the travel switches, and a local position indication.

c. The valve will be manually controlled from the Master Control System.

d. The maintenance of the control valve and related equipment will require system shutdown.

6.1.3 Steam Generator Feedwater Header Isolation Valve

The valve is located downstream of the feedwater heater no. 1. It is intended to isolate the feedwater heater no. 1 during start-up feedwater recirculation.

a. The open/closed flow control valve operates on a remote signal. The valve has no interlocks.

b. The valve is fail as is. The valve is equipped with an electric actuator, the travel switches, and a local position indication.

c. The valve will be manually controlled from the Master Control System.

d. The maintenance of the valve and related equipment will require system shutdown.

6.1.4 Main Feedwater to Flash Tank Recirculation Isolation Valves (3)

The three valves are used to allow feedwater flow to flash tank from each steam generator feedwater line during feedwater warm-up phase.

a. The on/off control valve operates on a remote signal. The valve has no interlocks.

b. The valve is fail closed/air to open. This is to prevent flow to flash tank when such flow is not required. The valve is equipped with a pneumatic operator and a positioner.

c. The valve will be manual/auto controlled from the Master Control System.

d. The maintenance of the control valve and related equipment will require system shutdown.

6.1.5 Start-up Recirculation Feedwater Steam Generator Isolation Valves (3)

These valves are used to shut-off feedwater flow to each steam generator during feedwater warm-up phase.

a. The on/off control valve operates on a remote signal. The valve has no interlocks.

b. The valve is fail as is. The valve is equipped with an electric actuator, the travel switches, and a local position indication.

c. The valve will be manually controlled from the Master Control System.

d. The maintenance of the control valve and related equipment will require system shutdown.

6.1.6 Main Steam Attemperator Water Spray Temperature Control Valve

The valve controls flow of feedwater to main steam attemperator in order to maintain the main steam temperature at the desired set point. See DCM No. D23-13-I.

a. The modulating flow control valve operate on a remote signal in response to main steam temperature. The valve is interlocked with the main steam attemperator water spray isolation valve.

b. The valve is fail closed/air to open. This is to prevent possible damage to turbine due to excessive cooling of steam. The valve is equipped with a pneumatic actuator and a positioner.

c. The valve will be manual/auto controlled from the Master Control System. The controller will have a proportional plus integral control and will be direct acting.

d. The maintenance of the control valve and related equipment will require system shutdown.

6.1.7 Main Steam Attemperator Water Spray Isolation Valve

The valve is located upstream of the attemperator water spray temperature control valve. It is intended to prevent water flow into attemperator when no steam flowing.

a. The on/off control valve operates on a remote signal.

b. The valve is fail as is. The valve is equipped with an electric actuator, the travel switches, open/closed switches, and a local position indication.

c. The valve will be manually controlled from the Master Control System.

d. The maintenance of the valve and related equipment will require system shutdown.

6.1.8 Auxiliary Steam Attemperator Water Spray Temperature Control Valve

The valve controls flow of feedwater to auxiliary steam attemperator in order to maintain the auxiliary steam temperature at the desired set point. See DCM No. D23-20-I.

a. The modulating control valve operates on a remote signal in response to auxiliary steam temperature.

b. The valve is fail closed/air to open. This is to prevent possible excessive cooling of auxiliary steam. The valve is equipped with a pneumatic actuator and a positioner.

c. The valve will be manual/auto controlled from the Master Control System.

d. The maintenance of the control valve and related equipment will require system shutdown.

6.1.9 Condensate Pump Recirculation Control Valve

The valve allows condensate to flow from a point downstream of feedwater heater no. 4 to the main condenser. The purpose is to provide minimum flows for the condensate pumps and gland steam condenser and to provide high flows for the system clean-up.

a. The modulating flow control valve operates on a condensate flow signal with the set point established by the system operating mode based on one or two pump operation.

b. The valve is fail open/air to close. This provides pump protection. The valve sizing shall allow no more than 75% of condensate pump design flow to pass in the failed position.

c. The valve will be manual/auto controlled from the Master Control System. The controller will have a proportional plus integral control and will be direct acting.

d. The maintenance of the control valve and related equipment will require system shutdown.

6.1.10 Feedwater to Steam Generators Flow Measurement

Flow nozzles shall be used to measure feedwater flows to each steam generator. In each case, a minimum flow nozzle will measure from 0-10% and a normal flow nozzle shall be used from 10-100%. All measurements are Master Control System inputs and shall be square root extracted before input. The total feedwater flow signal shall be the result of control system calculations using the proper flow signals.

6.1.11 Start-up Recirculation Feedwater Isolation Valves (3)

The valves are located downstream of the start-up feedwater heater. The valve control minimum flow (2%) of feedwater recirculation flow to flash tank during warm-up procedure.

a. The on/off flow control valve operates on a remote signal. The valve has no interlocks.

b. The valve is fail closed/air to open. The valve is equipped with a pneumatic actuator and a positioner.

c. The valve will be manually controlled from the Master Control System.

d. The maintenance of the control valve and related equipment will require system shutdown.

6.1.12 Auxiliary Steam to Steam Generator Flow Control Valves (3)

The valve is located in the auxiliary steam line before intersection to the main feedwater header of the steam generator (the intersection is located after the steam generator feedwater isolation valve). The valve will supply the auxiliary steam to the steam generator during start-up operation.

a. The open/closed control valve operates on a remote signal. The valve has no interlocks.

b. The valve is fail closed/air to open. The valve is equipped with a pneumatic actuator and a positioner.

c. The valve is manually controlled from the Master Control System.

d. The maintenance of the valve and related equipment will not require system shutdown.

6.2 Indication

6.2.1 Local

a. Gland Steam Condenser Tube Inlet Pressure

b. Feedwater Heater No. 5 Tube Inlet Pressure

c. Feedwater Heater No. 4 Tube Inlet Pressure

d. Feedwater Heater No. 2 Tube Inlet Pressure

e. Feedwater Heater No. 1 Tube Inlet Pressure

f. Startup Feedwater Heater Tube Inlet Pressure

6.2.2 Remote, Master Control System Inputs

a. Feedwater leaving heater no. 1 temperature

b. Feedwater leaving startup FW heater temperature

c. Feedwater to steam generator 1 min. flow

d. Feedwater to steam generator 2 Min. Flow

e. Feedwater to steam generator 3 Min. Flow

f. Feedwater to Steam Generator 1 Normal Flow

g. Feedwater to Steam Generator 2 Normal Flow

h. Feedwater to Steam Generator 3 Normal Flow

6.3 Test Points

a. Gland Steam Condenser Tube Outlet Pressure

b. Gland Steam Cndenser Tube Inlet Temperature

c. Gland Steam Condenser Tube Outlet Temperature

d. Feedwater Heater No. 5 Tube Outlet Pressure

e. Feedwater Heater No. 5 Tube Inlet Temperature

f. Feedwater Heater No. 5 Tube Outlet Temperature

g. Feedwater Heater No. 4 Tube Outlet Pressure

h. Feedwater Heater No. 4 Tube Inlet Temperature

i. Feedwater Heater No. 4 Tube Outlet Temperature

j. Feedwater Heater No. 2 Tube Outlet Pressure

k. Feedwater Heater No. 2 Tube Inlet Temperature

l. Feedwater Heater No. 2 Outlet Temperature

m. Feedwater Heater No. 1 Tube Outlet Pressure

n. Feedwater Heater No. 1 Tube Inlet Temperature

o. Feedwater Heater No. 1 Tube Outlet Temperature

p. Startup Feedwater Heater Tube Outlet Pressure

7.0 Analysis

7.1 Indication

7.1.1 Local

a. Condensate Specific Conductivity (Condensate Pump Discharge Header)

b. Condensate Cation Conductivity (Condensate Pump Discharge Header)

c. Condensate Specific Conductivity (Polisher Outlet)

d. Condensate Cation Conductivity (Polisher Outlet)

e. Feedwater Specific Conductivity (Steam Generator Inlet Header)

f. Feedwater Cation Conductivity (Steam Generator Inlet Header)

g. Feedwater to Steam Generator PH

7.1.2 Remote, Master Control System

a. Same as Section 7.1.1, items 1-7

b. Condensate Pump Discharge Header Dissolved Oxygen

c. Feedwater Pump Discharge Header Dissolved Oxygen

d. Condensate Pump Discharge Header Sodium Ion

7.2 Recording

None

7.3 Alarms

7.3.1 Local

None

7.3.2 Remote, Master Control System

a. Condensate Pump Discharge Header Specific Conductivity High

b. Condensate Pump Discharge Header Cation Conductivity High

c. Condensate Polisher Specific Conductivity High

d. Condensate Polisher Cation Conductivity High

e. Feedwater to Steam Generation Specific Conductivity High

f. Feedwater to Steam Generator Specific Conductivity High

g. Feedwater to Steam Generator PH Conductivity High/Low

h. Condensate Pump Discharge Header Dissolved O_2 High

i. Feedwater Pump Discharge Header Dissolved O_2 High

j. Condensate Pump Discharge Header Sodium Ion High

7.3.3 Remote, Main Annunciator

Window Description: "Water Purity"

a. Condensate Pump Discharge Header Specific Conductivity High

b. Condensate Pump Discharge Header Cation Conductivity High

c. Condensate Polisher Specific Conductivity High

d. Condensate Polisher Cation Conductivity High

e. Feedwater to Steam Generation Specific Conductivity High

f. Feedwater to Steam Generator Specific Conductivity High

g. Feedwater to Steam Generator pH Conductivity High/Low

h. Condensate Pump Discharge Header Dissolved O_2 High

i. Feedwater Pump Discharge Header Dissolved O_2 High

j. Condensate Pump Discharge Header Sodium Ion High

4.4 CONDENSATE POLISHING SYSTEM (D23-16)

Engineering
76-370 2/81

DCM No. D23-16 Revision 01
Date 6-30-83
File No. D23-43600

PACIFIC GAS AND ELECTRIC COMPANY

30 MW SOLAR

DESIGN CRITERIA MEMORANDUM

Structure, System, or Component: CONDENSATE POLISHING SYSTEM

Prepared by: B.S. VAIS Date 6-30-83

Group Leader/Supervisor Review ________, ________ (Discipline) Date ________

Reviewed by Interfacing Disciplines:

Group Leader/Supervisor J.B. GEGAN

Group Leader/Supervisor M.E. CONLU

Group Leader/Supervisor K.G. ZAHAROFF
A.B. SCHUURMAN

Issued as report of preliminary design REPrice 6.30.83

Approved by:

Department Chief: J.V. ROCCA

Approved for Project use:

Project Engineer: R.E. PRICE

Page 2 through 7 attached; describing design inputs. Other attachments as indicated below.

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☒ Project Engineer R.E. PRICE

☒ Discipline Group Leader(s)/Supervisor(s)

☐ Manager, Steam Generation

Others

DESIGN CRITERIA
CONDENSATE POLISHING SYSTEM
30 MW SOLAR PROJECT
GM 6340160

Table of Contents

DESIGN CRITERIA
CONDENSATE POLISHING SYSTEM
30 MW SOLAR PROJECT
GM 6340160

1.0 Basic Functions

The condensate polishing system will remove practically all the impurities from the condensate, thereby protecting the steam system from scaling, corrosion, and failure.

The system will consist of two mixed-bed demineralizers, acid and caustic storage tanks, acid and caustic regenerant pumps, acid and caustic day tanks, a neutralization tank and pump, and distilled water transfer pumps. Only one bed will be operating at any time, with the second bed acting as backup. The beds will contain a mixture of anion, cation, and inert resin beads. As the condensate passes through these mixed-beds, the resins will release H^+ and OH^- ions in exchange for the water's ionic impurities. The H^+ and OH^- ions will then combine to form H_2O, further increasing the purity of the water.

When the mixed-bed exhausts its supply of H^+ and OH^- ions, it will be replaced in service with the backup bed. The exhausted bed will be regenerated during the plant's nightly downtime. The resins will be regenerated right in the mixed-bed vessel.

During regeneration, the mixed-bed will be backwashed with distilled water to segregate the resins. The inert resin will separate out between the cation and anion resin because its density falls between the other two. This inert layer will protect the resins from contacting the wrong regenerant, greatly reducing the odds of contaminating the water supply when the bed is put back in service.

All the regeneration waste water will be sent to the neutralization tank. Once there, the waste water pH will be adjusted to neutral, and then the water will be forwarded to the cooling water supply.

2.0 Performance Requirements

The condensate polishers will be located between the condensate pumps and the gland steam condenser. Each mixed-bed will be capable of handling from 115-460 gpm of water.

The product water quality will be:

TDS	50 ppb
Si	10 ppb
Iron	10 ppb
O_2	5 ppb
Na	3 ppb

The run length for each bed will be about one week under normal conditions. An exhausted bed will be regenerated in about 3 hours.

3.0 Codes and Standards

The condensate polishing system will be designed in accordance with the following codes and standards:

ANSI B31.1 - Code for Power Piping
ASME - Boiler and Pressure Vessel Code
CAL-OSHA - Industrial Safety
Hydraulic Institute

4.0 Design Conditions

Due to the daily cycling of the plant, the condensate will pick up impurities overnight. These will be almost entirely iron oxides. The expected water quality after an evening's shutdown will be:

TDS	100 ppb
Si	10 ppb
Iron	25 ppb
O_2	5-10 ppb
Na	3 ppb

The condensate polishers will be expected to bring these impurities down to the acceptable levels stated in Section 2.0. The polishers will also be relied on to remove crud accumulated in the steam system after extended shutdowns. Their are no special requirements for this situation. The polishers will just have to be cycled in and out of regeneration more frequently than normal.

Other design parameters are:

Pressure: 220 psi
Temperature: 121°F
Allowable pressure drop: 50 psi
Flowrates: 115-460 gpm

5.0 Loads

See Civil Design Criteria DCM No. D23-2 for the expected seismic loading on the equipment.

6.0 Environmental Conditions

All equipment will be installed in an open air, semi-arid environment. The site characteristics are:

Elevation	2000 ft
Min. Temp	10°F
Max. Temp	110°F
Normal Amb. Temp	55°F

Design Dry Bulb	106°F
Design Wet Bulb	72°F
Avg. Ann. Rainfall	3.5"
Seismic Zone	4

Heat tracing will be required for all caustic lines up to the day tanks and a heating element will be mandatory for the caustic storage tank.

7.0 Interface Requirements

The mixed-bed polishers will be a complete skid-mounted package. They will interface with the condensate system at the inlet and outlet water connections, and will require service air connections. There will also be piping interfaces with the regenerant storage tanks and neutralization tank and skid.

The regenerant storage and neutralization tanks will interface with the distilled water storage tank and the cooling water supply system.

8.0 Material Requirements

Stainless steel or CPVC will be used for piping that handles distilled water. Those lines which will see acid or caustic, both dilute and concentrated, will use CPVC or lined carbon steel. Valves will be of compatible materials.

9.0 Layout and Arrangement

Refer to the mechanical drawings.

10.0 Instrumentation and Control

See the I & C Design Criteria DCM No. D23-16-I for the condensate polishing system.

11.0 Reliability and Effect on Unit Availability

The condensate polishers will be critical to reliable operation of the steam system. Without the polishers, unit availability will be drastically reduced over time. Corrosion, fracturing, and reduced heat transfer capability will all result from not using the polishers.

For these reasons, the condensate polishers will be fully redundent for the on-stream portions. Those components used only for regeneration do not require redundancy.

12.0 Test Requirements

The system will be tested after installation from the lowest expected flow to full flow conditions. All performance requirements will be verified. The neutralization system will be checked for proper functioning. The regeneration system will also be tested to insure that all aspects of its functions are correct.

13.0 Accessability, Maintenance, and Repair

The polishers will need sufficient space to allow easy access for maintenance and repair. The caustic and acid storage tanks will be located where they can be easily refilled by truck.

14.0 Personnel Requirements

The system will need an operator during the startup of the regeneration cycle. All other operating modes will be unattended, as the system will function automatically.

15.0 Transportation Requirements

No special requirements.

16.0 Fire Protection

No special requirements.

17.0 Handling, Storage, and Shipping Requirements

The vessels and equipment will be shipped with all openings sealed. If stored outside, the equipment will be covered with plastic. The resins will be shipped and stored separately in sealed containers.

18.0 Public Health and Safety Requirements

The systems will not affect public health and safety. Safety showers and eyewash stations are required near the chemicals for plant personnel safety.

4.4.1 CONDENSATE POLISHING SYSTEM INSTRUMENTATION AND CONTROL (D23-16I)

Engineering
76-370 2/81

DCM No. D23-16-I Revision 0
Date 5-9-83
File No. 43600

PACIFIC GAS AND ELECTRIC COMPANY

30 MW SOLAR

DESIGN CRITERIA MEMORANDUM

Structure, System, or Component: CONDENSATE POLISHING SYSTEM (I&C)

Prepared by: P.D. MAXWELL / MT PERAKIS MTPerakis Date 5-9-83

Group Leader/Supervisor Review M&N Eng (Discipline) Date 5/11/83

Reviewed by Interfacing Disciplines:

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Group Leader/Supervisor ME. CONLU MEConlu Date 5-12-83

Group Leader/Supervisor K.G. ZAHAROFF Date 6-6-83

A.B. SCHUURMAN

Approved by:

Department Chief: J.V. ROCCA JVRocca Date: 6-13-83

Approved for Project use:

Project Engineer: R.E. PRICE REPrice Date: 6.14.83

Page 2 through 12 attached; describing design inputs. Other attachments as indicated below.

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30 MW SOLAR
CONDENSATE POLISHING SYSTEM
INSTRUMENTION AND CONTROL
DESIGN CRITERIA

Reference Documents:

Condensate Polishing System - System Design Criteria, DCM No. D23-16
Master Control System - Design Criteria, DCM No. D23-7
Instrumentation and Control - General Design Criteria, DCM No. D23-3

1.0 Scope

This criteria will define the Instrumentation and Control (I&C) requirements for the Condensate Polishing System.

1.1 Mechanical Equipment to be Controlled

1.1.1 Regeneration Equipment

1.1.2 Transfer Pumps (2)

1.1.3 Neutralization Tank Pump

1.2 Valves to be Controlled

None

1.3 Vessels to be Controlled

1.3.1 Mixed Bed Demineralizers (2)

1.3.2 Caustic Storage Tank

1.3.3 Acid Storage Tank

1.3.4 Neutralization Tank

2.0 Control System Interfaces

2.1 Condensate and Feedwater System

The Condensate and Feedwater System cannot be operated without the Condensate Polishing System in operation.

3.0 Operating Requirements

The Condensate Polishing System is intended to operate simultaneously and in-line with the Condensate and Feedwater System from start-up through full power operation. Unattended start-up, steady state, and shutdown operation is intended. Demineralizer regeneration will be attended start-up and unattended steady state operation. Regeneration will occur nightly, once a week, unless excessive condensate contamination requires a greater frequency. An operator will perform walkdowns during on-line operation and regeneration. It is expected that the demineralizers and a majority of the regeneration equipment will be a vendor supplied package.

4.0 Mechanical Equipment Process Control and Protection

4.1 Regeneration Equipment

The vendor will supply all instrumentation and control equipment necessary for automatic regeneration of the mixed bed demineralizers. The equipment supplied by the vendor will meet the following operating requirements as a minimum.

4.1.1 Control

4.1.1.1 Master Control System

None

4.1.1.2 Dedicated Automatic

A local programmable controller will be supplied by the vendor to control all the system regeneration equipment, including PGandE supplied equipment for support of regeneration. A detailed description of demineralizer regeneration will be included in later revisions.

4.1.1.3 Local Manual

Sufficient pump controls will be provided on the system control board to allow the operator to step through the sequence manually. Control valves will have manual/auto stations or manual overrides.

4.1.2 Trips and Interlocks

Local, hardwired protective trips will be provided for vendor supplied equipment, to prevent unsafe operation or equipment damage. Upon equipment trip, the automatic regeneration sequencing will stop. The operator must correct the problem, clear the trip, and resume the regeneration sequence. The sequence will resume from the point where it had stopped.

4.1.3 Indication

4.1.3.1 Local

Unless indicated otherwise, all status indication will be located on a local system control board. All process indication will be local to the equipment.

4.1.3.2 Master Control System

None

4.1.4 Recording

None

4.1.5 Alarms

4.1.5.1 Local

All alarms will appear at the local annunciator on the local control board.

4.1.4.2 Master Control System

Alarms which may occur during on-line operation will be individually annunciated in the Master Control System. Alarms which may occur during regeneration will be paralleled into a single "Polishers Regeneration Trouble" alarm in the Master Control System.

4.2 Transfer Pumps (2)

The transfer pumps take suction from the distilled water tank and discharge to the demineralizers and the Service Cooling Water System head tank. Under normal operation, one of the 100 percent capacity pumps will automatically cycle on/off during the regeneration process. The other pump will be on automatic standby start. When the Service Cooling Water System head tank level drops, the operator will receive a remote low level alarm and must manually (locally) start one pump (if not already running) and open the the discharge valve to the tank. Maintenance on one pump at a time will not prohibit normal system operation.

4.2.1 Control

4.2.1.1 Master Control System

None

4.2.1.2 Dedicated Automatic

Primary Pump Start/Stop

Standby Pump Start/Stop (during regeneration)

4.2.1.3 Local Manual (on system control board)

Transfer Pumps Standby Selector Switch (pump 1/ pump 2) (maintained contacts)

Pump No. 1 Stop/Auto/Start Switch

Pump No. 2 Stop/Auto/Start Switch (maintained positions)

4.2.2 Trips and Interlocks

Pump No. 1 Motor Overcurrent Trip

Pump No. 2 Motor Overcurrent Trip

Continuous recirculation through a restricting orifice to the distilled water tank provides deadhead protection. NPSH protection will not be provided. These trips will interrupt the regeneration sequence.

4.2.3 Indication

4.2.3.1 Local

Pump No. 1 Discharge Pressure

Pump No. 2 Discharge Pressure

Transfer Pump No. 1 Status (running/not running) (on system control board)

Transfer Pump No. 2 Status (running/not running) (on system control board)

4.2.3.2 Master Control System

None

4.2.3.3 Test Point

Pump Suction Header Pressure

4.2.4 Alarms

4.2.4.1 Local

Transfer Pump No. 1 Motor Overcurrent Trip

Transfer Pump No. 2 Motor Overcurrent Trip

4.2.4.2 Master Control System

Polishers Regeneration Trouble

The above local alarms will be paralleled into the "Polishers Regeneration Trouble" alarm in the Master Control System.

4.3 Neutralization Tank Pump

The pump takes suction from the neutralization tank and recirculates the waste back to the tank until it is sufficiently neutralized (through acid injection to the tank). The waste is then pumped to the treated water sump by opening of manual valves and closing off the recirculation line. It is expected that this pumping process will occur for every three or four regeneration cycles. An operator will be present while the pumps are running to control the neutralization process. Pump controls and status indication will be local to the pump and will not be wired through the programmable controller; they will be independently hardwired.

4.3.1 Control

4.3.1.1 Master Control System

None

4.3.1.2 Dedicated Automatic

Pump Stop - Neutralization Tank Level Low

4.3.1.3 Local Manual (at pump)

Neutralization Pump Stop/Neutral/Start Switch (start is spring return to neutral)

4.3.2 Trips and Interlocks

Pump Motor Overcurrent Trip

The pump will stop on tank low level to provide NPSH protection. No deadhead protection will be provided.

4.3.3 Indication

4.3.3.1 Local

Pump Discharge Pressure

Pump Status (running/not running)

pH Indication

4.3.3.2 Master Control System

None

4.3.4 Alarms

4.3.4.1 Local (on system control board)

Pump Motor Overcurrent Trip

pH Low Alarm

4.3.4.2 Master Control System

Polishers Regeneration Trouble

The above local alarms will be paralleled into the "Polishers Regeneration Trouble" alarm in the Master Control System.

5.0 Vessels Control and Protection

5.1 Mixed Bed Demineralizers (2)

The mixed bed demineralizers serve to remove nonorganic impurities from the Condensate and Feedwater System. During normal operation, one of two 100 percent capacity demineralizers will be in service, while the other will be on fully charged standby. The demineralizer in service will operate for a predetermined length of time. Prior to exhaustion of the operating bed, the operator must manually switch over to the standby unit. The partially exhausted unit will remain out of service until the Condensate and Feedwater System is shut down at night; it may then be regenerated. Only one unit may be regenerated at a time.

Note: This design has not been finalized. A separate regeneration tank may be added to allow for external regeneration during plant operation and to minimize chance of condensate contamination from acid leakage.

The demineralizers will be a vendor supplied package, including all control hardware and logic necessary for operation and regeneration. The equipment will meet the following operating requirements as a minimum.

5.1.1 Control

The demineralizers on-line operation can be controlled through the Master Control System only. Manual overrides will be provided on solenoid operated valves for emergency manual operation. For regeneration, the operator must switch off the demineralizer and initiate the sequence locally.

5.1.1.1 Master Control System

Demineralizer No. 1 Off/On-line

Demineralizer No. 2 Off/On-line

5.1.1.2 Dedicated Automatic

A detailed description of demineralizer operation will be available from vendor documents and will be included in later revisions.

5.1.1.3 Local Manual (on system control board)

Demineralizer No. 1 Regeneration Start Pushbutton (sealed in)

Demineralizer No. 2 Regeneration Start Pushbutton (sealed in)

5.1.2 Trips and Interlocks

None

5.1.3 Control Valves

Included in a later revision

5.1.4 Indication

5.1.4.1 Local

Demineralizer No. 1 Status (On-line/Regenerating/Standby/Off)

Demineralizer No. 2 Status (On-line/Regenerating/Standby/Off)

Demineralizer No. 1 Conductivity

Demineralizer No. 2 Conductivity

Feedwater Silica Content

Additional indication will be included in a later revision.

5.1.4.2 Master Control System

Demineralizer No. 1 Status (On-Line/Regenerating/Standby/Off)

Demineralizer No. 2 Status (On-Line/Regenerating/Standby/Off)

Additional indication will be included on later revisions.

5.1.5 Alarms

5.1.5.1 Local

Demineralizer No. 1 Volumetric End

Demineralizer No. 2 Volumetric End

Demineralizer No. 1 High Conductivity

Demineralizer No. 2 High Conductivity

Cation Rinse High Conductivity

Anion Rinse High Conductivity

Dilute Acid Concentration High/Low

Dilute Caustic Concentration High/Low

Strainer Differential Pressure High

Caustic Dilution Water Temperature High

Control Power Undervoltage

5.1.5.2 Master Control System

Demineralizer No. 1 Volumetric End

Demineralizer No. 2 Volumetric End

Demineralizer No. 1 High Conductivity

Demineralizer No. 2 High Conductivity

Strainer Differential Pressure High

Control Power Undervoltage

5.1.5.3 Remote Main Annunicator

None

5.2 Caustic Storage Tank

The tank will provide caustic storage capacity for the system. The tank and all caustic lines must be electrically heated to prevent the caustic from freezing.

5.2.1 Control

None

5.2.2 Trips and Interlocks

None

5.2.3 Control Valves

None

5.2.4 Indication

5.2.4.1 Local

Caustic Tank Level (bubbler)

Electric Heater On

5.2.4.2 Master Control System

None

5.2.5 Alarms

5.2.5.1 Local

Caustic Tank Temperature Low

Caustic Tank Level Low

5.2.5.2 Master Control System

Caustic Tank Temperature Low

5.3 Acid Storage Tank

The tank provides acid storage capacity for the system.

5.3.1. Control

None

5.3.2 Trips and Interlocks

None

5.3.3 Control Valves

None

5.3.4 Indication

5.3.4.1 Local

Acid Storage Tank Level (bubbler)

5.3.4.2 Master Control System

None

5.3.5 Alarms

5.3.5.1 Local

Acid Storage Tank Level Low

5.3.5.2 Master Control System

None

5.4 Neutralization Tank

The tank receives regeneration waste water from the demineralizers, and provides suction head for the neutralization tank pump.

5.4.1 Control

5.4.1.1 Master Control System

None

5.4.1.2 Dedicated Automatic

Tank Low Level - Stop Neutralization Tank Pump

5.4.1.3 Local Manual

None

5.4.2 Trips and Interlocks

None

5.4.3 Control Valves

None

5.4.4 Indication

5.4.4.1 Local

Neutralization Tank Level

5.4.4.2 Master Control System

None

5.4.5 Alarms

5.4.5.1 Local

Neutralization Tank Level High

5.4.5.2 Master Control System

None

6.0 Miscellaneous Instrumentation and Control

6.1 Indication

6.1.1 Local

Neutralization pH Indication

Engineering
76-370 2/81

DCM No. D23-17 Revision 0
Date May 5, 1983
File No. D23-01700

PACIFIC GAS AND ELECTRIC COMPANY

DESIGN CRITERIA MEMORANDUM

Structure, System, or Component: Extraction, Drain, and Vent System

Prepared by: Raymond J. Dracker R J Dracker Date 3-14-83

Group Leader/Supervisor Review M&NE Date 5-6-83
C. R. Ashworth (Discipline)

Reviewed by Interfacing Disciplines:

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Group Leader/Supervisor J. B. Gegan JB Gegan Date 5-4-83

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DCM No. D23-17
Rev. 0

Design Criteria

Extraction, Drains, and Vents

30 MW Solar Project

GM 6340160

Contents

1. Basic Function

Steam is withdrawn at various stages of the steam turbine and is routed to feedwater heaters in order to transfer the thermal energy (both sensible and latent heat) from this steam to the boiler feedwater. For constant main steam flow, this raises the feedwater inlet temperature to the steam generators while decreasing heat input and generator output. This is the regenerative feature of the cycle.

The average temperature difference across which thermal energy is transferred in the cycle is reduced, and the heat rate of the cycle is improved.

The steam bled off the turbine is the extraction. After all of the steam's latent heat and as much of its sensible heat as is economically practical has been transferred to the feedwater, the condensed extraction is drained to the next lower pressure feedwater heater or the condenser in order to add the balance of its available sensible heat to the feedwater. This condensed extraction is the drains.

The cycle fluid contains noncondensible gases. These gases are present either because they were dissolved in the feedwater make-up or because of in-leakage to the system. The feedwater heaters contain vents which are present to remove and transport these noncondensible gases from the feedwater back to the condenser or the deaerator where the gas is removed from the cycle.

2. Rating and Capacity

The extraction, drain, and vent pipe design pressure and temperature should match that of the associated feedwater heater shell (refer to Design Criteria D23-15). Normal, full load operating conditions at the heater shell inlet are as follows:

Heater No.	Flow Rate	Temperature	Pressure
1	20154 pph	690°F	373 psia
2	16784 pph	531°F	166 psia
3	15117 pph	762°F	59 psia
4	11004 pph	215°F	15.6 psia
5	11027 pph	166°F	5.4 psia

The rating of the valves shall comply with ANSI B16.34. A corrosion/erosion allowance of .0625 shall be included in the pipe wall thickness calculation.

Routing of the drains will be in accordance with the optimized heat balance (refer to heat balance diagram) and will be flexible enough to accommodate start-up and low load conditions if deemed necessary.

Pipe sizing and insulation thickness will be determined by an economic and technical evaluation of pressure drops, head requirements, thermal loss, equipment location, and personnel safety. Drip pumps may be required in certain location to accommodate low load conditions.

Extraction and drain nozzle size and location on the feedwater heaters shall be determined in accordance with HEI Standards for closed feedwater heaters.

Feedwater terminal temperature difference and drains approach to feedwater inlet temperature requirements will be specified in the heat balance design. Desuperheat and drain subcooling sections will be included in the feedwater heaters as appropriate to facilitate these requirements.

3. Codes and Standards

The extraction, drain, and vent system piping hangers and supports shall comply with ANSI B31.1 and the material and dimensional standards referred to in ANSI B31.1. Also, design of the systems will comply with HEI Standards for closed feedwater heaters and ASME TWDPS-1 Standards.

The erected system shall meet the requirements of the State of California Administrative Code, Title 8 - Industrial Relations, Chapter 1 - Cal OSHA; Chapter 4 - Industrial Relations; Subchapter 7 - General Industry Safety Orders.

4. Design Conditions

The extraction, drain, and vent piping shall include provisions to accommodate daily start-up of the unit. All lines shall have appropriate valving such that:

(1) Feedwater temperature and purity can be brought to required conditions as defined in Power Conversion System Design Criteria, D23-5.

(2) Routing of drains has the required flexibility to accommodate low-load conditions.

(3) Feedwater heaters can be bypassed while the unit is operating to facilitate heater repair or to increase unit capacity.

Provisions for additional start-up venting should be incorporated in the design of the vent piping.

Design of all extraction, drain, and vent piping shall result in acceptable nozzle loads.

All heaters will be vented continuously through vent connections provided. The operating vent from each feedwater heater shall be run separately to the condenser and shall not be cascaded or headered with other vent lines. Throttle valves will be provided to adjust vent flowrate.

Feedwater heater shells shall contain a method of protection against shell overpressure due to a tube leak.

All extraction piping shall contain appropriate valving to protect the turbine from overspeed due to the stored energy of the contained liquid and to confine flashed vapor. Particular attention should be given to the deaerating heater and the pegging steam source from the auxiliary steam system, where a large volume of saturated water is present.

5. Design Loads

The extraction drain and vent piping will be designed for the loads described in ANSI B31.1.

The seismic loading will be specified in the Civil Engineering Design Criteria D23-2. Where expansion joints are used, anchors or control rods shall be used to absorb the static thrust from the pipe internal pressure.

6. Environmental Conditions

Portions of the extraction and drains system may not be protected by enclosed structures. Those portions of the equipment exposed to ambient weather conditions should be protected accordingly. Freeze protection should be provided for all fluid lines potentially exposed to subfreezing temperatures. Pipe insulation should be protected from atmospheric moisture where required.

7. Interface Requirements

The extraction, drain, and vent system will interface with:

(a) the steam turbine

(b) the condenser

(c) the deaerator

(d) the feedwater system

(e) gland steam seal system

(f) the auxiliary steam system

(g) the master control system

System pipe design shall accommodate allowable nozzle load requirements for all feedwater heaters, vessels, and the steam turbine.

Isolation valves used to keep heaters pressurized during overnight shutdown should be designed to meet this requirement.

Attention should be given to system piping which interfaces with auxiliary and seal steam system. Design should accommodate the full range of operating conditions which may be experienced.

8. Material Requirements

The materials used for all pressurized pipe and vessels shall be in accordance with ANSI B31.1 and ASTM BPVC Section VIII material specification. Feedwater purity requirements should be considered when specifying extraction, drain, and vent materials, especially for the higher pressure components which transport feedwater to the steam generators without first passing through the condensate polishers. All heaters are upstream of the polishers; however, the high pressured heater drains go to the deaerating heater and therefore bypass the polisher.

9. Layout and Arrangement

Routing of extraction, drain, and vent piping will accommodate location of condensate, feedwater, and turbine equipment. Pipe runs and valve location will take into consideration stress and loads inherent to the system, cost, maintainability, and accessability.

Considerable care should be taken when routing drain piping. Slope of the lines is of critical importance for proper drainage. Design should be according to ASME TWDPS-1 Standards.

Feedwater heater high level spill connections on the heater shell should not bypass the drain cooler section (to avoid operating with drain lines handling flashable saturated water).

10. Instrumentation and Control Requirements

All extraction nonreturn valves shall trip closed when the unit trips and therefore will be controlled by the turbine control system. Extraction line drain valves will be power operated. They should be set to open automatically on a turbine trip and be remotely operable from the control room. Should a feedwater heater experience a high water level, extraction line drain valves should open automatically routing drips to the main condenser and extraction nonreturn valves should close automatically.

Refer to the Extraction, Drain, and Vent section of the Instrumentation and Control Design Criteria, D23-17I for more detailed criteria.

11. Access and Administrative Control Requirements

There are no special requirements beyond that which are standard to PGandE power plants.

12. System Reliability and Redundancy Requirements

All equipment will be designed for a 30-year life and a forced outage rate of less than 4%. All components will be designed to accomodate daily startup and thermal cycling.

Each extraction line will contain both a nonreturn check valve as well as a motor operated stop valve capable of tight shutoff as required by ASME Standard TWDPS. Double nonreturn valves are required in the deaerator extraction line. The unit shall be able to operate at maximum guaranteed load with any feedwater heater out of service.

13. Unit Reliability

All extraction, drain, and vent system equipment will be designed to ASME TWDPS-1 Standards to ensure high reliability of the drain system under high water level conditions. No single failure of equipment should result in water entering the turbine.

14. Test Requirements

All valves and pumps shall be inspected and tested in the fabricator's shop. Refer to Instrumentation and Control Design Criteria, D23-17I for special testing criteria for control valves.

Test stations will be located at each extraction nonreturn valve so that they may be operated and visually verified for freedom of motion.

15. Maintenance Requirements

Continuous drain orifices should be located and designed so that they can be cleaned frequently and will not be susceptible to plugging by debris. All heaters will have the capability to be safely isolated from the cycle to allow for maintenance while the unit is on line. Refer to Standard ASME TWDPS-1 for additional maintenance requirements.

16. Personnel Requirements

No training beyond that which is required of power plant staff is required to operate or maintain the system.

17. Transportation Requirements

There are no special requirements.

18. Fire Protection

No special fire protection equipment is required.

19. Handling, Storage and Shipping Requirements

There are no special requirements.

20. Health and Safety Requirements

There are no special requirements.

21. Process ,Parts, and Equipment Requirements

There are no special requirements.

4.5.1 EXTRACTION, DRAINS, AND VENT SYSTEM INSTRUMENTATION AND CONTROL (D23-17I)

Engineering
76-370 2/81

DCM No. D23-17I Revision 0
Date MAY 4, 1983
File No. D23—48000

PACIFIC GAS AND ELECTRIC COMPANY

30MW SOLAR

DESIGN CRITERIA MEMORANDUM

Structure, System, or Component: INSTRUMENTS AND CONTROLS: EXTRACTION STEAM SYSTEM

Prepared by: J.M. WALEWSKI / M.T. PERAKIS MTPerakis JMWalewski Date 5-4-83

Group Leader/Supervisor Review A.F. ARIEY AF Ariey (Discipline) Date 5/13/83

Reviewed by Interfacing Disciplines:

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Group Leader/Supervisor M.E. CONLU ME Conlu Date 5-12-83

Group Leader/Supervisor K.G. ZAHAROFF KG Zaharoff Date 6-12-83

A.B. SCHUURMAN A.B. Schuurman, 6-16-83

Approved by:

Department Chief: J.V. ROCCA JV Rocca Date: 6-17-83

Approved for Project use:

Project Engineer: R.E. PRICE RE Price Date: 6-17-83

Page 2 through 15 attached; describing design inputs. Other attachments as indicated below.

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30 MW SOLAR
EXTRACTION STEAM SYSTEM INSTRUMENTATION AND CONTROL DESIGN CRITERIA

Reference Documents:

Extraction Steam System - System Design Criteria, DCM No. D23-17
Master Control System - Design Criteria, DCM No. D23-7
Instrumentation and Control - General Design Criteria, DCM No. D-23
Closed Feedwater Heaters - Performance Test Code - ASME PTC 12.1 - 1978

1.0 Scope

These criteria will define the Instrumentation and Control (I&C) requirements for the Extraction Steam System.

1.1 Mechanical Equipment to be Controlled

None

1.2 Valves to be Controlled

1.2.1 Extraction Steam Isolation Valves (5)

1.2.2 Extraction Steam Nonreturn Valves (7)

1.2.3 Extraction Steam Line Drain Valves (5)

1.2.4 Feedwater Heater High Level Spill Control Valves (4)

1.2.5 Feedwater Heater Level Control Valves (5)

1.3 Vessels to be Controlled

1.3.1 Feedwater Heater No. 1

1.3.2 Feedwater Heater No. 2

1.3.3 Feedwater Heater No. 4

1.3.4 Feedwater Heater No. 5

1.3.5 Deaerator Heater (Refer to DCM No. D23-15-I)

2.0 Control System Interface

2.1 The temperature of the feedwater heater no. 1 demands the auxiliary steam supply during start-up operation. The auxiliary steam pressure is controlled with a pressure signal from the steam extraction line (D23-20-I).

