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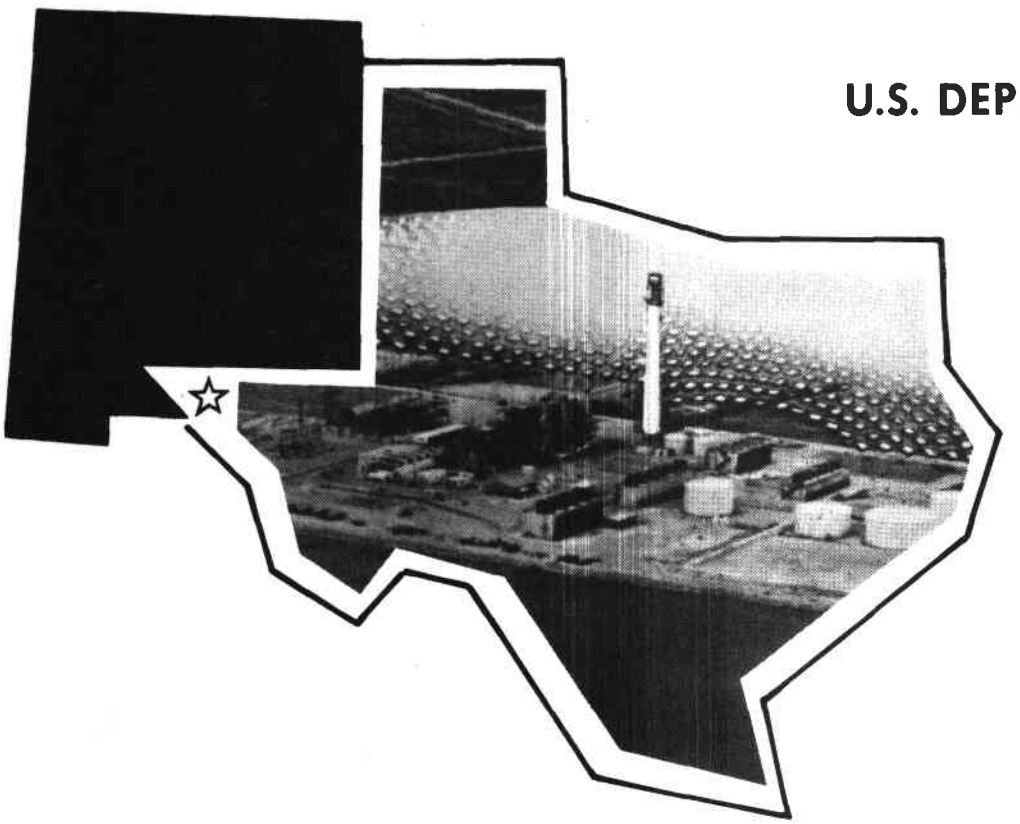
NEWMAN UNIT 1 SOLAR REPOWERING PRELIMINARY DESIGN

FINAL REPORT

Volume 3

prepared for:
U.S. DEPARTMENT OF ENERGY



NOVEMBER 1983

EL PASO ELECTRIC COMPANY

Volume 3

NEWMAN UNIT 1
SOLAR REPOWERING
PRELIMINARY DESIGN

1249

FINAL REPORT

EL PASO ELECTRIC COMPANY
NEWMAN UNIT 1 SOLAR REPOWERING
PRELIMINARY DESIGN

NOVEMBER 1983

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Prepared for
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LIST OF ABBREVIATIONS AND ACRONYMS

*NOTE - Abbreviations used for equipment mark numbers and plant systems have not been included in this table

A

A	- ampere
ac	- alternating current
AFI	- allowance for indeterminates
AFUDC	- allowance for funds used during construction
AISC	- American Institute of Steel Construction
ANSI	- American National Standards Institute
APS	- Arizona Public Service
ASME	- American Society of Mechanical Engineers
Attemp	- attemperator

B

B&W	- Babcock & Wilcox
BCS	- beam characterization system
BOP	- balance of plant
Btu	- British thermal unit

C

°C	- degree Celsius
c-c	- combined cycle
cl	- class
cm	- centimeter
CPU	- computer processing unit
CRT	- cathode ray tube
c-t	- combustion turbine plant
C/V	- cost/value

D

dc	- direct current
DDC	- direct digital control
DEH	- digital electrohydraulic control
DNB	- departure from nucleate boiling
DOE	- Department of Energy
DOE-SAN	- Department of Energy-San Francisco Operations Office

E

EHL	- extreme high level
el	- elevation
EPE	- El Paso Electric Company
EPGS	- electric power generating system
EPRI	- Electric Power Research Institute

F

°F	- degree Fahrenheit
FAA	- Federal Aviation Administration
FMEA	- failure mode and effects analysis
ft	- foot
ft^2	- square foot
FTA	- fault tree analysis

G

gpm	- gallons per minute
GWh	- gigawatt hour
GWhe	- gigawatt hour electric

H

HAC	- heliostat array controller
HC	- heliostat controller
HFC	- heliostat field controller
Hg	- mercury
hp	- horsepower
hr	- hour
HVAC	- heating, ventilating, and air conditioning
HWL	- high water level
Hz	- hertz

I

ID	- inside diameter
IEEE	- Institute of Electrical and Electronic Engineers
in.	- inch
IIE	- Instituto de Investigacionas Electricas
I/O	- input/ouput
IP	- intermediate pressure
I/P	- current to pneumatic converter

J

K

kg/h	- kilograms per hour
kJ/kWh	- kilojoules per kilowatt hour
km	- kilometer
km^2	- square kilometer
kPa	- kilopascal
kV	- kilovolt
kVA	- kilovolt ampere
kW	- kilowatt
kWh	- kilowatt hour

L

lb/hr	- pounds per hour
ldc	- load duration curve
lp	- low pressure

M

m	meter
m^2	square meter
MBtu	million British thermal units
MCC	motor control center
MCR	maximum continuous rating
MCS	master control system
m^3/h	cubic meters per hour
MJ	mega joules
mm	millimeter
MOV	motor operated valve
MPa	mega pascals
mph	miles per hour
m/s	meters per second
MVA	megavolt amperes
MW	megawatt
MWe	megawatt electric

N

NEMA	- National Electric Manufacturers Association
NERC	- National Energy Reliability Council
NFPA	- National Fire Protection Association
Nm	- Newton meter
NPDES	- National Pollution Discharge Elimination System
NPRD	- nonelectric parts reliability data
NPSH	- net positive suction head
NRC	- Nuclear Regulatory Commission
NRV	- nonreturn valves
NSRM	- Newman Solar Repowering Model
NUREG	- Nuclear Regulatory Commission Report
NWL	- normal water level

O

OA/FA	- oil air/forced air
OD	- outside diameter
O&M	- operation and maintenance
OSHA	- Occupational Safety and Health Administration

P

lb/ft^3	- pounds per cubic foot
pf	- power factor
P&I	- piping and instrumentation
PID	- piping and instrumentation diagram
ppb	- parts per billion
lb/ft^2	- pounds per square foot
psi	- pounds per square inch
psia	- pounds per square inch absolute
psig	- pounds per square inch gage

Q

R

R&D	- research and development
RH	- reheat
ROE	- return on equity
ROW	- right-of-way
RV	- relief valve

S

SEC SH	- secondary superheater
SH	- superheater
Solar One	- DOE 10MWe Solar Thermal Central Receiver Pilot Plant - Barstow, California
SWEC	- Stone & Webster Engineering Corporation

T

TDH	- total dynamic head
TEMA	- Tubular Exchanger Manufacturers' Association
T-G	- turbine-generator
thk	- thick
TMY	- typical meteorological year
TX	- Texas

U

UBC	- Uniform Building Code
UAC	- Utility Advisory Council
USGS	- United States Geodetic Survey

V

V	- volt
VWO	- valves wide open

W

WEC	- Westinghouse Electric Corporation
W/m^2	- Watts per square meter

X

Y

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NOTICE

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APPENDIX H

Specification No. 14380 - P201V

APPENDIX H

SPECIFICATION FOR

HELIOSTAT FIELD

NEWMAN UNIT 1 ADVANCED SOLAR REPOWERING
EL PASO ELECTRIC COMPANY
EL PASO, TEXAS

May 1983

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Errata Sheet

Specification for Heliostat Field 14380-P201V

Based on review of the specification subsequent to its preparation and use, the following improvements and corrections have been identified.

Page/Section/Paragraph	Correction
3-33, 3.6.5.2, 4	(Add last sentence) Alternate systems will be permitted if all functional requirements are satisfied.
3-24, 3.6.1, 1	...The Heliostat control system (3.6.2) and electrical system (3.6.7) shall include all equipment necessary to safely control the heliostat during all modes of operation...
3-26, 3.6.1.1, 2	...Heliostat alignment shall take place on a periodic basis under the control...
3-37, 3.6.6, 1	(Add first sentence) The Contractor shall provide a test plan for check-out and verification of all operating modes of the heliostat.
3-39, 3.6.6, 2	... Motion from the stow to the stand-by position shall be controlled so as to prevent focusing of any portion of the array on anything that would cause a potential hazard.
3-40, 3.6.6.2, 1	...Again, as during startup, the array shall be moved in a way that precludes the focusing of any portion of it onto anything that would cause a potential hazard.
3-41, 3.6.6.2, 1	...This "Emergency Stow" mirror face-up position shall be used in this case because it constitutes the shortest travel time in elevation to achieve. Also, it permits a safe control of the reflected beams and the airspace involved... The "Emergency Standby" position shall be initiated manually by HAC or PCS operator command or automatically through power failure detectors, receiver failure, or turbine trip. "Emergency Shut-

	down" will take place if storm-early-warning devices are activated.
3-53, 3.7.7, 2	...Continuous fluxes on tower and normally unirradiated portions of the Receiver Subsystem are limited to (25) KW/M^2 (7880 BTU/ft^2hr). However, the use of radiation shields would permit a higher allowance of spillage.
3-54, 3.7.7, 2	...The heliostat field design, as well as all modes and transitions, shall be consistent with...
3-38, 3.6.6, 2	(Add sentence) The Beam Control Strategy and equipment shall protect personnel and property within and outside the plant facility including airspace. The characteristics relative to each mode...

1.0 SCOPE

This Specification covers the technical and quality assurance requirements for the design, fabrication, delivery, installation, testing, and checkout of the heliostat field including all auxiliary equipment necessary to achieve erection and field performance.

The Bidder will furnish data and drawings, provisions required for onsite storage, reliability data, and other information summarized in Section 6.5 and described in detail in Section 3.

Engineering by the Contractor during the Final Design Phase is not included in the scope of this specification, but will be covered under a separate procurement.

The Contractor shall also furnish data, drawings, installation and operating instructions, and recommended spare parts plus the detailed equipment, materials, and services as listed in Section 6.4 of this Specification.

The Purchaser will furnish information, services, and assistance as specified in Section 6.3 of this Specification.

2.0 APPLICABLE DOCUMENTS

The equipment, material, design, installation, checkout procedures, and construction of the heliostat field shall comply with all Federal, state, local, and user standards, regulations, codes, laws, and ordinances which are currently applicable for siting in El Paso, Texas and to the using utility, the El Paso Electric Company (Purchaser). These shall include, but are not to be limited to, the documents itemized below. If there is an overlap or conflict between the requirements in this Specification and the applicable Federal, state, county, or municipal codes, laws or ordinances, Stone & Webster Engineering Corporation, (Engineers) will resolve the issue. If there is, or seems to be, a conflict between this Specification and a referenced document, the matter shall be referred to the Engineers.

The following documents in effect as of the date of Contract, form a part of this Specification to the extent specified herein.

2.1 Standards

MIL-STD-454	1983	Standard General Requirements for Electrical Equipment
MIL-STD-1472	1983	Human Engineering Design Criteria

ANSI CI-1975	1983	American National Standards Institute
ANSI A58.1	1982	Minimum Design Loads for Buildings and Other Structures
NEMA	1983	National Electrical Manufacturer's Association Standards
Manual of Steel Construction 8th Edition	1980	American Institute of Steel Construction
Uniform Building Code 1979 Edition	1979	International Conference of Building Officials
ACI 318-77	1977	Building Code Requirement for Reinforced Concrete - American Concrete Institute
NFPA 70	1975	National Electrical Code
AWS D1.1	1982	Structural Welding Code - American Welding Society
SSPC	1982	Steel Structures Painting Council Systems And Specifications Volume II

SNT-TC-1A	1980	Recommended Practices, Nondestructive Testing, Personnel Qualification and Certification - American Society for Nondestructive Testing

2.2 Other Publications

Environmental Conditions (See Attachment 1)

OSHA Title 29, Part 1910 Occupational Safety and Health Standards

3.0 TECHNICAL REQUIREMENTS

3.1 Project Type and Location

The project includes a field of heliostats having a total reflective area of approximately 178,000 m^2 with guaranteed capability described in this Specification and all necessary auxiliary equipment.

The project is a 50 percent (41 MWe) solar repowering of Purchaser's Newman Station Unit 1 in El Paso, Texas. Newman Station consists of four electric generating units with a combined rating of 498 MWe. Newman Unit 1 is rated at 82 MWe (net). The site is accessible by road and by a railway siding located approximately 6 miles to the southeast of the plant.

This installation is identified as Solar Repowered Newman Unit 1 of the El Paso Electric Company and will be located in El Paso, Texas at and north of the existing Newman station. The site is near the intersection of War Highway (extension of the North-South Freeway) and Farm-to-Market Road 2529, northeast of El Paso, Texas.

3.2 Overall Project Design Requirements

A 160 degree arc collector field north of a single receiver tower will be utilized.

The tower will support a water/steam-cooled central receiver. The collector field will be designed so that 133 MWt of the redirected solar energy will impinge on the receiver at noon winter solstice with a normal insolation value of 1,000 W/m^2. The collector field shall be sized to allow 2 percent of the heliostats to be out of service for maintenance purposes while permitting the basis of design to be satisfied by the balance of the collector field. The Bidder may select either of the following approaches for determining the number and arrangement of required heliostats.

Approach 1

The Bidder may use the following information developed by Westinghouse Electric Corporation. Westinghouse, using the MIRVAL computer program, has estimated that 178,000 m^2 of reflective surface is required to satisfy receiver requirements (95 m^2 heliostat was assumed as a nominal value representative of state-of-the-art heliostats). This value includes a 2 percent allowance for spares to permit heliostats to be taken out of service for maintenance. Drawing 14067-FM-31B-SR "General Arrangement - Heliostat Field" shows a preliminary heliostat arrangement and exclusion areas for existing structures, rights-of-way, etc.

Approach 2

The Bidder may use his own in-house computer programs, etc, to estimate the number and arrangement of heliostats required based on the following information. Figure 3.2-1 shows the dimensions of the receiver. The receiver has an arc angle of 216 deg and is divided into segments as shown in Figure 3.2-2. Figure 3.2-3 shows the desired maximum vertical heat flux profile at design conditions. The peak flux, not to exceed 420 kW/m^2, should occur in the lower half of the main receiver. An aiming strategy for the receiver, should provide a smooth profile.

The heliostats shall generally redirect their image towards receiver vertical centerline. The vertical profile shape should remain similar for all receiver segments. It is desirable to try to provide uniform incident power on the largest number of segments. Any spillage beyond the boundary of the absorber surface shall not exceed 30 kW/m^2. Site interferences are listed as mathematical equations relative to true North and the location of the receiver towers in Table 3.2-1.

TABLE 3.2-1

EXCLUSION AREA BOUNDARIES

Exclusion		Excluded Area Boundary Equations
1. Gas Pipeline Right-of-Way		$y > -.810x + 863.1$ $y < -.810x + 937.7$
2. Transmission Lines		$Y < .0078x + 148.6$ $x < (y/35.0) - 71.6$
3. Gas Lines		$y < .0039x + 207.6$ $y > .0039x + 192.4$
4. East-West		$-772.4 > x > 772.4$
5. Included Angle		If $x > 0$, $y < 0.15838x$ If $x < 0$, $y < -0.15838x$
6. Road		$y < .0104x + 53.3$
7. Gas Meter		$153.3 < y < 181.9$ $5.7 < x < 39.1$
8. Well		$529.6 < x < 543.8$ $122.8 < y < 136.2$
9. Small Pipes or Roads	a.	$y < 154.3$ $23.2 < x < 26.3$
	b.	$y < 194.3$ $64.8 < x < 68.6$
	c.	$136.2 < y < 194.3$ $535.3 < x < 537.2$

Where

x = positive in east direction, meters
y = positive in north direction, meters

Receiver is located at (0,0) and directions are based on true north.

External Receiver (Steam-Water)

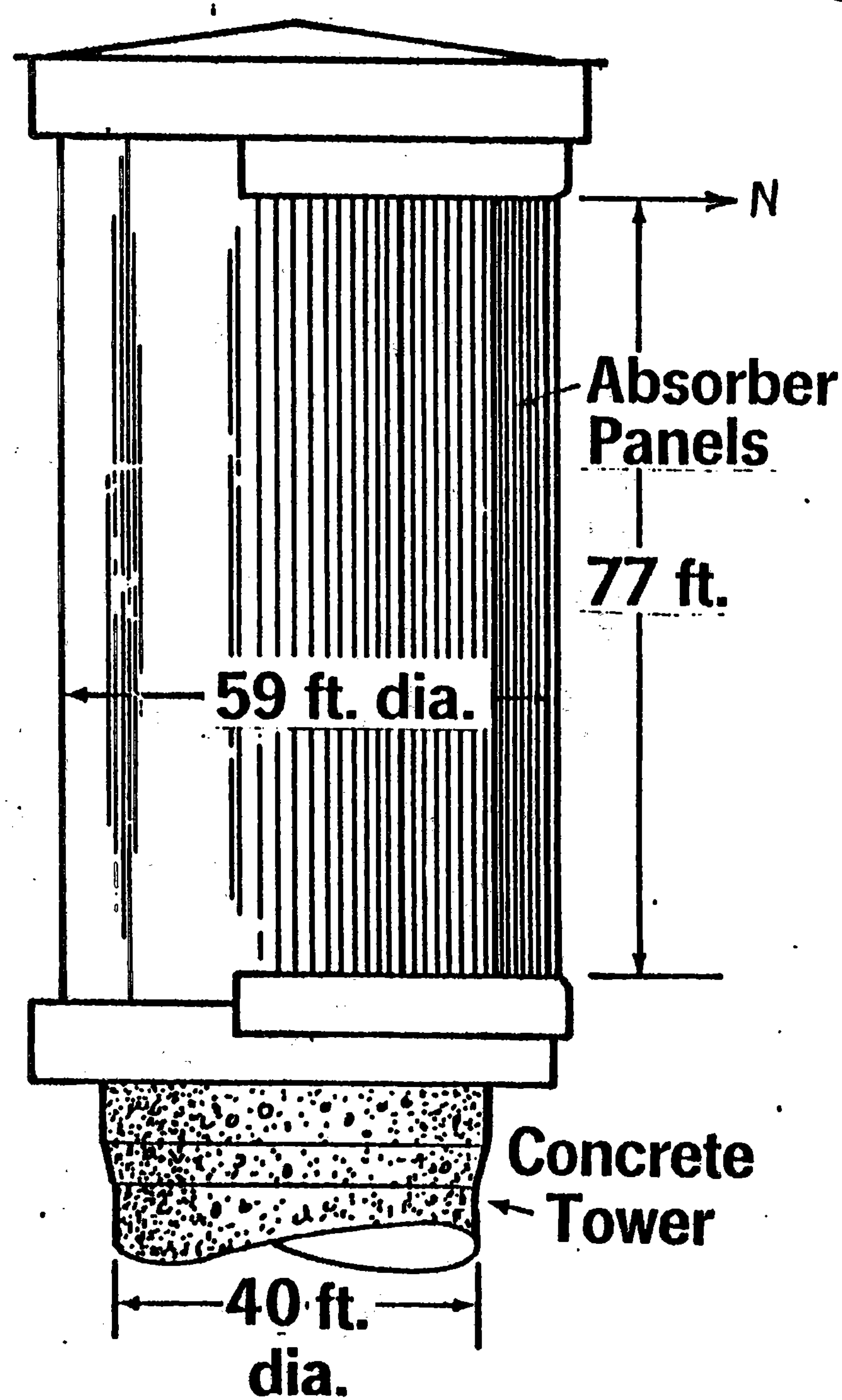
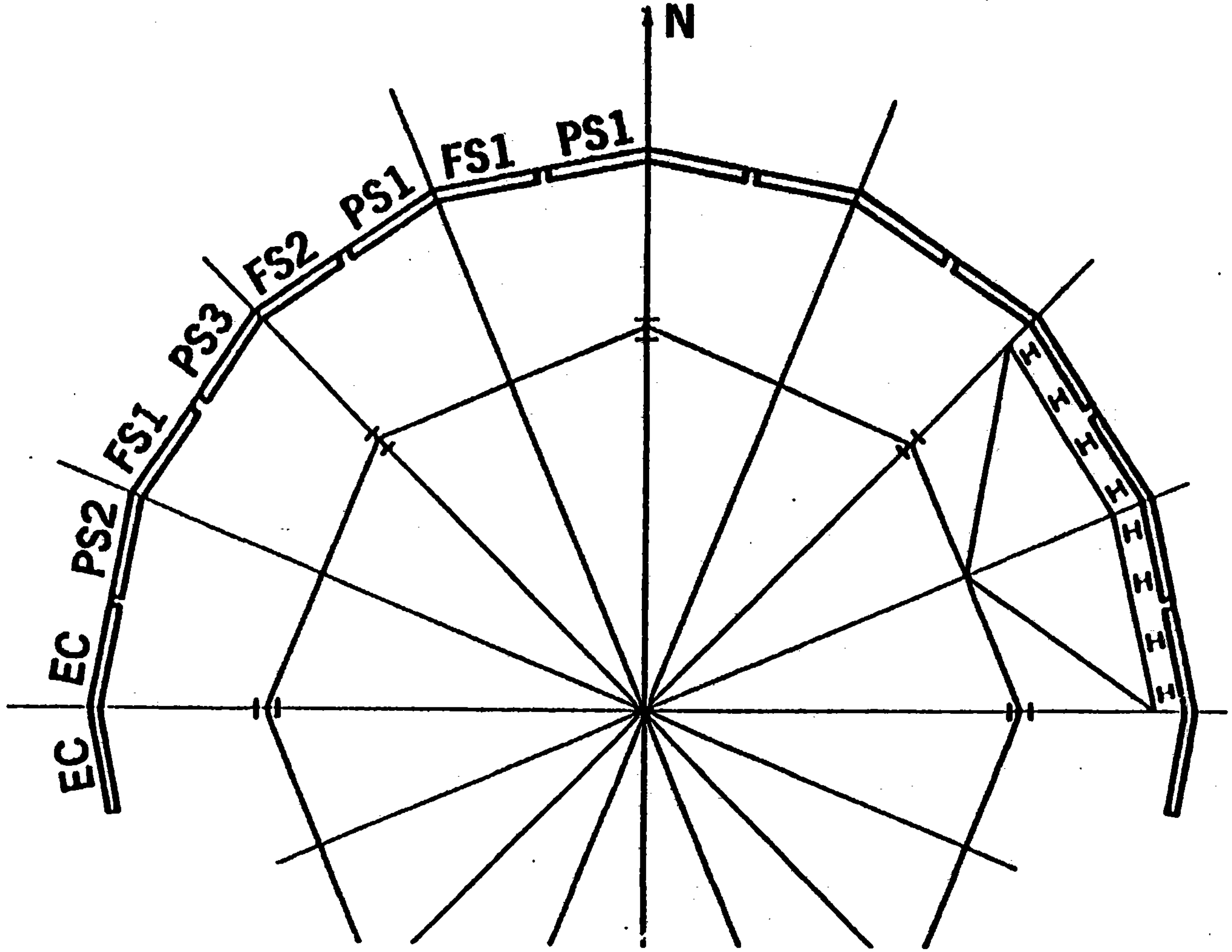