2.2 The temperature and pressure of the deaerator heater demand the auxiliary steam supply (pegging steam) for the purpose of maintaining a positive pressure in the deaerator. The pegging steam supply pressure is controlled with a pressure signal from the deaerator heater (D23-20-I).

2.3 Deaerator heater controls (D23-15-I).

2.4 Turbine trip conditions cause the extraction steam isolation valves to close and the drain valves to open (D23-7).

3.0 Operating Requirements

The extraction steam system takes extraction steam from the five stages of the steam turbine through the turbine steam nozzles and the extraction steam lines down to the feedwater heaters and the deaerator heater.

The purpose of this process is to enhance overall unit efficiency and at the same time to warm-up boiler feedwater to the operating temperature level and this minimizes steam generator inlet temperature gradients.

Each feedwater heater operates at the operating water level controlled by the condensate drip level controller.

As a protection against the feedwater heater and steam turbine floodings during the condensate feedwater tube ruptures, a condensate drip high level spill controller and a spill control valve are provided in each feedwater heater drain line.

4.0 Mechanical Equipment Process Control and Protection

None

5.0 Vessels to be Controlled

5.1 Feedwater Heaters Numbers 1, 2, 4, and 5

The feedwater heaters will heat-up boiler feedwater with auxiliary steam during start-up operation. During normal operation, extraction steam from the steam turbine will be used to increase unit operating efficiency.

5.1.1 Controls

5.1.1.1 Remote Automatic, Master Control System

a. Each feedwater heater will be equipped with normal condensate drip level control (4).

The signal is taken from the local level transmitter.

5.1.1.2 Remote Automatic, Dedicated

None

5.1.1.3 Local Automatic

a. Each feedwater heater will be provided with condensate drip high level spill control (4).

The signal taken from the local level controller regulates the local high level spill control valve.

5.1.1.4 Remote Manual, Master Control System

a. Extraction Steam Isolation Valves (5)

b. Extraction Steam Nonreturn Valves (7)

c. Extraction Steam Line Drain Valves (5)

d. Feedwater Heater Condensate Drip Level Control Valves (5)

5.1.1.5 Remote Manual, Dedicated

None

5.1.1.6 Local Manual

None

5.1.2 Trips and Interlocks

a. High Level Trip of Nonreturn Valves

b. Turbine Trip of Nonreturn Valves

5.1.3 Control Valves

5.1.3.1 Extraction Steam Isolation Valves (4)

Extraction steam isolation valves are motor operated valves installed in each steam extraction line to the feedwater heaters.

The valves manually open through the Master Control System during turbine starts. The Master Control System closes the valves when turbine trips. The valves are closed when the plant is shutdown in order to keep the feedwater heaters pressurized.

a. The control valve operates closed on a turbine trip signal through the Master Control System. The valve has no interlock.

b. The valve fails as is. The valve is equipped with open/closed position switches for indication to the Master Control System. Also, the valve is equipped with open/closed limit stops and the torque limit stops.

c. The extraction steam isolation valve will be manual/auto controlled open/closed from the Master Control System.

d. The maintenance of the control valve and related equipment will require system shutdown.

5.1.3.2 Extraction Steam Nonreturn Valves (5)

The extraction steam nonreturn valve is installed in each extraction steam line downstream of the extraction steam isolation valve.

The extraction steam line to the feedwater heater no. 1 contains two nonreturn valves.

The extraction steam nonreturn valve prevents reversed flow to the turbine.

The nonreturn valve can be open only when the differential pressure across the valve is high.

The valves trip closed on turbine trip to prevent overspeed of the turbine when high energy drips flash due to decreased pressure.

The valve can be opened when the feedwater heater condensate drip level is not high. The valve trips when the feedwater heater condensate drip level is high.

a. The open/closed control valve operates on a feedwater heater condensate drip level high trip signal (from the high level switch) and on a turbine trip signal. The valve has no interlock.

b. The valve is fail close/air to open. This will prevent water or steam flow from the feedwater heater to the turbine. The valve has a pneumatic, power assisted (spring) actuator, a solenoid valve, and open and closed position switches.

c. The extraction steam nonreturn valve will be manually operated open/closed through the Master Control System.

d. The maintenance of the control valve and related equipment can be accomplished by isolating the corresponding feedwater heater and isolating the extraction steam line from the turbine.

5.1.3.3 Extraction Steam Line Drain Valves (4)

The extraction steam line drain valve is located in the drain line upstream of the extraction steam isolation valve. The drain valve will drain the condensate and will prevent the turbine from flooding if the isolation valve remains closed.

a. The open/closed control valve operates through the Master Control System on a signal from the extraction steam line isolation valve and turbine trip signal. The drain valve opens when the corresponding extraction steam line isolation valve closes or the turbine trips. The drain valve closes when the extraction steam line isolation valve opens. The valve has no interlock.

b. The valve is fail open/air to close. This will protect the turbine from flooding. The valve has a pneumatic actuator, a solenoid valve, and open and closed position switches.

c. The extraction steam line drain valve will be manual/auto controlled from the Master Control System.

d. The maintenance of the control valve and related equipment will require system shutdown.

5.1.3.4 Feedwater Heater High Level Spill Control Valves (4)

The feedwater heater condensate drip level high control valve is located in the high level spill line of each feedwater heater.

The high level spill line is connected to the normal level spill line at the intersection downstream of the feedwater heater drain nozzle. The valve drains the condensate to the main condenser when the feedwater heater water level is high. The valve modulates to control condensate drips level during high feedwater heater level.

a. The modulating level control valve operates on a level signal from the feedwater heater condensate drip high level spill controller. The valve has no interlocks.

b. The valve is fail open/air to close. This will prevent feedwater heater from flooding. The valve has a pneumatic actuator, a positioner, and a closed position switch.

c. The valve will be local auto controlled with a modulating signal from a local controller. The controller will have a proportional plus integral control and will be reverse acting.

d. The maintenance of the control valve and related equipment can be accomplished by isolating the corresponding feedwater heater.

5.1.3.5 Feedwater Heater Level Normal Control Valves (5)

The feedwater heater water level normal control valves are installed in the condensate drip lines between:

a. Feedwater Heaters No. 1 and No. 2

b. Feedwater Heater No. 2 and Deaerator Heater

c. Feedwater Heaters No. 2 and No. 4

d. Feedwater Heaters No. 4 and No. 5

e. Feedwater Heater No. 5 and Main Condenser

The valve drains the condensate from the higher pressure heater to the lower pressure heater and finally to the main condenser.

The valve modulates to maintain the higher pressure feedwater heater condensate drip level. The valve closes when the higher pressure feedwater heater condensate drip level decreases to prevent steam blow through to lower pressure heaters.

a. The modulating level control valve operates on a level signal from the feedwater heater condensate drip level control through the Master Control System. The valve has an interlock.

b. The valve is fail close/air to open. This will prevent the higher pressure heater from drying. The valve has a pneumatic actuator and a positioner.

c. The valve will be manual/auto controlled from the Master Control System. The controller will have a proportional plus integral control and will be reverse acting.

d. The maintenance of the control valve and related equipment will require an isolation of the higher pressure feedwater heater from the system.

5.1.4 Indication

5.1.4.1 Local

a. Feedwater Heater No. 1 Level

b. Feedwater Heater No. 2 Level

c. Feedwater Heater No. 4 Level

d. Feedwater Heater No. 5 Level

5.1.4.2 Remote, Master Control System Inputs

a. Feedwater Heater No. 1 Level

b. Feedwater Heater No. 1 Level Condensate Drip Temperature

c. Feedwater Heater No. 1 High Spill Drain Temperature

d. Extraction Steam Line to Feedwater Heater No. 1 Inlet Steam Pressure

e. Extraction Steam Line to Feedwater Heater No. 1 Inlet Steam Temperature

f. Feedwater Heater No. 2 Level

g. Feedwater Heater No. 2 Condensate Drip Temperature

h. Feedwater Heater No. 2 High Spill Drain Temperature

i. Extraction Steam Line to Feedwater Heater No. 2 Inlet Steam Pressure

j. Extraction Steam Line to Feedwater Heater No. 2 Inlet Steam Temperature

k. Feedwater Heater No. 4 Level

l. Feedwater Heater No. 4 Condensate Drip Temperature

m. Feedwater Heater No. 4 High Spill Drain Temperature

n. Extraction Steam Line to Feedwater Heater No. 4 Inlet Steam Pressure

o. Extraction Steam Line to Feedwater Heater No. 4 Inlet Steam Temperature

p. Feedwater Heater No. 5 Level

q. Feedwater Heater No. 5 Condensate Drip Temperature

r. Feedwater Heater No. 5 High Spill Drain Temperature

s. Extraction Steam Line to Feedwater Heater No. 5 Inlet Steam Pressure

t. Extraction Steam Line to Feedwater Heater No. 5 Inlet Steam Temperature

u. Status of the Extraction Steam Line to Feedwater Heater No. 1 Isolation Valve (Open and Closed)

v. Status of the Extraction Steam Line to Feedwater Heater No. 1 Nonreturn Valve (Open and Closed)

w. Status of the Extraction Steam to Feedwater Heater No. 1 Nonreturn Valve No. 2 (Open and Closed)

x. Status of the Extraction Steam Line to Feedwater Heater No. 1 Drain Valve (Open and Closed)

y. Status of the Extraction Steam Line to Feedwater Heater No. 2 Isolation Valve (Open and Closed)

z. Status of the Extraction Steam Line to Feedwater Heater No. 2 Nonreturn Valve (Open and Closed)

aa. Status of the Extraction Steam Line to Feedwater Heater No. 2 Drain Valve (Open and Closed) bb. Status of the Extraction Steam Line to Feedwater Heater No. 4 Isolation Valve (Open and Closed)

cc. Status of the Extraction Steam Line to Feedwater Heater No. 4 Nonreturn Valve (Open and Closed)

dd. Status of the Extraction Steam Line to Feedwater Heater No. 4 Drain Valve (Open and Closed)

ee. Status of the Extraction Steam Line to Feedwater Heater No. 5 Isolation Valve (Open and Closed)

ff. Status of the Extraction Steam Line to Feedwater Heater No. 5 Nonreturn Valve (Open and Closed)

gg. Status of the Extraction Steam Line to Feedwater Heater No. 5 Drain Valve (Open and Closed)

5.1.4.3 Remote, Dedicated

None

5.1.5 Test Points

a. Extraction Steam Line to Feedwater Heater No. 1 Inlet Steam Pressure

b. Extraction Steam Line to Feedwater Heater No. 2 Inlet Steam Pressure

c. Extraction Steam Line to Feedwater Heater No. 4 Inlet Steam Pressure

d. Extraction Steam Line to Feedwater Heater No. 5 Inlet Steam Pressure

e. Extraction Steam Line to Feedwater Heater No. 1 Inlet Steam Temperature

f. Extraction Steam Line to Feedwater Heater No. 2 Inlet Steam Temperature

g. Extraction Steam Line to Feedwater Heater No. 4 Inlet Steam Temperature

h. Extraction Steam Line to Feedwater Heater No. 5 Inlet Steam Temperature

i. Feedwater Heater No. 1 High Spill Drain Pressure

j. Feedwater Heater No. 2 High Spill Drain Pressure

k. Feedwater Heater No. 4 High Spill Drain Pressure

l. Feedwater Heater No. 5 High Spill Drain Pressure

m. Feedwater Heater No. 1 High Spill Drain Temperature

n. Feedwater Heater No. 2 High Spill Drain Temperature

o. Feedwater Heater No. 4 High Spill Drain Temperature

p. Feedwater Heater No. 5 High Spill Drain Temperature

q. Feedwater Heater No. 1 Condensate Drip Pressure

r. Feedwater Heater No. 2 Condensate Drip Pressure

s. Feedwater Heater No. 4 Condensate Drip Pressure

t. Feedwater Heater No. 5 Condensate Drip Pressure

u. Feedwater Heater No. 1 Condensate Drip Temperature

v. Feedwater Heater No. 2 Condensate Drip Temperature

w. Feedwater Heater No. 4 Condensate Drip Temperature

x. Feedwater Heater No. 5 Condensate Drip Temperature

5.1.6 Recording

None

5.1.7 Alarms

5.1.7.1 Local

None

5.1.7.2 Remote, Master Control System

a. Feedwater Heater No. 1 Level High

b. Feedwater Heater No. 1 Level High Trip

c. Feedwater Heater No. 1 High Level Spill Not Closed

d. Feedwater Heater No. 2 Level High

e. Feedwater Heater No. 2 Level High Trip

f. Feedwater Heater No. 2 High Level Spill Not Closed

g. Feedwater Heater No. 4 Level High

h. Feedwater Heater No. 4 Level High Trip

i. Feedwater Heater No. 4 High Level Spill Not Closed

j. Feedwater Heater No. 5 Level High

k. Feedwater Heater No. 5 Level High Trip

l. Feedwater Heater No. 5 High Level Spill Not Closed

5.1.7.3 Remote, Annunciator

None

5.2 Deaerator Heater

The deaerator heater removes dissolved oxygen from the steam generator feedwater and vents it to atmosphere. This process is accomplished in the deaerating section of the deaerator heater (D23-15-I). As the deaerator pressure could go below atmospheric pressure, "pegging" steam is provided for the purpose of maintaining a positive pressure in the deaerator heater (D23-20-I). The auxiliary steam header is a source of "pegging" steam.

5.2.1 Controls

Refer to DCM No. D23-15-I.

5.2.2 Trips and Controls

Refer to DCM No. D23-15-I.

5.2.3 Control Valves

5.2.3.1 Extraction Steam Isolation Valve

The extraction steam isolation valve is a motor operated valve installed in the steam extraction line to the deaerator heater.

The valve opens when the turbine starts. The valve closes when the turbine trips. The valve is closed when the plant is shutdown in order to keep the feedwater heater pressurized.

a. The open/closed control valve operates on a turbine trip signal. The valve has no interlock.

b. The valve fails as is. The valve is equipped with open and closed position switches, open/close limit stops, and the torque limit stop.

c. The extraction steam isolation valve will be manual/auto controlled from the Master Control System.

d. The maintenance of the control valve and related equipment will require system shutdown.

5.2.3.2 Extraction Steam Nonreturn Valves (2)

The extraction steam line to the deaerator heater contains two nonreturn valves. The valves are installed downstream of the extraction steam isolation valve.

The extraction steam line nonreturn valve prevents reversed flow to the turbine.

The valve opens when the deaerator heater water level is not high. The valve closes when the deaerator heater water level is high and when the turbine shutdown.

a. The open/closed control valve operates on a deaerator heater water level signal and on a turbine trip signal. The valve has no interlock.

b. The valve is fail close/air to open. This will prevent water flow from the deaerator heater to the turbine. The valve has a pneumatic, power assisted (spring) actuator, a solenoid valve, and the position switches.

c. The extraction steam nonreturn valve will be manually operated open/closed through the Master Control System.

d. The maintenance of the control valve and related equipment can be accomplished by isolating the deaerator heater and isolating the extraction steam line from the turbine.

5.2.3.3 Extraction Steam Line Drain Valve

The extraction steam line drain valve is located in the drain line at the intersection upstream of the extraction steam line isolation valve. The drain valve will drain the condensate and will prevent the turbine from flooding.

The drain valve opens when the corresponding extraction steam line isolation valve closes or the turbine trips. The drain valve closes when the extraction steam nonreturn valve opens.

a. The on/off control valve operates on a signal from the extraction steam nonreturn valve and a turbine trip signal. The valve has no interlock.

b. The valve is fail open/air to close. This will protect the turbine from flooding. The valve has a pneumatic actuator, a solenoid valve, and the position switches.

c. The extraction steam line drain valve will be manual/auto controlled from the Master Control System.

d. The maintenance of the control valve and related equipment will require system shutdown.

5.2.3.4 Pegging Steam Pressure Control Valve

Refer to DCM No. D23-20-I.

For the other control valves on the Deaerator Heater System, refer to DCM No. D23-15-I.

5.2.4 Indication

5.2.4.1 Local

None

5.2.4.2 Remote, Master Control System Inputs

a. Extraction Steam to Deaerator Heater Inlet Pressure

b. Extraction Steam to Deaerator Heater Inlet Temperature

c. Status of the Extraction Steam Line to Deaerator Heater Isolation Valve (Open and Closed)

d. Status of the Extraction Steam Line to Deaerator Heater Nonreturn Valve No. 1 (Open and Closed)

e. Status of the Extraction Steam Line to Deaerator Heater Nonreturn Valve No. 2 (Open and Closed)

f. Status of the Extraction Steam Line to Deaerator Heater Drain Valve (Open and Closed)

Note: For the other indication inputs on the Deaerator Heater System, refer to DCM No. 23-15-I.

5.2.5 Test Points

a. Extraction Steam Line to Deaerator Heater, Steam Pressure

b. Extraction Steam Line to Deaerator Heater, Steam Temperature

Note: For the other test points on the Deaerator Heater System, refer to DCM No. D23-15-I.

4.6 CIRULATING WATER SYSTEM
(D23-18)

Engineering
76-370 2/81

DCM No. D23-18 Revision 1
Date March 15, 1983
File No. 30 MW Solar - D23-~~31000~~ 01700

PACIFIC GAS AND ELECTRIC COMPANY
CARRIZO PLAIN
ENGINEERING DEPARTMENT

DESIGN CRITERIA MEMORANDUM

Structure, System, or Component: Circulating Water System

Prepared by: Richard B. Myers Date Mar 16, 83

Group Leader/Supervisor Review JBGegan JBGegan, M&NE (Discipline) Date Mar. 18 83

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Department Chief: JVRocca JVRocca Date: 4-1-83

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1
Page 2 through 8 attached; describing design inputs. Other attachments as indicated below.

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Design Criteria
Circulating Water System

Contents

Circulating Water System

1. Basic Function

1.1 The circulating water will provide the heat sink for the Rankine cycle and service water cooling loads.

1.2 The zero effluent blowdown subsystem will also provide the means of disposing of various waste water streams such as demineralizer regeneration waste.

1.3 If feasible, the circulating water will also be an added source of water for fire fighting.

2. Equipment List

2.1 One cooling tower capable of rejecting approximately $179(10^6)$ Btu/hr depending upon the final heat balance selection (this will include fans and the associated 480 VAC MCC electrical starters and controls

2.2 Two 50% capacity circulating water pumps complete with two 480 VAC motor starters and controls as part of the 480 VAC SWGR

2.3 Two 100% capacity chemical feed pumps and associated storage and mixing equipment complete with two 480 VAC MCC electrical starters and controls (one for acid, one for other such as a polyacrylate)

2.4 A chlorine injection system and associated storage and mixing equipment complete with 480 VAC MCC electrical starters and controls (as required)

2.5 A blowdown evaporation pond

2.6 Main turbine condenser

2.7 Mechanical vacuum hogging and holding system

2.8 One lime soda circulating water softener system

3. Codes and Standards (Sections and dates will be part of equipment specification.)

 3.1 Cooling Tower Institute

 3.2 Heat Exchanger Institute

 3.3 Hydraulic Institute

 3.4 American Society of Mechanical Engineers

 3.5 National Fire Protection Association Standards

 3.6 National Electrical Equipment Manufacturers

 3.7 PGandE Engineering Standard 95

 3.8 Cal-OSHA

 3.9 PGandE Thermal Electric Design Standards

4. Design Conditions

 4.1 The circulating water system is a closed-loop system. Water is circulated from the cooling tower through the main turbine condenser and the plant service cooling water system.

 4.2 The circulating water flows from the cooling tower basin to the pump pits. The unit is provided with two half-capacity circulating water pumps operating in parallel against the design system resistance. Fixed screens at the pump pit inlet will protect the condenser from debris.

4.3 A pump pit bypass line is provided for system filling.

4.4 Makeup from the raw water storage to the tower basin will compensate for all the water losses in the system. Blowdown to control the total solids in the circulating water is removed from the system after the condenser and prior to return to the cooling tower.

4.5 The exact raw water conditions are not known. For design purposes, we will use the analysis shown on Table 1 which is from a well near to the proposed site. This analysis did not measure silica so an estimate was made based on analysis from wells somewhat more distant.

4.6 By controlling alkalinity with acid injection and with a side stream lime soda softener, it should be able to operate the system at high cycles of concentration of the raw water. Blowdown will be estimated on this basis. The softener will not be shutdown overnight.

4.7 Low alkalinity and a pH of six to seven will mean care must be taken in the selection of materials to avoid corrosion.

4.8 The cooling tower is a full-capacity wood mechanical draft design with fiberglass reinforced piping. It will be provided with a tower bypass to the basin for startup and shutdown. It will be sized and optimized using the PGandE "TOWER" program.

4.9 The design point is 72°F wet bulb, 106°F dry bulb, and an 12°F approach.

4.10 Biologic control will be by periodic injection of chlorine. The amount and frequency are dependent upon the conditions which may exist at the time of operation. The baseline system will employ sodium hypoclorite.

4.11 Blowdown will be disposed of in an evaporation pond. This could be up to 10 acres.

(Note: The evaporation rate in the area is estimated to be 70 inches per year with a standard deviation of 4-5 inches. Of this, 70 percent occurs from May through October.)

4.12 The condenser will be sized as part of the cooling tower optimization.

4.13 Mechanical vacuum pumps will be used (no steam ejectors).

4.14 Condenser vacuum will be broken during overnight shutdowns. Hogging and holding will be with mechanical vacuum pumps.

4.15 Circulating water-side of the main condenser shall have automatic venting at each waterbox.

5. Design Load

See Civil Engineering Design Criteria for seismic and wind loads.

6. Environmental Conditions

6.1 The plant must have zero discharge of waste water.

6.2 Solids will be hauled away to a Class I dump.

6.3 Cooling tower drift will be specified as no greater than 0.008 percent of the circulating water. (Note: Lower values are obtainable at added cost. However, we have no economic basis for specifying lower values.)

6.4 The ambient wet bulb temperatures and relative humidity will approximate those at Bakersfield. These valves are tabulated for clear daylight hours (Table 2).

7. Interface Requirements

The system will interface with:

7.1 Raw Water System (make-up)

7.2 Boiler Makeup System (demineralizer regeneration waste)

7.3 Service Water System (heat load is not yet defined)

7.4 Fire System

7.5 Evaporation Pond/Effluent Disposal (system blowdown)

7.6 Condensate Polisher System (regeneration effluent)

7.7 Miscellaneous Waste Water Sources

7.8 The Main Control Room Annunciator

7.9 Electrical SWGR and Motor Control Centers

7.10 Electric Control Systems

8. Material Requirements

8.1 The possibility of having low pH levels and low alkalinity will require careful evaluation of materials. Noncorrosive materials will be preferred. Where corrosion is expected, margins on material thickness will be specified.

8.2 Fiberglass-reinforced plastic will be evaluated for the circulating water pipes.

8.3 Stainless steel and titanium tubes will be evaluated for the condenser tubes. Copper alloys are to be avoided to reduce the possibility of copper oxide induced corrosion in the steam generators. The circulating water will contain some clorides. Thus the effect upon stainless tubes will be evaluated.

8.4 The preferred cooling tower fill will be plastic though wood, if proposed, will be evaluated.

8.5 All buried steel piping will have cathodic protection.

8.6 Design life is 30 years.

9. Layout and Arrangements

Cooling tower should be located down wind from the power plant and heliostat field (the prevailing wind is northwest to southeast) to reduce the possibility of the drift fouling the mirrors or electrical gear. It should also be located as near as feasible to the condenser to reduce pumping costs. (These requirements tend to be at odds with one another.)

10. Instrumentation and Controls

10.1 This system will be required to start daily and then operate continuously at 100 percent capacity. When one circulating water pump is out of service, the system should be able to continue to operate at about 50 percent of capacity. (Actual capacity on one pump must be calculated.)

10.2 Tower blowdown will be manually set, based upon periodic analysis of the circulating water. Makeup will be automatic, based upon the tower basin water level.

10.3 Refer to I&C Criteria D23-18I.

10.4 See Paragraph 4.15 regarding auto venting.

10.5 There will be an automatic bypass of the cooling tower for cold weather startup.

10.6 The system must be controlled during startup to avoid hydraulic surge.

10.7 Circulating water chemistry will be periodically manually checked, and adjustments to blowdown and chemical injection rates will be made.

11. Access Requirement for Security

Not applicable.

12. Reliability (See 13 below)

13. System Reliability Effect on Unit Availability

13.1 The plant reliability is directly related to this system's reliability. At this stage, we assume that the cost and reliability of the circulating pumps are such that two 50 percent capacity units are appropriate. If one unit is out of service, the plant will operate slightly in excess of 50 percent capacity. Both vertical and horizontal pumps will be evaluated for reliability.

13.2 For all other systems, redundant pumps (i.e., two 100 percent or three 50 percent capacity) will be evaluated.

13.3 Provisions will be made to plug leaking condenser tubes so to keep the unit in service. (Condensate will be monitored for conductivity.)

14. Examinations, Inspection, and Testing

All equipment will be shop-inspected. Pumps and motors will be shop tested. Electrical starters and MCC will be shop tested.

15. Maintenance

All equipment will require periodic maintenance. Access space, laydown areas, special tools, if any, and hoisting or pulling facilities will be required.

16. Personnel Requirements

No special skill required for operation. However, a plant chemist will be required.

17. Shipping

No special requirement.

18. Fire Protection

18.1 Refer to the I&C Criteria D23-23I.

18.2 The cooling tower shall be protected by a dry deluge type sprinkler system to supply .33 gpm/ft^2 under the fan deck, including the fan opening and 0.5 gpm/ft^2 over the fill areas, with water being supplied to two cells.

18.3 A fire detection system will be required.

18.4 A water recirculation system will be provided to keep the cooling tower from drying out during prolonged shutdowns. The primary service water pump(s) can be used for this purpose.

19. Storage

No special requirement; will follow manufacturer's recommendations.

20. Health and Safety of the Public

20.1 Presents no hazard. (Note: The waste water stream will be evaporated and solid wastes hauled to a Class I dump.)

20.2 It is unlikely that cooling tower drift or fogging plume will extend beyond the plant site, but they will be evaluated and corrective measures will be taken if a problem exists.

21. Materials and Fabrication

No special requirement.

Refer to pump data sheets.

Refer to Cooling Tower Institute Standards.

TABLE I

WATER MINERAL ANALYSIS

		Well Water Design Basis
pH		8.0
Electrical conductivity	mhos/cm	1156.
Calcium ion	mg/l	78.
Magnesium ion	mg/l	20.
Sodium ion	mg/l	142.
Potassium ion	mg/l	.8
Alkalinity	mg/l $CaCo_3$	155.
Sulfate	mg/l	236.
Chloride	mg/l	80.
Nitrate ion	mg/l	97.
Boron	mg/l	.69
Fluoride ion	mg/l	.5
Silica	mg/l SiO_2	35.
TDS	mg/l	797.
Total Hardness	mg/l	274.
Noncarbonate hardness	mg/l	122.
Sodium absorbtion ratio		3.7

TABLE 2

```
 BAKERSFIELD WET BULB TEMP VS R.H.
 FAIR SKIES - DAYLIGHT HOURS - 1948-1980
     *****FREQUENCY TABLE*****

                                      ROW   ROW
                                      SUMS  AVG
                   R.H.
WB TEMP
               0.0 12.5 37.5 62.5 87.5
               TO   TO   TO   TO   TO
              12.5 37.5 62.5 87.5100.0
******************************************
 15.00- 25.00    0    1    3    1    0     5 49.6
 25.00- 35.00    0   38  107  113   18   276 60.3
 35.00- 45.00   15  852 1735 1033  112  3747 52.3
 45.00- 55.00  104 4681 6344 1804   75 13008 44.5
 55.00- 65.00  31014611 8232  686    6 23845 34.4
 65.00- 75.00  20513523 1921   36    0 15685 27.0
 75.00- 85.00    0   84   10    0    0    94 29.2
******************************************
COLUMN
 SUMS,         634337901 8352 3673  211 56660
AVG R.H.           =                          36.0
```

4.7 SERVICE COOLING WATER
(D23-19)

Engineering
76-370 2/81

DCM No. D23-19M Revision 1
Date March 15, 1983
File No. 30 MW Solar

PACIFIC GAS AND ELECTRIC COMPANY

DESIGN CRITERIA MEMORANDUM

Structure, System, or Component: Service Cooling Water

Prepared by: Richard B. Myers RBM Date Mar 16, 83

Group Leader/Supervisor Review JBRegan, M&NE (Discipline) Date March 18 83

Reviewed by Interfacing Disciplines:

Group Leader/Supervisor ABSchuurman ABSchuurman Date 3-18-83

Group Leader/Supervisor ENZ KGZaharoff K.G. Zaharoff Date 3-30-83

Group Leader/Supervisor MTPerakis M.T. Perakis Date 3-30-83

Approved by:

Department Chief: JVRocca JVRocca Date: 4-1-83

Approved for Project use:

Project Engineer: REPrice REPrice Date: 4.2.83

Page ~~2~~ 1 through 6 attached; describing design inputs. Other attachments as indicated below.

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☐ Manager, Steam Generation

Others

DCM D23-19M
REV. 1

Design Criteria
Service Cooling System
30 MW Solar Project
GM 6340160

Contents

1. Basic Function

This system provides the cooling water for a variety of plant systems.

2. Equipment List

2.1 Two 100 percent capacity primary cooling water pumps

2.2 Two 100 percent capacity secondary cooling water pumps

2.3 Two 100 percent capacity cooling water heat exchangers

2.4 One chemical mix/feed tank (bypass feeder system)

2.5 One makeup head tank

3. Codes and Standards

(Sections and dates will be part of the equipment specifications.)

The installation shall be in conformance with:

3.1 Hydraulic Institute

3.2 Institute of Electrical and Electronic Engineering

3.3 American Society for Testing and Materials

3.4 American National Standards Institute

3.5 Tubular Exchanger Manufacturers Assoc.

3.6 National Electric Manufacturer Assoc. Standards

4. Design Conditions

The cooling water system is a combination of both the primary and secondary cooling water systems. The secondary system provides clean water to those pieces of equipment which could be easily fouled or corroded by using circulating water. The primary system provides circulating water to those less sensitive pieces of equipment and those which can benefit from the lower temperature water.

4.1 Secondary Cooling Water System

Cold water from a cooling water heat exchanger is supplied to two secondary cooling water pumps, each rated at 100 percent capacity. The secondary cooling water pump is supplying cold water to miscellaneous plant heat exchangers.

The cooling water heat exchanger transfers its heat to the primary system, i.e., the circulating water system.

Make-up water will come from the condensate water system.

4.2 Primary Cooling Water System

The primary cooling water system draws water from the cooling tower pump pit. The water is returned to the cooling tower in a manner similar to the circulating water.

4.3 Heat Loads

The system heat loads are dependent upon the equipment ultimately selected. At this stage, the flow rates estimated below should be adequate:

	Operating	Overnight Shutdown
Primary Cooling Water System		
Mechanical Vacuum Pump Heat Exch.	210 gpm	
Cooling Water Heat Exchange	790 gpm	790 gpm
	1000 gpm	790 gpm
Closed-Cooling Water System		
Turbine/Generator Lube Oil Coolers	115 gpm	115 gpm
Generator Coolers	430 gpm	
Air Compressor Heat Exchangers	40 gpm	40 gpm
B.F. Pumps, Bearings, and L.O.	20 gpm	
Sample Coolers	30 gpm	
Miscellaneous Bearings and L.O.	20 gpm	
Miscelleneous	30 gpm	
HVAC	20 gpm	
	705 gpm	40 gpm

5. Design Loads

See the Civil Engineering Design Criteria.

6. Environmental Conditions

The closed-cooling water will be chemically treated for corrosion prevention and so must be handled the same as steam generator chemical cleaning water. We should attempt to avoid inhibitors such as dichromate, which cannot easily be disposed of.

7. Interface Requirements

This system will interface with:

7.1 Circulating Water System (Heat Sink)

7.2 Condensate Water System (Make-up Water)

7.3 Mechanical Vacuum Pumps (Load)

7.4 Turbine-Generator Lube Oil Coolers (Load)

7.5 Miscellaneous Coolers (Load)

7.6 Air Compressors (Load)

7.7 Miscellaneous Plant Bearings (Load)

7.8 HVAC System (Load)

7.9 Sample Coolers (Load)

7.10 480 VAC Switchgear or MCC Centers

7.11 Local and Remote Electrical Control Stations

8. Material Requirments

The circulating water may be somewhat corrosive (see DCM D23-18M). Selection of noncorrosive materials or corrosion allowances must be considered for this system and interfacing systems.

9. Layout and Arrangements

To be determined.

10. Instrumentation and Control

10.1 This system must be in operation when the plant is running. During shutdown, the system can be operated at reduced capacity.

10.2 The standby cooling water pumps will start automatically upon failure of the unit in service.

10.3 The selection or isolation of either heat exchangers can be manual.

10.4 Refer to I&C Criteria D23-19I.

11. Access Requirements for Security

Not applicable.

12. Reliability

12.1 Two 100 percent capacity primary and secondary cooling water pumps are required.

12.2 Two 100 percent cooling water heat exchangers are required.

13. System Reliabilty Effect on Unit Availability

The plant will not operate without this system in operation. Portions of the system must continue in operation when the power plant is shut down overnight.

14. Examinations, Inspection, and Testing

14.1 The equipment will be shop inspected.

14.2 Heat exchangers and tanks should be hydrotested and certified.

14.3 Pumps and motors will be shop tested.

15. Maintenance

The equipment will require periodic maintenance. Access, laydown, pull-space, and any special tools must be provided.

16. Personnel Requirements

No special training needed.

17. Shipping

No special requirement.

18. Fire Protection

Not applicable.

19. Storage

Facilities must be provided for storage of cooling water chemicals (chemicals not yet defined).

20. Health and Safety of the Public

Presents no hazard (see Paragraph 6).

21. Materials and Fabrication

To be developed.

4.7.1 SERVICE COOLING WATER INSTRUMENTATION AND CONTROL

(D23-19I)

Engineering
76-370 2/81

DCM No. D23-19-I Revision 0
Date 5-6-83
File No. 72200

PACIFIC GAS AND ELECTRIC COMPANY

30 MW SOLAR

DESIGN CRITERIA MEMORANDUM

Structure, System, or Component: SERVICE COOLING WATER SYSTEM (I&C)

Prepared by: P.D. MAXWELL / M.T. PERAKIS MPerakis Date 5-6-83

Group Leader/Supervisor Review ________, ________ (Discipline) Date ________

Reviewed by Interfacing Disciplines:

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Group Leader/Supervisor K.G. ZAHAROFF Date 5-23-83

A.B. SCHUURMAN ABSchuurman 5-25-83

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Approved for Project use:

Project Engineer: R.E. PRICE REPrice Date: 5-25-83

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30 MW Solar
Service Cooling Water System
Instrumentation and Control Design Criteria

Reference Documents:

Service Cooling Water - System Design Criteria, DCM No. D23-19
Instrumentation and Control(I&C) - General Design Criteria, DCM No. D23-3
Master Control System - Design Criteria, DCM No. D23-7

1.0 **Scope**

This criteria will provide the I&C requirements for the service cooling water system.

1.1 Mechanical Equipment to be Controlled

Primary Service Cooling Water Pumps (2)

Secondary Service Cooling Water Pumps (2)

1.2 Valves to be Controlled

Air Compressors Cooling Water Temperature Control Valves (2)

Generator Air Coolers Temperature Control Valve

Turbine Generator Lube Oil Coolers Temperature Control Valve

1.3 Vessels to be Controlled

Service Cooling Water Head Tank

Service Cooling Water Heat Exchangers (2)

Chemical Mix/Feed Tank

2.0 **Control System Interfaces**

2.1 Compressed Air System

High temperature of the cooling water at the outlet of an air compressor will trip that air compressor.

2.2 Main Steam

The Generator Air Cooler and Turbine Generator Lube Oil Coolers Temperature Control valves will receive control signals through the Master Control System.

3.0 Operating Requirements

The service cooling water system will be controlled such that it will operate during all expected plant operating conditions, including normal overnight shutdown periods. The system will have attended start-up, unattended operation, and attended shutdown. The system will not be operable during blackout conditions (emergency power only).

4.0 Mechanical Equipment Process Control and Protection

4.1 Primary Service Cooling Water Pumps (2)

Under normal operating conditions, one of two 100 percent capacity pumps will be started manually and run continuously, drawing suction from the cooling tower basin and discharging through the shell side of one of the service cooling water heat exchangers (the other Hx is valved out). The other pump will remain on operator selectable standby and will automatically start on discharge header low pressure. The pumps must be stopped manually.

4.1.1 Control

4.1.1.1 Master Control System

None

4.1.1.2 Dedicated Automatic

Standby Pump Start - System Low Pressure

4.1.1.3 Local Manual

Pump No. 1 Stop/Auto/Run Switch

Pump No. 2 Stop/Auto/Run Switch (Maintained contacts)

Pumps Standby Selector (Pump No. 1/Pump No. 2)
(Maintained contacts)

4.1.2 Trips and Interlocks

Pump No. 1 Motor Overcurrent

Pump No. 2 Motor Overcurrent

No NPSH or deadhead protection will be provided. The loop has no automatic control devices that would lead to a deadhead condition.

4.1.3 Indication

4.1.3.1 Local

Pump No. 1 Status (Running/Not Running)

Pump No. 2 Status (Running/Not Running)

Pumps Incomplete Set-up (Either pump switched off)

Pump Discharge Pressure (2)

4.1.3.2 Master Control System

Pump No. 1 Status (Running/Not Running)

Pump No. 2 Status (Running/Not Running)

4.1.3.4 Test Points

Pump Suction Pressure (2)

4.1.4 Alarms

4.1.4.1 Local

None

4.1.4.2 Master Control System

Pump No. 1 Motor Overcurrent Trip

Pump No. 2 Motor Overcurrent Trip

Both pumps running

4.2 Secondary Service Cooling Water Pumps (2)

Under normal operating conditions, one of two 100 percent capacity pumps will be started manually and run continuously, drawing suction from the tube side outlet of one of the service cooling water heat exchangers. The other pump will remain on operator selectable standby and will automatically start on discharge header low pressure. The pumps must be stopped manually.

4.2.1 Controls

4.2.1.1 Master Control System

None

4.2.1.2 Dedicated Automatic

Standby Pump Start - System Low Pressure

4.2.1.3 Local Manual

Pump No. 1 Stop/Auto/Run Switch

Pump No. 2 Stop/Auto/Run Switch (Maintained contacts)

Pumps Standby Select (Pump No. 1/Pump No. 2)
(Maintained contacts)

4.2.2 Trips and Interlocks

Pump No. 1 Motor Overcurrent

Pump No. 2 Motor Overcurrent

No NPSH or deadhead protection will be provided. The loop has no automatic control devices that would lead to a deadhead condition.

4.2.3 Indication

4.2.3.1 Local

Pump No. 1 Status (Running/Not Running)

Pump No. 2 Status (Running/Not Running)

Pumps Incomplete Set-up (Either pump switched off)

Pump Discharge Pressure (2)

4.2.3.2 Master Control System

Pump No. 1 Status (Running/Not Running)

Pump No. 2 Status (Running/Not Running)

4.2.3.3 Test Points

Pump Suction Pressure (2)

4.2.4 Alarms

4.2.4.1 Local

None

4.2.4.2 Master Control System

Pump No. 1 Motor Overcurrent Trip

Pump No. 2 Motor Overcurrent Trip

Both Pumps Running

5.0 Vessels Process Control and Protection

5.1 Service Cooling Water Head Tank

The head tank provides make-up for small water losses or leakage in the secondary cooling water loop. Make-up to the tank will come from the transfer pumps of the condensate polishing system. When head tank level drops, the operator will receive a low level alarm and must manually (locally) turn on one transfer pump and valve in the line to fill the tank. When tank level is sufficient, the low level alarm will drop out and the operator must turn off the pump, and close the fill valve.