Fig. 3.2-1

RECEIVER DIMENSIONS

Interlaced panel arrangement around receiver periphery



PS = Primary Superheater
FS = Final Superheater

Fig. 3.2-2

Flow Diagram
Panel Arrangement

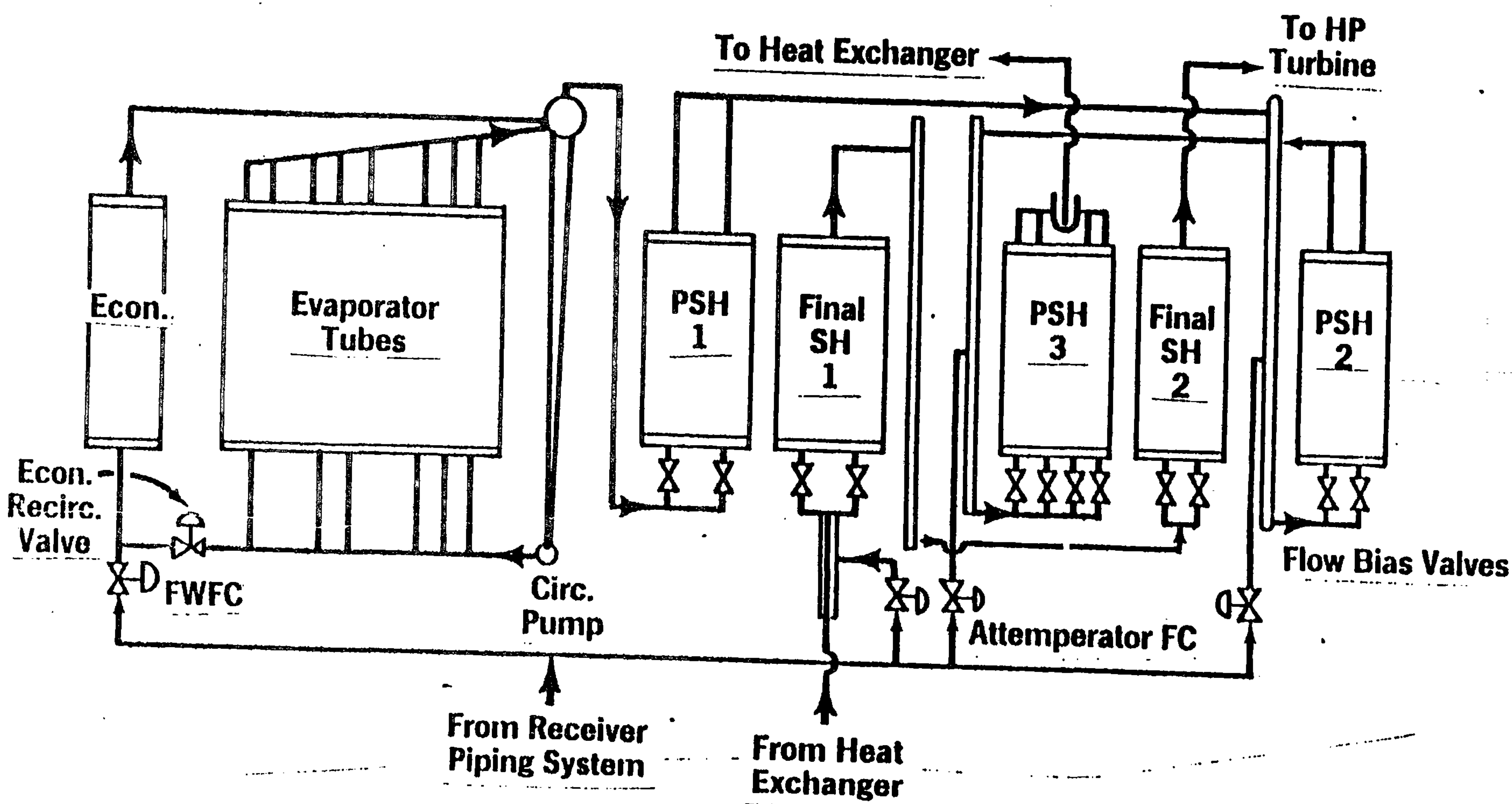


Fig. 3.2-3

HEAT FLUX PROFILE LIMIT
FOR INTERLACED TUBE DESIGN

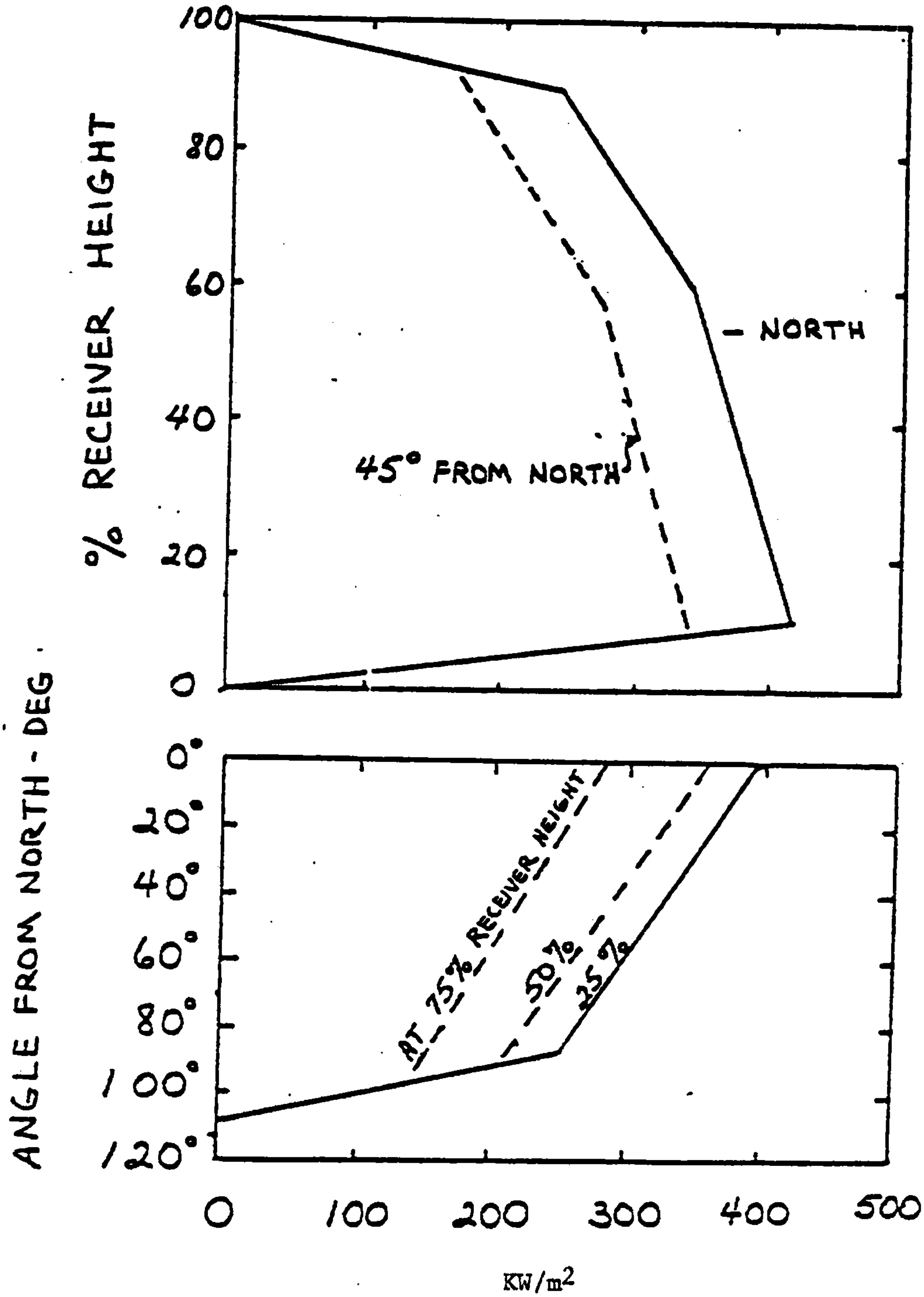


Fig. 3.2-4

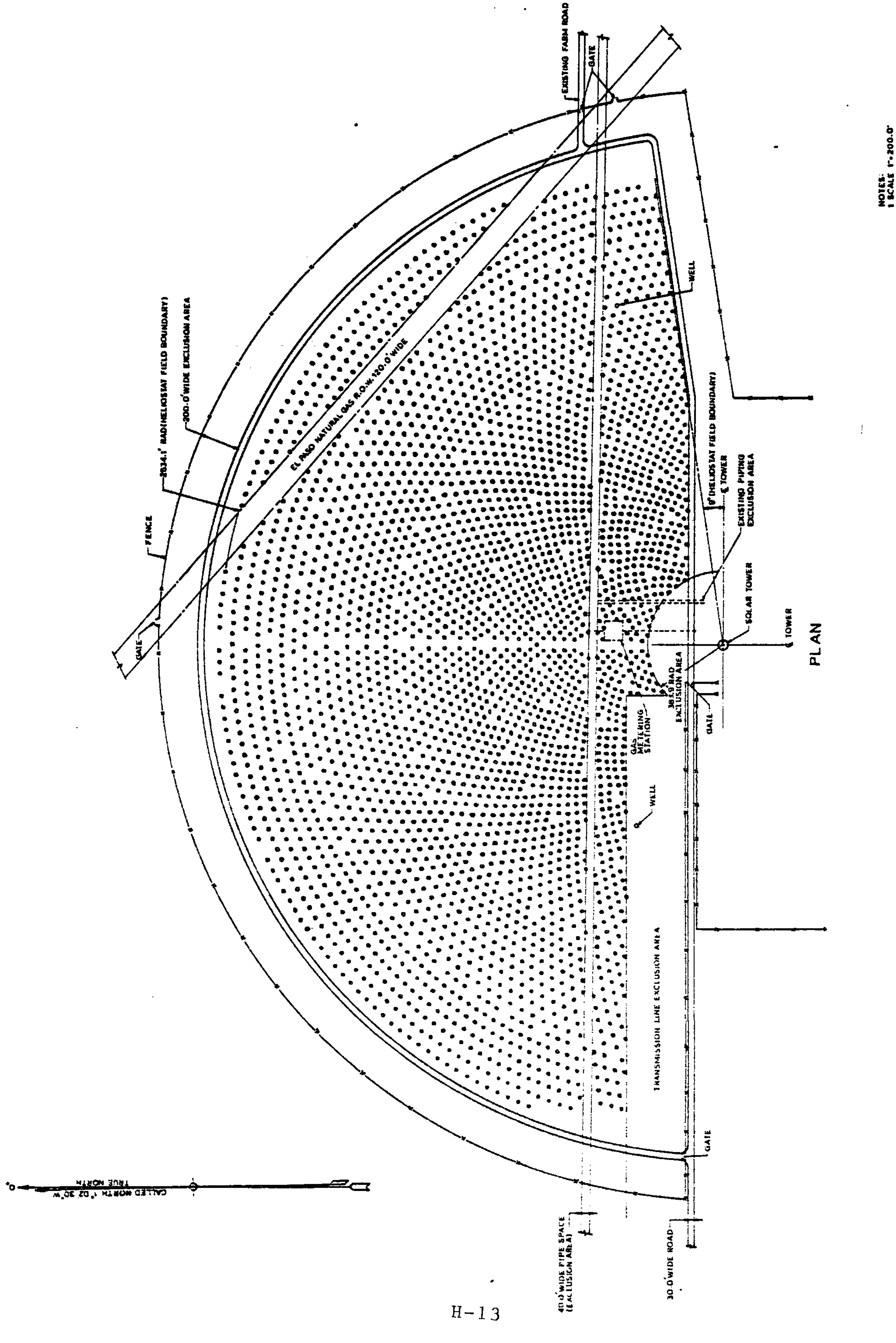


Fig. 3.2-5 Plot Plan

3.3 Heliostat Field Scope of Supplier Equipment

3.3.1 Scope

The heliostat array shall reflect solar radiation onto the elevated absorber (boiler/superheater) of the receiver system in a manner which satisfies receiver incident heat flux requirements. Deviations from this Specification are acceptable, with sufficient justification, to improve performance or cost-effectiveness. Performance shall be considered on an annual energy basis and costs include initial capital costs as well as operation and maintenance costs.

The heliostat array components shall be:

1. Heliostats

    a. Mirror modules

       Reflector

       Mirror support substrate

    b. Structural support

    c. Drive units

    d. Control sensors

    e. Pedestal and mounting interface to foundation

    f. Heliostat cabling and termination boxes (to interface points defined by Bidder)

       Power

       Signal

2. Support Equipment and Procedures

   a. Alignment

   b. Washing (optional)

   c. Operation and maintenance

   d. Repair and replacement

   e. Installation and removal

3.4 Functional Requirements

3.4.1 Optical Performance

In order to attain overall plant field performance such that at least 97 percent of the redirected energy shall impinge on the receiver with an incident angle of less then 60 deg, the following requirements have been established for designing and evaluating individual heliostats.

3.4.1.1 Beam Pointing Error

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

Wind - none

Temperature - 0° to 50°C (32°F to 122°F)

Gravity Effects - at all elevation and azimuth angles that could occur in a heliostat field.

Azimuth Angles - at all angles except during gimbal lock and during stow.

Sun Location - at least 0.26 rad above horizon, any time of year.

Individual 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). Beam pointing error shall be verified by the Beam Characterization System (BCS). Bidder shall identify frequency of BCS verification, time required to check and time required for realignment.

3.4.1.2 Beam Quality

Beam quality shall be such that a minimum of 90 percent 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 realigment. 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 azimuth angles that could occur in a heliostat field.

Sun Location - at least 0.26 rad above horizon, any time of year.

Heliostat Location - any position in the field and at any slant range.

Operating Mode - tracking on plant receiver or on a BCS calibration target.