5.1.1 Control

5.1.1.1 Master Control System

None

5.1.1.2 Dedicated Automatic

None

5.1.1.3 Local Manual

None

5.1.2 Trips and Interlocks

None

5.1.3 Control Valves

None

5.1.4 Indication

5.1.4.1 Local

Head Tank Level

5.1.4.2 Master Control System

None

5.1.5 Alarms

5.1.5.1 Local

None

5.1.5.2 Master Control System

Head Tank Level Low

5.2 Service Cooling Water Heat Exchangers (2)

One heat exchanger will be in operation at a time, the other will be manually valved out. The manual valve on the outlet of each heat exchanger may be throttled when the vessel is put in service in order to control primary cooling water flow and provide a backpressure for the pump. The heat exchangers serve to transfer heat from the secondary cooling loop to the primary cooling loop.

5.2.1 Control

None

5.2.2 Trips and Interlocks

None

5.2.3 Control Valves

None

5.2.4 Indication

5.2.4.1 Local

Heat Exchanger Outlet (Tube Side) Pressure (2)

Heat Exchanger Outlet (Tube Side) Temperature (2)

Heat Exchanger Outlet (Shell Side) Pressure (2)

Heat Exchanger outlet (Shell Side) Temperature (2)

5.2.4.2 Master Control System

None

5.2.4.3 Test Points

Heat Exchanger Inlet (Tube Side) Pressure (2)

Heat Exchanger Inlet (Tube Side) Temperature (2)

5.2.5 Alarms

5.2.5.1 Local

None

5.2.5.2 Master Control System

None

5.3 Chemical Mixing Tank

The tank serves as chemical feed for treatment of the secondary loop water. The tank is first isolated from the system and chemicals are manually added. The tank is then valved into the flow stream and the chemicals are drawn into the system.

5.3.1 Control

None

5.3.2 Trips and Interlocks

None

5.3.3 Control Valves

None

5.3.4 Indication

None

5.3.5 Alarms

None

6.0 Miscellaneous Instruments

6.1 Air Compressor Cooling Water Temperature Control Valves (2)

The valve modulates cooling water flow from the service cooling water system through the air compressor head. The head temperature must be kept within a certain range to prevent compressor damage from high heat or condensation in the cylinders. The valve closes down on low water temperature and opens up on high water temperature.

The valve will have:

a) no interlocks - water temperature downstream of the air compressor head will provide the control measurement

b) fail open operation - the valve will have a capillary type fluid actuator

c) modulating, proportional, direct acting control

d) a minimum flow bypass, which will protect the compressor if valve failure occurs. Maintenance work on the valve will require shut down of that compressor.

6.2 Generator Air Coolers Temperature Control Valve

The valve is located on the cooler inlet header and modulates to control cooling water flow through one of the coolers at a time (the other cooler is valved out). The valve closes down on low outlet water temperature and opens up on high outlet water temperature.

The valve will have:

a) no interlocks - water temperature downstream of the coolers will provide the controlling variable

b) air to close/fail open operation, with a pneumatic actuator and electro-pneumatic positioner

c) modulating, proportional, direct acting control through the master control system

d) a minimum flow bypass which will allow the coolers to operate when the valve is removed for maintenance

6.3 Turbine Generator Lube Oil Coolers Temperature Control Valve

The valve is located on the cooler inlet header and modulates to control cooling water flow through one of the coolers at a time (the other cooler is valved out). The valve closes down on low outlet water temperature and opens up on high outlet water temperature.

The valve will have:

a) no interlocks - water temperature downstream of the coolers will provide the controlling variable

b) air to close/fail open operation, with a pneumatic actuator and electro-pneumatic positioner

c) modulating, proportional, direct acting control through the master control system

d) a minimum flow bypass which will allow the coolers to operate when the valve is removed for maintenance

6.4 Miscellaneous Indication

6.4.1 Local

Vacuum Pump Heat Exchanger Outlet SCW (Shell Side) Pressure

Vacuum Pump Heat Exchanger Outlet SCW (Shell Side) Temperature

Air Compressor SCW Flow (2)

Air Compressor SCW Outlet Temperature (2)

Service Cooling Water Secondary Loop Temperature

Air Compressors SCW Inlet Header Temperature

Air Compressors SCW Inlet Header Pressure

Boiler Feed Pump Oil Cooler SCW Outlet Temperature (2)

Boiler Feed Pump Oil Cooler SCW Outlet Pressure (2)

Turbine E. H. Cooler SCW Outlet Temperature (2)

Turbine E. H. Cooler SCW Outlet Pressure (2)

Generator Air Cooler SCW Outlet Temperature (2)

Generator Air Cooler SCW Outlet Pressure (2)

Turbine Generator Lube Oil Cooler SCW Outlet Temperature (2)

Turbine Generator Lube Oil Cooler SCW Outlet Pressure (2)

6.4.2 Master Control System

None

6.4.3 Test Points

Vacuum Pump Heat Exchanger SCW Inlet (Shell Side) Temperature

Vacuum Pump Heat Exchanger SCW Inlet (Shell Side) Pressure

Heat Exchanger SCW Inlet (Shell Side) Temperature (2)

Heat Exchanger SCW Inlet (Shell Side) Pressure (2)

Air Compressor No. 1 SCW Outlet Pressure

Air Compressor No. 2 SCW Outlet Pressure

Aftercooler No. 1 SCW Outlet Pressure

Aftercooler No. 2 SCW Outlet Pressure

Boiler Feed Pump Oil Cooler SCW Inlet Temperature (2)

Boiler Feed Pump Oil Cooler SCW Inlet Pressure (2)

Turbine E. H. Cooler SCW Inlet Temperature (2)

Turbine E. H. Cooler SCW Inlet Pressure (2)

Generator Air Cooler SCW Inlet Temperature (2)

Generator Air Cooler SCW Inlet Pressure (2)

Turbine Generator Lube Oil Cooler SCW Inlet Temperature (2)

Turbine Generator Lube Oil Cooler SCW Inlet Pressure (2)

6.5 Alarms

6.5.1 Local

None

6.5.2 Master Control System

Air Compressor No. 1 SCW Outlet Temperature High

Air Compressor No. 2 SCW Outlet Temperature High

4.8 AUXILIARY STEAM SYSTEM
(D23-20)

Engineering
76-370 2/81

DCM No. DC23-20 Revision 0
Date January 25, 1983
File No.

PACIFIC GAS AND ELECTRIC COMPANY

DESIGN CRITERIA MEMORANDUM

Structure, System, or Component: Solar Power Plant, Aux. Steam System

Prepared by: J. B. Gegan JB Gegan 3-1-83 Date 1-25-83

Group Leader/Supervisor Review A. F. Ariey M&NE (Discipline) Date [illegible]

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Group Leader/Supervisor EWZ K. G. Zaharoff Date 3-16-83

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Project Engineer: R. E. Price REPrice Date: 4-2-83

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DESIGN CRITERIA D23-20

AUXILIARY STEAM SYSTEM

30 MW SOLAR PROJECT

GM 6340160

Contents

DESIGN CRITERIA D23-20

AUXILIARY STEAM SYSTEM

30 MW SOLAR PROJECT

GM 6340160

1.0 Basic Function

The function of the auxiliary steam system will be to supply steam to the plant auxiliary equipment that require steam:

- Feedwater heating during start-up
- Deaerator pegging steam
- Hotwell deaeration
- Building heating
- Main turbine shaft sealing

2.0 Rating, Capacity, and Source

The auxiliary steam system, during plant start-up, must be capable of heating the feedwater to the steam generators to a minimum of 450°F. The auxiliary steam system operating pressure will, therefore, be 455 psig saturated (460°F). The design pressure shall be 500 psig, and temperature 500°F. Valves and flanges shall be ANSI Class 300.

The normal source of auxiliary steam during unit operation will be main steam through a pressure control valve and desuperheater. When the unit is shutdown and during start-up, an immersed-element electric boiler will be used to supply auxiliary steam.

The electric boiler is preliminarily sized at 1,000 kW which is 3.413×10^6 Btu/hr and will generate 3,298 lbs/hr of 455 psig steam from 212°F feedwater. ~~The electric boiler will also be required to supply 450°F water to the steam generators during start-up.~~ JFG 3-1-83

The preliminary flow requirement of the main steam supply to the auxiliary steam system is 12,000 lbs/hr with 550 psig in the main steam line.

3.0 Codes, Standards, and Permits

- ASME Boiler and Pressure Vessel Code
- ANSI B31.1 and all standards referred to in B31.1
- ANSI B16.5 Pipe flanges and flanged fittings
- ANSI B16.34 Steel butt-welding end valves
- ANSI B16.9 Butt-welding fittings

- CAL/OSHA Title 8, Chapter 4, Subchapter 2
- CAL/OSHA Title 8, Chapter 4, Subchapter 7

- Underwriters Listed electric boiler

An operating permit will be required for the auxiliary boiler.

4.0 Design Conditions of Operation

~~During the daily hot start procedure, 450°F water will be pumped from the electric auxiliary boiler into the steam generators during the 30-minute one percent flow period and the 15-minute two percent flow period.~~ When the feedwater flow step reaches four percent flow, sufficient heat will be picked up from the sodium to heat the feedwater in feedwater heater No. 1 to 450°F and the electric auxiliary boiler may be shut down.

JKG
3-1-83

The use of 455 psig (saturated) auxiliary steam in feedwater heater No. 1 will require that the feedwater heater shall be designed for this pressure even though full load extraction steam pressure may be lower.

5.0 Design Loads

The auxiliary steam system piping will be designed for the loads described in ANSI B31.1, paragraph 101.

The seismic loading to be applied to the piping and supports will be those specified in the plant ~~seismic~~ civil design criteria.

ABS 3-[illegible]

The use of expansion joints to provide for thermal expansion shall be avoided unless the use of piping loops is impractical.

The auxiliary steam piping will have a relief valve downstream of the pressure reducing valve. The reaction forces and stresses shall be analyzed according to B31.1, nonmandatory Appendix II.

6.0 Environmental Conditions

The auxiliary steam piping will be installed in an outdoor plant; however, some portions will be under an overhead floor slab. The auxiliary boiler will be indoors.

7.0 Interface Requirements

The auxiliary steam system will interface with the main steam system and the systems listed in paragraph 1.0.

Auxiliary boiler feedwater must be distilled water and deaerated. The auxiliary boiler steam and condensate will mix with the main steam and condensate; therefore, main unit cycle water or a no-solids feedwater treatment, NH_3, and N_2H_2, should be used. A phosphate type treatment would carry solids over with the steam and water and will not be used.

3-1-83

8.0 Material Requirements

The material used in the auxiliary steam piping system will be carbon steel for temperatures below 750°F, low alloy steel for 750°F and up, to meet the design conditions as determined in ANSI B31.1 and specified in "Piping Specifications" issued by the M&NE Department's piping group. Butt-welding or socket weld fittings and valves will be used as far as possible, flanges are to be used only where special conditions call for their use.

9.0 Layout and Arrangement

Consideration shall be given to an arrangement with redundant auxiliary boilers or other means of back-up so that the plant start-up is not totally dependent on the operation of a single auxiliary boiler.

The auxiliary boiler shall be installed and operated in accordance with CAL/OSHA, Title 8, Chapter 4, Subchapter 2 requirements.

The boiler shall be of the electric immersed element type.

13.0 System Reliability Effect on Unit Availability

The auxiliary steam system must be available for operation in order to start-up the plant each day (to preheat the feedwater and steam to match turbine metal temperature, to deaerate the feedwater, and to seal the turbine shaft glands).

The auxiliary steam system may be required to take the unit off the line each night, or to seal the turbine if vacuum is to be held overnight. The turbine shaft must be sealed until the unit has coasted down slow enough to break vacuum. Depending on final plant design, this steam could come from another source such as stored energy in the deaerating feedwater heater storage tank.

14.0 Examinations, Inspection, and Testing

The auxiliary steam system piping examination, inspection, and testing shall conform to ANSI B31.1. The system piping shall successfully pass a hydrostatic leak test as described in B31.1.

The auxiliary steam boiler (or boilers) will be given an acceptance test at the manufacturer's shop to test conformance to the guaranteed capacity, controls, and safety devices.

The auxiliary boiler will be subject to annual inspection as required by CAL/OSHA, Chapter 4, Subchapter 2.

15.0 Maintenance

Sufficient room shall be provided around the auxiliary steam boilers for maintenance. Platforms and ladders shall meet CAL/OSHA General Industry Safety Orders requirements.

16.0 Personnel Requirements

The auxiliary boilers will require supervision and attendance as required by CAL/OSHA, Chapter 4, Subchapter 2.

17.0 Shipment

The auxiliary boiler shall be subject to inspection at the supplier's shop. Shipment to the jobsite without specific release by the PGandE inspector will not be permitted. Adequate protection, to meet the inspector's requirements, will be provided.

18.0 Fire Protection

The auxiliary boiler installation shall meet the requirements of:

- PGandE Engineering Standard No. 95
- CAL/OSHA General Industry Safety Orders

19.0 Storage

All equipment shall be protected from corrosion and damage while in storage.

The electric boiler including its controls must be stored indoors.

20.0 Health and Safety of the Public

Not applicable.

21.0 Materials and Fabrication

Materials are covered in paragraph 8. Fabrication of the auxiliary steam piping system shall comply with the requirements of ANSI B31.1, Chapter V.

The auxiliary steam piping system shall be of all welded construction as far as practical.

Engineering
76-370 2/81

DCM No. D23-20I Revision 0
Date APRIL 28, 1983
File No. ______

PACIFIC GAS AND ELECTRIC COMPANY

30 MW SOLAR

DESIGN CRITERIA MEMORANDUM

Structure, System, or Component: AUXILIARY STEAM SYSTEM

Prepared by: J.M. WALEWSKI / M.T. PERAKIS MTPerakis MWalewski Date 4/29/83

Group Leader/Supervisor Review A.F. ARLEY AF Arley (Discipline) Date ______

Reviewed by Interfacing Disciplines:

Group Leader/Supervisor J.B. GEGAN JB Gegan Date May 2 1983

Group Leader/Supervisor M.E. CONLU ME Conlu Date May 2, 1983

Group Leader/Supervisor K.G. ZAHAROFF KG Zaharoff Date 5-10-83

A.B. SCHUURMAN AB Schuurman 5-18-83

Approved by:

Department Chief: J.V. ROCCA JV Rocca Date: 5-27-83

Approved for Project use:

Project Engineer: R.E. PRICE RE Price Date: May 26 '83

Page 2 through ______ attached; describing design inputs. Other attachments as indicated below.

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30 MW SOLAR
AUXILIARY STEAM SYSTEM
INSTRUMENTATION AND CONTROL
DESIGN CRITERIA

Reference Documents:

Auxiliary Steam System - System Design Criteria DCM No. D23-20
Master Control System - Design Criteria DCM No. D23-7
Instrumentation and Control - General Design Criteria DCM No. D23-3

1.0 Scope

This criteria will define the Instrumentation and Control (I&C) requirements for the Auxiliary Steam System.

1.1 Mechanical Equipment to be Controlled

None

1.2 Valves to be Controlled

1.2.1 Auxiliary Steam Pressure Reducing Valve

1.2.2 Gland Steam Seal System Isolation Valve

1.2.3 Auxiliary Boiler No. 1 Water Level Control Valve

1.2.4 Auxiliary Boiler No. 2 Water Level Control Valve

1.2.5 Auxiliary Steam to Feedwater Heater No. 1 Pressure Control Valve

1.2.6 Auxiliary Steam to Feedwater Heater No. 3 Pressure Control Valve

1.2.7 Auxiliary Steam to Start-up Feedwater Heater Pressure Control Valve

1.2.8 Auxiliary Steam to Feedwater Heater No. 1 Shut-off Valve

1.2.9 Auxiliary Steam to Feedwater Heater No. 3 Shut-off Valve

1.2.10 Auxiliary Steam to Start-up Feedwater Heater Shut-off Valve

1.3 Vessels to be Controlled

1.3.1 Steam Attemperator

1.3.2 Auxiliary Boiler No. 1

1.3.3 Auxiliary Boiler No. 2

2.0 Control System Interface

2.1 The temperature of the auxiliary steam controls the Attemperator Water Spray System valve (D23-15-I).

2.2 The available auxiliary boiler feedwater pressure allows the auxiliary steam boilers to operate (D23-15-I).

3.0 Operating Requirements

The Auxiliary Steam System will supply auxiliary steam to the plant equipment and to the building heating system. During start-up and shutdown procedures, auxiliary steam will be supplied from auxiliary boiler no. 1 or boiler no. 2. During the normal plant operation, auxiliary steam will be supplied from the main steam header through the steam attemperator.

4.0 Mechanical Equipment Process Control and Protection

None

5.0 Vessels to be Controlled

5.1 Steam Attemperator

The steam attemperator desuperheats main steam with a water spray system controlled by steam temperature at the attemperator outlet.

5.1.1 Controls

5.1.1.1 Remote Automatic, Master Control System

a) Auxiliary Steam Temperature

The signal is taken from a local mounted temperature transmitter at the outlet of the attemperator.

5.1.1.2 Remote Automatic, Dedicated

None

5.1.1.3 Local Automatic

None

5.1.1.4 Remote Manual, Master Control System

a) Auxiliary Steam Temperature

5.1.1.5 Remote Manual, Dedicated

None

5.1.1.6 Local Manual

None

5.1.2 Trips and Interlocks

None

5.1.3 Control Valves

5.1.3.1 Attemperator Water Spray Temperature Control Valve

This valve is a part of the Condensate and Feedwater System (D23-20-I).

5.1.3.2 Auxiliary Steam Pressure Reducing Valve

The purpose of this valve is to reduce the main steam pressure of 1400 psia to the lower pressure of 470 psia. This valve will be controlled from the Master Control System with a variable signal taken from a local mounted pressure transmitter at the down stream of the control valve.

The valve opens when the main steam pressure decreases. The valve closes when the main steam pressure increases.

a) The modulating pressure control valve operates on a pressure signal from the main steam inlet to the attemperator. The valve has no interlocks.

b) The valve is fail close/air to open. This will protect the attemperator from overpressure. The valve has a pneumatic actuator and a positioner.

c) The main steam pressure reducing valve will be manual/auto controlled from the Master Control System. The controller will have a proportional plus integral control and will be reverse acting.

d) The maintenance of the control valve and related equipment will require system shutdown.

5.1.4 Indication

5.1.4.1 Local

a) Auxiliary Steam Temperature

5.1.4.2 Remote, Master Control System Inputs

a) Auxiliary Steam Temperature

b) Auxiliary Steam Pressure

5.1.4.3 Remote, Dedicated

None

5.1.5 Test Points

a) Auxiliary Steam Header Temperature

5.1.6 Recording

None

5.1.7 Alarms

5.1.7.1 Local

None

5.1.7.2 Remote, Master Control System

a) Auxiliary Steam Temperature High/Low (independent from the analog control signal)

b) Auxiliary Steam Pressure High/Low

5.1.7.3 Remote, Annunciator

None

5.2 Auxiliary Boilers (2)

The auxiliary boilers no. 1 and no. 2 will be piped into the auxiliary steam header and will supply auxiliary steam on demand, particularly during plant start-up operation.

The boilers will be of the immersion element type boilers employing several controls for the efficient operation.

The boilers will be local manually controlled. The manufacturer will supply a local control station for each boiler.

The local control station shall incorporate an electrical cabinet equipped with:

a) Main Power Lugs

b) Magnetic Contactors

c) Interlock Connections for External Interlocks

d) High Pressure Cutoff

e) Low Water Cutoff Protection

f) Auxiliary Low Water Cutoff

g) Pressure Sensor

h) Pilot Switch

i) Pilot Lights

j) External Interlock Contacts

k) Alarm Contacts

l) Solid State Progressive Sequencing Step Control

m) Individual Step Pilot Lights

Each boiler shall be supplied with:

a) Pressure Gauge

b) Pressure Relief valve

c) Blowdown Valves

d) Water Level Gauge Glass

5.2.1 Controls

5.2.1.1 Remote Automatic, Master Control System

None

5.2.1.2 Remote Automatic, Dedicated

None

5.2.1.3 Local Automatic

a) The boiler drum water level controller will send a modulating signal to the boiler feedwater level control valve (see Section 5.2.3).

b) The boiler drum steam pressure will control power supply to the heating elements with a solid-state progressive step control system.

c) The boilers will be provided with the automatic blowdown systems equipped with a manual adjustment for the length of blowdown and the interval between the blowdown cycles.

5.2.1.4 Remote Manual, Master Control System

None

5.2.1.5 Remote Manual, Dedicated

None

5.2.1.6 Local Manual

a) Before turning the boilers into the daily service, all auxiliary boilers' start-up functions will be provided locally by an operator.

b) The boilers will be provided with a manual resetting.

5.2.2 Trips and Interlocks

5.2.2.1 Trips

a) Boiler Drum Water Level Low Trip

b) Boiler Feedwater Pressure High Trip

The boilers will be equipped with an auxiliary low water cutoff switch set below the low water level to provide a back-up protection against the low water conditions.

The high pressure cutoff will be set to actuate prior to the safety relief valve actuation.

5.2.3 Control Valves

5.2.3.1 Auxiliary Boilers Water Level Control Valves (2)

The purpose of this valve is to maintain the required normal water level in the boiler drum.

The valve opens when water level decreases.
The valve closes when water level increases.

a) The modulating level control valve operates on a level signal from the drum water level controller. The valve has no interlocks.

b) The valve is fail close/air to open. This will protect the boiler from overflooding. The valve has a pneumatic actuator and a positioner.

c) The valve will be local auto controlled with a modulating signal from a local controller. The controller will have a proportional plus integral control and will be reverse acting.

d) The maintenance of the control valve and related equipment will require system shutdown.

5.2.4 Indication

5.2.4.1 Local

None

5.2.4.2 Remote, Master Control System Inputs

a) Auxiliary Boiler No. 1 Pressure

b) Auxiliary Boiler No. 2 Pressure

5.2.5 Test Points

a) Water Analysis Sample Connection

5.2.6 Recording

None

5.2.7 Alarms

5.2.7.1 Local

a) Water Level Low (2)

b) Steam Pressure High (2)

5.2.7.2 Remote, Master Control System

a) Auxiliary Boiler Trouble (2)

5.2.7.3 Remote, Annunciator

None

6.0 Miscellaneous Instruments

6.1 Local

6.1.1 Auxiliary Steam Pressure Control Valve to Feedwater Heater No. 1

Auxiliary steam pressure control valve is located in the auxiliary steam line before intersection to the extraction line of the feedwater heater no. 1. (The intersection is located after the extraction steam isolation valve.) The valve will supply the auxiliary steam to the feedwater heater no. 1 during start-up operation.

The valve opens when the extraction steam line pressure decreases. The valve closes when the extraction steam line pressure increases.

a) The modulating pressure control valve operates on a pressure signal from the extraction line. The valve has no interlock.

b) The valve is fail close/air to open. This will protect the feedwater heater no. 1 from overpressure. The valve has a pneumatic actuator and a positioner.

c) The auxiliary steam pressure control valve to the feedwater heater no. 1 will be manual/auto controlled from the Master Control System. The controller will have a proportional plus integral control and will be reverse acting.

d) The maintenance of the control valve and related equipment will require system shutdown. Upstream of the valve a manual shut-off valve is to be provided.

6.1.2 Auxiliary Steam Pressure Control Valve to Feedwater Heater No. 3

The valve is located in the auxiliary steam line down stream of the motor operated isolation valve. The auxiliary steam line is directly connected to the feedwater heater no. 3 shell nozzle. This valve will supply auxiliary steam to the feedwater heater no. 3 during start-up operation.

The valve opens when the extraction steam line pressure decreases. The valve closes when the extraction steam line pressure increases.

a) The modulating pressure control valve operates on a pressure signal from the extraction line. The valve has no interlock.

b) The valve is fail close/air to open. This will protect the feedwater heater no. 3 from overpressure. The valve has a pneumatic actuator and a positioner.

c) The auxiliary steam pressure control valve to the feedwater heater no. 3 will be manual/auto controlled from the Master Control System. The controller will have a proportional plus integral control and will be reverse acting.

d) The maintenance of the control valve and related equipment will require system shutdown.

6.1.3 Auxiliary Steam Pressure Control Valve to Start-up Feedwater Heater

The valve is located in the auxiliary steam line down stream of the motor operated isolation valve. This valve will supply auxiliary steam to the start-up feedwater heater during start-up operation.

a) The modulating pressure control valve operates on a pressure signal from the start-up feedwater heater inlet line. the valve has no interlocks.

b) The valve is fail close/air to open. This will protect the start-up feedwater heater from overpressure. The valve has a pneumatic actuator and a positioner.

c) The auxiliary steam pressure control valve to the start-up heater will be manual/auto controlled from the Master Control System. The controller will have a proportional plus integral control and will be reverse acting.

d) The maintenance of the control valve and related equipment will require system shutdown.

6.1.4 Gland Steam Seal System Isolation Valve

The purpose of this valve is to isolate the Gland Steam Seal System from the Auxiliary Steam System.

a) The auxiliary steam flow shut-off control valve operates on a remote signal. The valve has no interlocks.

b) The valve is fail as is. The valve has a motor actuator and is equipped with the position switches.

c) The Gland Steam Seal System valve will be manually controlled from the Master Control System in the on/off mode only.

d) The maintenance of the control valve and accessories will require system shutdown.

e) The open/closed positions of the valve will be indicated in the Master Control System.

6.1.5 Auxiliary Steam Isolation Valves (3)

The auxiliary steam isolation valves are motor operated valves installed in each of the auxiliary steam line to the feedwater heaters no. 1 and no. 3 and the start-up feedwater heater. The valves will be open during start-up operation.

a) The valve is an on/off type control valve operating on a remote signal. The valve has no interlocks.

b) The valve fails as is. The valve is equipped with the position switches.

c) The auxiliary steam isolation valve will be manual/auto controlled from the Master Control System.

d) The maintenance of the control valve and related equipment will require system shutdown.

e) The open/closed positions of the valve will be indicated in the Master Control System.

6.1.6 Deaerator Heater Pegging Steam Pressure Control Valve

The deaerator pegging steam pressure valve is a modulating control valve supplying pegging steam for the purpose of maintaining a positive pressure in the deaerator heater.

The valve opens when the deaerating heater pressure decreases. The valve closes when the deaerator heater pressure increases.

a) The modulating pressure control valve operates on a pressure signal from the deaerator heater chamber.

b) The valve is fail close/air to open. This will protect the deaerator water from overpressure. The valve has a pneumatic actuator and a positioner.

c) The pegging steam pressure control valve will be manual/auto controlled from the Master Control System. The controller will have a proportional plus integral control and will be reverse acting.

d) The maintenance of the valve and related equipment will require system shutdown. Downstream of the valve, a manual shut-off valve is to be provided.

6.2 Indication

6.2.1 Local

a) Auxiliary Steam Header Pressure

6.2.2 Remote, Master Control System Inputs

None

4.9 LUBE OIL TRANSFER AND STORAGE SYSTEM (D23-22)

Engineering
76-370 2/81

DCM No. D23-22 Revision 0
Date June 9, 1983
File No. D23-77000

PACIFIC GAS AND ELECTRIC COMPANY

DESIGN CRITERIA MEMORANDUM

Structure, System, or Component: Lube Oil Transfer and Storage System

Prepared by: W. R. Carrothers Date June 9, 1983

Group Leader/Supervisor Review AFA By M&NE Date June 10 83
A. F. Ariey (Discipline)

Reviewed by Interfacing Disciplines:

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Group Leader/Supervisor M. T. Perakis

M. E. Conlu

Issued as report of preliminary design. R E Price 6.10.83

Approved by:

Department Chief: J. V. Rocca

Approved for Project use:

Project Engineer: R. E. Price

Page ~~2~~ 1 through 4 attached; describing design inputs. Other attachments as indicated below.

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DESIGN CRITERIA D23-22
LUBE OIL TRANSFER AND STORAGE SYSTEM
30 MW SOLAR PROJECT

1.0 Basic Function

The lube oil system stores clean and dirty oil, provides for oil transfer to the L.O. reservoir for use in the turbine-generator operating system, and purifies the oil to protect the turbine from impurities and water contamination.

2.0 Rating and Capacity

The quantity of storage and circulated lube oil depends on turbine-generator requirements and size of the L.O. reservoir supplied with the turbine-generator system. Turbine-generator reservoir storage is assumed to be 1,500 gallons.

Storage Capacity:	
Clean Oil Tank	5,000 gallons
Dirty Oil Tank	5,000 gallons
Purifier Flow, 15% of Storage	225 gph
Transfer Pump	37 gpm @ 50 psi head

3.0 Codes and Standards

Piping: Follows ANSI B31.1
See PGandE Piping Specification J

Tanks: API Code, Section 650
State of California Division of Industry Safety Requirements

ASME Standard Nos. 116 and 117
PGandE Engineering Standard 95
Fire Protection Design Criteria

4.0 Design Conditions

Refer to Section 2.0.

New oil will be delivered by truck through piping connections to the clean oil storage tank or directly to the system through the truck's pumping system.

Oil can be transferred by the L.O. transfer pump from the clean oil tank to the turbine L.O. reservoir or the suction of the L.O. purifier. Also, oil can be transferred to the dirty oil storage tank and from the dirty oil tank to the clean oil tank, through the purifier.

Lube oil in the turbine-generator reservoir will be continually centrifuged.

5.0 Design Loads

Piping loads shall follow ANSI B31.1

Civil Engineering design criteria will describe loads on clean and dirty oil storage tanks.

6.0 Environmental Conditions

Oil from the dirty oil storage tank can be pumped to a truck to haul away for dumping, or the truck pump may be used.

A gravel blotter around the storage tanks will retain minor spills for housekeeping purposes. See Engineering Standard 95, Section 9, Paragraph 3.13.

A berm or wall will surround the lube oil storage tank to retain the contents in case of tank rupture or spill (refer to Fire Protection, D.C. 23-23).

7.0 Interface Requirements

The Lube Oil System will interface with the following systems:

The Turbine-Generator Lube Oil Reservoir

The Auxiliary Cooling Water System (at the turbine-generator lube oil coolers)

Fire System

8.0 Material Requirements

For piping, refer to Section 3.0.

For storage tanks, material will be carbon steel.

9.0 Layout and Arrangement

The clean and dirty oil storage tanks will be located outside near the turbine building and near the turbine-generator reservoir. Connections and access will be available for delivery and removal of oil by truck.

The lube oil transfer pump will be located outside near the storage tanks.

The lube oil purifier will be located near the L.O. reservoir on the ground level. Connections will be required for clear, sealing water inlet.

The lube oil reservoir and associated equipment will be supplied as part of the turbine-generator package. The reservoir will be located below the turbine on the ground level. It will have a containment curb to hold the reservoir capacity. Refer to Fire Protection Design Criteria D23-23.

10.0 Instrumentation and Control

The lube oil purifier will be a manually cleaned system. Instrumentation and controls will be included with the manufacturer's package. Instrumentation and controls for the lube oil reservoir will be supplied as part of the turbine-generator package.

The clean and dirty oil storage tanks will be supplied with level indicators.

Refer to I&C Design Criteria D23-22-I.

11.0 Access Requirements for Security

Not applicable.

12.0 Reliability

The turbine-generator cannot operate without a supply of clean, cooled lube oil.

The plant could operate for a limited time without the purifier. The supply of clean oil in the storage tank should be kept sufficiently full to back up the lube oil reservoir.

A single lube oil transfer pump will be available. Loss of the pump or electrical power will limit lube oil to that stored in the reservoir.

The equipment located outside should be protected from accidental contact with delivery trucks or other vehicles.

A supply of critical parts for all equipment should be kept on site.

13.0 System Reliability Effect on Unit Availability

Same as Section 12.0.

14.0 Examination, Inspection, and Testing

Performance tests at manufacturer's shop of the L.O. transfer pump shall be at the discretion of the systems engineer.

The lube oil purifier shall be subject to shop inspection and performance testing by PGandE inspectors before shipment.

15.0 Maintenance

Sufficient clearance shall be provided around the equipment to allow convenient and proper maintenance. Consideration shall be given to overhead structures with clear lifting space for use of hoisting gear to dismantle pumps or remove heavy pieces of equipment.

16.0 Personnel Requirements

The lube oil purifier shall be the manually cleaned type.

17.0 Shipping

Storage tanks, purifier, and transfer pump should be shipped completely assembled and skid mounted, if appropriate, to reduce field erection costs.

18.0 Fire Protection

An overhead sprinkler system should be installed over the lube oil reservoir and purifier area.

A berm or wall will surround the reservoir, sized to contain the contents of the tank in case of rupture.

The storage tanks should have a graveled blotter area around the base to contain the oil in case of spill. Refer to Fire Protection Design Criteria 23-23.

19.0 Storage

Lube oil transfer pump and motor should be stored indoors with space heaters energized.

Lube oil purifier should be stored indoors.

20.0 Health and Safety of the Public

The State of California Administrative Code, Title 8, Chapter 4, Subchapter 7, General Industry Safety Orders must be complied with.

21.0 Materials and Fabrication

Refer to Sections 3.0 and 8.0.

4.9.1 LUBE OIL SYSTEM INSTRUMENTATION AND CONTROL (D23-221)

Engineering
76-370 2/81

DCM No. D23-22-I Revision 0
Date 5/13/83
File No. D23-77000

PACIFIC GAS AND ELECTRIC COMPANY

30MW SOLAR

DESIGN CRITERIA MEMORANDUM

Structure, System, or Component: INSTRUMENTS AND CONTROLS: LUBE OIL SYSTEM

Prepared by: J.M. WALEWSKI / M.T. PERAKIS MT Perakis JM Walewski Date 5/13/83

Group Leader/Supervisor Review A.F. ARIEY A.F. Ariey M+NE (Discipline) Date 5/14/83

Reviewed by Interfacing Disciplines:

Group Leader/Supervisor J.B. GEGAN JB Gegan Date 5-24-83

Group Leader/Supervisor M.E. CONLU ME Conlu Date 5-24-83

Group Leader/Supervisor K.G. ZAHAROFF Date 6-14-83

A.B. SCHUURMAN AB Schuurman 6-16-83

Approved by:

Department Chief: J.V. ROCCA JV Rocca Date: 6-17-83

Approved for Project use:

Project Engineer: R.E. PRICE RE Price Date: 6.16.83

Page 2 through 7 attached; describing design inputs. Other attachments as indicated below.

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☐ Manager, Steam Generation

Others

30 MW SOLAR
LUBE OIL SYSTEM
INSTRUMENTATION AND CONTROL
DESIGN CRITERIA

Reference Documents:

Lube Oil System - System Design Criteria, DCM No. D23-22
Master Control System - Design Criteria, DCM No. D23-7
Instrumentation and Control - General Design Criteria, DCM No. D23-3

1.0 Scope

These criteria will define the instrumentation and control (I&C) requirements for the Lube Oil Transfer and Storage System.

1.1 Mechanical Equipment to be Controlled

1.1.1 Transfer Pump

Note: The instrumentation and controls for the centrifuge and turbine lube oil reservoir will not be discussed in this design criteria. Refer to vendor drawings for this information.

1.2 Valves to be Controlled

None

1.4 Vessels to be Controlled

1.4.1 Clean Lube Oil Tank

1.4.2 Dirty Lube Oil Tank

1.5 Miscellaneous Equipment

1.5.1 Mist Eliminator

2.0 Control System Interface

2.1 Turbine Lube Oil System

Lube oil is provided to and received from the Turbine Lube Oil System.

2.2 Service Cooling Water System

Water from the Service Cooling Water System shall be supplied to the lube oil centrifuge to be used for sealing.

3.0 Operating Requirements

The Lube Oil System will be manually controlled such that it will operate during all expected plant operating conditions. The system will not be operable during emergency power conditions.

4.0 Mechanical Equipment Process Control and Protection

4.1 Transfer Pump

The lube oil transfer pump transfers lube oil between the lube oil centrifuge and clean lube oil tank and turbine lube oil reservoir.

4.1.1 Controls

4.1.1.1 Remote Automatic, Master Control System

None

4.1.1.2 Remote Automatic, Dedicated

None

4.1.1.3 Local Automatic

None

4.1.1.4 Remote Manual, Master Control System

None

4.1.1.5 Remote Dedicated

None

4.1.1.6 Local Manual

Lube oil transfer pump will be put into service with start/stop pushbuttons.

4.1.2 Trips and Interlocks

a. Lube Oil Transfer Pump Overcurrent Trip

4.1.3 Control Valves

None

4.1.4 Indication

4.1.4.1 Local

a. Lube Oil Transfer Pump Suction Pressure

b. Lube Oil Transfer Pump Discharge Pressure

c. Lube Oil Transfer Pump On/Off

4.1.4.2 Remote, Master Control System

a. Lube Oil Transfer Pump Running/Not Running

4.1.5 Test Points

None

4.1.6 Recording

None

4.1.7 Alarms

4.1.7.1 Local

None

4.1.7.2 Remote, Master Control System

a. Lube Oil Transfer Pump Overcurrent

4.1.7.3 Remote, Annunciator

None

5.0 Vessels to be Controlled

5.1 Clean Lube Oil Tank

The clean lube oil tank is provided for the purpose of storage of the clean lube oil received from the lube oil centrifuge.

5.1.1 Controls

None

5.1.2 Trips and Interlocks

None

5.1.3 Control Valves

None

5.1.4 Indication

5.1.4.1 Local

a. Clean Lube Oil Tank Level

5.1.4.2 Remote, Master Control System

None

5.1.4.3 Remote, Dedicated

None

5.1.5 Test Points

a. Clean Lube Oil Tank Sample Point

5.1.6 Recording

None

5.1.7 Alarms

None

5.2 Dirty Lube Oil Tank

The dirty lube oil tank is provided for the purpose of storage of the dirty lube oil received from the turbine lube oil reservoir.

5.2.1 Controls

None

5.2.2 Trips and Interlocks

None

5.2.3 Control Valves

None

5.2.4 Indication

5.2.4.1 Local

a. Dirty Lube Oil Tank Level

5.2.4.2 Remote, Master Control System

None

5.2.4.3 Remote, Dedicated

None

5.2.5 Test Points

a. Dirty Lube Oil Tank Sample Point

5.2.6 Recording

None

5.2.7 Alarms

None

6.0 Miscellaneous Equipment

6.1 Mist Eliminator

Mist eliminator vents the air and gases received from the turbine lube oil reservoir through the vapor extractor and drains trapped moisture to the drain system. The operation is continuous without an operator interference.

6.1.1 Controls

None

6.1.2 Trips and Interlocks

None

6.1.3 Control Valves

None

6.1.4 Indication

None

6.1.5 Test Points

a. Mist Eliminator Inlet Sample Point

b. Mist Eliminator Inlet Pressure

c. Mist Eliminator Outlet Sample Point

d. Mist Eliminator Outlet Pressure

6.1.6 Recording

None

6.1.7 Alarms

None

6.2 Miscellaneous Indications

6.2.1 Local

a. Turbine Lube Oil Reservoir Overflow Sight Glass

6.3 Miscellaneous Alarms

6.3.1 Local

None

6.3.2 Remote, Master Control System

a. Lube Oil Centrifuge Trouble

6.3.3 Remote, Annunciator

None

4.10 BOILER MAKEUP WATER
(D23-24)

Engineering
76-370 2/81

DCM No. D23-24 Revision 0
Date February 24, 1983
File No.