Facet (Individual Mirror) Alignment - as planned by the Contractor.

Theoretical Beam Shape - the theoretical beam contour, determined by HELIOS (Computer model developed by and available from Sandia Laboratories for Heliostat field and beam design) is the isoflux contour that contains 90 percent of the total power. This isoflux contour will be increased by 1.4 mrad fringe.

Verification of beam quality shall be accomplished by the Beam Characterization System.

3.4.1.3 Reflective Surface Static Deflections

Overall structural support shall limit reflective surface static deflections to an effective 1.7 mrad standard deviation for a field of heliostats in a 12 m/s (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 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 are less than 1.7 mrad, the rms value of the slope errors taken over the entire reflective surface of an individual heliostat, computed under the worst conditions of wind and heliostat orientation (but excluding foundation 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 foundation deflection from the total surface slope error (1.7 - .5 = 1.2 mrad standard deviation x 3 = 3.6 mrad 3-sigma). The conditions under which this requirement applies are:

Wind, including gusts - 12 m/s (27 mph) at 10 m (33 ft) elevation

Temperature - 0° to 50°C (32° to 122°F)

Heliostat Location - any position in the field at any time of the year.

Gravity Effects - not included

Mirror Module Waviness - none

Facet Alignment Error - none

Contractor shall propose a verification technique for implementation during startup and/or operation of the facility.

3.4.1.4 Receiver Size

The heliostat array shall concentrate the redirected energy onto the receiver. The receiver is a vertical cylinder approximately

18.1m (59.4 ft) in diameter and 25.9m (85 ft) in length and the center is 155m (473 ft) above ground level.

3.4.2 Operational Control Specification

Operational control requirements are as follows:

1. The heliostats 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 with step changes no larger than 10 percent of the total heliostat field output.

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

3. Elevation and azimuth drives shall not drift from last commanded positions due to environmental loading.

4. Drive systems must be capable of resolving south field control singularity (i.e., "over-the-shoulder" limits or gimbal lock) within 15 minutes.

5. Drive systems shall provide for cost effective stowage of the reflective surface to minimize reflected beam safety hazards and dust or dirt buildup on the mirrors.

Heliostat orientation shall be available to master control at all times. Calculated gimbal angles are acceptable; orientation sensors are not required.

A typical heliostat configuration and field control configuration are shown in Figures 3.4-1 and 3.4-2, respectively.