PACIFIC GAS AND ELECTRIC COMPANY

DESIGN CRITERIA MEMORANDUM

Structure, System, or Component: Solar Power Plant, Boiler Make-Up Water

Prepared by: J. B. Gegan JB Gegan Date 2-25-83

Group Leader/Supervisor Review A. F. Ariey M&NE (Discipline) Date 2/25/83

Reviewed by Interfacing Disciplines:

Group Leader/Supervisor A. B. Schuurman Date [illegible]

Group Leader/Supervisor K. G. Zaharoff Date 3-1-83

Group Leader/Supervisor M. T. Perakis M T Perakis Date 3-3-83

Approved by: M. E. Conlu M. E. Conlu 3-5-83

Department Chief: J. V. Rocca Date: 3-[illegible]-83

Approved for Project use:

Project Engineer: R. E. Price Date: 3.5.83

Page 2 through ______ attached; describing design inputs. Other attachments as indicated below.

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DESIGN CRITERIA D23-24

BOILER MAKEUP WATER SYSTEM

30 MW SOLAR PROJECT

GM 6340160

CONTENTS

DESIGN CRITERIA D23-24

BOILER MAKEUP WATER SYSTEM

30 MW SOLAR PROJECT

1.0 Basic Function

The Boiler Makeup Water System will replenish the water lost from the distilled water system and from the turbine cycle.

2.0 Rating and Capacity

The capacity of the Makeup Water System shall be based on an estimate of the losses including, but not limited to:

- Leakage losses
- Drains and vents and possibly blowdown occurring at the daily startups
- Condensate polisher regeneration and rinse water
- Sample drains
- Auxiliary boiler makeup
- A conservative margin

The preliminary design and cost estimate will be based on an estimated 10,000 gallons per day capacity, assuming continuous, 24 hrs per day, operation of the boiler makeup water system, (includes a 100% margin).

The feedwater chemistry shall be in accordance with the following table from Rockwell's Steam Generator Design Criteria page 28, Draft 3.

	Expected Purity Level During Preheat/Startup Operation	Maximum Impurity Level During Steady State Operation	Best Purity Level Expected During Steady State Operation
Total Dissolved Solids	150 ppb	100 ppb Max	50 ppb
Silica, SiO_2	20 ppb	20 ppb Max	10 ppb
Iron	100 ppb	10 ppb Max	10 ppb
Copper	5 ppb	2 ppb Max	2 ppb
Dissolved Oxygen	10 ppb	7 ppb Max	5 ppb
Free Caustic	-	Zero	Zero
pH	8.5 - 9.2	8.5 - 9.2	8.5 - 9.2
Percent of Operating Period Expected	Less than 1.0 percent	10 percent	89 percent

There will be a full flow condensate polisher in the cycle downstream of the condensate pumps.

The purity requirements of the make-up water system product water shall be:

200 ppb Total Dissolved Solids

10 ppb Silica

The makeup water will be pumped to the distilled water tank.

The distilled water tank will be sized to contain at least the total water contained in the Power Conversion System or one week's makeup requirements, whichever is the larger.

3.0 Codes and Standards

- ANSI B31.1, Power Piping, and the material and dimensional standards referred to in B31.1
- ASME Boiler and Pressure Vessel Code, Section VIII, and the material specifications referred to therein
- State of California Administrative Code, Title 8, Industrial Relations; Chapter 1, CAL/OSHA; Chapter 4, Subchapter 7, General Industry Safety Orders
- API Standard 620--Large Storage Tanks
- PGandE Supplementary Specification for Centrifugal Pumps
- PGandE Department of Engineering, Engineering Standard No. 95, Fire Protection.

4.0 Design Conditions (also refer to Section 2)

The Makeup Water System will be supplied with raw water from the raw water storage tank. The raw water will be treated and processed so as to reduce the total dissolved solids and silica to the required degree (see Section 2). The product water will be pumped to the distilled water tank. Makeup water to the turbine cycle will flow from the distilled water tank to the condenser. The distilled water tank will be vented to the atmosphere. The makeup to the condenser will be in a manner that will provide deaeration in the condenser.

The process used to remove the dissolved solids will be determined by an economic analysis of alternate methods including:

- A RO-DI system using well water feed
- A vapor-compression evaporation system using well water feed
- A cooling tower blowdown concentrator

The process to be used to produce the makeup water must be independent of the status of the main unit, that is, it must be capable of producing "distilled" water at any time.

The preliminary design and cost estimate will be based on using vapor compressors evaporation units using well water feed.

Centrifugal pumps supplied for the Makeup Water System shall meet the requirements of PGandE Supplementary Specification for Centrifugal Pumps as applicable in the judgment of the system engineer.

5.0 Design Loads

The Makeup Water System piping and supports shall be designed for the loads described in ANSI B31.1.

The Civil Engineering Design Criteria will describe the loads on the Distilled Water Tank and other tanks and specify the seismic design criteria.

6.0 Environmental Conditions

Certain of the equipment which will be considered in the alternate systems should be installed in a weather protected area. These would include:

- RO elements
- RO-DI control panels
- Vapor compression units
- Chemical mixing equipment and feedpumps
- Softener control panels

7.0 Interface Requirements

The Makeup Water System will interface with:

- The raw water system
- The condenser makeup
- The auxiliary boiler makeup
- The service cooling water system makeup
- The condensate polisher regeneration
- The waste water system, to accept the blowdown or reject from the makeup process
- The circulating water system

8.0 Material Requirements

The Makeup Water System product water piping shall be FRP, PVC, or stainless steel but not carbon steel.

The distilled water tank shall be carbon steel internally coated and externally painted.

9.0 Layout and Arrangement

The system will consist of two, half-sized, units. The distilled water tank will be located close to the turbine building to shorten the makeup and reject piping from the condensate system. The makeup water system processing equipment will be located in the vicinity of the turbine building for convenient access by operating personnel. The alternate water purification processes will require periodic checking by an operator.

The reject water or blowdown water from the RO-DI or vapor compression evaporator will be routed to the cooling tower.

10.0 Instrumentation and Control (refer to Instrumentation and Control Design Criteria D23-24-I)

The product water conductivity, pH, and flow rate will be measured and recorded. Out-of-spec product water will be routed to the circulating water system or the process may be tripped. Makeup water processing equipment trouble will be annunciated in the main control room.

11.0 Access Requirements for Security

Not applicable.

12.0 Reliability

The unit cannot operate without makeup water to the cycle, condensate polisher rinse water, or auxiliary boiler makeup water being available. The availability of makeup water will be enhanced by the sizing of the distilled water storage tank to carry the plant through an extended outage of the raw water processing equipment. A supply of the critical spare parts of the makeup processing equipment should be kept at the site. Two half-sized units will be used for reliability and diversification of output.

13.0 System Reliability Effect on Unit Availability

See paragraph 12.0.

14.0 Examination, Inspection, and Testing

The processing equipment shall be subject to shop inspection during manufacture and a performance test and acceptance by the purchaser's inspector before shipment. All vessels with a design pressure over 15 psig shall be designed, fabricated, tested, and stamped in accordance with the ASME BPVC, Section VIII.

Centrifugal pumps supplied for the Makeup Water System shall, at least, be subject to a shop running test to prove satisfactory mechanical operation. Performance tests shall be at the discretion of the System Engineer.

15.0 Maintenance

Sufficient clearance shall be provided around the equipment to allow convenient and proper maintenance. Consideration shall be given to overhead structures with a clear lifting space for the use of hoisting gear to dismantle pumps or remove heavy covers on vessels, or remove heat exchanger tube bundles.

16.0 Personnel Requirements

This system will require chemical treatment of the water. A plant chemist will be required.

17.0 Shipping

The makeup water processing equipment should be shipped as completely assembled and skid mounted as practical to reduce field erection costs.

18.0 Fire Protection

Vapor compressor evaporators have gear boxes and lubricating oil systems. The "Working Committee" of the PGandE Central Fire Protection Committee shall be consulted in regards to the fire protection to be provided.

19.0 Storage

Certain of the equipment which will be considered in the alternate systems should be stored indoors. They include:

- RO elements
- Control panels and loose instrumentation
- Vapor compression evaporators
- Chemical mixing tanks and pumps
- Chemicals and resins
- Pump and motors, with space heaters energized, unless mounted on a skid that is too large. If outdoors, they should be covered with space heaters on.
- Control valves

20.0 Health and Safety of the Public

The State of California Administrative Code, Title 8, Chapter 4, Subchapter 7, General Industry Safety Orders must be complied with.

If acid or caustic solutions are to be handled, quick acting showers and eye wash fountains shall be provided. Vapor compressors can cause noise problems which must be considered in the installation design.

21.0 Materials and Fabrication

This subject is covered in paragraph 8.

4.10.1 BOILER MAKEUP WATER INSTRUMENTATION AND CONTROL (D23-241)

Engineering
76-370 2/81

DCM No. D23-24-I Revision 0
Date 5-12-83
File No. 74200

PACIFIC GAS AND ELECTRIC COMPANY

DESIGN CRITERIA MEMORANDUM

Structure, System, or Component: BOILER MAKE-UP WATER SYSTEM (I&C)

Prepared by: P.D. MAXWELL / MT PERAKIS MJPerakis Date 5-12-83

Group Leader/Supervisor Review May 12 (Discipline) Date

Reviewed by Interfacing Disciplines:

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30 MW Solar
Boiler Make-Up Water System
Instrumention and Control Design Criteria

Reference:
1. Boiler Make-up Water System - Design Criteria No. D23-21i
2. Master Control System - Design Criteria No. D23-7
3. Instrumentation and Control(I&C) - General Design Criteria No. D23-3

1.0 Scope

This criteria will define the I&C requirements for the boiler make-up water system.

1.1 Mechanical Equipment to be Controlled

1.1.1 Auxiliary Boiler Feed Pumps

1.1.2 Boiler Feedwater Hydrazine Pump

1.1.3 Boiler Feedwater Ammonia Pump

1.1.4 Auxiliary Boiler Feedwater Hydrazine Pump

1.1.5 Auxiliary Boiler Feedwater Ammonia Pump

1.2 Valves to be Controlled

1.2.1 Vacuum Deaerator Level Control Valve

1.3 Vessels to be Controlled

1.3.1 Vapor Compression Evaporators (2) (Includes all associated equipment)

1.3.2 Distilled Water Tank

1.3.3 Vacuum Deaerator

1.3.4 Hydrazine Tank

1.3.5 Ammonia Tank

2.0 Control System Interfaces

None

3.0 Operating Requirements

The boiler make-up water system will be controlled such that it will be fully operational during all expected plant operating conditions, including normal overnight shutdown periods. The system will not be able to operate during plant blackout conditions.

4.0 Mechanical Equipment Control and Protection

4.1 Auxiliary Boiler Feed Pumps

There are 2 "sets" of Auxiliary Boiler Feed Pumps.

Pumps No. 1 and 2 take suction from Feedwater Heater No. 3 and discharge to the Auxiliary Boiler Inlet Header. These pumps are used during the normal morning start-up sequence to take hot, deaerated water from the heater since it has remained hot overnight. The pumps may be started manually or automatically by the Master Control System plant start-up logic.

Pumps No. 3 and 4 take suction from the Vacuum Deaerator and discharge to the Auxiliary Boiler Inlet Header. These pumps are used during a cold start-up sequence when no hot, deaerated water is available from the Feedwater Heater No. 3. These pumps will have manual start/stop through the Master Control System and local switches.

For both sets of pumps, one pump will start and run continuously, while the other pump is on operator selectable automatic standby start.

4.1.1 Control

4.1.1.1 Master Control System

Pump No. 1 Stop/Auto/Start

Pump No. 2 Stop/Auto/Start

4.1.1.2 Dedicated Automatic

Standby Pump Start - pump discharge header low pressure.

4.1.1.3 Local Manual

Pump No. 1 Stop/Auto/Start

Pump No. 2 Stop/Auto/Start

Pump No. 3 Stop/Auto/Start

Pump No. 4 Stop/Auto/Start

Pumps Standby Select (Pump No. 1/Pump No. 2) (Pump No. 3/Pump No. 4) (All Switches Maintained Contacts)

4.1.2 Trips and Interlocks

Pump No. 1 Motor Overcurrent Trip

Pump No. 2 Motor Overcurrent Trip

Pump No. 3 Motor Overcurrent Trip

Pump No. 4 Motor Overcurrent Trip

Continuous recirculation flow to the Vacuum Deaerator or Feedwater Heater No. 3 will provide deadhead protection. No NPSH protection will be provided.

4.1.3 Indication

4.1.3.1 Local

Pumps Discharge Pressure (4)

Pump No. 1 Status (Running/Not Running)

Pump No. 2 Status (Running/Not Running)

Pump No. 3 Status (Running/Not Running)

Pump No. 4 Status (Running/Not Running)

Pumps Incomplete Set-up (any pump switched off)

4.1.3.2 Master Control System

Pump No. 1 Status (Running/Not Running)

Pump No. 2 Status (Running/Not Running)

Pump No. 3 Status (Running/Not Running)

Pump No. 4 Status (Running/Not Running)

4.1.3.3 Test Points

Pumps Suction Pressure (4)

4.1.4 Alarms

4.1.4.1 Local

None

4.1.4.2 Master Control System

Pump No. 1 Motor Overcurrent Trip

Pump No. 2 Motor Overcurrent Trip

Pump No. 3 Motor Overcurrent Trip

Pump No. 4 Motor Overcurrent Trip

4.2 Boiler Feedwater Hydrazine Pump

Under normal operating conditions, the pump will be started manually and run continuously, supplying hydrazine injection to the boiler feedwater. The pump will shut off automatically on shutdown of the BFW pumps. The pump will be part of a vendor supplied chemical system. The following requirements will be met as a minimum.

4.2.1 Control

4.2.1.1 Master Control System

None

4.2.1.2 Dedicated Automatic

Pump Stop - BFW Pump Shutdown

4.3.1.3 Local Manual

Pump Stop/Neutral/Start Switch (Start is spring return to neutral)

4.2.2 Trips and Interlocks

Pump Motor Overcurrent

High pressure relief to a chemical sump will provide deadhead protection. No NPSH protection will be provided.

4.2.3 Indication

4.2.3.1 Local

Pump Discharge Pressure (Vendor Supplied)

Pump Status (Running/Not Running)

Hydrazine Injection Flow Indicator (PGandE Supplied)

4.2.3.2 Master Control System

Pump Status (Running/Not Running)

4.2.4 Alarms

4.2.4.1 Local

None

4.2.4.2 Master Control System

Pump Motor Overcurrent Trip

4.3 Boiler Feedwater Ammonia Pump

Under normal operating conditions, the pump will be started manually and run continuously, supplying ammonia injection to the boiler feedwater. The pump will shut off automatically on BFW pump shutdown. The pump will be part of a vendor supplied chemical system. The following requirements will be met as a minimum.

4.3.1 Control

4.3.1.1 Master Control System

None

4.3.1.2 Dedicated Automatic

Pump Stop - BFW Pump Shutdown

4.3.1.3 Local Manual

Pump Stop/Neutral/Start Switch (Start is spring return to neutral)

4.3.2 Trips and Interlocks

Pump Motor Overcurrent

High pressure relief to a chemical sump will provide deadhead protection. No NPSH protection will be provided.

4.3.3 Indication

4.3.3.1 Local

Pump Discharge Pressure (Vendor Supplied)

Pump Status (Running/Not Running)

Ammonia Injection Flow Indicator (PGandE Supplied)

4.3.3.2 Master Control System

Pump Status (Running/Not Running)

4.3.4 Alarms

4.3.4.1 Local

None

4.3.4.2 Master Control System

Pump Motor Overcurrent Trip

4.4 Auxiliary BFW Hydrazine Pump

Under normal operating conditions, the pump will be started manually and run continuously, supplying hydrazine injection to the auxiliary boiler feedwater. The pump will shut off automatically upon Auxiliary BFW pump shutdown. The pump will be part of a vendor supplied chemical system. The following requirements will be met as a minimum.

4.4.1 Control

4.4.1.1 Master Control System

None

4.4.1.2 Dedicated Automatic

Pump Stop - Auxiliary BFW Pump Shutdown

4.4.1.3 Local Manual

Pump Stop/Neutral/Start Switch (Start is spring return to neutral)

4.4.2 Trips and Interlocks

Pump Motor Overcurrent

High pressure relief to a chemical sump will provide deadhead protection. No NPSH protection will be provided.

4.4.3 Indication

4.4.3.1 Local

Pump Discharge Pressure (Vendor Supplied)

Pump Status (Running/Not Running)

Hydrazine Injection Flow Indicator (PGandE Supplied)

4.4.3.2 Master Control System

Pump Status (Running/Not Running)

4.4.4 Alarms

4.4.4.1 Local

None

4.4.4.2 Master Control System

Pump Motor Overcurrent Trip

4.5 Auxiliary BFW Ammonia Pump

Under normal operating conditions, the pump will be started manually and run continuously, supplying ammonia injection to the auxiliary boiler feedwater. The pump will shut off automatically on Auxiliary BFW pump shutdown. The pump will be part of a vendor supplied chemical system. The following requirements will be met as a minimum.

4.5.1 Control

4.5.1.1 Master Control System

None

4.5.1.2 Dedicated Automatic

Pump Off - Auxiliary BFW Pump Shutdown

4.5.1.3 Local Manual

Pump Stop/Neutral/Start Switch (Start is spring return to neutral)

4.5.2 Trips and Interlocks

Pump Motor Overcurrent

High pressure relief to a chemical sump will provide deadhead protection. No NPSH protection will be provided.

4.5.3 Indication

4.5.3.1 Local

Pump Discharge Pressure (Vendor Supplied)

Pump Status (Running/Not Running)

Ammonia Injection Flow Indicator (PGandE Supplied)

4.5.3.2 Master Control System

Pump Status (Running/Not Running)

4.5.4 Alarms

4.5.4.1 Local

None

4.5.4.2 Master Control System

Pump Motor Overcurrent Trip

5.0 Vessels Control and Protection

5.1 Vapor Compression Evaporators (2) (Vendor Supplied)

Under normal operating conditions, one of two 50 percent capacity evaporators will be manually started to fill the distilled water tank. The evaporator will automatically shut off on tank high level. The other evaporator will be a spare and will be started manually by the operator in case of malfunction or maintenance of the first unit. The evaporators will have requirements of attended start-up, unattended operation, and unattended shutdown.

All equipment protective trips will be local and hardwired. An evaporator will proceed to a safe, automatic shutdown when tripped due to equipment failure. All evaporator control, alarms, and status indication will be provided on a Local Control Panel. Process variable indication will be local to the equipment. The local annunciator will provide a single remote "Evaporator Trip" alarm to the Master Control System.

The evaporators will be two skid mounted, fully contained, vendor supplied units. The evaporators will have sufficient vendor supplied I&C to meet the requirements of this criteria as a minimum. Evaporator equipment to be controlled by the vendor includes the following:

Distillate Pump

Blowdown Pump

Evaporator

Deaerator

Heat Exchangers

Immersion Heater

Vapor Compressor

Control Valves

Chemical Tanks, Pumps

5.1.1 Control (Identical for each unit)

5.1.1.1 Master Control System

None

5.1.1.2 Dedicated Automatic

Automatic control will include, as a minimum, the following:

Deaerator Steam Supply Control

Feedwater Flow Control

Blowdown Flow Control

Evaporator Distillate Level Control

Distillate Flow Control - Valves to automatically route distillate to either the distilled water tank or the cooling tower based on TDS concentration.

Feedwater Chemical Injection

Vapor Compressor

Immersion Heater

5.1.1.3 Local Manual

Local manual control will be provided for, as a minimum, the following:

Distillate Pump

Vapor Compressor

Blowdown Pump

Immersion Heater

Distillate Flow Control Valving

Evaporator Manual/Auto/Start (Start is spring return to auto) - This switch will initiate the automatic start sequence of the unit. The manual position will allow all equipment to be operated manually.

5.1.2 Trips and Interlocks

The following conditions will cause the evaporator unit to proceed to a safe shutdown:

Feedwater Level Low/High

Feedwater Pressure Low

Deaerator Steam Supply Pressure Low

Immersion Heater Water Level Low

Evaporator Shell Pressure High

Evaporator Shell Vacuum

Compressor Bearing Temperature High

Compressor Lube Oil Temperature High

Compressor Lube Oil Pressure Low

Compressor Inlet Temperature High

Compressor Surge

Compressor Vibration High

Other unsafe conditions as specified by the supplier

5.1.3 Indication

5.1.3.1 Local

Evaporator

a) Evaporator Status (Running/Not Running)

b) Evaporator Distillate Level

c) Evaporator Blowdown Level

d) Evaporator Pressure

Distillate Pump

a) Pump Status (Running/Not Running)

b) Pump Discharge Pressure

c) Pump Discharge Temperature

Blowdown Pump

a) Pump Status (Running/Not Running)

b) Pump Discharge Temperature

c) Pump Discharge Pressure

Vapor Compressor

a) Vapor Compressor Status (Running/Not Running)

b) Lube Oil Tank Level

c) Lube Oil Pressure

d) Lube Oil Temperature

e) Bearing Metal Temperature

f) Compressor Suction Pressure

g) Compressor Suction Temperature

h) Compressor Discharge Pressure

i) Compressor Discharge Temperature

Immersion Heater

a) Status (On/Off)

b) Water Level

c) Electric Current Usage

d) Pressure

Other

a) Status of All Control or Recirculation Valves (Open/Closed)

b) Distillate - Blowdown - Feedwater Heat Exchanger Inlet Temperature

c) Distillate - Blowdown - Feedwater Heat Exchanger Outlet Temperature

d) Blowdown Flowrate (Instantaneous and Totalized)

e) Blowdown Outlet Pressure

f) Blowdown Outlet Temperature

g) Distillate Flowrate (Instantaneous and Totalized)

h) Distillate pH

i) Distillate Conductivity

j) Feedwater Inlet Pressure

k) Feedwater Inlet Temperature

l) Chemical Feed Rate

m) Control Air Pressure

n) Deaerator Steam Supply Pressure

5.1.3.2 Master Control System

Evaporator No. 1 Status (Running/Not Running)

Evaporator No. 2 Status (Running/Not Running)

5.1.4 Recording

5.1.4.1 Local

Distillate Flowrate

Distillate pH

Distillate Conductivity

Feedwater Flowrate

Blowdown Flowrate

5.1.4.2 Master Control System

None

5.1.5 Alarms

5.1.5.1 Local

Distillate Conductivity High

Distillate pH High

Feedwater Level Low/High Trip

Feedwater Pressure Low Trip

Deaerator Steam Supply Pressure Low

Immersion Heater Water Level Low Trip

Evaporator Shell Pressure High Trip

Evaporator Shell Vacuum Trip

Compressor Bearing Temperature High Trip

Compressor Lube Oil Temperature High Trip

Compressor Lube Oil Pressure Low Trip

Compressor Inlet Temperature High Trip

Compressor Surge Trip

Compressor Vibration Trip

5.1.5.2 Master Control System

Evaporators Trouble Alarm

All of the above local alarms will be paralleled into a single "Evaporators Trouble" alarm in the master control system.

5.2 Distilled Water Tank

The tank receives distillate from the evaporators and supplies water to the auxiliary boilers, condenser hotwell (make-up), and other plant systems. It is expected that the tank volume will be large, and fast level fluctuations are not anticipated.

5.2.1 Control

5.2.1.1 Master Control System

None

5.2.1.2 Dedicated Automatic

Tank level will be maintained by cycling of the evaporators (see Section 5.1).

5.2.1.3 Local

None

5.2.2 Trips and Interlocks

None

5.2.3 Indication

5.2.3.1 Local

Tank Level

5.2.3.2 Master Control System

Tank Level

5.2.4 Alarms

5.2.4.1 Local

None

5.2.4.2 Master Control System

Distilled Water Tank Level High/Low (generated from analog signal)

5.3 Vacuum Deaerator

The deaerator serves to remove entrapped air from the auxiliary boiler feedwater before it reaches the auxiliary boiler feed pumps nos. 3 and 4.

5.3.1 Control

5.3.1.1 Master Control System

None

5.3.1.2 Dedicated Automatic

Deaerator Level (see Section 5.3.3)

5.3.1.3 Local Manual

None

5.3.2 Trips and Interlocks

None

5.3.3 Control Valves

5.3.3.1 Vacuum Deaerator Level Control Valve

The valve is located on the inlet from the distilled water tank to the deaerator. The valve will operate as follows:

Tank Level High - Valve Closing

Tank Level Low - Valve Opening

The valve will have:

a) no interlock - tank level will be the controlling variable

b) air to close/fail open operation, with a pneumatic actuator and positioner

c) modulating control, through a local dedicated equipment - the controller will be mounted near the tank

d) no bypass - maintenance work on the valve will prevent operation of the two feed pumps

5.3.4 Indication

5.3.4.1 Local

Deaerator Pressure

Deaerator Level

5.3.4.2 Master Control System

None

5.3.5 Alarms

5.3.5.1 Local

None

5.3.5.2 Master Control System

None

5.4 Hydrazine Tank

The tank serves as the hydrazine mixing and storage tank for the Auxiliary BFW hydrazine feed pump and the primary BFW ammonia feed pump. The tank will be part of a vendor supplied chemical system. The following requirements will be met as a minimum.

5.4.1 Control

None

5.4.2 Trips and Interlocks

None

5.4.3 Indication

5.4.3.1 Local

Hydrazine Tank Level

5.4.3.2 Master Control System

None

5.4.4 Alarms

None

5.5 Ammonia Tank

The tank serves as the ammonia mixing and storage tank for the Auxiliary BFW ammonia feed pump and the primary BFW ammonia feed pump. The tank will be part of a vendor supplied chemical system. The following requirements will be met as a minimum.

5.5.1 Control

None

5.5.2 Trips and Interlocks

None

5.5.3 Indication

5.5.3.1 Local

Ammonia Tank Level

5.5.3.2 Master Control System

None

5.5.4 Alarms

None

6.0 **Miscellaneous I&C**

6.1 Miscellaneous Indication

6.1.1 Local

Auxiliary Boiler Feedwater Pressure (2)

Auxiliary Boiler Feedwater Flow (2)

6.1.2 Master Control System

None

4.11 STEP-UP TRANSFORMER AND HIGH VOLTAGE SWITCHYARD

(D23-8)

Engineering
76-370 2/81

DCM No. D23-8 Revision 0
Date April 20 ,1983
File No. 51000

PACIFIC GAS AND ELECTRIC COMPANY

DESIGN CRITERIA MEMORANDUM

Structure, System, or Component: Step-Up Transformer & High Voltage Switchyard 30 MW Solar Project - Carrisa Plains

Prepared by: K. K. Williams K K Williams Date 4-20-83

Group Leader/Supervisor Review KGZ/ADS EE (Discipline) Date 4-25-83

Reviewed by Interfacing Disciplines:

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Group Leader/Supervisor J. B. Gegan JBGegan Date 4-29-83

Group Leader/Supervisor M. T. Perakis MTPerakis Date 5-9-83

Approved by:

Department Chief: JWC/JRH Date: 5/18/83

Approved for Project use:

Project Engineer: R. E. Price REPrice Date: 5-19-83

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STEP-UP TRANSFORMER & HIGH VOLTAGE SWITCHYARD
30 MW SOLAR PROJECT - CARRISA PLAINS

1.0 CRITERIA SUMMARY AND SCOPE

A means of connecting the 30 MW solar project to the transmission system at Carrisa Plains is accomplished by the high voltage switchyard. The following design criteria is intended to provide the necessary data, guidelines, standards, and other fixed values relating to the design and interface of the switchyard to the plant and transmission system.

2.0 BASIC FUNCTION

The step-up transformer and high voltage switchyard will provide the electrical connection between the generator, transmission line, and auxiliary power equipment. Power will be generated at 12 KV and then transformed by the step-up transformer to a transmission voltage of 115 KV. The auxiliary power equipment may be operated by power generated by the plant or by power fed through the step-up transformer from the transmission line.

Arrangement of the switchyard equipment will be:

2.1 The step-up transformer will be connected to a short section of aluminum tubing bus from the generator breaker disconnect switch.

2.2 A tap on the 12 KV bus between the low voltage terminals of the transformer and the generator breaker disconnect switch will serve the auxiliary power transformers.

2.3 Open aluminum tubing will lead from the high voltage terminals of the transformer to the transmission line circuit breaker.

2.4 Instrumentation for measuring transmission line voltage and metering line current will be provided on the bus leading to the transmission line dead-end structure. Provisions for metering MVAR's, MW, and KWH will also be made.

2.5 An air break disconnect switch will be provided on the transmission line dead-end structure to separate the line from the high voltage switchyard.

3.0 RATINGS AND DESIGN CONDITIONS

3.1 The step-up transformer will be sized to match the rating of the generator less the power requirements of the auxiliary power equipment. The rating of the transformer will not limit the full power output of the generator. As a three-phase, 60 Hz unit, the transformer will step-up the generated 12 KV delta voltage to 115 KV grounded wye. The high voltage winding will have a minimum BIL of 550 KV and a minimum low voltage BIL of 110 KV. A self cooled (OA) rating and one or two stages of forced cooling will accommodate 10% loading overnight and full loading during plant operation. A temperature rise of 65°C over ambient will be allowed. The transformer will be protected from lightning surges by lightning arrestors.

3.2 All equipment in the high voltage switchyard will withstand the maximum expected available momentary fault current when exposed to maximum fault conditions. The transmission line breaker will be capable of interrupting the maximum short circuit current available during fault conditions. Calculation of the maximum fault current will be based on a system short circuit rating of 723 MVA. Contributions to the fault current from the generator and additional current from motors included as auxiliary power equipment must also be considered. Buses and switches will be designed to meet the continuous rating of the generator and any fault condition that may occur.

3.3 Equipment in the switchyard will be arranged to readily allow access for maintenance or replacement. Spare transformers, breakers, or buses will not be provided for back-up service.

3.4 Facilities in the high voltage switchyard will be designed for outdoor operation. Temperature ratings will be based on a minimum temperature of -10°F and a maximum temperature of 110°F. Effects of the plant altitude of 2000 ft. will also be considered when rating equipment. Enclosures in the switchyard will be dust and rain proof. Because of cooling towers, the outdoor electric equipment will be subject to contamination. Adding insulation, provisions for washing, and greasing insulators will be studied as solutions to the contamination problem.

3.5 All important components, foundations, anchorages, and structures of the high voltage switchyard will be designed to withstand the effect of an earthquake. Seismic analysis and requirements will meet the Civil Engineering seismic criteria.

4.0 INSTRUMENTATION AND CONTROL

4.1 The step-up transformer will be protected with differential current relays, phase and ground relays, sudden pressure relays, and gas analyzers. AC and DC control voltages will be provided for the operation of protection equipment.

4.2 Revenue metering instrumentation will be provided to meter the power being supplied to the transmission system.

5.0 CODES AND STANDARDS

The latest revisions of the following standards are applicable in the design and selection of switchyard equipment:

ANSI	C29	Insulators
ANSI	C37	Power Circuit Breakers and Air Switches
ANSI	C39	Instrumentation and Control
ANSI	C57	Transformers and Regulators
ANSI	C62	Lightning Arrestors

6.0 REGULATIONS

6.1 The constructed switchyard will meet the requirements of the California Public Utilities Commission, General Order No. 95.

6.2 All applicable Occupational and Health Administration (OSHA) directives will be followed.

7.0 INTERFACE REQUIREMENTS

The high voltage switchyard will interface with:

7.1 Lighting System

7.2 Grounding Grid

7.3 Generator and Generator Bus

7.4 115 KV Transmission Line

7.5 Auxiliary Power Equipment

7.6 Instrumentation and Control

4.12 STATION GROUND SYSTEM
(D23-9)

Engineering
76-370 2/81

DCM No. D23-9 Revision 1
Date May 4, 1983
File No. D23-65101

PACIFIC GAS AND ELECTRIC COMPANY

GENERAL

DESIGN CRITERIA MEMORANDUM

Structure, System, or Component: Station Ground System (30 MW Solar Thermal P.P.)

Prepared by: D. M. White/E. W. Levijoki EWL Date Dec. 10, 1982

Group Leader/Supervisor Review KGZ KGZabaroff EE (Discipline) Date 1-5-82

Reviewed by Interfacing Disciplines:

Group Leader/Supervisor JBG JBGegan Date 1-10-83

Group Leader/Supervisor ABS ABS Date 1-12-'83

Group Leader/Supervisor MTP MTPerakis Date 4-28-83

Approved by:

Department Chief: JWC J W Colwell Date: 5/4/83

Approved for Project use:

Project Engineer: REP REPrice Date: May 17, 1983

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STATION GROUND SYSTEM

SUMMARY:

The station ground system is used to:

1. Provide a low-impedance ground fault current return path.
2. Maintain safe step and touch voltages across the station area and within the station structures during electrical transients.
3. Minimize the effects of lightning surges on equipment and structures.
4. Minimize arcing and unnecessary electrical noise related to power system operation.

SEISMIC:

None.

REGULATORY REQUIREMENTS:

All applicable OSHA requirements will be complied with, including CAL/DOSH applicable directives.

CODES AND STANDARDS:

Standards applying to station ground systems are listed in Appendix I.

DESIGN CRITERIA:

IEEE Standard No. 80 is the guide for this criteria.

1. Ground grid design is based on maximum ground fault current available at station for 0.38 second (23 cycles) clearing time.
2. Ground system resistance is 1 ohm or less--if practical.
3. The ground grid consists of stranded bare copper cable. Equipment and structure connection can be either exothermic or bolted.
4. Power plant equipment is connected to the ground system in accordance with ANSI C2 (NEC Section 250), IEEE Stds. 32, 80, 141 & 142.
5. Lightning protection is provided as necessary for structures and equipment. This protection is connected solidly to the station ground system. Lightning protection has not been considered for the collector field.

DESIGN CRITERIA: (Continued)

6. **Property fence is grounded, if possible, independently of station ground system,** and at least 8 feet outside the station ground and away from other equipment. If the property fence is connected to the station ground system, the perimeter grid must extend a minimum of 8 feet outside the fence.

OPERATING AND ENVIRONMENTAL:

The station ground system is in operation at all times. Any detected break must be repaired as soon as possible to maintain ground system integrity.

The ground system must be able to operate in the local environment.

INTERFACES:

The station ground system interfaces with the following systems:

High Voltage Switchyard

Lighting

Conduit and Raceways

Station Auxiliary Power

Instrument and Control

Step-up Transformers

Transmission

Wire and Cable

Civil Engineering

APPENDIX I

APPLICABLE STANDARDS

The following list of standards is general and may be applicable. If these standards are used in reference, they must be identified by number, title, and paragraph(s).

ANSI

C 2	National Electrical Safety Code

IEEE

1	Temperature Limits
32	Neutral Grounding Devices
80	Substation Grounding
141	Electrical Distribution for Industrial Plant
142	Grounding of Industrial Systems

ISA

S5.1	Instrumentation Symbols and Identification

5.0 MASTER CONTROL SYSTEM
(D23-7)

76-370 2/81

DCM No. D23-7 Revision 0
Date MARCH 21, 1983
File No. D23-01700

PACIFIC GAS AND ELECTRIC COMPANY
CARRIZO PLAINS
30 MW SOLAR PLANT
DESIGN CRITERIA MEMORANDUM

Structure, System, or Component: MASTER CONTROL SYSTEM

Prepared by: G.R. VEERKAMP Gary Veerkamp Date 3-21-83

Group Leader/Supervisor Review MTP JBG SFA M+NE (Discipline) Date
AFA, MTP

Reviewed by Interfacing Disciplines:

Group Leader/Supervisor AB SCHUURMAN Date 3-28-83

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DCM NO: D23-7
REVISION NO: 0
DATE: 4-27-83

Master Control System
Design Criteria
30 MW Solar Plant

Reference Documents

DCM-D23-1, Plant Design Criteria
DCM-D23-3, General Design Criteria Instrument and Control
"Design Specification," Rockwell International ESG, 1/6/83

1.0 **Scope**

1.1 General

This document defines the design requirements of the Master Control System for the Carrizo Plains Solar Power Plant. Included in this system are all elements required to provide:

1.1.1 An integrated operator interface to all plant systems requiring remote display/control capability.

1.1.2 Control of all plant systems that require remote operation, adjustment, and/or coordination with other systems.

1.1.3 Interface with the Collector and Heat Transport subsystems.

1.1.4 Access to necessary I/O for display, recording, logging, etc.

1.1.5 Communication capability to a remote data gathering site.

Specific system requirements as they relate to the Master Control System are listed in each system's I&C design criteria. Plant protective requirements are listed in DCM No. D23-3.

1.2 Code Requirements

There are no directly applicable code requirements.

2.0 **Control Interfaces**

2.1 Collector System

Interface requirements are limited to necessary communications and coordination with the Collector System. Physical interface will be with the heliostat array controller.

2.2 Heat Transport System

Interface will be via redundant communication links to Rockwell's HTS Control System, with necessary data interchange to provide coordination between the HTS, EPGS, and the Collector System. Addition HTS interface will be via HTS status inputs terminated at the MCS. Input quantity are TBD by Rockwell.

A common hardware supplier shall be selected for supply of both the MCS and the HTS Control System. Control room operator interface to the HTS will be via the MCS.

2.3 EPGS Systems

Interface with the EPGS System other than for I/O of various subsystems terminated to the MCS will include:

2.3.1 Turbine load controller. Speed/load raise/lower and rate and turbine speed/load hold capability shall be provided via this interface. Design of this interface shall provide that, on its loss, speed/load setpoint will fail as is.

2.3.2 Capability for communication and data transfer with a remote data analysis location. Microwave and/or voice grade link interface capability shall be provided. Link requirements are listed in section 4.2.4.

3.0 Functional Requirements

The Master Control System shall be computer/microcomputer based, independent of plant hardwired protective and display systems, with sufficient capability to:

3.1 Provide a CRT-based operator interface integrating equipment/loop access/control, data display, system mimics, and discrete point annunciation in a concentrated manner. This interface shall include/support:

3.1.1 Plant control room operator interface. This interface will provide system/device status indication and will provide the means for initiation of system/device starts/stops, valve open/close, overall plant startup/shutdown, and control loop auto/manual interaction.

Access speed to operating equipment is a primary design requirement. Response criteria are listed in section 4.2.3.

3.1.2 Display of plant operating data. Operating data displayed shall include all contact and analog input values with associated alarm/over-underrange indication, control loop setpoints, control valve demands (and position feedback as required), motor status (on/off/tripped), and valve status (open/closed/midposition).

3.1.3 Graphic presentation of plant systems controlled/coordinated by the Master Control System and selected critical system components/subsystems. Graphics shall include update features described in section 3.1(b) (e.g., on/off or open/closed, alarm indication, etc.).

3.1.4 Alarming of selectable analog and contact inputs. Alarm limits shall be adjustable by the operator.

3.1.5 Trending and logging of analog and contact inputs. Trend and log point assignment shall be operator selectable. Trend printout shall be, at the operator's selection, either at a CRT or a hardcopy device.

3.1.6 Hardcopy printout of logs, trends, sequence of events points, and all point alarms.

3.1.7 Addressable indicators and recorders. Point assignment shall be via the CRTs.

3.2 Monitor the status of plant systems controlled/coordinated by the Master Control System. Status shall include overall system on/off indication, along with key operating parameters and their alarm status.

3.3 Provide automatic, coordinated control, and control mode changes for those plant systems under the coordination of the Master Control System. This shall include calculations required to coordinate turbine loading so as to maximize daily generation.

3.4 Provide automatic loop control. Loop control algorithms may be implemented either in a central processor and/or in distributed microprocessor-based controllers.

3.5 Provide sequence of events (SOE) logging for a selected quantity of contact inputs. SOE resolution shall be a minimum of sixteen milliseconds.

3.6 When no sequencing or remote control is required, certain systems may be controlled locally. However, indication and alarming of required operating parameters shall be provided at the control room operator interface.