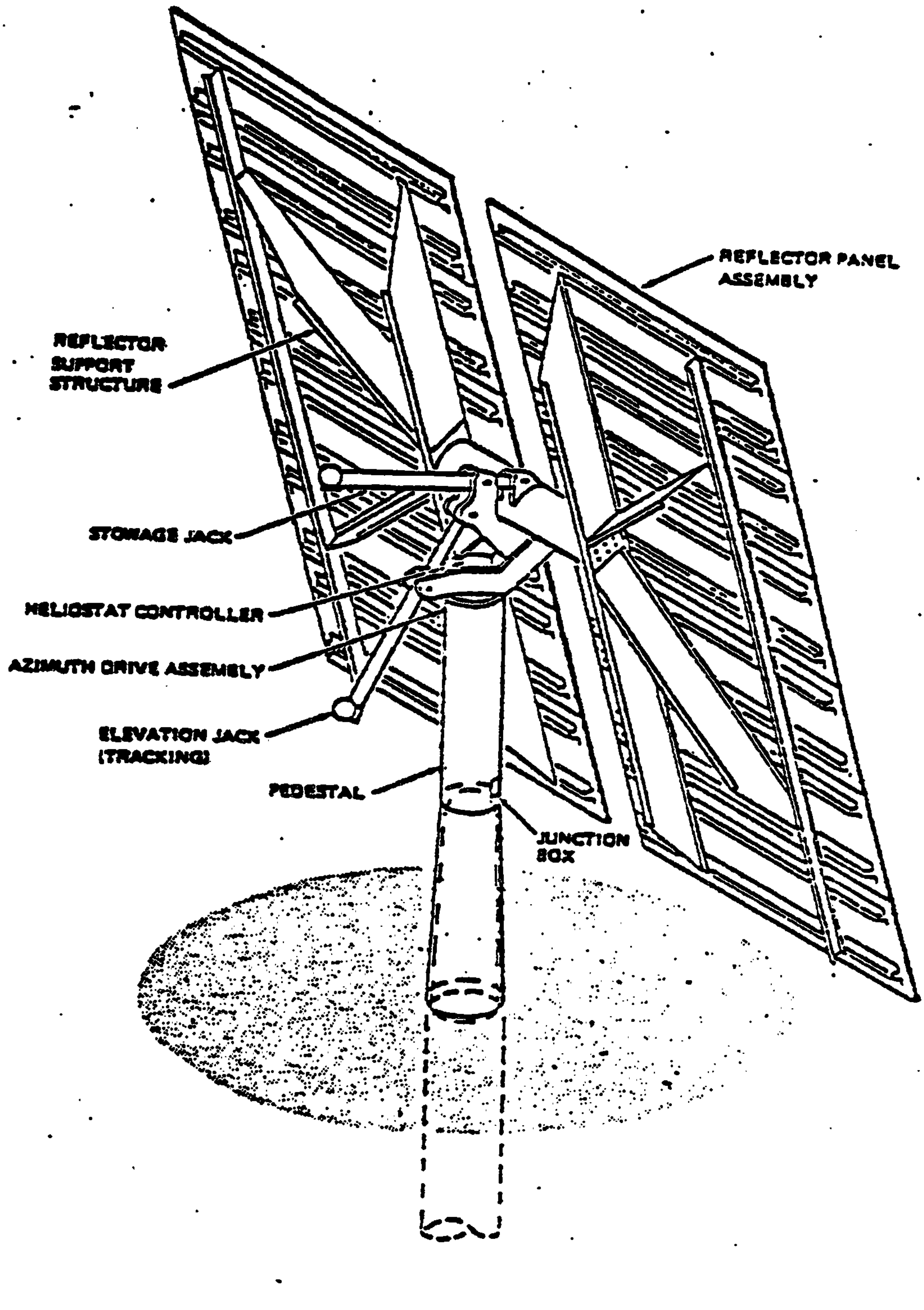


Fig. 3.4-1 Heliostat Configuration
BX214380-3

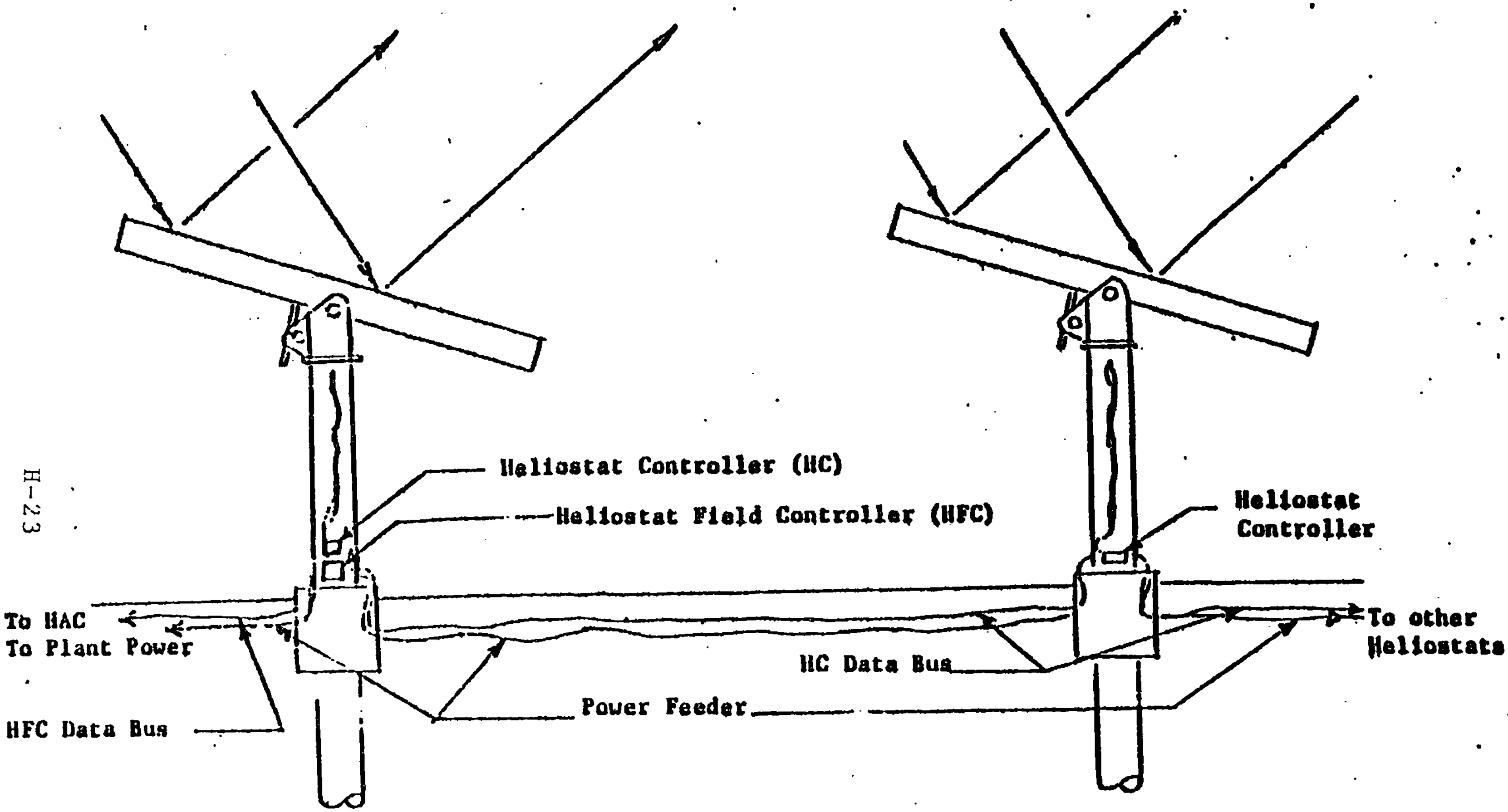


Fig. 3.4-2 Heliostat Field Control Configuration

3.5. Environmental Design Conditions

"Environmental Conditions" (Attachment 1) describes representative site conditions to be encountered and survived by the heliostat. The heliostat must maintain structural integrity in any applicable combination of these environments.

3.5.1 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 heliostat 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.

The heliostat shall be capable of operating in winds with a maximum speed, including gusts, of 16 m/s (35 mph). Performance requirements shall be met for winds with a maximum speed, including gusts, of 12 m/s (27 mph).

The heliostat, in any orientation, shall survive winds with a maximum speed, including gusts, of 22 m/s (50 mph), without damage. In the horizontal position, the heliostat shall survive winds with a maximum speed, including gusts, of 40.2 m/s (90 mph), without damage. A local wind vector variation of

+10 deg from the horizontal shall be assumed for the survival conditions.

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 ±10 deg from the horizontal.

3.5.2 Operational Limits

The heliostat and related equipment must meet performance requirements for the following conditions:

Environment	Level
Wind, including gusts	12 m/s maximum (27 mph)
Temperature	0 to 50°C (32°F to 122°F)
Gravity	All elevation angles

To achieve morning operational positioning or evening stow position, the heliostat will be required to function with ambient temperatures down to -9°C (16°F) and component temperatures that are colder or hotter than ambient temperatures due to thermal lag and/or absorption of direct insolation.

3.5.3 Stowage Initiation

The heliostats will continue to track the target with wind speeds up to 16 m/s (35 mph), but with degraded performance allowed, 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.

3.5.4 Hail

The heliostat, in any orientation, must survive 19 mm (0.75 in.) diameter, 0.9 specific gravity, hail impacting at 20 m/s (65 ft/s). In stowed position, the heliostat shall survive 25 mm (1 in.), 0.9 specific gravity, hail impacting at 23 m/s (75 ft/s) at a temperature of 6.7°C (22°F). The temperature of simulated hail shall be -6.7°C (20°F) for all tests.

3.5.5 Lightning

The heliostat field 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.

For design purposes, the maximum current in a lightning strike shall be limited to 200,000 amp.

3.5.6 Snow

The heliostat shall survive a static snow load of 250 Pa (5 lb/ft^2).

3.5.7 Rain

The heliostat shall survive rainfall conditions at a maximum rate of 75 mm (3 in.)/24 hrs, and 25 mm/hr (1 in./hr).

3.5.8 Ice

The heliostat shall survive freezing rain and ice deposits in a layer 50 mm (2 in.) thick.

3.5.9 Sandstorm Environment

The heliostat shall survive in fully operational condition after being exposed to flowing dust comparable to the conditions described by Methods 510 of the MIL-STD-810B.

3.5.10 Soil Conditions

The soil conditions at the site vary from very hard cemented soils which will support high structural loads to slightly cemented soils which essentially collapse upon saturation with water. These conditions are discussed along with preliminary foundation recommendations for the heliostats in the Preliminary Foundation Report prepared by the Engineers and issued in April 1983. Based upon this report, the heliostats will be founded upon 30 inch diameter reinforced concrete piers, 15 to 20 feet deep. Analyses, based upon preliminary design loading, indicate that these piers meet the requirements for rotation and tilting specified herein. Additional test borings and field and laboratory testing will be performed prior to final design to confirm these preliminary studies.

The drilled pier foundations will be furnished by others to a cut off grade 6 inches above the adjacent finished grade. The connection with the heliostat pedestal will be by anchor bolts or other similar means as mutually agreed between the Contractor and the Engineers.

The Contractor may propose an alternate foundation design which he considers better adapted to the configuration of his proposed heliostat pedestal or more cost-effective. Such alternates are subject to the approval of the Engineer and must meet the requirements for rotation and tiltng specified herein.

3.6 Heliostat Control and Electrical Requirements

Note: The following heliostat control concept is derived from the Barstow Solar One installation. Bidders are requested to confirm this approach or provide an alternative concept that satisfies functional requirements.

3.6.1 Scope

The heliostat control system (3.6.2) and electrical system (3.6.7) shall include all equipment necessary to position the heliostat field during all modes of operation, including startup, normal tracking, synthetic tracking, maintenance, emergency operation, and contingency operation. The major components of this system are the heliostat controllers (HC), heliostat field controllers (HFC), and the heliostat array controller (HAC).

3.6.1.1 Furnished by the Contractor

Redundant heliostat array controllers (HAC)

Heliostat controller peripherals:

- CRT(s)
- Keyboard(s)
- Disk(s)
- Printer(s)

Interconnecting Cables

Heliostat control software

Heliostat beam characterization equipment:

Television cameras

BCS targets

Meteorological and solar monitoring sensors

Heliostat Field Controllers (HFC)

Heliostat Controllers (HC)

Fiber optic cable, connectors, and connecting equipment, and supervisory personnel (if fiber optic data highways are used.)

Data highway and peripheral cable and connector/connections specifications (if coaxial or twisted shielded pair data highways are used).

Field receiving, storage, assembly, erection, and checkout including field supervision personnel and an operator training program. Bidder will quantify personnel requirements and describe a proposed operator training program.

3.6.1.2 <u>Furnished by Purchaser</u>

480 V, 3 phase, 60 Hz power supplies to termination points described by Bidder.

120 V, 60 Hz, 1 phase uninterruptible power supply for HAC and peripherals (Contractor to provide load requirements).

Data highways installation and supervision.

HAC installation.

Installation of BCS targets (as specified by Contractor).

Installation of peripheral equipment cable.

3.6.2 <u>Heliostat Control System Description</u>

Control of the heliostat array shall be through a three-level distributed microprocessor-based system (see Figure 3.6-1). The first level contains approximately 1875 HCs (based on 95 sq m heliostats) which provide closed-loop position maintenance control over the individual heliostats. The HCs also provide sun tracking control and heliostat position data acquisition on demand from the HFC.

The second level contains approximately 80 HFCs each providing control over approximately 25 HCs (one "cell" of heliostats). The HFCs perform the basic level of sun-tracking control and maintain a data base of their heliostat position information.

Communication between the HFCs is via a nonredundant data highway.

The third and highest level of heliostat control is the redundant HAC. Supervisory control of the heliostat array is performed by the HAC. The beam characterization system (BCS) control is resident in the HAC and provides automatic real time evaluation of any heliostat's quality of beam and pointing accuracy.

The HAC maintains communications with the HFCs via redundant data highways.

3.6.3 Heliostat Controller (HC)

3.6.3.1 Description

The heliostat controller shall be a single 16 bit microprocessor with programmable or erasable programmamble read only memory (PROM or EPROM) as well as random access memory (RAM). Additional components include input/output, isolation/drivers, and a data highway port with a 9600 baud rate. The HC shall be enclosed in a weathertight enclosure mounted on the heliostat.

3.6.3.2 Functional Requirements

The HC shall receive azimuth and elevation position data from the heliostat azimuth and elevation position encoder signals and output position control commands to the heliostat azimuth and elevation drive motors. The HC shall transmit the heliostat position data to the HFC on demand and receive the HFC sun-tracking and stow positions control commands. Communications with the HFC shall be via a nonredundant data highway port capable of serial transmission at 9600 baud.

No failure in the data highway, HFC, or other HCs on the data highway shall affect the closed-loop heliostat position maintenance control or the local control capabilities. Conversely, no failure within the HC shall affect the data highway, HFC, or other HCs. Local control shall be provided to perform maintenance on each heliostat.

Means shall also be provided to select remote or local control locking out whichever mode is not selected. Data on the mode (local/remote) shall be transmitted to the HAC.

3.6.3.3 Maintenance

Design of the HC shall be modular to facilitate ease of maintenance. No component shall obstruct the removal of any other component.

3.6.3.4 Environmental

The HC shall be designed to be operable in all modes without degradation due to the ambient environmental conditions as specified in Environmental Conditions (Attachment 1).

If supplemental heating/cooling is required to maintain proper operation, it shall be furnished by the Contractor. The Bidder shall identify the power requirements for any heating/cooling equipment.

3.6.3.5 Power Supplies

The Purchaser will supply a 480 V, 3 phase, 60 Hz, power supply or heliostat array controller (HAC) to each heliostat. The Contractor shall furnish any conversion equipment necessary to convert to proper voltage type and level required by the heliostat control and drive equipment, including any filtering equipment necessary to limit voltage spikes from power line drive motors from affecting the heliostat microprocessor equipment. The Bidder shall identify these equipment requirements. The Purchaser will provide power wiring between HACs and individual heliostats, if required.

3.6.3.6 Input/Output Interfaces

Solid state equipment shall be isolated from inputs by optical isolators. Outputs shall be isolated by relays with high cycle duty contacts rated for the azimuth and elevation drive motor maximum current and voltage.

3.6.3.7 Data Highway Interface

The HC shall interface with the HFC via a data highway port capable of serial transmission at a minimum of 9600 baud.

3.6.4 Heliostat Field Controller

3.6.4.1 Description

The HFC is a single 16 bit microprocessor with programmable or erasable programmer read only memory (PROM or EPROM), a minimum of 48K bytes of random access memory (RAM) and 32K of bubble memory. Additional components include I/O parts for interface with the HCs and the HAC. The HFC shall be enclosed in a weathertight enclosure mounted on selected heliostats.

3.6.4.2 Functional Requirements

The HFC shall be a nonredundant microprocessor-based controller. The HFC shall be capable of controlling and receiving data from a minimum of 25 HCs. The HFC shall interrogate each of the HCs for azimuth and elevation position as well as local remote control status and maintain this information in memory for subsequent transmission to the HAC upon demand. An open-loop, sun-tracking algorithm shall be performed by the HFC which will position the individual heliostats automatically via the data highway. The HFC shall receive individual heliostat position commands from the HAC for retransmission to the HCs. All detailed control algorithms for operation of the heliostats during the various operational modes (see Section 3.4.2) shall be stored in the bubble memory of the HFC.

3.6.4.3 Maintenance

Design of the HFC shall be modular to facilitate ease of maintenance. No component shall obstruct the removal of any other component.

3.6.4.4 Environmental

The HFC shall be designed to be operable in all modes without degradation due to the ambient environmental conditions as specified in Environmental Conditions (Attachment 1).

If supplemental heating/cooling is required to maintain proper operation, it shall be furnished by the Contractor. The Contractor shall state the power requirements for any heating/cooling equipment.

3.6.4.5 Data Highway Interfaces

The HFC shall contain a single data highway port for serial communication to its HCs at a minimum of 9600 bAUD.

The HFC shall contain redundant data highway ports for serial data transmission to/from the HAC at a minimum of 9600 bAUD. Isolation between the redundant HAC communication ports shall be provided to prevent failure of one port from affecting transmission on the redundant port.

3.6.5 Heliostat Array Controller (HAC)

3.6.5.1 Description

The HAC shall be a minicomputer system with redundant central processing units (CPU) and 256K bytes of resident memory. The HAC shall include peripherals such as cathode ray tubes (CRT), line printer, disk unit for long-time storage, and a keyboard or touch sensitive CRT overlay or similar as recommended by the heliostat Vendor. The HAC shall contain redundant data links to the redundant process computer system portion of the main control subsystem (MCS). Also, the HAC shall contain data highway ports in accordance with redundant HAC to communicate with the HFCs via redundant data highways. These data highway ports shall be capable of serial data transmission at 9600 bAUD minimum.

The HAC shall contain I/O ports for the BCS, resident in software, within one of the redundant HACs. These ports shall communicate with the three field-mounted television cameras, the three calibration targets, and the meteorological and solar data monitoring equipment which are a part of the heliostat control system.

The Contractor shall be responsible to provide the interface between the HAC and the Process Computer System (PCS) based on the protocol furnished by the PCS manufacturer.

3.6.5.2 Functional Requirements

The HAC shall communicate with each of the heliostat sectors simultaneously.

In order to further increase the flexibility of the collector array, the control system shall be designed to operate without the HAC with respect to the main modes of operation.

The HAC shall be needed only to coordinate certain maintenance and alignment operations (it shall direct, for example, a given heliostat to track its beam onto the calibration target) and to update or modify the normal control sequence for any sector, field, or single heliostat as desired by the operator. Since the HAC shall fully interface with the process computer system, the above functions shall, at the request of the operator (or automatically), be initiated at the HAC or be relayed to and from the PCS.

The beam characterization system shall be a software-based system resident within one of the redundant HACs. The BCS also consists of three heliostat field-mounted television cameras and three calibration targets mounted on the receiver tower with its own interface at the HAC to provide the necessary heliostat data and control for beam quality and accuracy measurements.

The purpose of the system is to permit automatic real-time evaluation of quality of the beam and pointing accuracy provided by any heliostat. The whole operation shall be under software control and require no operator intervention. At any one time, three heliostats, one from each third of the array, shall be directed to deflect their beams from the receiver to their respective calibration target. Beam size, shape, centroid, flux distribution, and power shall then be measured for each heliostat. This shall be a passive process made possible by use of video cameras aimed at the calibration targets. Their output shall be digitized, calibrated, and processed. Software modules shall detect any abnormality and provide the operator or maintenance personnel, through the interface with the PCS, with data necessary to perform any eventual heliostat beam adjustment. Pointing information shall be delivered to the HAC for use in performing automatic realignment.

Each remotely controlled camera shall be permanently installed in the field. Temperature stablizer, environmental enclosure, and camera filters shall be part of the field installation.

Calibration targets shall have a Lambertian high temperature surface paint with remotely controlled pyrheliometers for absolute flux measurements. The output of the sensors shall be transmitted to the BCS computer. Camera output shall also be transmitted to the BCS computer where a video switch shall select each camera in turn. Central processing units, CRT displays, keyboards, printers, video digitizers, and data recorders shall be utilized to extract needed data. The Heliostat contractor shall supply meteorological data and solar irradiance data inputs to the BCS computer shall be used to close the loop on evaluation of heliostat beam characteristics.

The BCS computer and the HAC shall work in direct communication, under PCS supervision, in selection of the heliostats to be aligned and calibrated. Once a heliostat is selected, the BCS shall give the instructions to the HAC to direct the heliostat beam from the receiver to the standby position and then to the calibration target to perform the measurements. The operator shall be able to intervene at any time to modify or take active part in the operation.

The BCS shall also be capable of operating on its own, without the connection to the PCS, in its basic interactions with the collector system through the HAC. Total failure of the HAC or the BCS computer may interrupt the beam characterization process. Failure of the BCS shall not immediately affect the actual performance of the heliostats; no redundant BCS system is required. The unit operator shall be alerted so that he can take necessary action to restore normal conditions.

The HAC shall be capable of modifying or updating the routines in the HFCs by downloading new routines through the same communication network utilized for control of the array. Status of each heliostat or set of heliostats shall be available at all times at the request of the HAC operator.