3.7 Master Control System design shall meet single failure criteria. This requires that system functions supporting plant control, along with the operator interface, be unaffected by the loss of any one component used in support of that function. This design shall be adequate to produce a system with an overall availability of at least 99.9%, with a mean time to repair of no more than eight hours.

I/O critical to plant control shall be evaluated for redundancy requirements. Redundant I/O channels shall be provided as needed.

3.8 To enhance overall availability, self-diagnosis of hardware problems shall be a design requirement. Indication of faults to the card level shall be provided. This indication may be provided at the remote operator interface or at the device. To the maximum extent possible, repair shall be performed with the system operational.

3.9 Design philosophy shall be that, on Master Control System "failure," the Plant Protective System shall automatically initiate a plant shutdown, with all pumps and valves reverting to their fail-safe state. "Failures" that initiate a plant shutdown shall consist of:

3.9.1 Total loss of the remote operator interface.

3.9.2 Loss of any distributed element necessary for either safe operation or whose loss compromises the ability for a safe shutdown.

3.9.3 Loss of any central computer function required for the support of 3.9.1-2.

4.0 Specific Requirements

4.1 Software

All control-level programming shall be developed in a top down, structured fashion, using a higher level language producing run-time object code. Operating system modules and handlers shall, to the extent possible, follow this requirement, with the exception that they may be assembly language programmed.

With the exception of control loops, all control software shall run at a frequency no less than once per second. Control loops shall run at a frequency appropriate for their loop dynamics, with the provision that all may run at a frequency of at least twice a second and still maintain processor loading requirements of section 4.2.2. Software supporting communications to the remote data analysis location, and all miscellaneous logging and trending programs, may run at any frequency appropriate for the timely servicing of these functions, with the restriction that data transfer to the remote site shall be of low priority, and may be temporarily interrupted during a major plant transient.

Documentation (flow charts and written descriptions) shall be provided of a quality that permits full source code development. While not needed for undertanding of program functioning, well commented source code of all modules, both operating system and control level, shall be required.

4.2 System Capacity and Capability

4.2.1 I/O

System I/O capacity shall be sized for the combined requirements of the EPGS system and those listed in the Rockwell "Design Specification," Appendix A-11, with an additional 35 percent of the above total included for future requirements. I/O termination cabinets separate from system electronics cabinets shall be provided for termination of field wiring.

The system shall have the flexibility to add on additional I/O hardware if required and be designed to provide either redundancy of function or single loop integrity or both if required for loops critical to plant operation.

4.2.2 Processors

The central processors shall be designed to allow operation of all I/O, communication, control, display, and system software in real time, while maintaining an average machine loading of no more than 50 percent. Design shall preclude the use of rotating bulk devices for on-line control software and control data storage. Static bulk devices, however, may be used. Rotating bulk devices may be used where their functioning is not critical to normal plant operation (e.g., historical data storage, program generation, etc.).

Sufficient communication channels shall be provided to handle all required peripherals and I/O, plus the capability for an additional 100 percent increment should future conditions warrant.

4.2.3 Operator Interface

Operator interface shall be CRT based. For all control and alarm acknowledge functions, system response time shall not exceed 0.5 seconds per keystroke. Response time for noncontrol functions (trending, graphic displays, alarm limit changes, etc.) shall not exceed two seconds.

User-assignable dedicated function pushbuttons shall be available for assignment, if needed, to initiate predefined actions for certain devices (e.g., "Start Condensate Pump No. 1"). In no event shall more than three keystrokes be required to control a device.

All keyboard pushbuttons used for modulating control shall have an apparant response equivalent to that of a hardwired analog control station. Modulation shall begin when the button is depressed and terminate and when the button is released. Dual speed buttons for fast and slow modulation shall be provided. Similarly, all keyboard buttons used for on/off control shall have the apparent response of a hardwired system.

All control room functions shall meet single failure criteria. To enhance availability, all CRT functions shall be assignable to any CRT.

4.2.4 Offsite Communications

Provisions for a nonredundant, slow speed, offsite communications link shall be included. Maximum required transfer rate is 9600 BAUD.

Link interface shall be EIA R2-232. Communications availability, while not critical, should be greater than 80 percent.

4.2.5 Programmers Station

An off-line programmers station shall be provided separate from the operator interface. All source code generation, compiling, linking, loading, listing, and testing shall be performed here. In addition, all noncontrol related displays (trends, graphics, etc.) shall be presentable at this station.

4.3 Noise

Noise immunity shall be a prime design requirement. All analog I/O shall provide, as a minimum, 140 dBA common mode noise rejection and 60 dBA normal mode rejection at 1000 ohm input impedance.

All I/O shall be provided with some form of isolation from the field (e.g., optical, transformer, etc.). This design shall be sufficient to prevent damage to or false operation of the Master Control System when the I/O field interface hardware is subjected to the IEEE SWC test wave per ANSI C37.90a-1974.

Communications links shall provide point to point isolation and be designed for automatic error detection/correction using CRC codes or equivalent schemes.

4.4 Grounding

Grounding of the system shall be such as to minimize induced noise. No plant equipment ground leads shall be tied to Master Control System grounds.

4.5 Power

Power to all Master Control System components shall be uninterruptible, regulated, and filtered. Filtering shall be sufficient to meet computer/peripheral/IO noise requirements. Power feeds to the regulating/filtering equipment shall be from a redundantly fed bus, with capability for automatic transfer to a standby source on UPS failure. Standby source shall feed the filter and shall itself be provided with, as a minimum, voltage regulation sufficient for system requirements.

4.6 Environment

All control room/computer room equipment shall be provided with a clean, dry, air-conditioned environment. Redundant, full size air conditioners shall be provided.

Remote electronics shall be housed in waterproof enclosures. Clean, dry, filtered purge air shall be provided of a quantity sufficient for the heat removal requirements of the electronics.

No Master Control System components shall be directly exposed to plant environment. All components, including rack backplains shall, however, be conformally coated or sprayed to increase their resistance to any possible environmental damage.

Packaging, shipping, handling, and any temporary on-site storage shall be in accordance with ANSI N45.2.2, Appendix A.3. Control panels shall be level B as a minimum.

4.7 System Security

4.7.1 Mechanical

All system components shall be housed in lockable structures. This includes all remote electronics enclosures, processor cabinets, and UPS cabinetry.

4.7.2 Fire Protection

Insulation on all external cables between cabinets, and to peripherals, shall be flame retardant and self-extinguishing. Cabinet interiors shall be coated with UL listed flame retardant paint having a class A rating.

Halon 1301 fire extinguishers shall be provided at all plant locations containing Master Control System hardware, with sufficient capacity to protect system hardware against small-scale electrical fires. Automatic detection equipment shall be provided in the computer room, with annunciation separate from the Master Control System provided in the remote control room.

4.7.3 Communications

Redundant communication cables between processors and remote I/O are required. Physical routing separation of these cables shall be provided. Likewise, communications cables to operator interface devices shall be physically distributed among multiple conduits to reduce the possibility of total loss of the interface due to accidental damage. Separation shall be a minimum of 2 feet between I/O cables and 2 feet between any two adjacent operator interface cables.

4.7.4 Structural Requirements

All system structures (processor cabinets, I/O racks, etc.) shall be rigid and self-supporting, constructed and braced in such a fashion so as to prevent warpage and maintain the integrity of the electronics during shipment and installation.

Seismic criteria shall be developed for all plant locations containing Master Control System hardware. All components shall be designed (including housing attachment points to floors, control boards, etc.) and installed such that, when subjected to the seismic loading, their housings, and any internal racks remain undamaged. The Master Control System need not operate through and immediately after the seismic event. Cabinet design, however, shall provide reasonable protection against "significant" damage to internal electronics. "Significant" damage shall be correctable by replacing, at most, two of each basic system component (unique card types, power suppliers, etc.).

4.7.5 Alarms

As a minimum, each remote Master Control System electronics cabinet shall be provided with a temperature element for input to the system. An additional computer room temperature input shall be provided. All temperatures shall be displayed, and alarmed when high, at the remote operator interface.

6.0 BALANCE-OF-PLANT, CIVIL, AND ARCHITECTURAL (D23-2)

DCM No. D23-2 **Revision** 0
Date March 8, 1983
File No.

PACIFIC GAS AND ELECTRIC COMPANY

ENGINEERING DEPARTMENT
DESIGN CRITERIA MEMORANDUM

Structure, System, or Component: Solar Power Plant, Civil And Architectural
Prepared by: C. F. Allen CFAllen TK 3/4 **Date** 3/9/83
Group Leader/Supervisor Review E. P. Wollak , CE EPWollak **Date** 3/11/83
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Group Leader/Supervisor M. T. Perakis MTPerakis **Date** 3-30-83

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CIVIL AND ARCHITECTURAL DESIGN CRITERIA

SOLAR 30 MW POWER PLANT PROJECT

CIVIL DESIGN CRITERIA AND GUIDELINES FOR 30 MW SOLAR POWER PLANT

INTRODUCTION

This document provides design criteria for site and structures for the Carrizo Plain 30 MW Solar Project. General Civil Criteria are contained in Sections 1 through 4, where more specific design information is provided in the following sections. For overall project design criteria refer to DCM D23-1.

CIVIL DESIGN CRITERIA FOR SOLAR 30 MW PROJECT

INDEX

SECTION

APPENDICES

CIVIL DESIGN CRITERIA AND GUIDELINES FOR 30 MW SOLAR POWER PLANT

1 CODES AND STANDARDS

All design work shall comply with the following codes and standards. In the event of conflict between the codes and standards, or any other criteria contained in this document, the more stringent shall govern unless specifically stated otherwise.

1.1 GENERAL:

1.1.1 Uniform Building Code and Uniform Building Code Standards, 1982 Edition.

1.1.2 American National Standard Building Code Requirements for Minimum Design Loads in Building and Other Structures, ANSI A58.1 - 1972.

1.1.3 Occupational Safety and Health Act, 1970.

1.1.4 San Luis Obispo County Zoning Code.

1.1.5 National Fire Protection Association, No. 72A.

1.1.6 California Building Standards Title 24; Division 5, 6, 7.

1.1.7 For Electrical and Mechanical Codes and Standards refer to Project Design Criteria, DCM D23-1.

1.2 CONCRETE:

1.2.1 Building code Requirements for Reinforced Concrete, ACI-318-77.

1.2.2 Building Code Requirements for Structural Plain Concrete, ACI-322-72.

1.2.3 Recommended Practice for Shotcreting, ACI-506-66.

1.3 STRUCTURAL AND MISCELLANEOUS STEEL:

1.3.1 American Institute of Steel Construction (AISC) - Manual of Steel Construction, Eighth Edition, 1980.

1.3.2 AISC Specification for Structural Joints using ASTM A325 and A490 Bolts, August 1980.

1.3.3 American Iron and Steel Institute Specification for the Design of Light Gage Cold-Formed Steel Structural Members, 1980.

1.3.4 PGandE Engineering Standard Concrete Expansion Anchors for Static and Seismic Loading, Drawing #054162, Rev. 3. (See Appendix C)

1.4 WELDING:

1.4.1 American Welding Society Structural Welding Code, AWS D1.1-82.

1.4.2 American Welding Society Reinforcing Steel Welding Code, AWS 12.1-75.

1.5 TIMBER:

1.5.1 National Design Specification for Stress-Grade Lumber and its Fastenings, 1971.

1.6 ROADWORK AND PAVING:

1.6.1 American Association of State Highway Officials Standard Specifications for Highway Bridges - 11th Edition 1973.

1.6.2 State of California Standard Specifications, January 1978.

1.7 PILE FOUNDATIONS:

1.8.1 Section 49.f, State of California Standard Specification, 1978.

2 MATERIALS

2.1 CONCRETE:

2.1.1 Reinforced Concrete shall develop a f'c $\geq$ 3000 psi in 28 days.

2.1.2 Plain Concrete shall develop a f'c $\geq$ 3000 psi in 28 days.

2.1.3 Shotcrete shall develop a f'c $\geq$ 3000 psi.

2.1.4 Masonry:

2.1.4.1 Hollow Block-Grade N (grouted solid) f'm = 1500 psi.

2.1.4.2 Grout - Minimum Compressive Strength = 2000 psi in 28 days.

2.1.4.3 Mortar - Type S, Minimum Compressive Strength = 1800 psi in 28 days.

2.2 REINFORCING:

2.2.1 Reinforcing Bars shall be ASTM A615 Grade 60. Sizes shall be confined to #4, #6, #8, #9 & #11. Sizes #10 & #14 may be used in special cases. Typical bar spacing in slabs shall not be less than 12" o.c. Where local slab stresses require heavier reinforcing, bars may be added provided that the resulting bar spacing is not less than 4" o.c.

2.2.2 Welded Wire Fabric shall conform to ASTM A185 using wire meeting ASTM A82. Preferably only one size shall be used throughout the job.

2.2.3 Mechanical Splices - Acceptable proprietary couplings are Fox-Howlett, Dywidag and Cadweld. However, if splicing is needed in the Turbine Generator Pedestal, use only Cadweld T-series for minimum ultimate strength of material.

2.2.4 Welded Splices - Use only the direct butt weld splice as defined by The American Welding Society AWS D12.1-75 Reinforcing Steel Welding code. However, in the Turbine Generator Pedestal the welded splice is not an acceptable alternative to the Cadweld T-series splice.

2.3 STRUCTURAL STEEL:

2.3.1 Plates and Structural Shapes - Framing.

2.3.1.1 Typical framing shall be ASTM A36 hot dip galvanized, unless specified otherwise.

2.3.1.2 Receiver tower shall be ASTM A572-50 hot dip galvanized.

2.3.1.3 Framing in contact with steam condensate shall be stainless steel ASTM A276, Type 304.

2.3.1.4 Framing at the circulating water pump pit shall be ASTM A36, hot dip galvanized.

2.3.2 Embedded Metal

2.3.2.1 Plates or shapes used as anchor plates and to which equipment, brackets, or dowels will be welded shall be ASTM A36.

2.3.2.2 Plates or shapes which are used as protective edging or support for checkered plate or grating shall be A36, hot dip galvanized after fabrication.

2.3.2.3 Anchor Bolts shall be ASTM A307 except when special bolts are called for by equipment manufacturers.

2.3.2.4 Anchor bolts exposed to weather shall be A307, hot dip galvanized at the top for a distance equal to at least the projection plus 2 inches. Nuts and washers shall also be galvanized.

2.3.2.5 Anchor bolts and nuts in contact with steam condensate shall be Stainless Steel ASTM A276, Type 304.

2.3.3 Connection Bolts

2.3.3.1 All field connections shall be bolted joints using ASTM A325 bearing type bolts (no threads in shear plane). Only one size bolt shall be used throughout the job. However, the responsible engineer may authorize use of larger bolts in specialized connections.

2.3.3.2 Use stainless steel bolts equivalent to A325 bolts when connecting stainless steel members.

2.3.3.3 Use mechanically galvanized A325 bolts when connecting galvanized framing. Galvanizing of bolts shall be in conformance with ASTM B454-76.

2.3.4 Concrete expansion anchors shall meet requirements of Table A, and note (a) of PG&E Standard Drawing 054162, Revision 3, (See Appendix C).

2.3.5 Welded studs shall comply with AWS D1.1-82, Section 4, Part F. Stainless steel studs shall be used on stainless steel members.

2.3.6 Folded metal decking shall be H. H. Robertson Decking, or equivalent, as approved by responsible engineer, capable of use as a diaphragm in carrying lateral loading.

2.3.7 Floor plates shall be galvanized skid resistant raised pattern plate, commonly called checkered plate, made of A36 steel not less than 1/4 inch thick.

2.3.8 Grating shall be galvanized welded steel with rectangular steel bars 1-1/4" x 3/16" spaced 1-3/16" o.c. Allowable stress 18000 psi. Clear span determined by loading, but not to exceed 4'-6".

2.4 TIMBER:

2.4.1 Structural Use: (a) California Redwood Clear Heart structural grade treated in accordance with CTI Bulletin WMS-112 or AWPA Standard C2 or (b) Douglas Fir Dense Select Structural Grade treated in accordance with CTI Bulletin STD-114.

2.4.2 Other Use: (a) California Redwood Select Structural Code treated as above or (b) Douglas Fir grade treated as above.

2.5 PIPE:

2.5.1 Structural Steel Pipe shall be ASTM A-53 hot dip galvanized.

2.5.2 Exterior Circulating Water Piping shall be Filament-Wound Reinforced Thermosetting Resin.

2.5.3 Exterior Water Supply Piping shall be PVC or FRP with mechanical joints. Cemented joints are not allowed.

2.6 PAVING:

2.6.1 Paved roads shall have 2 inches of asphalt concrete.

2.6.2 Paved parking areas shall be 2 inches of asphalt concrete.

2.7 BEARINGS:

2.7.1 Low friction bearings shall be fluorgold or lubrite slide or approved equivalent.

2.7.2 Vibration reducing bearings shall be Fabreeka or engineer approved equivalent.

2.8 WATER SEALS:

2.8.1 Water stops for construction joints shall be PVC Double Bulb type not less than 6 inches wide.

3 SOIL CONDITIONS

3.1 GENERAL:

The following geological information is based upon two test bores drilled on the Carrizo Plains Substation in the N.W. corner of Section 28. For log bores and test results refer to Appendix A.

The general site geological formation is a recent alluvium (Qal) consisting of unconsolidated stream and river channel deposits. The soil classification is CH, inorganic clays with high plasticity, in the Unified Soil Classification System. Interbedded with the clays are some thin layers of sand.

The first 10 feet has an average blow count of approximately 100 blow/ft. The material between 10 to 60 feet is somewhat softer, wetter and finer and has a blow count range from 34 to 39 blows/ft. The groundwater level is at a depth of 50 to 60 feet.

3.2 SHALLOW SPREAD FOUNDATIONS:

Spread foundations shall be placed on native soil after vegetation and top soil has been removed. Subgrade shall compacted to a minimum relative density of 95% of maximum density. Soft material in the original ground shall be removed and replaced with suitable, compactable material. Backfill shall be placed in layers not to exceed 8 inch lifts.

3.2.1 A maximum allowable bearing pressure of 3000 psf shall be used for the design of dead plus live loads. This value may be increased by one-third for temporary loadings such as seismic or wind.

3.2.2 An angle of internal friction of 32° shall be used in design.

3.3 PILE FOUNDATIONS

All pile driving shall meet the requirements of Section 49 of the State of California Standard Specifications, 1978. The piles used shall be precast concrete, designed as friction type, of the following sizes:

10-inch square (50 tons)
12-inch square (70 tons)

3.3.1 The <u>ultimate</u> load capacity of the piles shall be determined by the following formulas:

(Bearing) $P_{ult} = CN_{cs}A_p + C_aLP$

(Pullout) $T_{ult} = C_aLP$

where: C = 750 psf (Cohesion)
C_a = 600 psf (Adhesion)
N_{cs} = 9 (Bearing Capacity Factor)
A_p = Cross-Sectional Area of Pile (ft^2)
P = Pile Perimeter (ft)
L = Length of Pile (ft)

3.3.2 The allowable design capacity of the piles shall have a factor of safety of 2.0, i.e. $P_{allow} = P_{ult}/2$

$$T_{allow} = T_{ult}/2$$

3.3.3 Pile cluster effects shall be considered when determining load capacity.

3.3.4 For temporary loadings, such as seismic or wind, pile capacities may be increased by one-third.

3.4 SETTLEMENT:

3.4.1 For spread foundations with bearing values of 3000 psf a static settlement less than one inch can be expected.

3.4.2 Foundations supported by piles can be expected to have negligible static settlement with any settlement occurring during initial construction and loading.

4 SEISMIC LOADING .

Seismic loading shall comply with Section 2312, UBC-82 unless otherwise stated.

4.1 BASE SHEAR FOR STRUCTURES:

4.1.1 The following values shall be used to determine the base shear (V) on a structure unless otherwise specified: Zone 4; Importance Factor = 1.0; K = Appropriate Value Table 23-I; C = .12 unless otherwise established by Formula (12-2); S = 1.5 unless otherwise established by Formulas (12-4) and (14-4A) - (NOTE: $CS \leq .14$); W = DL + .15LL as defined in Section 6.3.

$$V = ZIKCSW$$

However, the minimum design base shear shall be V = .20W.

4.1.2 Receiver tower shall be designed for a minimum base shear of V = .25W.

4.1.3 Base shear distribution shall be done in accordance with Sec. 2312(e).

4.2 Base Shear on Elements of Structures and Non-Structural Components:

4.2.1 Minimum horizontal seismic loadings shall be in accordance with Sec. 2312(g) unless otherwise specified. Values for Zone 4 and Importance Factor = 1.0 shall be used.

4.2.2 Minimum horizontal seismic force for battery racks shall be $F_p = .50 Wp$.

4.3 VERTICAL LOADS:

4.3.1 The items covered above in Sections 4.1 and 4.2 shall be designed for a simultaneously applied reversible vertical load of two-thirds the magnitude of their horizontal seismic loads. These vertical seismic loads shall be applied at the center of mass.

5 SITE WORK

5.1 SURVEYING:

5.1.1 The Engineering Department shall provide the topographic maps of the site.

5.1.2 The intersection horizontal center lines of the Receiver Tower shall have a plant coordinate system of 10,000 feet North and 10,000 feet East. The relation between the plant coordinate system and the California State Coordinate System shall be shown on the grading plan. The Engineering Department shall also provide the coordinates of at least two control points to which the power plant is to be related.

5.2 DRAINAGE:

5.2.1 Sizing of outfall structures, culverts and ditches will be based on the Hydraulic Engineering Intensity curve for Carrizo Plain (Dwg. 107342) assuming a design recurrence of 25 years.

5.2.2 Use open ditches for drainage where closed conduits cannot be justified economically and where open ditches do not interfere with intended use of an area. Open ditches shall be lined with asphalt concrete or air blown mortar. Storm drains shall be CMP bituminous coated both surfaces, minimum 16 gage or Class III reinforced concrete, minimum size pipe 12" Ø. All buried drainage systems shall be designed to support a superimposed H20-S16 loading as specified in the ASSHO standard specification.

5.2.3 All open ditches or drainage pipes shall have a gradient sized for a minimum velocity of 2-1/2 feet per second for self cleaning during storm flow. CMP laid on steep slopes shall terminate with a tee section at a rip-rap apron or in a designed energy dissipator or sedimentation basin.

5.2.4 A minimum yard gradient not less than 0.5% for paved areas where catch basins and inlets are used to remove surface runoff, otherwise not less than 1%.

5.3 ROADS:

5.3.1 The site shall be graded to provide the following:

(a) A 20 feet width paved access road leading to the main entrance door of the turbine building, between the cooling tower and turbine building. The minimum radius measured from the centerline of the road shall be 55 feet.

(b) Minimum 10 feet width paved access around the cooling tower and turbine building outside of areas covered in 5.3.1(a). The minimum radius measured from the centerline of the road shall be 20 feet.

(c) Heliostat Field shall have a 10 foot wide access road of crushed rock with oil seal.

5.4 PAVING:

5.4.1 Paved roads (Sec. 5.31) and parking areas shall be surfaced with 2 inches of asphaltic concrete. Roads in Section 5.31(a) shall have a 6 inch aggregate base. Roads in Sec. 5.31(b) and parking areas shall have a 4 inch aggregate base.

5.5 FENCES:

5.5.1 The site perimeter, including the heliostat field, shall be encircled with an 7 foot chain-link fence.

5.5.2 The switchyard shall be enclosed with a 7 foot chain-link fence.

5.6 LANDSCAPING AND EROSION CONTROL:

To be determined during final design.

6 TURBINE-GENERATOR AND STEAM GENERATOR STRUCTURE

6.1 DESCRIPTION:

6.1.1 Superstructure - Structural Steel (A36-Galv.) Open structure composed of 2-story bents, except in the steam generator area where higher support is required. The bents will carry the gantry crane and operating floor, and will provide support for the steam generators. Lateral support shall be provided by vertical bracing on all four sides from the operating floor down to the ground floor foundation.

6.1.2 Operating Floor - Composed of a concrete slab on folded metal decking at an elevation 20 feet above the ground floor. The metal decking shall carry construction loads without shoring. Steel members supporting slab shall be designed as laterally supported beams with fusion welds to the metal decking. The steel framing shall not be supported by the turbine pedestal. Necessary provisions for drainage shall be provided.

6.1.3 Ground Floor - Shall be concrete slab on grade with a minimum thickness of 12 inches. The slab thickness shall be increased in areas serving as foundation for the superstructure as required by design. Drainage for the entire area, including pits, shall be provided. Separate drainage for the lube oil reservoir and in the sodium pump area shall be provided as required. Construction joints below ground elevation shall have waterstops.

6.1.4 Enclosed Areas - The entire structure will be open with exception of the battery and machine shop rooms on the ground floor. These two areas will be completely enclosed and waterproofed. Enclosure walls shall be insulated metal panels with factory finish. Acid resistant expoxy coating without hardener shall be applied to the broomed finished concrete slab in the battery room. Drainage shall be provided for in both areas.

6.2 DESIGN:

6.2.1 Increases in Allowable Stresses:

6.2.1.1 Increases in allowable stresses for concurrent vertical and lateral seismic loads shall follow the provisions of applicable code(s).

6.2.1.2 Allowable stresses may be increased 20% for water test loads.

6.2.2 Overturning - The resistance to overturning of the structure by soil pressure, soil friction, or anchors shall not be less than 1.5 times the overturning moment due to any lateral design load.

6.2.3 Resistance to Sliding - The resistance of the structure to sliding by passive soil pressure, soil friction, or anchors shall not be less than 1.5 times the sliding force due any lateral design load. The effect of uplift loads shall be considered when applicable.

6.2.4 Resistant to Uplift:

6.2.4.1 Uplift Due to Wind - The resistance to uplift of the roof as a whole or any component part of the roof shall not be less than 1.25 times the uplift force caused by the loading given in Paragraph 3.2.2 This resistance to uplift also applies at any horizontal plane through the building.

6.2.4.2 Uplift due to Buoyancy - The DL and/or anchorage resistance to uplift due to buoyancy of any submerged or partially submerged structure at any time including the construction period, shall not be less than 1.25 times the uplift due to hydrostatic pressures of the fluid. LL and equipment loads supported by the structure should not be considered in balancing buoyancy force. The condition of submergence also refers to structures buried in soil.

6.2.4.3 Uplift due to Wind/or Seismic Plus Buoyancy:

The DL and/or anchorage resistance of the structure to uplift shall not be less than 1.1 times the combined uplift caused by wind/or seismic plus buoyancy.

6.2.5 Allowable Deflections:

6.2.5.1	Concrete	PER ACI 318-77
6.2.5.2	Crane Grider	L/800
6.2.5.3	Steel Beams and Griders	L/300
6.2.5.4	Grating	L/200

6.3 LOADING:

6.3.1 Dead Load (DL) - Is defined as the weight of all roofing, floor slabs, framing, permanent partitions and walls, foundations and normal operating equipment whose weight exceeds 2 kips.

6.3.2 Live Loads (LL)

6.3.2.1 The following Uniform Loads shall be used for the design live loads:

Operating Floor (Elev. 20')	350 psf
Ground Floor	350 psf
Warehouse & Shop	250 psf
Battery Area	350 psf (to be checked with actual loads)
Platforms, Walkways, Stairs*	100 psf 1000 lb (concentrate)

6.3.2.2 Discussion on Live Loads - In general LL is to be applied as uniform loading. It is intended to include allowances for small equipment, small piping, conduit, lighting fixtures and movable partitions. Its major purpose is to provide for the laydown loading which occurs during a major plant maintenance shutdown. At that time the major power plant equipment is taken apart and the various pieces are stored at random points within the building. Also areas for work benches and storage of tools are established at random points. The location of each of these heavier loaded areas will vary unpredictably. However, while an individual floor span, beam, girder, or column can experience the full live loading, the entire story will not be loaded to that intensity. The actual density of the heavy loading over the entire story is less than that of a warehouse. With the exception of the generator rotor, or field, the weight of the piece divided by its required laydown floor area is less than the designed LL. Components of the turbine generator unit are large and massive but are supported at localized points, not over the entire floor area required for laydown. The point loads at the supports are spread over the floor by cribbing so that the design live load is not exceeded locally at these points. Cribbing area does not exceed the laydown area for the piece.

*These loads are concurrent. Place concentrate load to produce maximum stress being checked.

Laydown areas shall be checked for actual weight of piece and method of support in final design. This is especially critical for rotor laydown.

Some locations will also require checking for concentrated live loads. Wheel loads of trucks or fork lifts must be considered at the ground floor.

All areas accessible to a forklift shall be checked for the wheel loads of a Towmotor Model B-10 forklift; maximum front wheel axle load is 6 tons and rear wheel axle load is 4 tons. The distance between front and rear wheel is 8 feet. The width of axle is 6 feet. Floor and exterior basement walls at rolling door shall be designed for H-20 wheel load.

6.3.3 Snow Load - Snow load shall be 5 psf.

6.3.4 Piping and Conduit Loading - This loading will be concurrent with live loads. Support framing for sodium lines, main steam lines, and main circulating water lines support framing shall be designed for actual loads and anchor forces as determined by pipeline analysis. Preliminary design loads may be estimated, however, the structure shall be checked using final pipe support loads.

6.3.5 Dynamic Loading - Supports for rotating equipment (except turbine-generator See Section 7).

6.3.5.1 The natural frequency of the supporting members under vibrating load shall be at least 20% less or 20% greater than the normal operating frequency of the rotating equipment. Note that only loads possessing mass should be considered as vibrating loads.

6.3.5.2 Supporting beams and connections shall be designed for operating weight plus 50% impact.

6.3.5.3 Foundations on soil shall have a mass of concrete not less than 5 times the weights of rotating parts nor less than 3 times the total weight of the equipment.

6.3.6 Wind Loading - The following loads are based upon UBC-82 for main structures for basic wind speed of 70 mph. Refer to applicable sections of code for design pressures on components and local areas.

6.3.6.1 Wind pressure on flat vertical projections:

Feet Above Grade	
0 to 20	22 psf
20 to 40	24 psf
40 to 60	27 psf
60 to 100	29 psf

6.3.7 Seismic Loading - See Section 4.

6.3.8 Crane Loads - Crane equipment vendor drawings shall be followed for wheel loads, equipment loads and weight of moving parts.

6.3.8.1 Vertical Load - Maximum Design Wheel Loads shall be (DL + LIFT) plus 25% impact.

6.3.8.2 Lateral Load - Two types of lateral forces must be considered:

(a) Transverse, 10% of total of lift load plus weight of trolley perpendicular to top of each runway rail.

(b) Longitudinal, 10% of maximum wheel loads parallel to top of runway rail.

6.3.8.3 Fatigue Loading - Condition 1 as outlined in Appendix B of AISC Code shall apply to crane runway girders, connections and columns.

6.4 DESIGN LOAD COMBINATIONS:

Structures shall be designed for the following load combinations:

Case 1: DL + LL + SNOW
Case 2: DL + LL + ½ SNOW + WIND
Case 3: DL + .15 LL + SEISMIC
Case 4: DL + .15 LL + WIND

7 TURBINE-GENERATOR PEDESTAL

7.1 DESCRIPTION:

7.1.1 Pedestal - Shall be designed of reinforced concrete with a top elevation at the operating floor level (20 feet). The pedestal shall be isolated such so that it will not transmit vibration to the turbine-generator superstructure. However, ground floor and basement slabs may be doweled to the pedestal mat.

7.1.2 Foundation - The pedestal shall be supported by either a mat foundation or, if soil conditions deem preferable, a pile foundation.

7.2 DESIGN:

7.2.1 Manufacturer's criteria and recommendations shall be followed. Any conflict between the manufacturer's standards and provisions of this criteria shall be resolved by PGandE's Engineering Department.

7.2.2 The following construction requirements shall be stated clearly on the drawings.

(1) Pedestal pier haunches shall be poured monolithically with pedestal deck.

(2) Vertical construction joints are not permitted in pedestal deck.

(3) Tolerances for setting embedded anchor bolts for equipment and structural steel, and other embedded items shall be as follows:

Tolerance Symbol in Drawings	Tolerance
T1	±1/16 inch
T2	±1/8 inch
T3	±3/16 inch
T4	±1/4 inch
T5	±5/16 inch
T6	±3/8 inch
T7	±7/16 inch
T8	±1/2 inch

7.2.3 Natural Frequency - The turbine pedestal shall be so proportioned that the natural frequency of the structure shall avoid the operating speed of the machine by ±20% and twice operating speed by ±15%. Loads used when determining natural frequency shall be actual vibrating masses, i.e., equipment weights, weight of deck plus top 1/3 of piers. Rotor critical speeds shall be avoided by ±10%. Rotor criticals will be furnished by the turbine manufacturer, for preliminary calculations that may be assumed to be between 1/3 to 2/3 the operating speed of the machine. The entire structure, deck, piers, mat and soil spring shall be assumed to act as a space frame. In addition, the natural frequency of each bent within the space frame shall be checked. Ideally, these bent frequencies shall be approximately equal. The natural frequency of cantilevered members shall be checked separately and shall not fall within stated critical speed ranges.

7.2.4 Deflection:

The deflections at the bearings during operation shall meet the manufacturer's criteria. These limits are unique to each machine and should be established by the manufacturer. The generalized deflections for structures quoted in the manuals do not apply. The following criteria may be used during preliminary design.

(1) The vertical or horizontal deflection at any bearing relative to a line drawn between the extreme end bearings of the unit shall not exceed 20 mils. The loads used in determining these deflections shall be confined to those operating loads applied after the machine is aligned, i.e., vacuum load, torque load, thermal expansion loads.

(2) The radius of curvature criteria shall determine the limits of relative deflections between 3 adjacent bearing points of support. This assumes that the relative deflection between the two outer points and the inner point is not excessive when the radius of a circle passing through the 3 points is not less than a specified distance. This radius is 100 miles for 1800 RPM machines and 150 miles for 3600 RPM machines. The loads causing these deflections are those that occur after the machine is aligned. The formula is:

$$R = \frac{L_1 L_2}{KD}$$

R = Radius in miles.
L_1 = Distance between 1st and 2nd bearing support point.
L_2 = Distance between 2nd and 3rd bearing support point.
D = Deflection of point 2 from line drawn between points 1 & 3.
K = .88 when L_1 and L_2 are in feet and D is in mils.

These criteria shall be applied to all bearings of the Turbine-Generator set in rotation, i.e., 1-2-3, 2-3-4, 3-4-5, 4-5-6, etc.

(3) The actual deflection at any bearing due only to the dynamic load of the allowable rotor imbalance shall not exceed 1.5 mil . The same speed ranges which govern natural frequency requirements shall govern this deflection limitation.

7.2.5 For overturning, sliding and uplift refer to sections 6.2.2, 6.2.3, and 6.2.4.

7.3 LOADING:

7.3.1 Dead Load (D) - Pedestal and Mat Concrete.

7.3.2 Live Load (L) - Equipment weight (per Mfgr's. Drawings) plus 50% for impact.

7.3.3 Static Equivalent (SE) - Dynamic Equivalent (a) transverse (perpendicular to unit centerline) 50% of equipment weight; (b) Longitudinal (parallel to unit centerline) 20% of equipment weight.
NOTE: These loads are not concurrent and are reversible in direction.

7.3.4 Normal Torque (N) - (5 x 7040 x KW)/RPM.

7.3.5 Short Circuit Torque (Q) - (30 x 7040 x KW)/RPM.

7.3.6 Temperature Loads (T) -

(a) Anchor Forces (Per Mfgr.)
(b) Equipment Expansion Forces (100% sole plate loads)
(c) Piping Expansion (Per Mfgr. & PGandE)

7.3.7 Miscellaneous Loads (M) -

(a) Thermal Expansion of Deck 20°F above mat temperature - axial expansion only.

(b) Shrinkage of deck equivalent to 20°F below mat temperature - axial expansion only.

NOTE: These loads are not concurrent.

7.3.8 Seismic (E) - Refer to Section 4.

7.4 DESIGN LOAD COMBINATIONS:

The strength design of members shall be based on the greatest value of U as found from the following load combinations:

$U = 1.4D + 1.7 (L + SE + N) + 1.0 (T + M)$
$U = .75 + (1.4D + 1.7 (L + SE + N) + 1.87E) + T$
$U = .75 (1.4D + 1.7 (L + SE) + 1.0 (T + Q)$
$^{*}U = .9D + 1.43E + 1.0 (T + M)$

*For this condition D shall also include the equipment weight.

8 UNDERGROUND PIPE:

8.1 The portions of pipe that shall be placed in trenches and backfilled shall conform to the loading requirements of AASHO HS20-44.

8.2 All pipe bedding and compaction shall conform to Section 19, Paragraph 19-306, Method "A" of the State of California, Division of Highways Standard Specifications.

8.3 Backfill shall be a minimum of 3 feet and a maximum of 6 feet deep from the top of the pipe.

8.4 Thrust blocks shall be provided where required.

9 MISCELLANEOUS YARD STRUCTURES

9.1 DESCRIPTION:

This section applies to the supporting of miscellaneous tanks, pipeways, electrical conduits, and switchyard structures. It does not apply to the heliostats (by ARCO) or the hot and cold sodium storage tanks (by Rockwell).

9.2 DESIGN:

9.2.1 General - Refer Section 6.2, but with special note that thermal forces are even more important in these structures than in Turbine building.

9.2.2 Tanks:

9.2.2.1 Tanks requiring hold down shall be supported on a concrete slab foundation.

9.2.2.1.1 Top of foundation shall be a minimum of six inches above grade and sloped to insure adequate drainage.

9.2.2.2 Tanks not requiring hold down shall be supported on a well compacted pad of crushed rock made up of Class 2 Aggregate Base material. Compaction shall be 95% max. ASTM 1557-70(D).

9.2.2.2.1 Top of foundation shall be a minimum of one foot above grade and sloped to insure adequate drainage.

9.2.2.2.2 The crushed rock shall be sealed with 2" of Asphalt Concrete.

9.2.2.2 Top of foundation shall be a minimum of one foot above grade and sloped to insure adequate drainage.

The crushed rock shall be sealed with 2" of Asphalt Concrete.

9.2.3 Pipeways and Electrical Conduit - Each support and foundation shall be designed resist loads and combination of loads in order that supported item can perform its intended purpose. Loads and specific criteria shall be provided by mechanical and electrical disciplines as required.

9.2.4 Switchyard Structures - Each structure and foundation shall resist the loads or combination of loads to give worst conditions so that it can support the electrical equipment to perform its intended function. Loads and specific criteria shall be provided by Electrical Engineering Department as required. Power circuit breakers and transformer foundations shall be fitted with embedded plates to provide an area for welding the electrical equipment boxes to the foundation. The location of these is determined by the equipment outline. Foundations shall follow PGandE standard drawings.

9.3 LOADING - REFER TO APPLICABLE PORTIONS OF SECTIONS 6.3

9.4 DESIGN LOADING COMBINATIONS - REFER TO SECTION 6.4

10 BUILDINGS:

1. Administration/Control/Computer
2. Warehouse/Welding Shop/Change Facility
3. Auxiliary Boiler/Make-up Water
4. Fire Pump
5. Paint Storage

10.1 ADMINISTRATION/CONTROL/COMPUTER BUILDING

10.1.1 Description:

This building will house the administration, offices, laboratory, control room for plant operation, and computer operations. The building is a 3-story 40' x 80' x 40' (height). It will consist of a steel frame with insulated metal siding on a concrete slab on grade. The second floor will have a metal deck with concrete. The entire third floor will be 2-hour fire-rated. The third floor will be raised 2 feet above the metal deck with concrete. The raised floor will provide for HVAC ducts, and cable spreading and computer control wiring.

The first and second floor will be fire sprinklered. The third floor will have halon gas for fire protection.

The entire building will be heated, air conditioned and ventilated. The control and computer rooms will have a separate backup air conditioning system.

10.1.2 OCCUPANTS:

10.1.2.1 FIRST FLOOR:

	AREA
1. General Office	1,200 SF
2. Instrument Shop	384
3. Chemistry Laboratory	576
4. Communication	160
5. Electrical	180
6. Elevator/Equipment	112
7. Circulation	588
	3,200 SF

10.1.2.2 SECOND FLOOR

	AREA
1. Plant Superintendent	272 SF
2. Plant Engineer	288
3. Supervisor: Operation	224
4. Supervisor: Maintenance	224
5. Conference	800
6. Men's Toilet	160
7. Women's Toilet	160
8. Elevator/Duct	144
9. Kitchen/Janitor/Storage	270
10.Circulation	658
	3,200 SF

10.1.2.3 THIRD FLOOR

1. Control	1,200 SF
2. Computer	1,324
3. Part Storage	70
4. Elevator/Duct	144
5. Electrical	90
6. Toilet	81
7. Kitchen	36
8. Circulation	255
	3,200 SF

There is a bridge from the third floor to the turbine structure at elevation 20 feet.

10.1.3 MATERIALS

Materials that constitute various major sections are as follows:

10.1.3.1 Exterior walls

(a) Metal siding is factory finished and insulated aluminum or steel paneling for each of the buildings.

(b) Metal trim and flashing is factory finished sheet metal to match the metal siding.

(c) Louvers are aluminum or steel to match the metal siding.

10.1.3.2 Interior walls

Interior walls are metal stud drywall construction except for metal panel construction at the welding shop, warehouse, and auxiliary boiler/make-up water divider wall.

10.1.3.3 Suspended ceilings are as follows:

(a) Acoustical at all offices, lobby, conference room, control, computer,chemistry laboratory and instrument shop.

(b) Water resistant gypsum board on drywall ceiling framing at all toilets and shower areas.

10.1.3.4 Floor finishes are as follows:

(a) Ceramic mosaic floor tile on recessed concrete at all toilet and shower areas.

(b) Resilient tile on troweled concrete at all offices, lobby, conference room, chemistry laboratory, control, computer, storage, and instrument shop.

10.1.3.5 Windows

(a) Windows at control room are 1/4" solarbrey 14% tempered.

(b) Remaining windows aluminum, fixed with 1/8" double strength.

10.1.3.6 Doors

(a) Exterior - heavy duty 1-3/4 inch, seamless, hollow steel construction with heavy duty hardware.

(b) Interior - Standard duty 1-3/4 inch, seamless, hollow steel construction with heavy duty hardware.

(c) Roll-up are electric motor operated.

10.1.3.7 Toilet partitions are floor supported flush metal with baked enamel factory finish.

10.1.3.8 Roofing is as follows:

(a) Factory mutual Class I, 20 year bondable, gravel-surfaced, built-up roofing over rigid insulation applied directly to steel decking at the Administration/Control Building.

(b) Insulated metal panels with factory-finish at the other buildings.

(c) Elastomeric wearing surfaces at the exposed operating floor slab of the Turbine Structure.

10.1.3.9 Special Equipment

(a) Elevator:

Type: Hydraulic - Otis LRV2011
Capacity: 2000 lb
Speed: 115 feet per minute

(b) Kitchen equipment is a combination of individual freestanding appliances and built-in casework.

(c) Lockers are factory finished and steel mounted on concrete curbs.

10.1.4.1 Air Conditioning

Air Conditioning is provided for the administration/control/computer building. The system is designed for two 100% air conditioning systems. Provide "auto" start of spare a/c on primary failure or computer room high temperature. Primary and spare air conditioning system and ducting should be designed to operate at the same time on an interim basis.

10.2 WAREHOUSE/WELDING SHOP/CHANGE FACILITY:

10.2.1 Description:

This building will house the spare parts, the welding shop and provide for men's and women's change facilities. The building will consist of a steel frame with insulated metal siding on a concrete slab on grade. The overall dimensions are 50' x 100' x 14' (height).

The areas are:

1.	Warehouse	3,300
2.	Welding shop	646
3.	Change facility	1,054
		5,000 SF

One hour fire rated barrier will separate each of the rooms.

10.2.2

The warehouse area has the following rooms:

1.	Office	96
2.	Secured Storage	810
3.	Electrical-Counter	152
4.	Open Storage	2,242
		3,300 SF

This area is one-hour fire rated with a fire sprinkler system.

There is a 12' x 12' electric operated roll-up door and two exterior 3' x 7' personnel doors.

10.2.3 WELDING SHOP

This shop is enclosed with one-hour fire rated walls. The area will be fire sprinklered.

The exterior doors are 1-10' x 10' electric operated roll-up door and one exterior 3' x 7' personnel door.

10.2.4 CHANGE FACILITY

The change room will be used by the daily maintenance personnel and the emergency repair crews.

The facility will house, the lockers, showers, and toilet facilities. The size of the facility is 1054 SF.

The following are the change room facilities:

Men's Change Room

1. 6 wash basins
2. 3 toilets
3. 3 urinals
4. 10 showers
5. 36 lockers

Women's Change Room

1. 2 wash basins
2. 2 toilets
3. 2 showers
4. 6 lockers

10.3 AUXILIARY BOILER/MAKE-UP WATER; FIRE PUMP; AND PAINT STORAGE BUILDING

Each of these buildings are pre-engineered metal buildings set on a concrete slab on grade. Each building will be insulated.

10.3.1 AUXILIARY BOILER/MAKE-UP WATER BUILDING

This building will house two electric operated auxiliary boilers and two make-up water equipment. The building is 40' x 40' x 14' height with a one-hour fire rated wall dividing the area into two rooms.

Each room will have 10' x 10' electric operated roll-up door and a 3' x 7' personnel door.

10.3.2 FIRE PUMP BUILDING

This building will house two electric operated fire pumps and an emergency diesel generator.

The building is 24' x 40' x 14' height with a 12' x 12' electric operated roll-up door.

The building will have fire sprinkler system.

10.3.3 PAINT STORAGE BUILDING

This building will storage paints and equipment. The

building is a 20' x 32' x 14' height with one 8' x 8' electric operated roll-up door and a 3' x 7' personnel door.

10.4 DESIGN/LOADING

10.4.1 The design is based on its function to house equipment and provide safe working conditions. The building materials are chosen for plant life of 30 years and for economy, durability and low maintenance.

Floor plans are arranged to meet functional needs, to provide sufficient working areas and oriented to give efficient circulation pattern in compliance with all safety and regulatory code requirements.

10.4.2 Refer to Section 6.2

10.4.3 Refer to Section 6.3

10.5 DESIGN LOAD COMBINATIONS:

Refer to Section 6.4.

11 CIRCULATING WATER SYSTEM AND COOLING TOWER

11.1 DESIGN

11.1.1 Superstructure:

As designed, detailed and constructed by cooling tower supplier and review by PGandE.

11.1.2 Basin:

Basin shall be reinforced concrete on grade, detailed in accordance with manufacturer's drawings. Expansion-contraction joints shall be located at each cell to minimize the effects of shrinkage and thermal cracking of the concrete. These joints shall be properly designed to prevent leakage. Interior concrete surfaces shall be protected with one seal coat of Chevron "Bonding Agent" and two finish coats of asphalt urethane. Provision shall be made for inflow piping from condenser, primary service, cold weather startup circulation, and overflow. The basin shall be in two sections, in order that the plant may operate at half capacity. The intent is that one half of the tower is completely shut down and that half of the basin drained and cleaned. The empty section is then filled to the halfway mark from the adjacent filled section and full tower operation resumed. Transfer of sediment from the dirty basin to the clean basin shall be prevented. Each section of the basin shall be provided with two clean-out sumps; one opposite and along each side of the basin dividing wall. That is, there will be a total of 4 sumps in the cooling tower basin.

All structures or parts of structures in contact with condensate shall be of one of the following materials: coated concrete, stainless steel, reinforced plastic, redwood or treated fir.

11.1.3 Circulating Water Pump Pit:

11.1.3.1 Dimensions of pit shall be established based on the requirements of the pump manufacturer, the flows required and the Hydraulics Institute Standards (latest edition).

11.1.3.2 Water shall be screened before reaching pump.

11.1.3.3 Velocity of flow at the pumps shall not exceed 1 fps.

11.1.4 Screen Design for Circulating Water Pump Pit:

11.1.4.1 The maximum screen hydraulic losses or forces shall be based on 50% uniform clogging of the screen area (50% includes area of member sizes.)

11.1.4.2 The screen openings shall be 3/4 inch.

11.1.4.3 Determine the area of rack or screen by assuming that the velocity of flow thru the rack or screen with 50% clogging does not exceed 2 fps.

11.1.4.4 Provide a bermed area for the washing of the screens. Wash water shall be returned to the cooling tower basin.

11.1.5 Pipe:

11.1.5.1 The main circulating water pipe shall be Filament-Wound Reinforced Thermosetting Resin Pipe.

11.1.5.2 All pipe and accessories shall conform to ASTM D2996-71.

11.1.5.3 All pipe connections shall be of the harness-welded bell and spigot type and of the flange type.

11.2 See DCM D23-18M for Mechanicl design requirements.

11.3 LOADING:

Refer to Section 6.3.

11.4 DESIGN LOADING COMBINATIONS:

Refer to Section 6.4.

12 REFERENCES:

12.1 Project Design Criteria DCM D23-1

12.2 Raw Water System DCM D23-25

12.3 Circulating Water System DCM D23-18M

12.4 Fire System DCM D23-23

12.5 Main Steam and Turbine DCM D23-13

12.6 Service Cooling Water DCM D23-19M

12.7 Boiler Make-up Water DCM D23-24

12.8 Condensate and Feedwater System DCM D23-15

12.9 Auxiliary Steam System DCM D23-20

12.10 Receiver Tower DCM D23-12

APPENDICES

A SOIL: LOGS AND TEST RESULTS
B HYDROLOGIC ENGINEERING RAINFALL, DRAWING #107342, REV. 1
C PGandE STANDARD DRAWING #054162, REV. 3

FIELD SOIL BORING LOG

Project: CARRIZO PLAINS
Job No.: GM 634016
Boring No.: B1
Sheet 1 of 2

Ground Elevation: —
Type & Diameter of Boring: 8" ⌀ HOLLOW AUGER
Location: 5 MILES WEST OF SIMMLER ON US 58

Bottom of Hole Elevation: —
Depth: 63'
Groundwater Elevation: ~49'
Date: 12-16-82
Date Started: 12-16-82
Finished: 12-16-82

Name of Driller: J. JOHNSON
Name of Inspector: RAMMANUS
Boring Contractor: PG&E

ELEVATION	DESCRIPTION	DEPTH (FT.)	SOIL SYMBOL	SAMPLE TYPE & NUMBER	RECOVERY (INCHES)	BLOWS/ 6 in.	NOTES ON GROUNDWATER LEVELS, WATER RETURN, CHARACTER OF DRILLING, METHOD OF ADVANCING BORING, SIZE OF CASING
	MED DARK BROWN SILTY/CLAYEY SAND.						
		5					
		10		SP	15"	25 35 50/5	
	[illegible] ORANGE/ BROWN CLAYEY SAND WITH [illegible] VERY [illegible] [illegible]-LIKE [illegible] SILTY [illegible]-[illegible].						
	SAME AS ABOVE-	2		2½	5T	5 35 45	
				SP	18"	15 25	23
	SAME AS ABOVE - SILTY/ SANDIER.	30		2½	3T	13 30 41	
				SP	19"	10 12 22	37

APPENDIX "A"

FIELD SOIL BORING LOG

Project: CARRIZO PLAINS SUB STA.
Job No.: GM 034016
Boring No.: B1
Sheet 2 of 2

Ground Elevation: —
Type & Diameter of Boring: 8"ϕ HOLLOW AUGER
Location: CARRIZO PLAINS

Bottom of Hole Elevation: —
Depth: 63
Groundwater Elevation: ~49'
Date: 12-16-82
Date Started: —
Finished: —

Name of Driller: J. JOHNSON
Name of Inspector: RAM CMANUS
Boring Contractor: PG&E

ELEVATION	DESCRIPTION	DEPTH (FT.)	SOIL SYMBOL	SAMPLE TYPE & NUMBER	RECOVERY (INCHES)	BLOWS/ 6 in.	NOTES ON GROUNDWATER LEVELS, WATER RETURN, CHARACTER OF DRILLING, METHOD OF ADVANCING BORING, SIZE OF CASING
	MED. BROWN CLAYEY SAND W/ WHITE VEINS OF LIME OR EVAPORITE MINERALS. SLIGHTLY MOIST HARD, DENSE, FINE GRAVEL @ 43'	45		2½	3T	6 14 27	
				SP	15"	13 35 50	85
							▽ BASED ON WET SAMPLE 12-16-82
	SAME AS ABOVE BUT SAND LAYERS A FEW INCHES THICK ARE SOFTER THAN MORE CLAYEY LAYERS. SANDIES MOIST AND FREE WATER ON SAMPLER.	50		2½	3T	7 15 24	PP 3.0, 3.75, 3.25, 4.5, 4.5
				SP	18"	13 17 18	35
	SAME AS ABOVE	55		2½		7 20 30	P.P. >4.5, >4.5, 4.5 TONS/FT²
				SP		9 17 22	39
	BOTTOM OF HOLE @ 63 ON 12-16-82						

FIELD SOIL BORING LOG

Project	Job No.	Boring No.	Sheet of
CARIZZO PLAINS SUB STA	GM 634016	B2	1 of 2

Ground Elevation	Type & Diameter of Boring	Location
	8" HOLLOW STEM AUGER	CARIZZO PLAINS

Bottom of Hole Elevation	Depth	Groundwater Elevation	Date	Date Started	Finished
—	63'	54'	12-16-82 9:00	12-15-82	12-15-82

Name of Driller	Name of Inspector	Boring Contractor
J. JOHNSON	R. McMANUS	PG&E

ELEVATION	DESCRIPTION	DEPTH (FT.)	SOIL SYMBOL	SAMPLE TYPE & NUMBER	RECOVERY (INCHES)	BLOWS/ 6 in.		NOTES ON GROUNDWATER LEVELS, WATER RETURN, CHARACTER OF DRILLING, METHOD OF ADVANCING BORING, SIZE OF CASING
	SURFACE - MEDIUM/FINE BROWN CLAYEY SAND AND RUSTY TAN [illegible] ROCK CHIPS TO 1/2"							
	MED. [illegible] DARK BROWN CLAYEY SAND							
	MEDIUM "ORANGE" BROWN CLAYEY SAND.	5						AUGER MAKING STEADY SMOOTH ADVANCE
				2½	2T	12 21 33		
	MED. "ORANGE" BROWN SILTY SAND. DRY, [illegible]			SP	12"	19 21 50	4"	
	SAME AS ABOVE BUT WITH A FEW ~~[illegible]~~ LIGHT	10		2½	2T	28 28 75		
	TAN OR WHITE PIECES OF SOFT ROCK. ALSO WAVY [illegible]			SP	18"	21 44 50	6" [illegible]	
	OF LIGHTER [illegible] IN CLAY - [illegible]? SL. MOIST.							
	SAME AS ABOVE - SOME GREENISH CHERTY FRAGS	15		2½	2T	33 35 22		
	AND WHITE [illegible] ONES.			SP	18	10 18 23	41	
	SAME AS ABOVE BUT BECOMING MORE CLAYEY WHEN	20		2½	3T	15 34 27		
	SAMPLE IS WETTED. LAYER OF MORE COARSE SAND SIZE			SP	18"	13 22 30	52	
	PARTICLES @ 21' ABOUT 1/2" THICK.							
	MORE SAND SIZE PARTICLES VISIBLE IN SOME	25		2½	2T	17 27 60		
	LAYERS - THESE ARE SOFTER LAYERS. ALSO FIRMER			SP	18	15 22 27	49	
	LAYERS OF SMALLER (SILT OR CLAY) PARTICLES AS ABOVE							
		30		2½	2T	20 35 48		
	MORE UNIFORM FINE SIZE PARTICLES, FIRM, SLIGHTLY			SP	18"	11 23 31	54	
	MOIST. VERY FEW ROCK FRAGS NOW VISIBLE.							
		35						

FIELD SOIL BORING LOG

Project: CARRIZO PLAINS SUB STA
Job No.: GM 63A016
Boring No.: B2
Sheet 2 of 2
Ground Elevation: —
Type & Diameter of Boring: 8" HOLLOW AUGER
Location: CARRIZO PLAINS
Bottom of Hole Elevation: —
Depth: 63'
Groundwater Elevation: —
Date: —
Date Started: —
Finished: —
Name of Driller: J. JOHNSON
Name of Inspector: RA McMANUS
Boring Contractor: PG&E

ELEVATION	DESCRIPTION	DEPTH (FT.)	SOIL SYMBOL	SAMPLE TYPE & NUMBER	RECOVERY (INCHES)	BLOWS/ 6 In.	NOTES ON GROUNDWATER LEVELS, WATER RETURN, CHARACTER OF DRILLING, METHOD OF ADVANCING BORING, SIZE OF CASING
		30					
		35		2½	2T	19 37 55	
	3" LAYER OF WHITE SAND AND FINE GRAVEL @ 37' MIXED IN WITH MED BROWN CLAYEY SAND.			SP.	18"	18 31 22	53
		40		2½	2T	– – –	
	ABOUT 50% VERY LIGHT BROWN CLAYEY SAND MIXED WITH MED BROWN CLAYEY SAND. SAMPLE HOLDS TOGETHER VERY WELL - FIRM, SLIGHTLY MOIST.			SP	18"	11 14 22	36
		45		2½	3T	15 19 23	
	SAME, WITH SANDIER LAYERS SEVERAL INCHES THICK - SOFTER THAN MORE CLAYEY LAYERS.			SP.	18"	11 13 15	28
		50		2½	3T	16 14 22	
	SAME - SANDY LAYERS WET.			SP.	18"	6 11 17	28 ▽ 12-14-82 (FROM WET SAM
							▽ 54 [illegible] W 12-16-82
		55		2½"	3T	11 16 20	
	VERY FIRM & COHESIVE SANDY CLAY - WHITE LIMEY DEPOSITS MIXED W/ MED BROWN.			SP.	18"	6 12 16	28
		60		2½	3T	6 10 20	PP. 2.5, 3.25, 3.5, >4.5 TONS/F
	SAME AS ABOVE			SP.	18	5 11 23	34
	END OF HOLE @ 63' ON 12-15-82 @ 16:00						

FIELD SOIL BORING LOG

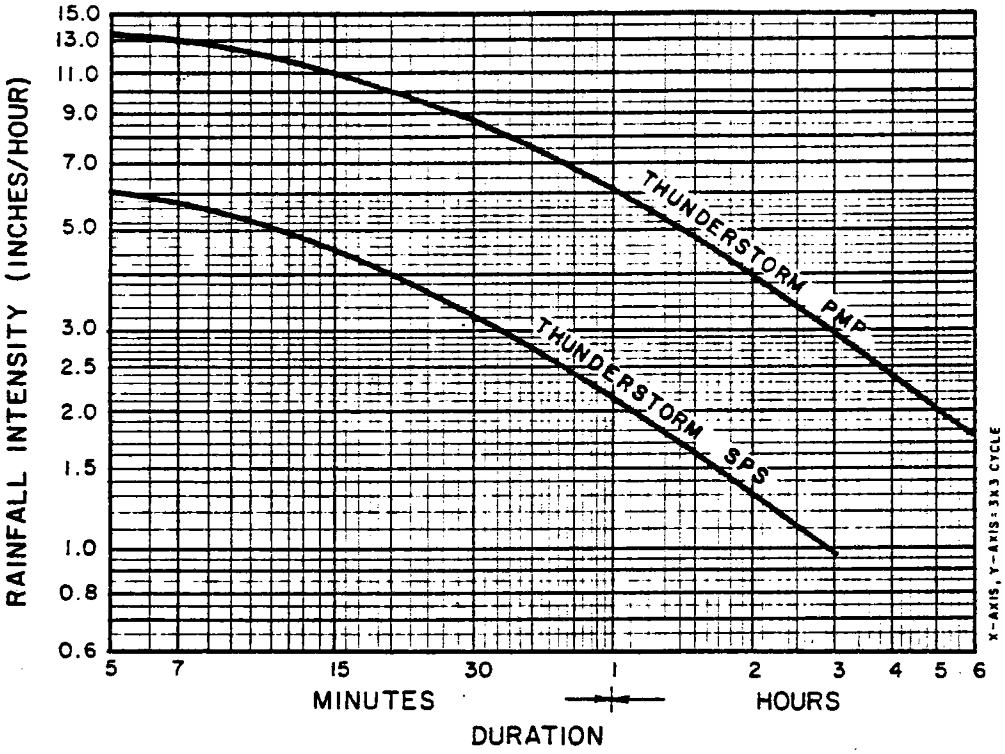
Project: CARIZZO PLAINS SUBSTATION
Job No.: GM634016
Boring No.: PERC 1
Sheet 1 of 2
Ground Elevation: —
Type & Diameter of Boring: 3" CASING
Location: CARIZZO PLAINS
Bottom of Hole Elevation: —
Depth: 8'
Groundwater Elevation:
Date:
Date Started: 12-14-82
Finished: 12-14-82
Name of Driller: J. JOHNSON
Name of Inspector: R.A. McMANUS
Boring Contractor: 880

ELEVATION	DESCRIPTION	DEPTH (FT.)	SOIL SYMBOL	SAMPLE TYPE & NUMBER	RECOVERY (INCHES)	BLOWS/ 6 in.	NOTES ON GROUNDWATER LEVELS, WATER RETURN, CHARACTER OF DRILLING, METHOD OF ADVANCING BORING, SIZE OF CASING
		5					
	AT 8' DEPTH, 28" HEAD ABOVE GROUND, 3 1/4" ɸ						
	CASING DRAINED 1/16" IN 30 min.	10					
	END OF TEST						
		15					

FIELD SOIL BORING LOG

Project: CARRIZO PLAINS SUB STATION
Job No.: GM 634016
Boring No.: PERC 2
Sheet 1 of 1
Ground Elevation: —
Type & Diameter of Boring:
Location: CARRIZO PLAINS
Bottom of Hole Elevation:
Depth: 12.75
Groundwater Elevation: —
Date: —
Date Started: 12-14-82 @ 14:00
Finished: 12-14-82
Name of Driller: J. JOHNSON
Name of Inspector: RAMcMAINS
Boring Contractor: PG&E

ELEVATION	DESCRIPTION	DEPTH (FT.)	SOIL SYMBOL	SAMPLE TYPE & NUMBER	RECOVERY (INCHES)	BLOWS/ 6 In.	NOTES ON GROUNDWATER LEVELS, WATER RETURN, CHARACTER OF DRILLING, METHOD OF ADVANCING BORING, SIZE OF CASING
		5					12-9 12-9 2-0
	DRILL CASING TO 8'. FILL TO TOP (+27½") NO MEASURABLE DRAINAGE AFTER 30 min.	8					
	ADVANCE 3"Ø HOLE TO 12'-9 BELOW SURFACE. CASING REMAINS AT -8', LEAVING 4'-9" EXPOSED BELOW BOTTOM OF CASING. SLOW DRILLING THROUGH CLAYEY MED BROWN/TAN SAND. WITH +27½ USED FULL CASING DRAINS:						
	1½" 1st 5 min - REFILL						
	1 9/16" 2nd 5 min - REFILL						
	1 11/16" 3rd 5 min "						
	7/16" 4th 5 min "						
	1 9/16" 5th 5 min "						
	1½" 6th 5 min						
	NOTE - SLIGHTLY MUDDY WATER USED FROM 4:30 PM TO 9:15 NEXT MORNING WATER DROPPED 7'-2" FROM TOP OF CASING (+27½ FROM GROUND SURF).						
	END OF TEST						



LEGEND

PMP = PROBABLE MAXIMUM PRECIPITATION
SPS = STANDARD PROJECT STORM

NOTES

1. THESE GRAPHS WERE PREPARED FROM CALCULATED POINT RAINFALL DEPTHS AT THE PLANT SITE ONLY. NO ADJUSTMENT WAS MADE FOR THE SIZE OF THE DRAINAGE AREA. THEREFORE, FOR HYDROLOGIC DESIGN OF HYDRAULIC STRUCTURES, THE APPROPRIATE DEPTH-AREA RELATION SHOULD BE APPLIED. RAINFALL RATES IN THIS CHART SHOULD NOT BE TRANSPOSED TO ANY OTHER PART OF THE WATERSHED(S) WITHOUT PROPER ADJUSTMENT.
2. THE WINTER PMP AND SPS ARE NOT PLOTTED HERE, BUT SHOULD BE CONSIDERED CRITICAL FOR LONG DURATION RAINFALL ON LARGE AREAS.
3. THE PLANT SITE IS IN SECTION 21 T.29S. R.18E. M.D.B.&M. AND THE AVERAGE LATITUDE 35°22'58" AND LONGITUDE 120°02'30" U.S.G.S. 7.5 MINUTE QUADRANGLE(S): LA PANZA N.E., 1966.

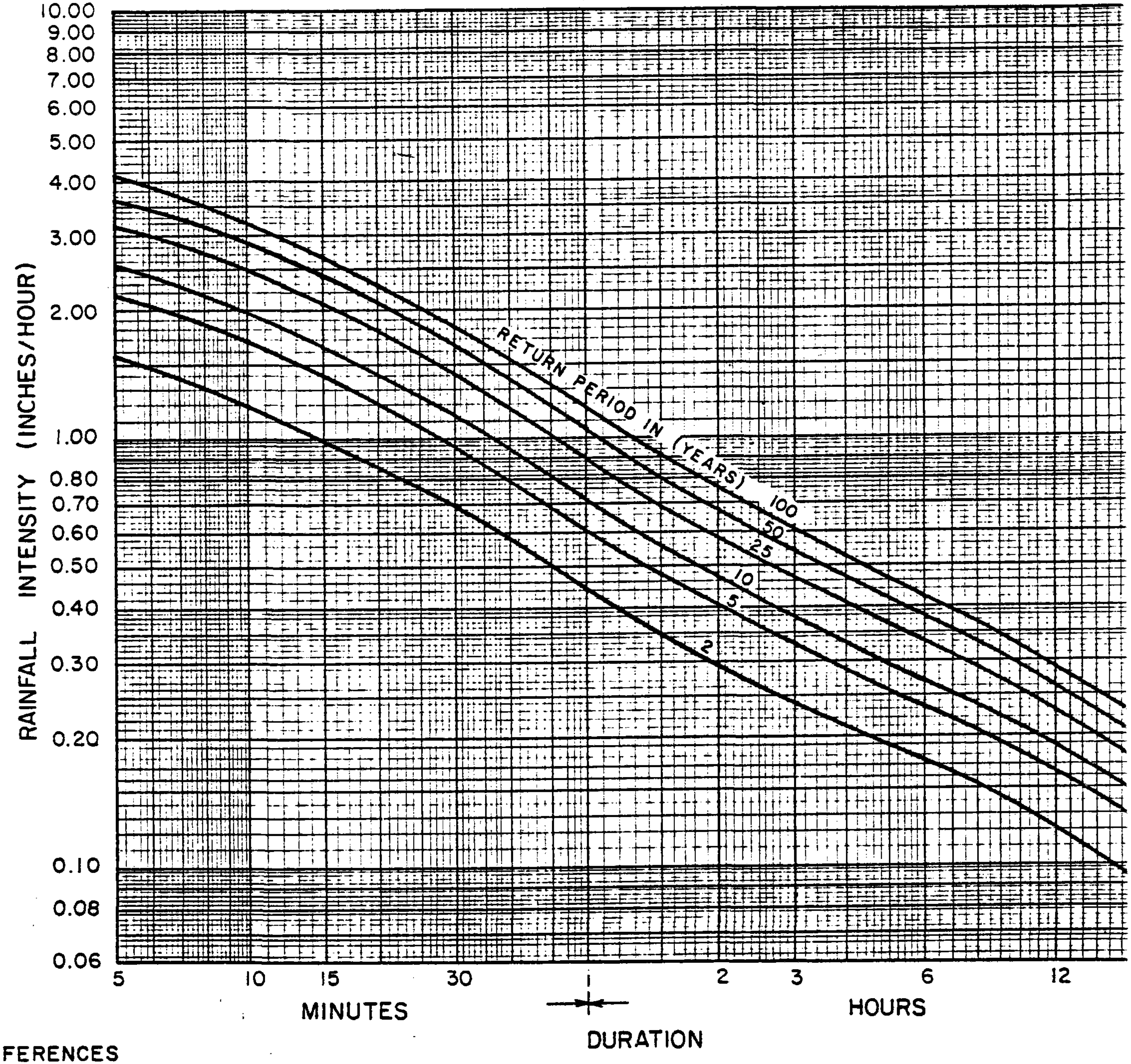
REGISTERED PROFESSIONAL ENGINEER
RICHARD V. BETTINGER
C7865
CIVIL
STATE OF CALIFORNIA

GM 6340160
SUPV. M.M. CALLEJAS
CALC. A.P. URBINA SR.
WN. A P.URBINA SR.
H. E.J. Kappler
O.K. mmc / S.S.
DATE NOV. 3, 1982
SCALE AS SHOWN

CIVIL-HYDROLOGIC ENGINEERING
RAINFALL
INTENSITY-DURATION-FREQUENCY
CARRIZO PLAIN
30 MW SOLAR POWER PLANT

DEPARTMENT OF ENGINEERING
PACIFIC GAS AND ELECTRIC COMPANY
SAN FRANCISCO, CALIFORNIA

DIVISION:
SAN JOAQUIN
SUPERSEDES
SUPERSEDED BY
SHEET NO.
SHEETS
DRAWING NUMBER 107342
CHANGE 1



REFERENCES

1. MILLER, J. F., FREDERICK, R. H., AND TRACEY, R. J., *"PRECIPITATION-FREQUENCY ATLAS OF THE WESTERN UNITED STATES,"* VOLUME XI - CALIFORNIA, U. S. DEPARTMENT OF COMMERCE, NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION, NATIONAL WEATHER SERVICE, SILVER SPRING, MARYLAND, 1973.

2. HANSEN, E. M., SCHWARZ, F. K., AND RIEDEL, J. T., *"PROBABLE MAXIMUM PRECIPITATION ESTIMATES, COLORADO RIVER AND GREAT BASIN DRAINAGES,"* HYDROMETEOROLOGICAL REPORT NO. 49, U.S. DEPARTMENT OF COMMERCE, NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION, AND U. S. DEPARTMENT OF ARMY CORPS OF ENGINEERS, SILVER SPRING, MARYLAND, SEPTEMBER, 1977

3. U. S. ARMY CORPS OF ENGINEERS, *"STANDARD PROJECT CRITERIA FOR GENERAL AND LOCAL STORMS, SACRAMENTO - SAN JOAQUIN VALLEY, CALIFORNIA,"* DEPARTMENT OF THE ARMY, SACRAMENTO DISTRICT, SACRAMENTO, CALIFORNIA, APRIL, 1971.

APPROVED BY

1	11-4-82	ISSUED	A.P.U. SR.	EJK	
NO.	DATE	DESCRIPTION	BY	CH	APPR

TABLE OF CHANGES

A. DESIGN

A.1.0 APPLICATIONS

A.1.1 Concrete expansion anchors should not be used indiscriminately. For important work, bolts should preferably be cast-in-place, welded, or grouted in drilled holes or in cast-in-place sleeves. Where those types of installation are for good reason impractical, expansion anchors may be used.

A.1.2 Provisions of this standard shall apply to the shell or stud type expansion anchors designated in Part B.

A.1.3 Anchors must be at least 1/2" diameter when used for structural connections or for anchorage of pipes, conduits or ducts greater than 2" diameter.

A.1.4 Anchors shall not be installed in prestressed concrete elements nor used to connect concrete elements which must have a specified value of fire resistance.

A.1.5 Embedded length of anchor shall be exclusive of thickness of grout pad or other overlay.

A.2.0 ALLOWABLE LOADS

A.2.1 Allowable loads shown in Table A, as modified by the provisions of this standard, shall apply to anchors installed in ordinary concrete.

A.2.2 For concrete strength between 2 ksi and 6 ksi, linear interpolation in Table A may be used. For concrete strength greater than 6 ksi, use 6 ksi allowable values. For sound concrete of unknown strength, use 2 ksi values.

A.2.3 Allowable load values given in this standard shall not be increased because of short duration of loading (e.g., for wind or seismic loads).

A.2.4 For anchors subjected to continuous or frequent (more than 500 times per year) reversal of loading, allowable loads shall be 1/3 of the allowable values given in this standard.

A.2.5 Allowable loads given in this standard are intended for use at "working load" levels. For "ultimate" or "limit" load design purposes, twice these values may be used.

A.2.6 Anchors installed in lightweight aggregate concrete shall have allowable loads equal to those provided for anchors in ordinary concrete with $f'_c = 2$ ksi.

A.2.7 Allowable loads of anchors of 1/2" or larger diameter may be increased by 50% if proof loading is done according to the instructions given in Part B.

A.2.8 If center to center spacing of anchors is less than 12 diameters and/or if distance from edges of concrete to center of anchor is less than 6 diameters, the allowable loads shall be reduced in accordance with the following formulae:

$$P_D = 2.25\, P_A \frac{N}{N+6} \frac{E}{E+3} \qquad S_D = 1.5\, S_A \frac{E}{E+3}$$

Where: P_D = allowable pullout load reduced for edge distance and/or spacing.
P_A = allowable pullout load from Table A
S_D = allowable shear load reduced for edge distance
S_A = allowable shear load from Table A
N = no. of diameters of anchor spacing
$(6 \leq N \leq 12)$: if $N > 12$, use $N = 12$
E = no. of diameters of edge distance
$(3 \leq E \leq 6)$: if $E > 6$, use $E = 6$

Anchor spacing shall be not less than 6 times nominal diameter of anchor. Edge distance shall be not less than 3 times nominal diameter nor less than 3 inches. If edge of concrete is chamfered, edge distance shall be measured from nearest edge of chamfer.

APPROVED BY

REV.	DATE	DESCRIPTION	DWN.	CHKD.	APVD.
3	1-16-78	GENERAL REVISION. REDRAWN. SHEETS 3 & 4 ADDED	JF	BC	DWS

Richard V. Bettinger
CIVIL

GM
SUPV. MC
DSGN. SA, AA
DWN. JF
CHKD. BC
O.K. MC
DATE 4-17-73
SCALE NONE

ENGINEERING STANDARD

CONCRETE EXPANSION ANCHORS FOR STATIC AND SEISMIC LOADING

DEPARTMENT OF ENGINEERING
PACIFIC GAS AND ELECTRIC COMPANY
SAN FRANCISCO, CALIFORNIA

SUPERSEDES
SUPERSEDED BY
SHEET NO. 1 OF 4 SHEETS
DRAWING NUMBER 054162
REV. 3
MICROFILM

APPENDIX "C"

A.2.9 For anchors which will be subjected simultaneously to pullout and shear forces, the allowable load values used must satisfy the following formula (Figure 1):

$$\left(\frac{P_C}{P_D}\right)^{5/3} + \left(\frac{S_C}{S_D}\right)^{5/3} \leq 1$$

Where P_D, S_D = allowable loads (pullout, shear), reduced for spacing or edge distance if appropriate

P_C, S_C = allowable loads to be used in cases where pullout and shear loads may occur simultaneously

Note: For convenience in calculation, exponents in the above formula may, conservatively, be reduced to 1.0.

TABLE A
ALLOWABLE LOAD (KIPS) ON EXPANSION ANCHORS

NOMINAL DIAMETER (INCH)	CONCRETE STRENGTH, fc'									
	2 ksi		3 ksi		4 ksi		5 ksi		6 ksi	
	P	S	P	S	P	S	P	S	P	S
1/4	.25	.30	.275	.30	.30	.30	.325	.30	.35	.30
3/8	.40	.54	.50	.60	.60	.67	.70	.73	.80	.80
1/2	.70	.74	.87	.89	1.05	1.04	1.23	1.19	1.40	1.34
5/8	1.20	1.00	1.50	1.25	1.80	1.50	2.10	1.75	2.40	2.00
3/4	1.80	1.50	2.35	1.80	2.90	2.10	3.45	2.40	4.00	2.70
7/8	2.50	2.00	3.35	2.35	4.20	2.70	5.05	3.05	5.90	3.40
1	3.30	2.50	4.30	2.90	5.50	3.30	6.60	3.70	7.70	4.10
1 1/4	5.30	3.40	6.65	3.95	8.00	4.50	9.35	5.10	10.70	5.70

NOTE: P, PULLOUT; S, SHEAR
For expansion anchors installed in lightweight aggregate concrete, assume f'c = 2 ksi.
See par. A.2.6.

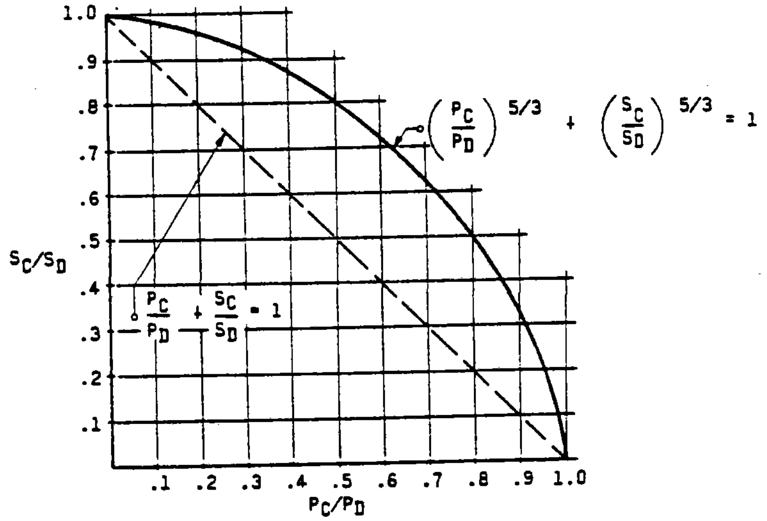


FIGURE 1
REDUCTION FACTORS FOR COMBINED PULLOUT AND SHEAR

CONCRETE EXPANSION ANCHORS FOR
STATIC AND SEISMIC LOADING

P G & E CO.

SHEET 2 OF SHEETS

DRAWING NUMBER
054162

REV.
3

MICROFILM

B. INSTALLATION

B.1.0 APPLICATIONS

B.1.1 Provisions of this standard shall apply to the following concrete expansion anchors. Other expansion anchors shall not be used without specific authorization of the Engineer.

SHELL ANCHORS: • PHILLIPS SELF-DRILLING, PHILLIPS NONDRILLING, DIAMOND, HILTI HDI, RAWL SABER-TOOTH.

STUD ANCHORS: • KWIK-BOLT, PARABOLT, PHILLIPS WEDGE, PHILLIPS SLEEVE, WEJ-IT ANKR-TITE.

- PHILLIPS STUD ANCHOR may be used in sizes up to 3/4" diameter.
- WEJ-IT (original style, with spade-shape wedges) may be used, provided embedment is 125% of that shown in Table B, with 50% of the allowable load values shown in Table A.

B.1.2 Anchors must be at least 1/2" diameter when used for structural connections or for anchorage of pipes, conduits or ducts greater than 2" diameter.

B.1.3 Anchors shall not be installed in prestressed concrete elements nor used to connect concrete elements which must have a specific value of fire resistance.

B.2.0 INSTALLATION

B.2.1 Installation of anchors shall be according to manufacturer's instructions as to tools, torque and tightening procedure.

B.2.2 If a hole cannot be drilled to the correct depth (e.g., if reinforcing steel is encountered while drilling), a new hole shall be drilled. There shall be at least 1/2" of sound concrete between abandoned hole and new hole. If an unused hole is within 4.5 nominal diameters of an expansion anchor, center to center, the unused hole shall be filled with grout or with an expanded anchor.