Heliostat control arrangement shall be designed to achieve intended performance at all levels with a minimum of human intervention. All modes of operation shall be selectable by a single operator by controlling the execution of appropriate instructions or set of routines, which shall be permanently stored in the computer software. Although operation routines shall be permanently stored, the ability shall exist to modify or update them at any time using the standard computer system software without affecting the hardware. Provisions shall be included to enable manual intervention in any function by the operator.

Heliostat alignment shall take place on a continuous basis under the control of the HAC utilizing calibration targets. The PCS and the BCS take part in this operation through their respective interfaces with the HAC.

Alignment data and control commands for heliostats undergoing alignment shall be exchanged with the BCS while the entire procedure occurs under the PCS supervision. One heliostat from each third of the field shall be commanded, in sequence, to reflect the suns's image onto the assigned calibration target. Heliostat beam pointing data from the BCS shall be transmitted through the HAC to the HFCs serving the applicable heliostats. At the same time, the HAC shall select the field of heliostats (served by a HFC) that must undergo alignment. The HFC then produces necessary commands to verify correct aiming at the calibration target and to make necessary adjustments for each heliostat under its control. Any biases necessary to make the calibration signal satisfy the alignment requirements are stored in the bubble memory of the HFC and are used in subsequent operation to correct the heliostat pointing. The HFC notifies the HAC that alignment of its set of heliostats has been completed so that the HAC can switch to the next set of heliostats. The entire procedure is to be under software control with provisions for manual operator intervention.

3.6.5.3 Power Supplies

The Purchaser will furnish a 120 V, 1 phase, 60 Hz, uniterruptible power supply for the HAC and peripheral equipment. All filtering and module power distribution shall be supplied by the Contractor.

3.6.5.4 Environmental

The HAC and its peripheral equipment (CRT's, printer, disk, etc) will be located in a controlled environment. The Contractor shall provide the environmental limits specifications including estimated heat load.

3.6.6 Heliostat Operational Modes

The following is a list of the heliostat modes of operation which can be implemented:

- Startup
- Shutdown
- Track
- Standby
- Align
- Manual
- Stow
- Communication

The characteristics relative to each mode are described in the following sections:

3.6.6.1 Startup

The heliostat array shall be normally in the stowed position prior to startup. The power supply units for the heliostat array controller (HAC), heliostat field controllers (HFCs), and heliostat controllers (HCs) may or may not be energized. If they are deenergized, the first operation at startup shall be to apply electrical power to the entire array and load the control software into the HAC random access memory (RAM). Upon power-up, the HFC software shall be automatically loaded into the HFC RAM from the resident magnetic bubble memory extension. The HC software shall be permanently stored in erasable programmable read only memory (EPROM) and shall not need to be loaded. Within a few seconds from the application of power, all software shall be loaded and the array shall be ready to respond to commands (from either a dedicated operator or from the unit's process computer system).

The first command shall be the Communications command, aimed at polling all heliostats and obtaining a response which indicates their operational status. The HAC cathode ray tube (CRT) displays shall provide a summary of the conditions relative to the respective heliostats. The Communication command shall also initialize the day and the time routines at each HFC so that appropriate sun position calculations can be performed at the cell level. Subsequently, the HAC shall transmit the first sun vector in order to calibrate the HFC sun position algorithm. At this point the startup procedure shall proceed with the issuance of the Standby command. All heliostats, or any portion as commanded, shall move so as to reflect the sun's image onto the standby point(s) (adjacent to, and away from the receiver) which shall complete the startup procedure. The heliostats shall, sequentially on command from the PCS, be switched from the Standby to the Track position (beam on the receiver) and vice versa at a rate dictated by the Master Control System. Motion from the Stow to the Standby position shall be controlled so as to prevent focusing of any portion of the array onto anything other than the Standby point(s). Bidder shall identify the amount of time required to bring heliostats from Standby to Tracking mode.

3.6.6.2 Shutdown

Shutdown is the operation that removes the beam from the receiver, and, eventually, places the array in a stowed position so that the next day's startup operation if facilitated. The Shutdown command shall start a sequence of actions at the HAC. The first action shall remove the beam from the receiver and put the array in Standby. Once the Standby position is reached, the array shall be moved from Standby to the Stow position. Again, as during startup, the array shall be moved in a way that precludes the focusing of any portion of it onto anything other than the Standby point(s).

There shall be two types of Shutdown operation: Normal Shutdown (used at sunset, etc) and Emergency Shutdown, (used prior to an unsafe condition such as a wind storm). During Normal Shutdown, the heliostats shall be Stowed with some predetermined orientation, facilitating Standby operation the next morning. A Normal Shutdown shall be initiated either by the operator (at the HAC or PCS) or automatically when the sun's elevation goes below a predetermined value.

An Emergency Shutdown shall move all heliostats to the Stowed position in the least amount of time possible. The initial emergency command shall move only the azimuth of the heliostats so as to remove the beam from the receiver and place it at an approximate Standby position. Subsequently, the heliostats shall be Stowed with the mirror facing up. This "Emergency Stow" mirror face-up position shall be used in this case because it constitutes the shortest travel time in elevation to achieve. When the emergency conditions disappear, the array shall be commanded to resume Normal operation or assume a Normal Shutdown position. The Emergency Shutdown operation shall be initiated manually by HAC or PCS operator command or automatically through power failure detectors, storm-early-warning devices, receiver failure, or turbine trip.

3.6.6.3 Track

The Track command shall be given for any number of heliostats through the HAC. At this command the heliostats shall be switched from standby target tracking to receiver tracking. The number of heliostats to be moved in accordance with unit time shall be determined by the PCS. The basic sun receiver tracking algorithm shall be resident in the HFC software. A more detailed algorithm shall be resident in the HAC software which periodically shall transmit a reference sun vector to the HFCs for calibration.

3.6.6.4 Standby

The Standby command shall be indentical to the Track command, except that in Standby the heliostats shall focus on a volume adjacent to the receiver, in free space. Sun position and pointing angle evaluations shall be carried out on a continuous basis to maintain the focus away from the receiver. The number of heliostats on Standby and number on Track shall be constantly varied by the PCS to maintain the desired steam pressure and temperature at the output of the reciver. The Standby mode of operation shall be selected automatically during Startup and Shutdown and shall constitute the intermediate step for the beginning or termination of power generation.

The data necessary for pointing angle evaluation shall be available at the HFC/HC at all times so that only the Standby or Track command need be issued together with the identification of the number of heliostats involved. As for any mode of operation, this command shall be issued either automatically by the control system software or manually by the HAC or PCS operator.

3.6.6.5 Align

Align operation shall take place on a continuous basis under the control of the HAC utilizing the beam characterization system (BCS). The PCS and BCS shall take part in this operation through their respective interfaces with the HAC. The purpose of the operation shall be to permit the automatic real-time evaluation of the quality of the beam and pointing accuracy provided by a heliostat. Each heliostat shall be commanded, individually in sequence, to reflect the sun's image onto the calibration target. Beam size, shape, centroid, flux distribution, and power shall be measured for each heliostat. These data shall be evaluated and made available to the HAC and the PCS operator. Pointing data (beam centroid) shall be used by the HAC to perform the necessary correction to the specific heliostat angles. The correction biases shall be stored in the HFC to update and maintain accurate pointing of the heliostats. Data relative to beam quality shall be used by the PCS operator to determine the need for mirror facet canting adjustment and/or mirror washing. The whole operation shall be under software control and require no operator intervention.

Initial alignment shall be performed following the installation of the heliostat to determine pointing biases caused by installation irregularities (such as nonperfect leveling of the foundation, orthogonality errors between vertical and horizontal rotational axes, etc). This initial alignment operation shall be repeated several times during an initializing 24-hour period. The pointing biases relative to each alignment shall be stored in the HFC for the specific heliostat. At the completion of the 24-hour alignment cycle, a special software routine shall be executed on the accumulated biases. Correction coefficients shall be evaluated so that the encoder reading (or motor count signal) of the respective heliostat shall be compensated for leveling and other mechanical installation errors.

Alignment shall also be performed on a regular basis during normal operation. Regular aligment shall not take more than approximately 1 minute to execute. The HAC software for the regular alignment sequence shall require one heliostat from each cell polled for alignment before the next heliostat from the same cell is selected to ensure that any problem associated with an HFC is readily identified. The operator shall be able to intervene at any time to modify the sequence or to perform alignment on any heliostat upon command.

3.6.6.6 Manual

The manual mode of operation shall be initiated from either the HAC or the PCS and shall be used to move the specified number of heliostats in any direction, both in azimuth and in elevation. In addition, individual heliostat local control shall be provided at the HC. Safeguards shall be provided to avoid excessive concentration of multiple heliostat beams at unacceptable targets during manual control.

3.6.6.7 Stow

The Stow operation shall place the specified number of heliostats in a position where the mirror facets are horizontal or vertical (or nearly so). This command shall be issued automatically during the Startup and Shutdown sequences as well as manually at the HAC or PCS. The heliostats to be Stowed are always on Standby as a starting mode. The features associated with this operation in normal or emergency conditions are described in the preceding Shutdown Section.

3.6.6.8 Communication

The Communication mode transfers data between the HAC, HFCs, and HCs, as needed, in the bi-directional communication links. Also, the HFC software shall be downloadable from the HAC when the array is installed, including initial downloading of data relative to the heliostat target coordinates (Track and Standby points), Stow positions, and alignment biases via the Communication mode.

Data relative to the array shall be collected in this mode. The communication mode shall not affect any other operating mode of the array. This mode shall coexist with any other previously established mode and shall be used only to permit the exchange of any data among the various computers in the control network.

3.6.7 Electrical System Requirements

3.6.7.1 Applicable Documents

National Electrical Manufacturer's Association, NEMA MG1-1978, Motors and Generators.

3.6.7.2 Motors

General

All motors shall conform to NEMA MG1, Section II, Parts 2, 10, 11, 12, and 14 with respect to materials, workmanship, design, and routine tests except as specified herein.

3.6.7.2.1 Electrical Design

A 480 V, 3 phase, 60 Hz power source will be brought to each heliostat. Each heliostat shall contain its own integral transformation or rectification equipment if motors are rated other than 480 V, 3 phase, 60 Hz.

Motors shall be NEMA Design B unless load torques require motors with special characteristics.

The full load current when operating at ±10 percent of rated voltage shall not exceed 1.15 times rated full load current.

3.6.7.2.2 Mechanical Design

Motors shall be totally enclosed, nonventilated (TENV) with nonhygroscopic insulation and shall be suitable for the service conditions specified in Section 3.5 of this specification.

Motors shall have antifriction bearings with suitable seals to prevent leakage of lubricant in either direction along the shaft.

Grease lubricated bearings shall be lubricated prior to shipment.