B.2.3 If axis of a drilled hole deviates from normal to concrete surface by more than 5^0 the hole shall not be used unless specifically authorized by the Engineer.

B.2.4 Minimum required embedment, for shell type anchors, is equal to the length of shell. For most shell anchors the shell may be recessed not more than 1/4 of the nominal diameter. Installed shells recessed to greater depths shall not be used unless specifically authorized by the Engineer.

Minimum required embedment for stud type anchors is given in Table B.

Embedment length is exclusive of thickness of any grout pad or other overlay.

B.2.5 Anchors shall be installed according to manufacturer's instructions. If, after starting from finger-tightened position, anchor slips more than 10% of minimum required embedment while being tightened, one of the following remedial actions shall be taken:

a. Remove bolt or nut, reset anchor, repeat tightening;

b. Remove anchor, substitute larger diameter or longer anchor;

c. Drill new hole and install additional anchor which satisfies the requirements of this standard.

B.2.6 Anchor spacing, center to center, shall be not less than 6 times nominal diameter of anchor nor shall edge distance be less than 3 times nominal diameter nor less than 3 inches unless specifically authorized by the Engineer.

B.2.7 If edge of concrete is chamfered, edge distance shall be measured from nearest edge of chamfer.

B.3.0 PROOF LOADING

When required by the Engineer, proof loading shall be done according to the following instructions:

B.3.1 Whenever an installation crew starts installing anchors at a job site, each of the anchors installed by that crew shall at first be proof loaded in tension to 250% of the allowable pullout load designated by the Engineer. After five successive anchor installations have been completed without failure, a random selection of 10% of the anchors of each size installed by the crew thereafter on the same project shall be tested in the above manner.

B.3.2 If proof loading is done by jacking against a surface area of concrete surrounding the anchor, the jacking pressure shall be distributed over an annular area of inner diameter at least 3 times the minimum required embedment given in Table B.

B.3.3 Criteria for failure of an anchor during proof loading are:
(1) concrete cracks, (2) anchor breaks, or (3) anchor slip during the test is greater than 5% of the minimum required embedment.

TABLE B

MINIMUM EMBEDMENT REQUIRED FOR STUD-TYPE EXPANSION ANCHORS INSTALLED IN CONCRETE

Nominal Diameter (Inches)	Minimum Embedment (Inches)
1/4	1-1/8
3/8	1-3/4
1/2	2-1/4
5/8	2-7/8
3/4	3-3/8
7/8	4
1	4-1/2
1-1/4	5-5/8

ENGINEERING STANDARD CONCRETE EXPANSION ANCHORS FOR STATIC AND SEISMIC LOADING	P G & E CO. SHEET 4 OF 4 SHEETS	DRAWING NUMBER 054162	REV. 3
		MICROFILM	

6.1 RECEIVER TOWER (D23-12)

Engineering
71-370 2/81

DCM No. D23-12 **Revision** 0
Date March 14, 1983
File No.

PACIFIC GAS AND ELECTRIC COMPANY

DESIGN CRITERIA MEMORANDUM

Structure, System, or Component: Receiver Tower 30 MW Solar

Prepared by: C. F. Allen CFAllen **Date** 3/14/83

Group Leader/Supervisor Review E. P. Wollak EPWollak C E **(Discipline)** **Date** 3/18/83

Reviewed by Interfacing Disciplines:

Group Leader/Supervisor J. B. Gegan M.E. JBGegan **Date** 3/23/83

Group Leader/Supervisor K. Zaharoff E.E. KZaharoff **Date** 3/24/83

Group Leader/Supervisor **Date**

Approved by:

Department Chief: R. V. Bettinger RVBettinger **Date:** 3-21-83

Approved for Project use:

Project Engineer: R. E. Price REPrice **Date:** 4.1.83

Page 2 through 9 attached; describing design inputs. Other attachments as indicated below.

cc:

☒ Approving Discipline Chief(s) R. V. Bettinger

☒ Chief, Engineering Quality Control C. E. Ralston

☒ Project Engineer R. E. Price

☒ Discipline Group Leader(s)/Supervisor(s) E. P. Wollak
J. B. Gegan
K. Zaharoff

☒ Manager, Steam Generation W. H. Barr

Others A. B. Schuurman

Receiver Tower
Design Criteria

Index

Section

1. Basic Function and Description

1.1 Structure - The tower will support the solar receiver subsystem, and all related components such as pipe chase, service supports, BCS targets, equipment room, elevator and stairs. The tower shall be a steel truss structure (A572-50 Galv.) with a square base dimension of 100 feet.

1.2 Foundation - The tower shall be supported at each leg by a pier-type foundation or pile foundation.

2. Codes and Standards

All design work shall comply with the listed codes and standards. In the event of conflict between the codes and standards, or any other criteria contained in this document, the more stringent shall govern unless specifically stated.

2.1 General:

2.1.1 Uniform Building Code and Uniform Code Standards, 1982 Edition.

2.1.2 Occupational Safety and Health Act, 1970.

2.2 Concrete:

2.2.1 Building Code Requirements for Reinforced Concrete, ACI-318-77.

2.2.2 Building Code Requirements for Structural Plain Concrete, ACI-332-72.

2.3 Structural and Miscellaneous Steel:

2.3.1 American Institute of Steel Construction (AISC) - Manual of Steel Construction, Eighth Edition, 1980.

2.3.2 AISC Specification for Structural Joints using ASTM A325 and A490 Bolts, August 1980.

2.3.3 American Iron and Steel Institute Specification for the Design of Light Gage Cold-Formed Steel Structural Members, 1980.

2.4 Welding:

2.4.1 American Welding Society Structural Welding Code, AWS D1.1-82.

2.4.2 American Welding Society Reinforcing Steel Welding Code, AWS 12.1-75.

2.5 Pile Foundations:

2.5.1 Section 49.f, State of California Standard Specification, 1978.

3. Material

3.1 Concrete:

3.1.1 Reinforced Concrete shall develop a f'c $\geq$ 3000 psi in 28 days.

3.1.2 Plain Concrete shall develop a f'c $\geq$ 3000 psi in 28 days.

3.1.3 Shotcrete shall develop a f'c $\geq$ 3000 psi.

3.2 Reinforcing:

3.2.1 Reinforcing Bars shall be ASTM A615 Grade 60. Sizes shall be confined to #4, #6, #9 & #11. Sizes #10 & #14 may be used in special cases. Typical bar spacing in slabs shall not be less than 12" o.c. Where local slab stresses require heavier reinforcing, bars may be added provided that the resulting bar spacing is not less than 4" o.c.

3.2.2 Welded Wire Fabric shall conform to ASTM A185 using wire meeting ASTM A82. Preferably only one size shall be used throughout the job.

3.2.3 Mechanical Splices - Acceptable proprietary couplings are Fox-Howlett, Dywidag and Cadweld.

3.2.4 Welded Splices - Use only the direct butt weld splice as defined by The American Welding Society AWS D12.1-75 Reinforcing Steel Welding Code.

3.3 Structural Steel:

3.3.1 Plates and Structural Shapes - Framing.

3.3.3.1 Receiver tower shall be ASTM A572-50 hot dip galvanized.

3.3.4 Embedded Metal

3.3.4.1 Plates or shapes used as anchor plates shall be ASTM A36.

3.3.4.2 Plates or shapes which are used as protective edging or support for checkered plate or grating shall be A36, hot dip galvanized after fabrication.

3.3.4.3 Anchor bolts shall be ASTM A307 except when special bolts are called for by equipment manufacturers.

3.3.4.4 Anchor bolts exposed to weather shall be A307, hot dip galvanized at the top for a distance equal to at least the projection plus 2 inches. Nuts and washers shall also be galvanized.

3.3.5 Connection Bolts

3.3.5.1 All field connections shall be bolted joints using ASTM A325 bearing type bolts (no threads in shear plane). Only one size bolt shall be used throughout the job. However, the responsible engineer may authorize use of large bolts in specialized connections.

3.3.5.2 Use mechanically galvanized A325 bolts when connecting galvanized framing. Galvanizing of bolts shall be in conformance with ASTM B454-76.

3.3.6 Welded studs shall comply with AWS D1.1-82, Section 4, part F. Stainless Steel studs shall be used on stainless steel members.

3.3.7 Folded metal decking shall be H. H. Robertson Decking, or equivalent, capable of use as a diaphram in carrying lateral loading.

3.3.8 Floor plates shall be galvanized skid resistant raised pattern plate, commonly called checkered plate, made of A36 steel not less than 1/4 inch thick.

3.3.9 Grating shall be galvanized welded steel with rectangular steel bars 1-1/4" x 3/16" spaced 1-3/16" o.c. Allowable stress 18,000 psi. Clear span determined by loading, but not to exceed 4'-6".

3.4 American Society for Testing and Material (ASTM)

3.4.1	ASTM A 6-77	Specification for General Requirements for Rolled Steel Plates, Shapes, Sheet piling, and Bars for Structural use
3.4.2	ASTM A 36-77	Specification for Structural Steel
3.4.3	ASTM A 53	Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless
3.4.4	ASTM A 123-73	Specification for Zinc (Hot Galvanized) Coatings on Products Fabricated from Roll, Pressed, and Forged Steel Shapes, Plates, Bars, and strip
3.4.5	ASTM A 307-76	Specification for Carbon Steel Externally Threaded Fastenerns
3.4.6	ASTM A 325-76	Specification for High-Strength Bolts for Structural Steel Joints
3.4.7	ASTM A 490-77	Specification for Quenched and Tempered Alloy Steel Bolts for Structural Steel Joints
3.4.8	ASTM A 525-77	Specification for Steel Sheet, Zinc-Coated (Galvanized) by the Hot-Dip Process, General Requirements
3.4.9	ASTM A 569-72	Specification for Steel, Carbon (0.15 maximum percent), Hot-Rolled Sheet and Strip, Commercial Quality

4. Design

4.1 Loadings:

4.1.1 Dead Load - including the weight and contents of the receiver, elevator machinery room, control room, operating and landing platform and stairways, BCS target, the normal operating weight of sodium lines, tower structure, and permanent fixtures and supports.

4.1.2 Live Loads (LL)

4.1.2.1 The following Uniform Loads shall be used for the design live loads:

Control Room Area	250 psf
Platforms, Walkways, Stairs*	100 psf 1000 lb (concentrate)

*These loads are concurrent. Place concentrate load to produce maximum stress being checked.

4.1.2.2 Discussion of Live Loads - In general LL is to be applied as uniform loading. It is intended to include allowances for small equipment, small piping, conduit, lighting fixtures and movable partitions.

4.1.3 Snow Load - Snow load shall be 5 psf.

4.1.4 Piping and Conduits Loading - This loading will be concurrent with live loads. Sodium lines shall be designed for actual loads and anchor forces as determined by pipeline analysis. Preliminary design loads may be estimated; however, the structure shall be checked using final pipe support loads.

4.1.5 Wind Loading - The design wind pressure shall be derived from ANSI A58.1-1972. The pressures are to be applied to the projected area of the structure in a direction(s) that produces the most severe condition.

Two wind speeds shall be considered (a) 70 mph (b) 30 mph. Note: These are basic wind velocities at 30 feet above ground and do not include gust factors.

4.1.6 Seismic Loading

Seismic loading shall comply with Section 2312, UCB-82 unless otherwise stated.

4.1.6.1 Base Shear for Structures

The following values shall be used to determine the base shear (V) on a structure unless otherwise specified: Zone 4; Importance Factor = 1.0; K = Appropriate Value. Table 23-I; C = as established by Formula (12-1); S = 1.5; - (NOTE: CS $\leq$ .14); W = DL + .15LL as defined in Section 4.1.2.

$$V = ZIKCSW$$

4.1.6.1.1 The minimum design base shear shall be V = .25W

4.1.6.1.2 Base shear distribution shall be done in accordance with Sec. 2312(e).

4.1.6.2 Base Shear on Elements of Structures and Non-Structural Components.

4.1.6.2.1 Minimum horizontal seismic loadings shall be in accordance with Sec. 2312(g) unless otherwise specified. Values for Zone 4 and Importance Factor = 1.0 shall be used.

4.1.6.2.2 Minimum horizontal seismic force for battery racks shall be F_p = .50 Wp.

4.1.6.3 Vertical Loads

4.1.6.3.1 The items covered above in Section 4.2.6.1 and 4.1.6.2 shall be designed for a concurrent reversible vertical load of two-thirds the magnitude of their horizontal seismic loads. These vertical seismic loads shall be applied with respect to center of mass.

4.1.7 Load Combinations

Structures shall be designed for the following load combinations:

Case I: DL + LL + SNOW
Case 2: DL + LL + ½ SNOW + WIND
Case 3: DL + .15 LL + SEISMIC
Case 4: DL + .15 LL + WIND

4.1.8 Overturning

The resistance to overturning of the structure by soil pressure, soil friction, or anchor shall not be less than 1.5 times the sliding force due any lateral design load. The effect of uplift loads shall be considered when applicable.

4.1.9 Allowable Tower Drift

4.1.9.1 Maximum tower drift shall be 12 inches during 30 mph wind.*

4.1.9.2 Maximum tower drift shall be 48 inches during 70 mph wind* or seismic loading.

4.2 Elevator:

4.2.1 The elevator and control wire chase shall be completely enclosed with metal panels.

*ANSI - Based wind velocity at 30 feet above ground, not including gust factor.

4.2.2 Siding shall be Reynolds Metal Co. "Boldbeam Aluminum Alclad #3304 Alloy, .040 inch thick, with "FLuropon" color as specified.

4.2.3 Elevator shall be:

Type: OTIS #2035
Weight: 2,000 lb capacity
Speed: 350 Ft/Minute
Stops: 4
Elevation of last landing: <u>+362 Feet</u>

4.3 Tower Platform

4.3.1 The tower platform shall be designed to match the mounting structure of the complete receiver subsystem.

4.3.2 Total weight of receiver subsystem is 627,000 lbs.

4.4 B.C.S. Targets

4.4.1 The B.C.S. targets shall consist of three steel plate panels 1/4 in. thick by 30 ft. by 20 ft. high. These panels shall be arranged in a "_/" configuration with the center panel of the arrangement facing due north centered on the center line of the heliostat field. The two outer wing panels of the "_/" are at 45 degrees to the flat face plane of the center panel. All three panels are welded together and are tipped down 25 degrees from horizontal. The top of the target shall be at elevation 383.

4.5 Equipment Control Room

4.5.1 The Control Room shall be located immediately below the 383-ft elevation level. It shall approximate a 20-ft by 20-ft configuration and have an 8-ft clear height ceiling. The Control Room shall be completely enclosed with insulated metal siding and be atmosphere controlled with an air conditioning unit having humidity control and heating capabilities.

5. References:

5.1 Project Design Criteria, DCM D23-1.

5.2 Civil and Architectural Design Criteria DCM D23-2

Engineering
76-370 2/81

DCM No. D23- [illegible] Revision 0
Date April 13, 1983
File No. 50020

PACIFIC GAS AND ELECTRIC COMPANY

DESIGN CRITERIA MEMORANDUM

Structure, System, or Component: Plant Auxiliary Electric Power System Carrisa Plains 30 MW Solar Project

Prepared by: E. W. Levijoki E.W. Levijoki Date 4-13-83

Group Leader/Supervisor Review KGZ (Discipline) Date 5-4-83

Reviewed by Interfacing Disciplines:

Group Leader/Supervisor JBG Date 4-28-83

Group Leader/Supervisor ABS Date [illegible]

Group Leader/Supervisor MTP Date 4/28/83

Approved by:

Department Chief: JRH/JWC Date: 5/18/83

Approved for Project use:

Project Engineer: REP Date: May 20, 1983

Page 2 through 9 attached; describing design inputs. Other attachments as indicated below.

cc:

☒ Approving Discipline Chief(s) JRH

☒ Chief, Engineering Quality Control CER

☐ Project Engineer

☒ Discipline Group Leader(s)/Supervisor(s) KGZ

☐ Manager, Steam Generation

Others

Plant Auxiliary Electric Power System
Carrisa Plains 30 MW Solar Project

1.0 BASIC FUNCTION

The basic function of the Plant Auxiliary Electric Power System is to provide reliable 4.16 kV, 480 VAC, 125 VDC, 208/120 VAC, uninterruptible 208/120 VAC power, and 480 VAC, 125 VDC, 208/120 VAC emergency power. A 480 VAC preferred load power supply is provided from normal AC source or the emergency engine driven generator for the fire pump, service water pump, raw water pump, receiver tower elevator, heliostat field and other preferred loads.

This Plant Auxiliary Electric Power System provides required power for all plant loads during, plant operation, overnight, start-up, emergencies, and long term outage periods.

2.0 RATINGS AND DESIGN CONDITIONS

The ratings and design conditions for the Plant Auxiliary Electric Power Systems shall be as follows:

2.1 Power cables shall be provided from the 12 kV generator bus to the auxiliary transformer.

2.2 A 12 kV to 4.16 kV auxiliary transformer, 3 phase, 60 hertz, oil-air cooled outdoor type shall be provided.

2.3 4.16 kV switchgear with (4) indoor type air circuit breakers shall be provided to supply the (2) 1500 KVA transformer described below, and to supply the (2) 750 Hp receiver sodium pumps. This switchgear shall be rated at minimum of 12500 amperes symmetrical.

2.4 Two (2) 4.16 kV to 480 VAC, 3 phase, 60 hertz, oil-air cooled, outdoor type, 1500 KVA transformers shall be provided.

2.5 Two (2) 480 VAC switchgear shall be provided with air circuit breakers to power the following loads. This switchgear shall be rated at minimum of 50,000 amperes symmetrical. Control voltage shall be 125 VDC from the plant battery.

275 Hp Circulating Water Pump No. 1	275 Hp Circulating Water Pump No. 2
700 Hp Boiler Feed-Water Pump with Variable Speed Drive	700 Hp Boiler Feed-Water Pump with Variable Speed Drive
990 KW Auxiliary Electric Boiler No. 1	990 KW Auxiliary Electric Boiler No. 2
1200 Ampere Circuit Breaker to Supply 480 VAC MCC No. 6	1200 Ampere Circuit Breaker to Supply 480 VAC MCC No. 5
1200 Ampere Circuit Breaker to Supply 480 VAC MCC No. 2	1200 Ampere Circuit Breaker to Supply 480 VAC MCC No. 3
800 Ampere Circuit Breaker to Supply 250 Hp Fire Pump #1 100 Hp Raw Water Pump #1 40 Hp Service Primary Water Pump No. 1	800 Ampere Circuit Breaker to Supply The preferred MCC bus No. 1 250 Hp Fire Pump #2 100 Hp Raw Water Pump No. 2 40 Hp Service Primary Water Pump No. 2

(Alternate supply to the above circuit is from the 250 KW Engine Generator.)

2.6 (1) 480 VAC MCC (No. 5) shall be provided for the following loads:

Auxiliary Boiler FW Pump

Cooling Tower Fan #1

Condensate Pump #1

Service Water Pump #1

Air Compressor #1

Vapor Compressor #1

Various smaller 480 VAC loads

2.7 (1) 480 VAC MCC (No. 6) shall be provided for the following loads:

Hydraulic Oil Pumps #1 & #2

Condensate Pump #2

Cooling Tower Fan #2

Air Compressor #2

Oily Water Separator

Vapor Compressor #2

Various smaller 480 VAC loads

2.8 (1) 480 VAC MCC (No. 1) shall be provided and rated for the preferred loads:

Battery Chargers

Motor Operated Valves

Auxiliary Lube Oil Pump

Cooling Water Pump for Vacuum Pump

Service Water Pump No. 2

Receiver Tower Elevator

Fire Pump No. 2

Raw Water Pump No. 2

208/120 VAC 150 KVA Transformer

2.9 (1) 250 KW, 480 VAC, 3 phase, 60 hertz engine-generator shall be provided to supply emergency power to the following loads on loss of normal AC power:

208/120 VAC 150 KVA Transformer

Lighting Panels

Emergency Power to the Heliostat Inverter Power Supply

Emergency Power to the Uninterruptible Inverter Power Supply for Master Control and Other Essential Loads

Battery Chargers

Fire Pump #2

Other Preferred Loads

2.10 (1) 480 VAC to 208/120V, 3 phase, 60 hertz transformer rated at 150 KVA shall be provided to supply the following loads:

Normal 208/120 Volt AC Loads

Lighting Panels

Alternate 120 Volt AC Loads through the Inverters Static Switches

2.11 (2) 208/120 VAC, 30, 4W Power Panels shall be provided.

2.12 (2) 208/120 VAC, 30, 4W Lighting Distribution Panels shall be provided.

2.13 (1) 125 VDC, 1200 ampere-hour station battery shall be provided to supply inverters for heliostat field, emergency lube oil pump, and other 125 VDC uninterruptible loads.

2.14 (2) 125 VDC output, 480 VAC input battery chargers shall be provided for float and equalize charging of the battery and to supply the 125 VDC load.

2.15 (1) 60 KVA, 208/120 VAC inverter shall be provided for the heliostat field loads.

2.16 (1) 30 KVA, 208/120 VAC inverter shall be provided for master control, computers, and other essential uninterruptible control loads.

3.0 CODES AND STANDARDS

The latest revisions of the following codes and standards are applicable:

3.1 ANSI:

N41.24 Design and Installation of Large Lead Storage Batteries for Generating Stations and Substations

C37.13, C37.13a, Standard for Low-Voltage AC Power Circuit Breakers Used in Enclosures

C37.20, C37.20d, Standard for Switchgear Assemblies Including Metal-Enclosed Bus

C37.50, C37.50a, C37.50b, Standard for Test Procedures for Low Voltage AC Power Circuit Breakers Used in Enclosures

C57.12.00, General Requirements for Distribution, Power, and Regulating Transformers

C57.12.10, Requirements for Transformer 230 kV and Below, 750/862 through 60000/80000/100000 KVA, Three Phase

3.2 IEEE:

450 Recommended Practice for Maintenance, Testing, and Replacement of Large Lead Storage Batteries

484 Recommended Practice for Installation Design and Installation of Large Storage Batteries

485 Recommended Practice for Sizing Large Lead Storage Batteries

3.3 NEMA:

AB-1, Molded Case Circuit Breakers

SG5, Power Switchgear Assemblies

SG3, Low Voltage Power Circuit Breaker

ESIGN LOADS

.1 For seismic loading see paragraph 4.0 of Civil Design Criteria Memorandum No. D23-2 dated March 8, 1983.

PERATING AND ENVIRONMENTAL CONDITIONS AND REQUIREMENTS

.1 The Plant Auxiliary Electric Power System shall operate and maintain the plant in a safe condition under all the following conditions:

5.1.1 With plant auxiliary power supplied from the line thru the start-up transformer.

5.1.2 With plant auxiliary power supplied from the plant generator.

5.1.3 With plant emergency power supplied as defined in paragraph 2.13 from the plant battery.

5.1.4 With plant emergency power supplied from the engine-generator and the plant battery as defined in paragraphs 2.9 and 2.13.

5.1.5 With the plant under normal operating conditions.

.2 All power equipment shall be able to operate for 40 years at ambient temperatures of -5°C to 44°C and humidity of 90%.

.3 All power equipment shall be operable up to an altitude of 3000' above sea level.

NTERFACE REQUIREMENTS

.1 The Plant Auxiliary Electric Power System shall provide reliable power to meet this criteria for the following:

6.1.1 The Heliostat System.

6.1.2 The Receiver-Steam-Generator System.

6.1.3 The Power Conversion System.

6.1.4 Auxiliary power as required for the main turbine generator, step-up transformer, protection system, and master control system.

6.1.5 Emergency power as required for safe shutdown after generator trip and loss of transmission power, and for emergency control equipment on loss of master control system.

6.1.6 Balance of plant.

LAYOUT AND ARRANGEMENTS

7.1 The Plant Auxiliary Electrical Power System shall be centrally located in and outside the turbine building for economical distribution of power to all systems listed under paragraph 6.1.

INSTRUMENTATION, CONTROL, AND PROTECTION

8.1 Instrumentation, control and protection equipment for the Plant Auxiliary Electrical Power System shall be provided in the main control room electrical control board for operation, protection and testing as required for safe and reliable operation of the system.

8.2 Balance of instrumentation, control, and protection of the Plant Auxiliary Electrical Power System shall be provided locally at the power system equipment as required for safe and reliable operation, protection, testing, and maintenance.

6.3 PLANT LIGHTING (D23-11)

Engineering
76-370 2/81

DCM No. D23-11 Revision 0
Date MAY 4 1983
File No. D23-68601

PACIFIC GAS AND ELECTRIC COMPANY

GENERAL

DESIGN CRITERIA MEMORANDUM

Structure, System, or Component: Lighting, 30 MW Solar Thermal Power Plant

Prepared by: E. W. Levijoki EWL Date 11-1-82

Group Leader/Supervisor Review KGZ, ZAHAROFF EE (Discipline) Date [illegible]

Reviewed by Interfacing Disciplines:

Group Leader/Supervisor JBG GEGAN Date 1-12-83

Group Leader/Supervisor ABS SCHUURMAN Date 1-12-83

Group Leader/Supervisor MTP Date 4-28-83

Approved by:

Department Chief: JWC J M Colwell Date: 5/4/83

Approved for Project use:

Project Engineer: REP REPrice Date: May 5 1983

Page 2 through 4 attached; describing design inputs. Other attachments as indicated below.

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☒ Approving Discipline Chief(s) JRH

☒ Chief, Engineering Quality Control CER

☒ Project Engineer REP

☒ Discipline Group Leader(s)/Supervisor(s) KGZ

☒ Manager, Steam Generation

Others

LIGHTING

1.0 SUMMARY

The lighting system - transformers, panelboards, circuit breakers, and fixtures - provides indoor and outdoor normal and standby lighting and 120 volt convenience outlets.

2.0 REGULATORY REQUIREMENTS

The applicable Occupational Safety and Health Administration (CAL/DOSH) directives shall be followed.

3.0 CODES AND STANDARDS

Standards applying to lighting are listed in Appendix I.

4.0 DESIGN CRITERIA

4.1 Normal Indoor Lighting:

4.1.1 Indoor lighting power is supplied from dry-type 480-208/120V or 480/277V transformers. Conductors from the transformer to the lighting distribution panelboard are sized to limit voltage drop to two percent.

4.1.2 Each system neutral is solidly grounded to the station ground grid at one point only. The transformer neutral is usually the ground point.

4.1.3 Transformers for the lighting system are initially loaded to 80 percent nameplate rating to allow future expansion.

4.1.4 Lighting panelboards and circuit breakers are rated for 125 percent of connected load. A minimum of 20 percent spares or spaces shall be provided in all lighting distribution panelboards. Lighting panels shall be sized on the basis of maximum possible load including spares and spaces.

4.1.5 Lighting panelboard circuit breakers for receptacle circuits will be GFCI type. For long circuits (over 150 ft.) standard circuit breakers and GFCI receptacles should be used. All circuit breakers will be capable of interrupting the highest available short circuit at the panelboard. Circuit breakers for high-intensity discharge lighting will allow for the starting current time characteristic of the ballast used. All lighting circuit breakers are to be equipped with lockout devices.

4.1.6 Lighting circuits in any area should be divided between two sources where practical.

4.1.7 Conductors for the lighting system are sized to limit branch circuit voltage drop to three percent.

4.1.8 Convenience outlets are part of the lighting system. Adequate outlets will be provided in all areas of the plant. All convenience outlets are duplex, 120 volt, 20 amp, 3 wire, grounding type, with minimum No. 10 AWG wiring.

4.1.9 Each branch circuit can supply a maximum of eight receptacles.

4.1.10 Local light switches are provided for energy conservation.

4.1.11 Locate lighting fixtures to facilitate maintenance and avoid interference with other plant systems.

4.1.12 Vapor tight lighting fixtures are required in battery rooms.

4.2 Normal Outdoor Lighting:

4.2.1 Outdoor lighting should be supplied from nearby load centers or motor control centers.

4.2.2 Outdoor security lighting maybe controlled by a combination of photoelectric cells and time clocks with manual override. Areas of frequent access will have local controls.

4.2.3 Receiver tower and cooling towers may be required to have aircraft hazard lights.

4.3 Standby Lighting DC System:

4.3.1 Standby lighting power in critical areas is supplied by the 125V, DC batteries, or indirectly powered DC light assemblies.

4.3.2 The DC lighting system is energized when the AC lighting system fails, or has a loss of power.

4.3.3 Remote areas and buildings DC lighting will be provided by emergency fixtures having self-contained batteries, charger and automatic switches. Batteries in these units are to provide light at rated level for two hours.

4.3.4 The standby lighting DC system has no local switches.

4.3.5 Standby DC lighting in areas having sodium vapor lamps will stay on for a short period after AC power is restored to permit restart. Restart time may vary from one to five minutes.

5.0 ILLUMINATION LEVELS

Illumination levels are to meet or exceed recommended levels in the Illuminating Engineers' Society Handbook. Typical levels are shown in Table 1.

6.0 MAINTENANCE

Provide normal design features for performance of maintenance. Access for lamp changing must be considered.

7.0 ENVIRONMENT

Lighting must be selected to withstand environmental conditions of plant site. Lighting over critical equipment to meet seismic loading as specified by Civil Engineering.

8.0 INTERFACE REQUIREMENTS

8.1 The lighting system has major interfaces with the following:

System Identity	Type Interface
480V, AC	Powers lighting
125V, DC	Powers standby lighting
Conduits and raceways	Routes wires to fixtures & panelboards
Cable	Identifies cable type for lighting
Ground	Lighting system is connected

APPENDIX I

APPLICABLE STANDARDS

The following standards list is to be used as a guide. If they are referred to, they should be identified by number, section, and paragraph.

ANSI

A11.1	Practice for Industrial Lighting
A85.1	Practice for Protective Lighting
A132.1	Practice for Office Lighting
C33.28	Safety Standard for Electric Lighting Fixtures for Use in Hazardous Locations
D12.1	Practice for Roadway Lighting

NEMA

AB-1	Molded Case Circuit Breakers
SG-3	Low-Voltage Power Circuit Breakers
SG-5	Power Switchgear Assemblies

TABLE I

ILLUMINATION LEVELS CURRENTLY RECOMMENDED FOR POWER PLANTS BY IES*

	Footcandles
POWER GENERATION FACILITIES (Indoor)	
Boiler platforms, cable room, circulator, pump bay	10
Burner platforms, screen house	20
Condensers, deaerator floor, evaporator floor, heater floors	10
Hydrogen and carbon dioxide manifold area	20
Precipitators, soot or slag blower platform, steam headers and throttles	10
Tunnels or galleries, piping	10
OUTDOOR WORK AREAS	
Catwalks	2
Fuel oil delivery headers	5
Oil storage tanks	1
Substation	
General horizontal	2
Specific vertical (on disconnects)	2
TURBINE BAYS	
Turbine subbasement	20
Turbine room	30
Platforms—boiler, turbine deck	5

ROADWAYS AND ENTRANCES	Footcandles
Entrances	
Generating or service building	
Main	10
Secondary	2
Gate house	
Pedestrian entrance	10
Conveyor entrance	5
Open yard	0.2
Roadway	
Between or along buildings	1
Not bordered by buildings	0.5
PERIMETER SECURITY	
Fence	0.2
INDOOR WORK AREAS	
Air conditioning equipment, air preheater, fan floor	10
Auxiliaries, battery rooms, boiler feed pumps, tanks, compressors, gauge area	20
Chemical laboratory	50
Control rooms	
Vertical face of switchboards	
Simplex or section of duplex operator	
Type A—large centralized control room, 66 in. above floor	50
Type B—ordinary control room, 66 in. above floor	30
Section of duplex facing away from operator	30
Bench boards (horizontal level)	50
Area inside duplex switchboards	10
Rear of all switchboard panels (vertical)	10
Emergency lighting, all areas	3
Dispatch boards	
Horizontal plane (desk level)	50
Vertical face of board (48 in. above floor, facing operator)	
System load dispatch room	50
Secondary dispatch room	30
Switchgear, power	20
Telephone equipment room	20
Visitors' gallery	20
Water treating area	20

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* Illuminating Engineering Society

GENERAL ELECTRIC Co.
OLP-1971A
MARCH 1981

6.4 COMPRESSED AIR SYSTEM
(D23-21)

Engineering
76-370 2/81

DCM No. D23-21 Revision 0
Date June 9, 1983
File No. D23-75000

PACIFIC GAS AND ELECTRIC COMPANY

DESIGN CRITERIA MEMORANDUM

Structure, System, or Component: Compressed Air System

Prepared by: W. R. Carrothers Date June 9, 1983

Group Leader/Supervisor Review AFA By RBm M&NE Date June 10 · 83
A. F. Ariey (Discipline)

Reviewed by Interfacing Disciplines:

Group Leader/Supervisor A. B. Schuurman

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Group Leader/Supervisor M. T. Perakis

M. E. Conlu

Approved by:

Department Chief: J. V. Rocca

Approved for Project use:

Project Engineer: R. E. Price

Unless and until final design on this project is undertaken, further review and approval of this D.C. will be suspended.
REP
6.10.83

Page 2 through ______ attached; describing design inputs.

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M. T. Perakis
A. B. Schuurman

☐ Manager, Steam Generation ~~W. H. Barr~~

Others I. F. Hall
J. B. Gegan
Department File

DESIGN CRITERIA D23-21
COMPRESSED AIR SYSTEM
30 MW SOLAR PROJECT

1.0 Basic Function

The compressed air system will provide the clean, dry, oil-free air for the instrument and service air systems. The air will be supplied at a minimum pressure of 80 psig. The instrument air system is of greater importance and will have an uninterrupted supply. The service air system includes the plant service air outlets in the plant for cleaning, maintenance, and for powering pneumatic tools.

In addition, instrument air will be supplied to the collector system (ARCO) and the heat transport system (Rockwell) portions of the plant.

2.0 Rating and Capacity

The capacity of the compressed air system shall be based on the requirements of the instrument and control system, plus the maximum requirement of service air.

The required equipment is

Compressors (2)	105 scfm, @ 100 psig
Aftercoolers (2)	4 gpm, cooling water
Air Dryer (1)	100 scfm, @ 100 psig

3.0 Codes and Standards

ASME Boiler and Pressure Vessel Code, Section VIII

ANSI B31.1 Power Piping Code

ANSI B16.5 Valve and Flange Code

State of California Administrative Code, Title 8

Industrial Relations; Chapter 1, CAL/OSHA

Chapter 4, Subchapter 7, General Industry Safety Orders

4.0 Design Conditions

The air compressors will have oil-free, nonlubricated cylinders. Casing jackets and aftercoolers will be cooled by service cooling water. Compressor inlet will be supplied with a silencer/filter.

A desiccant-type air dryer will operate continuously to remove moisture from the air. The dryer will have one column operating and one column reactivating. The air dryer will include instruments and controls to insure safe, proper operation.

During normal operation, the two compressors will be switched into the following modes: one will be running and one will be standby. The standby compressor shall automatically start when air receiver pressure drops or when low voltage occurs on the operating compressor.

The second compressor will be shut down manually when no longer required.

Also refer to Section 2.0.

5.0 Design Loads

Piping loads shall follow ANSI B31.1.

6.0 Environmental Conditions

Silencers will be supplied on the inlet to the air compressors to reduce plant noise level.

7.0 Interface Requirements

The compressed air system will interface with:

a. service cooling water system (4 gpm)

b. plant instrument and control system

8.0 Material Requirements

Compressed air piping shall be carbon steel or stainless steel tubing.

Air receivers shall be carbon steel and require an ASME code stamp.

9.0 Layout and Arrangement

A completely enclosed air compressor room shall be provided at ground level. The room, with at least one exposed wall, will be sized to fit the required equipment. Clearance will be allowed for required clearance of walkways and head room. Adequate space shall be provided for equipment maintenance.

10.0 Instrumentation and Control

The air compressors and aftercoolers will be supplied as a complete package, including instruments and controls. The air dryer will be supplied as a complete package, including instruments and controls. Refer to Instrument and Control Design Criteria, D23-21-I.

11.0 Access Requirements for Security

Not applicable.

12.0 Reliability

A single window in the main control board annunciator will indicate air system trouble. High cooling water temperature to the aftercoolers will trip the running compressor(s). The service air system shall be valved for low pressure refusal such that it will not be permitted to draw the system manifold pressure below 85 psig. All service air outlets will contain a "flow fuse" (OSHA requirement).

13.0 System Reliability Effect on Unit Availability

Same as Section 12.0.

14.0 Examination, Inspection, and Testing

The air compressors and air dryer shall be subject to shop inspection during manufacture. A performance test and acceptance by PGandE inspector will be made before shipment. Air receiver tanks shall be designed, fabricated, tested, and stamped in accordance with the latest edition of the ASME Unified Pressure Vessel Code, Section VIII.

15.0 Maintenance

Sufficient clearance shall be provided around the air compressors, receivers, and air dryers to allow convenient and proper maintenance. Consideration shall be given to overhead structures with a clear lifting space for use of hoisting gear to remove heavy pieces of equipment.

16.0 Personnel Requirements

Air compressors and air dryers will operate automatically. Refer to Operating Description, Section 4.0.

17.0 Shipping

Compressors and air dryer shall be shipped fully assembled and skid mounted to reduce field erection costs.

18.0 Fire Protection

No special requirements.

19.0 Storage

Compressors and air dryers shall be stored indoors.

20.0 Health and Safety of the Public

The State of California Administrative Code, Title 8, Chapter 4, Subchapter 7, General Industrial Safety Orders must be followed.

21.0 Materials and Fabrication

See Sections 3.0 and 8.0.

6.4.1 COMPRESSED AIR SYSTEM INSTRUMENTATION AND CONTROL

(D23-21I)

Engineering
76-370 2/81

DCM No. D23-21-I Revision 0
Date 5-6-83
File No. 75000

PACIFIC GAS AND ELECTRIC COMPANY

30 MW SOLAR

DESIGN CRITERIA MEMORANDUM

Structure, System, or Component: COMPRESSED AIR SYSTEM (I&C)

Prepared by: PD MAXWELL/MTPERAKIS MTPerakis Date 5-4-83

Group Leader/Supervisor Review ____________, ____________ (Discipline) Date ____________

Reviewed by Interfacing Disciplines:

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Group Leader/Supervisor M.E. CONLU MEConlu Date 5-24-83

Group Leader/Supervisor K.G. ZAHAROFF Date 6-14-83

A.B. SCHUURMAN . 6-16-83

Approved by:

Department Chief: J.V. ROCCA JVRocca Date: 6-17-83

Approved for Project use:

Project Engineer: R.E. PRICE REPrice Date: 6-16-83

Page 2 through 9 attached; describing design inputs. Other attachments as indicated below.

cc:

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30MW SOLAR
COMPRESSED AIR SYSTEM
INSTRUMENTATION & CONTROL
DESIGN CRITERIA

Reference Documents:

Compressed Air System - System Design Criteria (DCM No. D23-22).
Instrumentation and Control - General Design Criteria (DCM No. D23-3).
Master Control System - Design Criteria (DCM No. D23-7).

1.0 Scope

This criteria will define the Instrumentation and Control (I&C) requirements for the Compressed Air System.

1.1 Mechanical Equipment to be Controlled

1.1.1 Air Compressors (2)

1.2 Valves to be Controlled

1.2.1 Service Air Refusal Valve

1.3 Vessels to be Controlled

1.3.1 Air Dryer

1.3.2 Aftercoolers

1.3.3 Air Receivers

2.0 Control System Interfaces

2.1 Interface with other Pacific Gas and Electric Company (PGandE) systems

2.1.1 Service Cooling Water System

Service cooling water is used to cool the air compressor heads. The Service Cooling Water System must be in operation to operate the Compressed Air System.

The Service Cooling Water System will provide an air compressor cooling water outlet temperature high trip signal for each compressor (see section 4.1.2).

3.0 Operating Requirements

The Compressed Air System will operate with attended start-up and shutdown and unattended steady state operation. The system will be controlled such that compressed air is available during all expected plant operating conditions, including normal overnight shutdown periods. During plant blackout conditions, the Compressed Air System will not be operable.

Upon unit trip, the air receivers will provide enough reserve capacity to bring the plant to a safe shutdown.

4.0 Mechanical Equipment to be Controlled

4.1 Air Compressors (2)

Under normal operating conditions, one of two 100% capacity air compressors must be started manually, and will run continuously, automatically loading and unloading to maintain air receiver pressure. The other compressor will remain on standby and will automatically start when system pressure drops past a certain setpoint or on a trip of the operating compressor. A time delay will prevent loading a compressor which is starting, until full motor speed is reached. The operator will select which compressor will be on standby. The compressors will load and unload at the same pressure setpoint under control of the master unloader. When only one compressor is running, the operator may select that compressor to load and unload under control of its individual unloader (manufacturer provided). The compressors must be manually stopped.

4.1.1 Control

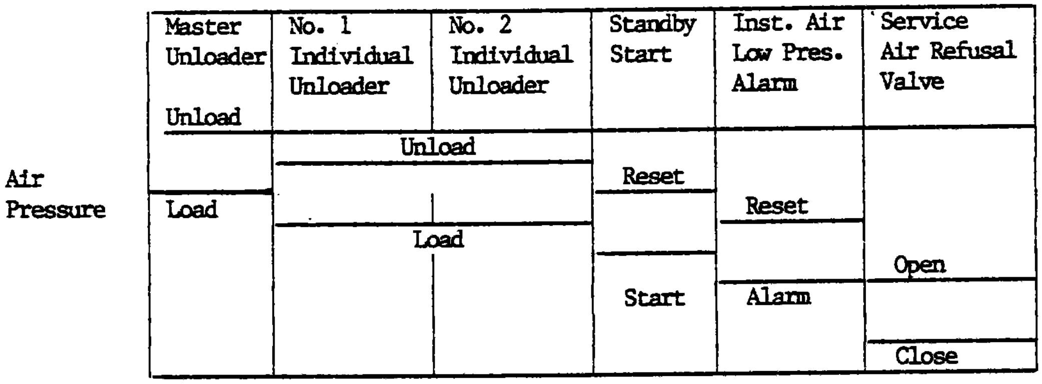
4.1.1.1 Master Control System

None

4.1.1.2 Dedicated Automatic

Local, hardwired, dedicated equipment will control the air compressors.

The service conditions for the air compressors and system alarm and trip setpoints can best be described by the following chart:



The master unloader will load and unload the compressors at the same pressure setpoint when switched on. The individual unloaders will be enabled whenever the master unloader is switched off.

4.1.1.3 Local Manual

Air Compressor No. 1 Start/Stop/Auto Switch

Air Compressor No. 2 Start/Stop/Auto Switch

Air Compressors Standby Select (Comp. No. 1/Comp. No. 2)

Master Unloader On/Off

(The above switches will be maintained contact.)

Air Compressor No. 1 Trip Relay Reset Pushbutton

Air Compressor No. 2 Trip Relay Reset Pushbutton

(The reset is a sealed-in pushbutton.)

4.1.1.4 Remote Manual

None

4.1.2 Trips and Interlocks (identical for each compressor)

Air Compressor Motor Overcurrent Trip

Air Compressor Cooling Water Outlet Temperature High Trip

Air Compressor Oil Pressure Low Trip

(Any of these signals will activate the trip relay for that compressor.)

4.1.3 Indication

4.1.3.1 Local

Air Compressor No. 1 Tripped/Reset

Air Compressor No. 1 Status (running/not running)

Air Compressor No. 2 Tripped/Reset

Air Compressor No. 2 Status (running/not running)

Air Compressor Discharge Air Pressure (2)

Miscellaneous indication (oil pressure, temperature, etc.) for the compressors will be provided by the manufacturer and listed on future revisions.

4.1.3.2 Master Control System

Air Compressor No. 1 Status (running/not running)

Air Compressor No. 2 Status (running/not running)

4.1.4 Alarms

4.1.4.1 Local

None

4.1.4.2 Master Control System

Both Air Compressors Running

Air Compressor No. 1 Motor Overcurrent Trip

Air Compressor No. 2 Motor Overcurrent Trip

Air Compressor No. 1 Cooling Water Outlet Temperature High

Air Compressor No. 1 Cooling Water Outlet Temperature High-High Trip

Air Compressor No. 2 Cooling Water Outlet Temperature High

Air Compressor No. 2 Cooling Water Outlet Temperature High-High Trip

Air Compressor No.1 Oil Pressure Low Trip (manufacturer provided)

Air Compressor No. 2 Oil Pressure Low Trip (manufacturer provided)

4.1.4.3 Remote Main Annunciator

None

5.0 Vessels to be Controlled

5.1 Air Dryer

The air dryer is a skid mounted, dual adsorbent bed, fully automatic, non-heated unit with all valves and control equipment to be supplied by the manufacturer. The following requirements will be provided by the manufacturer as a minimum:

5.1.1 Control

5.1.1.1 Master Control System

None

5.1.1.2 Dedicated Automatic

Local, hardwired, pneumatic controls will be provided. Compressed air is passed down through the first drying canister and out to the air receivers. Simultaneously, some of this dry air is passed backwards through the second drying canister to recharge the desiccant in it. After a specified length of time (not less than five minutes), the flow pattern is reversed and the first canister is recharged. This automatic cycling continues indefinitely.

5.1.1.3 Local Manual

Air dryer control power on/off switch

5.1.2 Trips and Interlocks

None

5.1.3 Control Valves

All valves will be pneumatically actuated. Flow control valves will be three-way or four-way type to minimize dead-heading.

5.1.4 Indication

5.1.4.1 Local

Air Canister Pressure (2) (manufacturer provided)

Air Dryer Regeneration Flow Indicator (manufacturer provided)

Air Dryer Outlet Header Pressure

5.1.4.2 Master Control System

None

5.1.4.3 Test Point

Air Dryer Outlet Sample Connection

5.1.5 Alarms

5.1.5.1 Local

None

5.1.5.2 Master Control System

Air Dryer Control Power Failure

Air Dryer Differential Pressure High

This alarm will require the operator to manually open an air dryer bypass valve.

5.2 Aftercoolers (2)

The aftercoolers are used to cool the compressed air leaving the air compressors.

5.2.1 Control

None

5.2.2 Trips and Interlocks

None

5.2.3 Control Valves

None

5.2.4 Indication

5.2.4.1 Local

Air Temperature Upstream of Aftercooler (2)

Air Temperature Downstream of Aftercooler (2)

Air Pressure Downstream of Aftercooler (2)

5.2.5 Alarms

None

5.3 Air Receivers (2)

The air receivers provide storage capacity for the system.

5.3.1 Control

None

5.3.2 Trips and Interlocks

None

5.3.3 Control Valves

None

5.3.4 Indication

5.3.4.1 Local

Air Receiver Pressure (2)

5.3.5 Alarms

None

6.0 Miscellaneous I&C

6.1 Control Valves

6.1.1 Service Air Refusal Valve

The valve will serve to limit air flow to the service air header when instrument header pressure is low. The valve will be a self-contained regulator.

The valve will have:

a) no interlocks; upstream (instrument air) pressure will provide the controlling measurement.

b) air to open/fail closed operation and a pneumatic actuator;

c) self-contained control action;

d) no bypass; maintenance on the valve will not require system shutdown, but will cause service air shutdown.

6.2 Miscellaneous Indication

6.2.1 Local

Air Pressure Downstream of First Strainer

Instrument Air Header Pressure

6.2.2 Master Control System

Instrument Air Header Pressure

6.2.3 Test Point

Service Air Pressure

Air Pressure Upstream of First Strainers

Air Pressure Downstream of Second Strainers

6.3 Alarm

6.3.1 Local

None

6.3.2 Master Control System

Instrument Air Pressure Low (from analog signal)

6.5 FIRE PROTECTION SYSTEM
(D23-23)

Engineering
76-370 2/81

DCM No. D23-3 Revision 1
Date March 15, 1983
File No. 30 MW Solar - D23-01700

PACIFIC GAS AND ELECTRIC COMPANY
CARRIZO PLAIN
ENGINEERING DEPARTMENT
DESIGN CRITERIA MEMORANDUM

Structure, System, or Component: Fire System

Prepared by: Richard B. Myers *M* Date *Mar 16, 83*

Group Leader/Supervisor Review *JBHogan*, M&NE (Discipline) Date *March 18 83*

Reviewed by Interfacing Disciplines:

Group Leader/Supervisor ABSchuurman Date *3-17-83*

Group Leader/Supervisor *ENL* KGZaharoff *K. G. Zaharoff* Date *3-30-83*

Group Leader/Supervisor MTPerakis Date *3-30-83*

CLewis

Approved by:

Department Chief: JVRocca *JVRocca* Date: *4-1-83*

Approved for Project use:

Project Engineer: REPrice *REPrice* Date: *4-2-83*

Page ~~2~~ *1* through 10 attached; describing design inputs. Other attachments as indicated below.

cc: Rockwell Procedures, Paragraph 1.3, not included.

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☐ Project Engineer

☐ Discipline Group Leader(s)/Supervisor(s)

☐ Manager, Steam Generation

☒ Others *C. LEWIS, Insurance Department, RM E271, 4 Embarcadero Center*
W. S. GARRETT, Safety Health + Claims

D23-23M
Rev. 1

Design Criteria
Fire System
30 MW Solar Project
GM 6340160

Contents

1. Basic Function

1.1 The fire protection system provides protection for the power plant, cooling tower, and yard buildings. It includes the following items:

1.1.1 An outside yard fire water loop around the power plant complex,

1.1.2 Automatic fire suppression systems for the turbine building, cooling tower, warehouse and administrative building, fuel oil pump house, fire pump house, and main transformers (if within 50' of any permanent building), and

1.1.3 Portable fire extinguishers for all areas.

1.2 The collector field requires no permanent equipment for protection. There are two hazzards: heliostat electrical fires and grass fires. Electrical fires will be contained by use of portable fire extinguishers. Protection against grass fires include:

1.2.1 Controlling vegetation within the field,

1.2.2 Disking a fire lane around the field, and

1.2.3 Portable fire extinguishers and other portable equipment on a truck (shovels, etc.).

1.3 Fire protection for the receiver tower and steam generators will be per Rockwell procedures.

2. Equipment List

2.1 Two U.L. listed, motor-driven automatic fire pumps sized to meet total required fire flow, complete with 480 VAC starter

2.2 Two U.L. listed motor-driven jockey pump with accumulator tank

2.3 Mobile fire truck (pick-up, etc., suitable for grass fire protection)

2.4 Various portable fire extinguishers

2.5 Firewater storage tank sized for minimum two-hour supply at maximum fire flow demand (may be combined with raw water storage provided the level never drops below the two-hour minimum)

3. Standards and Codes (Specific codes and sections will be itemized with equipment specifications.)

3.1 The Working Committee of the PGandE Central Fire Protection Committee shall be consulted of all features of the system design.

3.2 All equipment shall be F. M. approved or U. L. listed for fire protection use.

3.3 The installation shall be in conformance with the:

a) National Fire Protection Association Standards (NFPA) as applicable

b) Hydraulic Institute

c) Institute of Electrical and Electronic Engineers

d) American Society for Testing and Materials

e) American National Standards Institute

f) Steel Structures Painting Council

g) Cal/OSHA Standards

h) PGandE's Engineering Standard No. 95

i) PGandE Supplemental Specification for Centrifugal Pumps

j) PGandE Supplemental Specification for Squirrel Cage Induction Motors

k) PGandE Supplemental Specification for Equipment Noise Requirements

l) PGandE TED Standards

4. Design Conditions

4.1 Water for the fire loop will be provided from the raw water storage by a motor-driven automatic fire pump. A motor-driven jockey pump will maintain the fire water loop header pressure at 5-10 psi above the fire pump cut in pressure.

4.2 The fire pump installation will include the following connections:

a) Recirculation test system utilizing an orifice plate and test connectors

b) Gated wye for fire truck hookup on each supply tank

4.3 The raw water storage will be sized such that it will never be drawn down below the required two-hour supply for fire suppression purposes.

4.4 An underground fire loop header, supplied with redundant connections, is located outside of the buildings. It supplies fire water to the following areas:

a) Yard fire hose stations

b) Automatic wet pipe sprinkler systems for the fuel oil pump house

c) Automatic wet pipe sprinkler systems and hose stations for the warehouse and administrative building

d) Automatic deluge system for the cooling tower

e) Automatic water spray systems for main transformers (see Para. 1.1.2)

f) Fire pump house

g) Automatic wet pipe systems for turbine-generator lube oil storage tanks and purifiers, hydrogen seal oil (if hydrogen-cooled generator), and turbine/generator bearings

h) Automatic wet pipe sprinkler system for cable spreading areas and areas under the turbine platform

i) Automatic wet pipe sprinkler system for the auxiliary boiler oil burner area

j) Automatic wet pipe sprinkler system for the diesel-generator area

4.5 This underground loop also supplies the following standpipes for hose stations which shall be located such that at least two hose streams can be directed on any hazard: (The number of standpipes is an estimate. The exact number will be dependent upon the plant design features.)

a) Five standpipes and hose stations servicing the ground floor below the turbine and the turbine floor itself, including areas near control and relay rooms

b) Two standpipes and hose stations servicing the ground floor below the deaerator floor

c) Two standpipes and hose stations on the fan deck of the cooling tower, located at the end of the decks near the stairwell

4.6 Fire hoses with adjustable nozzles will be provided throughout the plant, except in areas of potential electrical hazard to personnel, where nonadjustable nozzles will be provided.

4.7 A fire detection system utilizing ionization type detector will be provided for the relay room and control room.

4.8 Various individual areas and equipment requiring fire protection are provided with one or more fire extinguishers, as shown in Table 1.

4.9 Additional items provided for plant fire protection include:

a) Dikes for fuel oil storage tanks (if above ground)

b) The cooling tower will have a wet-down system for keeping the unit from drying out during prolonged shutdowns

c) Fire barriers and fire doors as needed

4.10 The cooling tower shall be protected by a dry deluge type sprinkler system to supply .33 gpm/ft^2 under the fan deck, including the fan opening, and 0.5 gpm/ft^2 over the fill areas, with water being supplied to three cells.

4.11 The jockey pump must be able to maintain the system head at 5-10 psi above the fire pump cut in pressure.

5. Design Loads

See Civil design criteria for seismic and wind loading conditions.

6. Environmental Conditions

The fire pumps, drivers, and starters will be installed in an all-weather building remote from the rest of the plant.

7. Interface Requirements

7.1 The system will interface with the raw water storage system.

7.2 The system will interface with the electrical control system for electrical fire pump motor control.

7.3 The system will interface with the 480 SWGR for pump motor supply.

7.4 The system will interface with the compressed air system (pressurizing of the accumulator tank).

7.5 The emergency diesel-generator unit must be sized to power one of the fire pumps plus any other load that cannot be dropped during a fire emergency.

8. Material Requirements

See NFPA standards.

9. Layout and Arrangements

Will be determined by the plant layout. The sprinkler system will be designed by a licensed fire sprinkler contractor.

10. Instrumentation and Control

10.1 Demand from fire hydrants, hose reel stations, or any of the sprinkler, or deluge systems automatically starts the motor-driven fire pump. Increased system demand or loss of AC power while the demand exists automatically starts the backup. In addition, remote means of starting each fire pump will be provided in the control room.

10.2 Automatic sprinkler deluge or spray systems will start upon detection of a fire. Fusable heads and "protects" will be evaluated. An alarm shall be on the plant's main annunciator.

10.3 See I&C Design Criteria D23-23I.

11. Access Requirements for Security

Not applicable.

12. Reliability

Adherence to national fire protection standards and redundant fire pumps are provided.

13. System Reliability Effect Upon Unit Availability

None.

14. Examination, Inspection, and Testing

14.1 Fire protection equipment will be tested in accordance with NFPA Standards.

14.2 The pumps and drivers will be shop inspected.

14.3 The pumps and piping will be field tested.

14.4 The electrical motor starters shall be shop inspected.

15. Maintenance

The pump and drivers will require periodic maintenance and repair. Access, laydown, and tools will be needed.

16. Personnel Requirements

Plant personnel must be trained to use the fire fighting equipment.

17. Shipping

No special requirements.

18. Fire Protection

Not applicable.

19. Storage

No special requirements.

20. Health and Safety of the Public

Presents no hazard.

21. Materials and Fabrication

Refer to NFPA standards.

Refer to pump data sheets.

Portable Fire Extinguishers

System	Equipment Location	Number
Portable 20-lb purple "K" extinguishers	Operating floor	4 (two for each unit)
	Station switchyard	2
	Machine shop	2
	fuel oil pumphouse doorway	1
20-lb multi-purpose dry-chemical extinguishers	Machine shop	1
	Warehouse	1
17-lb halon 1211 extinguishers	Near MCC, switchgears, rotating equipment, relay rooms, control room, and chem. lab	8

6.5.1 FIRE PROTECTION SYSTEM
INSTRUMENTATION AND CONTROL
(D23-231)

Engineering
76-370 2/81

DCM No. D23-23I Revision 0
Date 5-6-83
File No. 78000

PACIFIC GAS AND ELECTRIC COMPANY
30 MW SOLAR
DESIGN CRITERIA MEMORANDUM

Structure, System, or Component: FIRE PROTECTION SYSTEM (I&C)

Prepared by: P.D. MAXWELL / M.T. PERAKIS Date 5-6-83

Group Leader/Supervisor Review , M&Nu Eng (Discipline) Date 5/6/83

Reviewed by Interfacing Disciplines:

Group Leader/Supervisor J.B. GEGAN Date 52-83

Group Leader/Supervisor M.E. CONLU MEC Date 5-10-83

Group Leader/Supervisor K.G. ZAHAROFF Date 5-23-83

A.B. SCHUURMAN 5-25-83

Approved by:

Department Chief: J.U. ROCCA Date: 5-25-83

Approved for Project use:

Project Engineer: R.E. PRICE Date: May 26 83

Page 2 through 10 attached; describing design inputs. Other attachments as indicated below.

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Others

30 MW Solar
Fire Protection System
Instrumentation and Control
Design Criteria

Reference Documents:

Fire Protection System - System Design Criteria, DCM No. D23-24
Master Control System - Design Criteria, DCM No. D23-7
Instrumentation and Control(I&C) - General Design Criteria, DCM No. D23-3

1.0 Scope

This criteria will define the I&C requirements for the fire protection system.

1.1 Mechanical equipment to be controlled

1.1.1 Jockey pumps (2)

1.1.2 Fire pumps (2)

1.2 Valves to be controlled

1.2.1 Cooling tower deluge valve

1.2.2 Main transformer deluge valve

1.2.3 Accumulator tank air supply solenoid valve

1.3 Vessels to be controlled

1.3.1 Accumulator tank

1.3.2 Cooling tower

2.0 Control System Interfaces

2.1 Interface with other EPGS systems

2.1.1 Circulating Water System

A cooling tower fire will trip the cooling tower fans.

2.1.2 Service Cooling Water System

The primary pumps in the service cooling water system must be operating in order to water spray the cooling tower for fire protection.

3.0 Operating Requirements

The fire protection system will operate as a fully automatic, independent system. The system will be controlled such that pressurized water is ready for immediate release upon demand during all expected plant conditions, including normal overnight shutdown periods and blackout conditions (only emergency power available).

4.0 Mechanical Equipment Process Control and Protection

4.1 Jockey Pumps (2)

One of two 100% capacity jockey pumps will cycle on/off to control level in the accumulator tank. The other pump will remain on operator selected standby and will start on tank low-low level. Both jockey pumps will be disabled when either fire pump is running.

4.1.1 Control

4.1.1.1 Master Control System

None

4.1.1.2 Dedicated Automatic

Primary pump start - accumulator tank level low

Standby pump start - accumulator tank level low low

Both pumps stop - accumulator tank level normal

Both pumps stop - any fire pump start

4.1.1.3 Local Manual

Jockey pump no. 1 stop/auto/start switch

Jockey pump no. 2 stop/auto/start switch

(Start is spring return to auto)

4.1.2 Trips and Interlocks

Jockey pump no. 1 motor overcurrent trip

Jockey pump no. 2 motor overcurrent trip

No NPSH protection will be provided. Continuous recirculation back to the Raw Water Storage Tank will provide deadhead protection.

4.1.3 Indication

4.1.3.1 Local

Pump discharge pressure (2)

Pump no. 1 status (running/not running)

Pump no. 2 status (running/not running)

Jockey pumps standby status (pump no. 1/pump no. 2)

Jockey pumps incomplete setup (either pump switched off)

4.1.3.2 Master Control System

None

4.1.3.3 Test Point

Pump Suction Pressure (2)

4.1.4 Alarms

4.1.4.1 Local

None

4.1.4.2 Master Control System

Jockey pump no. 1 motor overcurrent trip

Jockey pump no. 2 motor overcurrent trip

4.3 Motor Driven Fire Pumps (2)

Two 100% capacity motor driven fire pumps will provide dedicated primary and standby operation. The primary pump will start on system low pressure and the standby on system low low pressure in case the first pump cannot handle the system load. A pump will remain on until system pressure rises and the pump is manually shut off.

4.3.1 Control

4.3.1.1 Master Control System

None

4.3.1.2 Dedicated Automatic

Primary pump start - fire system pressure low

Standby pump start - fire system pressure low low

4.3.1.3 Local Manual

Fire pump no. 1 stop/auto/run switch

Fire pump no. 2 stop/auto/run switch

(Maintained contacts)

4.3.2 Trips and Interlocks

Pump No. 1 Overcurrent Trip

Pump No. 2 Overcurrent Trip

No NPSH protection will be provided. Continuous recirculation back to the raw water storage tank will provide deadhead protection. On/off recirculation control may be provided if the recirculation flow requirement is large.

4.3.3 Indication

4.3.3.1 Local

Pump discharge pressure (2)

Pump No. 1 status (running/not running)

Pump No. 2 status (running/not running)

Pump No. 1 electric power available

Pump No. 2 electric power available

4.3.3.2 Master Control System

Pump No. 1 status (running/not running)

Pump No. 2 status (running/not running)

4.3.3.3 Test Point

Pump suction pressure (2)

4.3.4 Alarms

4.3.4.1 Local

None

4.3.4.2 Master Control System

Fire pump running

Fire pump no. 1 trip

Fire pump no. 1 failed to start

Fire pump no. 1 switched off

Fire pump no. 2 trip

Fire pump no. 2 failed to start

Fire pump no. 2 switched off

Fire pumps electric power unavailable

4.3.4.3 Remote Main Annunciator

Fire pump running

5.0 **Vessels to be controlled**

5.1 Accumulator Tank

The accumulator tank serves to maintain system pressure, provide water storage capacity for the system, and to provide for system loss up to 100 GPM.

5.1.1 Trips and Interlocks

None

5.1.2 Control Valves

5.1.2.1 Accumulator Air Supply Valve

The valve serves to admit service air to pressurize the tank. It will operate as follows:

Valve open - accumulator tank water level high and air pressure low (air pressure not high)

Valve close - accumulator tank air pressure normal

The valve will have:

a) no interlocks

b) air to open/fail closed operation - the valve will be solenoid controlled

c) on/off automatic control through local dedicated equipment

d) no bypass - maintenance of the valve and related control equipment will **not** require system shutdown

5.1.3 Indication

5.1.3.1 Local

Tank water level

Tank air pressure

5.1.4.2 Master Control System

None

5.1.4 Alarms

5.1.4.1 Local

None

5.1.4.2 Master Control System

Accumulator tank low low level

Accumulator tank low low pressure

5.2 Cooling Tower

The cooling tower has a dry sprinkler system. Fire in a cooling tower cell will open the cooling tower deluge valve, allowing water to flow to the cells.

The primary pumps of the service cooling water system will supply water to the cooling tower for spray wetting purposes. The operator will initiate spray wetting, by opening a local isolation valve near the pump discharge, allowing water to flow to spray nozzles in the cooling tower. Spray wetting will continue until the valve is closed.

5.2.1 Trips and Interlocks

5.2.1.1 Cooling Tower Fans

A cooling tower fire will trip the cooling tower fans.

5.2.3 Control Valves

5.2.3.1 Cooling Tower Deluge Valve

The valve will be located at the base of the cooling tower, supplying fire water through a riser to the individual cells. Protecto-wire will be used for fire detection.

Fire in the cooling tower will cause the protecto-wire insulation to melt, which will cause the solenoid valve to vent and the deluge valve to open. The protecto-wire circuit will be powered from the station battery.

The upstream manual isolation valve must be used to shutoff water flow to the cooling tower after the deluge valve has opened.

The valve will have:

a) no interlocks.

b) air to close/fail open operation. The valve will have limit switches and a pneumatic actuator.

c) solenoid control. Venting of the solenoid will cause the valve to open.

d) no bypass. Maintenance of the valve or related control equipment will remove fire protection for the cooling tower.

5.2.4 Indication

5.2.4.1 Local

Cooling tower deluge valve air supply pressure

5.2.4.2 Master Control System

Cooling tower deluge valve status (open/closed)

5.2.5 Alarms

5.2.5.1 Local

None

5.2.5.2 Master Control System

Cooling tower deluge valve open

5.2.5.3 Remote Main Annunciator

Cooling tower deluge valve open

6.0 **Miscellaneous I&C**

6.1 Main Transformers Fire Protection

6.1.1 Control Valves

6.1.1.1 Main Transformer Deluge Valve

The main transformers area has a dry sprinkler system. Protecto-wire will provide fire detection.

The valve will have:

a) no interlocks.

b) air to close/fail open operation. The valve will have a pneumatic actuator, and limit switches.

c) solenoid control. Venting of the solenoid will open the valve. The upstream manual isolation valve must be used to shut off flow.

d) no bypass. Maintenance of the valve or related control equipment will remove fire protection for the area.

6.1.2 Indication

6.1.2.1 Local

Main transformer deluge valve air supply pressure

6.1.2.1 Master Control System

Main transformer deluge valve status (open/closed)

6.1.3 Alarms

6.1.3.1 Local

None

6.1.3.2 Master Control System

Main transformers ~~fire~~ deluge valve open

6.1.3.3 Remote Main Annunciator

Main transformers deluge valve open

6.2 Fire Pumps and Piping

6.2.1 Indication

6.2.1.1 Local

Fire water yard piping loop pressure

Fire pumps suction header pressure

6.2.1.2 Master Control System

Fire water yard piping loop pressure

6.2.1.3 Test Point

Fire pumps test flow element

6.6 RAW WATER SYSTEM
(D23-25)

DCM No. D23-25 Revision 0
Date March 8, 1983
File No.

PACIFIC GAS AND ELECTRIC COMPANY

ENGINEERING DEPARTMENT

DESIGN CRITERIA MEMORANDUM

Structure, System, or Component: Solar Power Plant, Raw Water
Prepared by: C. F. Allen Date 2-25-83
Group Leader/Supervisor Review E.P. Wollak, CE EWollak Date 2-25-83
(Discipline)

Reviewed by Interfacing Disciplines:
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Group Leader/Supervisor RBM K. G. Zaharoff Date 4-14-83
Group Leader/Supervisor M. T. Perakis MTPerakis Date 4/8/83

Approved by:
Department Chief: R. V. Bettinger R. V. Bettinger Date: 3/14/83

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1-10/27/78

Design Criteria
Raw Water System
Index

1. Basic Function

The system will establish access to ground water as the source of all water process, cooling, domestic, fire protection and maintenance for the 30 MW solar power plant. It will provide 600,000 storage including 360,000 gal. for fire protection. It will include water treatment equipment for the domestic water requirement only. It will provide the required NPSH for the fire protection pumps and for all raw-water transfer pumps.

2. Equipment List Rating and Capacity

2.1 Two wells (minimum number required).

2.2 Two well water pumps, motors and their controls.

2.3 One 600,000 gal. raw water storage tank (Diameter = 55 feet, Height = 35 feet).

3. Codes and Standards

All design work shall comply with the listed codes and standards. In the event of conflict between the code and/or standards, or any other criteria contained in this document, the more stringent shall govern unless specifically stated.

3.1 American Water Works Association Standard D100-73 (AWWA D100).

3.2 All materials referenced shall conform with the current standards of the American Society for Testing and Materials (ASTM).

3.3 For Electrical and Mechanical Codes and standards refer to Project Design Criteria, DCM D23-1.

3.4 For Civil and Architectural Codes and Standards refer to DCM D23-2.

4. Design Conditions

4.1 Groundwater is the only source of water supply to the Carrisa Plains Basin. The basin groundwater storage capacity, as listed by the California Department of Water Resources (DWR) in 1978 is 400,000 acre ft. One fourth of this storage capacity or 100,000 acre ft. is listed by DWR as usable and available for limited to moderate additional development. Groundwater wells yield flows at 500 to 1,000 gal/min. Well depths range from 175 to 600 ft.

4.2 Because of the range of possible well depths and flow rates, the pump heads cannot be determined until after the wells have been drilled and tested. For preliminary design, we will assume two wells with a flow rate of 500 gpm at a depth of 300 ft. If the well flow rates are less than 500 gpm, more wells will be needed.

4.3 The design maximum flow requirement is 500 gpm when the plant is operating. Maximum daily consumption is 330,000 gallons. Though one pump/well can meet this rate, two wells will be provided for reliability.

4.4 The raw water pumps will deliver water to a storage tank. The tank is sized by:

4.4.1 The maximum storage for fire protection of 360,000 gal. (Two hours at the maximum flow ratio for one fire pump.)

4.4.2 One day's (10 hours of operation) usage of water at a near maximum flow rate of 400 gpm or 240,000 gal.

4.4.3 A margin for unrecoverable water.

NOTE: The inventory maintained for fire protection will result in a minimum static head of approximately 20 ft. for other services.

4.5 The tank shall have a fire pump inlet connection for hooking up to a fire truck.

4.6 The estimated water usage at the design point is as follows:

4.6.1 Circulating water makeup = 400 gpm (during operation).

4.6.2 Domestic Water = 1200 gpd

4.6.3 Cyclewater including Demineralizer flushwater = 22.4 gpm

5. Raw Water Storage Tank

5.1 The tank shall have a capacity of 600,000 gallons.

5.1.1 The tank shall be carbon steel and have a nominal diameter of 55 feet and a height of 35 feet.

5.1.2 The roof shall be self-supporting and coned.

5.1.3 The tank shall be supported by a compacted pad of crushed rock of Class 2 Aggregate Base material. Compaction shall be 95% maximum. ASTM 1557-70 (D). The top of foundation shall be a minimum of one foot above grade and sloped to insure adequate drainage. The crushed rock shall be sealed with 2" of Asphalt Concrete.

5.2 Steel material for the tank shall be as set forth in AWWA D100.

5.2.1 Bolts and nuts for flanged connections shall conform with ASTM A307 Type B. Galvanized bolts and nuts for ladders, stairways, etc. shall conform with ASTM A394.

5.2.2 Material for tank nozzles and flanges shall be as required by AWWA D100. All nozzles shall be of the stub type inside and outside. All nozzles shall have a minimum inside and outside projection of 12 inches.

5.2.3 Pipe for handrailing shall be standard weight steel and shall conform in all respects to ASTM A53. Shop joints shall be welded and ground smooth. All pipe handrailing shall be galvanized after fabrication.

5.3 Loads: The tank shall be capable of resisting without damage each of the following loadings all acting simultaneously or if any combination that would result in larger stresses.

5.3.1 Roof live load shall be 25 pounds per square foot. (25 psf).

5.3.2 Total Dead loads.

5.3.3 Full Hydrostatic pressure. Specific Gravity = 1.0

5.3.4 Static Equivalent seismic load of 20 percent of the total deep load acting horizontal simultaneously with 13 percent of the total dead load acting vertical, Wind load of 32 pounds per square foot (32 psf).

5.4 Steel shell plate thickness shall be as required by AWWA D100 except that it shall not be less than the thickness, t, given by the following formula:

$$t = 0.0014 H (D)^{\frac{1}{2}}$$

t = shell plate thickness in inches exclusive of the corrosion allowance in Paragraph 5.6.

H = Depth in feet from the liquid level at max. filling height to the bottom of the course under consideration.

D = tank diameter in feet.

After determination of the shell plate thickness by usual formula or the above formula, a corrosion allowance shall be added as specified under Paragraph 5.6 of this Section.

5.5 Minimum thickness for steel shall be as specified in the following table unless otherwise approved by the Engineer.

Designation	Minimum Thickness (inches)
Shell plates	1/4
Roof plate	1/4
Bottom plate	5/16
Structural members or components	1/4
Non-Structural members or components	3/16

5.6 Corrosion Allowances: A 1/16" corrosion allowance shall be added to the designed thickness of shell plates. No corrosion allowance is to be added to the specified minimum thicknesses of roof and bottom plates, structural and non-structural members or components.

5.7 Temperatures: Tanks shall be designed for operating temperature of 150°F.

5.8 Tolerances: After erection, tank shall meet the following tolerances for plumbness, vertical straightness and roundness.

5.8.1 Plumbness: Tank shall be erected true and plumb. At any point out of plumb shall not exceed 1/240 of the height of the point above the bottom.

5.8.2 Vertical Straightness: Tank wall shall be checked with a 6-foot straight edge at any location. The maximum deviation shall not exceed 1/2 inch within any 6 feet of length.

5.8.3 Roundness: Completed tank shall be substantially round. The difference between the maximum and minimum diameters at any level shall not exceed 0.2 percent of the tank diameter. Local out of roundness shall be checked with a 6-foot template shaped to the true radius of curvature of the tank. At any location the maximum deviation shall not exceed 1/2" within any 6 feet of length.

5.9 Painting

5.9.1 Exterior Surfaces: All exterior surface shall receive one or more coats of self-cured inorganic zinc coating; minimum total dry film thickness shall be 2½ mils, maximum total dry film thickness 4 mils and two finish coats acrylic coating (dry film thickness 3 mils).

5.9.2 Interior Surfaces: All interior surface shall receive a coat tar epoxy paint system consisting of two or more finish coats; minimum total film thickness shall be 15 mils.

6. Environmental Conditions

6.1 No special considerations for the equipment.

6.2 No emissions.

7. Interface Requirements

This system will interface with:

Service	Maximum Rate
Circulating Water System	700 gpm
Domestic Water System	25 gpm

Fire Water System	3,000 gpm
Boiler Make-up System	25 gpm
480 VAC SWGR	

8. Piping

8.1 See DCM D23-2 section 2.5.3 for material specification.

8.2 See DCM D23-2 section 11.1.5 for underground piping specifications.

9. Layout and Arrangements

It would be desirable to locate the storage tank near the cooling tower. This should provide gravity feed of the cooling tower makeup.

10. Instrumentation and Control

Under normal operating conditions, only one pump at a time will be used. This pump can be manually selected. Under fire fighting conditions, both pumps should be capable of being used.

The pump should be automatically cycled to maintain water in the storage tank at 360,000 gal or more.

11. Security Requirements

A security fence should be provided around the pump and well unless it is otherwise within plant security boundary.

12. Reliability

Two 100 percent capacity pumps/wells are provided for reliability. In addition, the storage tank, when full, can provide water for ten hours of operation at maximum water use (with 360,000 gallons remaining for fire protection).

13. System Reliability Effect on Unit Availability

If both pumps are unavailable, operations will be curtailed to a point determined by weather and plant conditions.

14. Examinations, Inspections, and Testing

The pumps and motors will be shop tested.

15. Maintenance

The pumps will require periodic maintenance. Access space, laydown area, and special tools, if any, will be required.

16. Personnel Requirements

No special skills required.

17. Shipping

No special requirement.

18. Fire Protection

None.

19. Storage

No special requirement.

20. Health and Safety of the Public

Presents no hazard.

21. Materials and Fabrication

No special requirements.

22. References

22.1 Civil and Architectural Design Criteria DCM D23-2.

22.2 Project Design Criteria DCM D23-1.

6.6.1 RAW WATER SYSTEM INSTRUMENTATION AND CONTROL

(D23-25I)

Engineering
76-370 2/81

DCM No. D23-25-I Revision 0
Date 5-6-83
File No. 70800

PACIFIC GAS AND ELECTRIC COMPANY

30 MW SOLAR

DESIGN CRITERIA MEMORANDUM

Structure, System, or Component: RAW WATER SYSTEM (I&C)

Prepared by: P.D. MAXWELL / MT PERAKIS MTPerakis Date 4-6-83

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Reviewed by Interfacing Disciplines:

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Department Chief: Date: 5-26-83

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Project Engineer: R.E. PRICE REPrice Date: 5-23-83

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30 MW Solar Project
Raw Water System
I&C Design Criteria

Reference Documents:

Raw Water System - System Design Criteria, DCM No. D23-25
Master Control System - Design Criteria, DCM No. D23-7
Instrumentation and Control - General Design Criteria, DCM No. D23-3

1.0 Scope

This criteria will define the instrumentation and control (I&C) requirements for the raw water system.

1.1 Mechanical Equipment to be Controlled

~~1.1.1~~ Well Water Pumps (2)

1.2 Valves to be Controlled

None

1.3 Vessels to be Controlled

Raw Water Storage Tank

2.0 Control System Interfaces

None

3.0 Operating Requirements

The raw water system will be controlled such that it will be fully operational during all expected plant operating conditions, including normal overnight shutdown periods. The well water pumps (see Section 4.1) must be powered from the "preferred" or emergency bus in order to support fire pump operation during plant blackout conditions.

4.0 Mechanical Equipment Process Control and Protection

4.1 Well Water Pumps (2)

Under normal operating conditions, one of two 100 percent capacity pumps will automatically cycle on/off to maintain level in the raw water storage tank. The other pump will remain on operator selectable standby and will start on tank low-low level.

4.1.1 Control

4.1.1.1 Master Control System

None

4.1.1.2 Dedicated Automatic

Primary Pump Start - Tank Level Low

Standby Pump Start - Tank Level Low Low

Both Pumps Stop - Tank Level Normal

4.1.1.3 Local Manual

Pump Standby Selector Switch (Pump No. 1/Pump No. 2)

Pump No. 1 Stop/Auto/Start Switch

Pump No. 2 Stop/Auto/Start Switch (start is spring return to auto)

4.1.2 Trips and Interlocks

Pump No. 1 Motor Overcurrent Trip

Pump No. 2 Motor Overcurrent Trip

No NPSH protection or deadhead protection will be provided.

4.1.3 Indication

4.1.3.1 Local (near Raw Water Storage Tank)

Pump No. 1 Status (Running/Not Running)

Pump No. 2 Status (Running/Not Running)

4.1.3.2 Master Control System

None

4.1.3.3 Test Point

Pump No. 1 Discharge Pressure

Pump No. 2 Discharge Pressure

4.1.4 Alarms (identical for both pumps)

4.1.4.1 Local

None

4.1.4.2 Master Control System

Well Water Pump No. 1 Motor Overcurrent Trip

Well Water Pump No. 2 Motor Overcurrent Trip

5.0 Vessels to be Controlled

5.1 Raw Water Storage Tank

The tank receives discharge from the well water pumps and serves as storage for boiler make-up, fire protection, and other plant systems. It is expected that the tank volume will be large, and fast level fluctuations are not anticipated.

5.1.1 Control

5.1.1.1 Master Control System

None

5.1.1.2 Dedicated Automatic

Tank Level Low - Start Primary Well Water Pump

Tank Level Low Low - Start Standby Well Water Pump

Tank Level Normal - Both Pumps Stop

5.1.1.3 Local

(See Section 4.1.1.3)

5.1.2 Indication

5.1.2.1 Local

Raw Water Storage Tank Level

5.1.2.2 Master Control System

Raw Water Storage Tank Level

5.1.3 Alarms

5.1.3.1 Local

None

5.1.3.2 Master Control System

Raw Water Storage Tank Level Low Low/High (generated from analog signal)