Bearings requiring periodic regreasing shall have provisions for inservice positive lubrication with means to prevent damage due to overgreasing.

Bearings of the completely sealed or the prelubricated type shall not have provisions for inservice lubrication.

3.6.7.2.3 Motor Data

The Contractor shall provide a filled-in motor data sheet, for each type of motor being supplied.

3.6.7.2.4 Tests

Every motor shall be given a routine factory test, including high-potential test, in accordance with NEMA MG1.

3.6.7.2.5 Documentation

Five copies of a certified routine test and high-potential test of five motors of each type, picked at random from the assembly line, shall be provided.

3.6.7.3 Interfaces

The heliostat field controller (HFC) and heliostat control (HC) power compartments/junction boxes shall be provided with suitable terminal boards to accept incoming control and power cables. The compartments/junction boxes shall be watertight, NEMA Type 4 or equivalent. Provision shall be made for fastening a NO. 4/0 bare copper ground wire to the base of the heliostat.

MOTOR DATA SHEET

(Data to be Furnished)

Client

Project

Mark or Item No.

Make ____________________

Frame NO. ____________________

Horsepower ____________________

Voltage ____________________

Service ____________________

Full load, rpm ____________________

Full load, amp ____________________

Locked rotor, amp ____________________

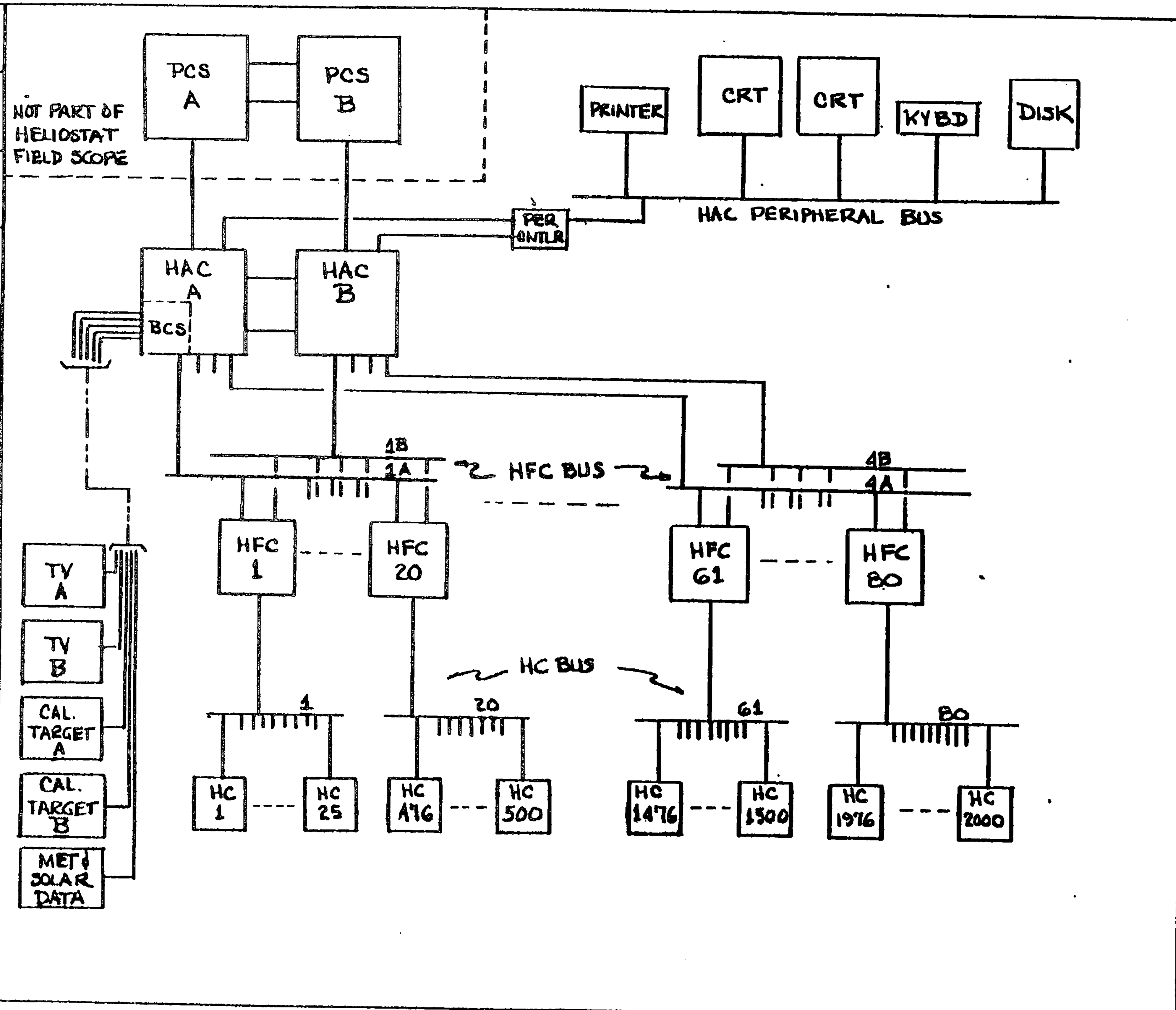
Bearing manufacturer and model

Outboard ____________________

Inboard ____________________

Lubrication ____________________

STONE & WEBSTER ENGINEERING CORPORATION



TITLE: FIGURE 3.6-1 HELIOSTAT CONTROL FUNCTIONAL BLOCK DIAGRAM

REF: SKETCH

DATE | PREP. | CHECK | APPR.

5 4 3 2 1

▲ 5215.9

3.7 General Design, Fabrication, and Erection Requirements

Commercial design and construction standards shall be employed. Where applicable, the Uniform Building Code (1979 Edition), ANSI A58.1 - 1982, ACI 318-77, and the AISC Manual of Steel Construction (8th Edition) shall be used. For electrical components, the National Electrical Code (ANSI C1), the National Electrical Manufacturer's 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 heliostat life.

3.7.1 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 noncommercially available parts shall be defined and documented in deliverable documents.

3.7.2 Electromagnetic Radiation

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

3.7.3 Flammability

In a high temperature, low humidity environment of a typical desert, the heliostat field shall not be vulnerable to extensive fire damage.

Given that a fire exists in any part of the heliostat field, the fire should not damage any heliostats that are not directly adjacent to the fire due to burning of a heliostat or any heliostat wiring. If a heliostat or any part of a heliostat burns for any reason the heliostat fire should not spread to other parts of the field due to blowing winds, component explosions, or any other means.

3.7.4 Nameplate and Product Marking

See Section 5.2

3.7.5 Quality

The level of quality shall conform to practices defined in the codes, standards, and specifications applicable to the plant site and the using utility. 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.

3.7.6 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. Heliostats do not need to be interchangeable within the array; however, the number of noninterchangeable types shall be limited to the most economic choice.

3.7.7 Safety

The heliostat field 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.

Operational safety requirements are as follows:

1. The heliostat shall be capable of emergency defocusing upon command to reduce peak incident radiation on the receiver to less than 3 percent of initial value within 120 sec.

2. Heat fluxes on tower and normally unirradiated portions 1
of the Receiver Subsystem are limited to (25) kW/m^2 (7880 Btu/ft^2 hr).

3. Beam control strategy and equipment shall protect personnel and property within and outside the plant facility including air space.

4. The heliostat field design shall be consistent with safety criteria identified for the Barstow Pilot Plant. The supplier of the Heliostats shall identify any deviations from these design criteria which affect safety. (Reference: 10 MWe Solar Thermal Central Receiver Pilot Plant System Safety Analysis, December 1980, SAN/0499-55).

3.7.8 Human Engineering

The Heliostat shall be designed to facilitate manual operation, adjustment, and maintenance as needed and to provide the optimum allocation of functions between personnel and automatic control. The heliostat 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. MIL-STD-1472, "Human Engineering Design Criteria", 1
shall be used as a guide in designing equipment.

3.7.9 Welding 1

All welding, welding procedures and qualifications, and welder 1
qualifications shall be in accordance with the Structural Welding 1
Code, D1.1-82, of the American Welding Society.

3.7.10 Cleaning

Bidder shall describe recommended cleaning methods and provide a plan for optimizing cleaning frequency.

3.7.11 Surface Preparation and Painting

All steel shall be cleaned and shop coated. Cleaning, coating materials, application methods and inspection procedures shall conform to the specifications, referred to herein, of the Steel Structures Painting Manual, Volume 2, "Systems and Specifications" by the Steel Structures Painting Council.

Prior to coating, all steel shall be blast cleaned after fabrication in accordance with SSPC-SP10, Near-White Blast Cleaning. All petroleum-based contaminents shall be cleaned from the surface prior to blast cleaning.

An organic zinc-rich primer shall be used. The topcoat shall be a vinyl copolymer enamel which provides excellent intercoat adhesion to itself and to the primer. The topcoat must withstand long-term exposure with negligible fading and chalking. The total system dry thickness shall be a minimum of 6 mils. The primer or the topcoat shall be a minimum of 2.5 mils. While maintaining the 6 mil total system thickness. The interior surfaces of the pedestal will not require painting.

3.7.12 Transportability

Heliostat components or assemblies shall be designed for transportability by highway handling equipment within applicable federal and state regulations.

3.7.13 Maintenance

The system shall be designed so that potential maintenance points can be easily reached and components such as electronic units, motor drivers, etc, can be readily replaced. Elements subject to wear and damage, such as supporting wheels, gears, etc, shall be identified for service or replacement. Items with a common function shall be provided with standard tolerances and connector locations to permit service interchangeability.

3.7.14 Service Life

The system shall be designed for a 30-year service life.

3.7.15 Standard Usage

Commercial design and construction standards relevant to the system's intended use shall be employed.

3.7.16 Component Availability

Standard materials and off-the-shelf components shall be used to the maximum extent possible.

3.8 Performance Measurement Methodology

Bidder shall propose a methodology for quantifying thermal power delivery by the heliostat field to the receiver aperture. This methodology should utilize beam pointing error and beam shape information from the Beam Characterization System, reflectivity measurements, direct normal insolation measurements, and flux measurements (at the BCS targets) if available. A formula will be developed that will be used to determine whether performance of the heliostat field satisfies design requirements. These periodic performance measurements shall be used to enforce performance guarantee conditions and penalties.

The methodology for heliostat performance measurement will require review and approval by the Purchaser, Engineers, and receiver supplier. The calculated flux delivery to the receiver is also intended to provide a basis for evaluating receiver performance.

4.0 QUALITY ASSURANCE

4.1 Quality Assurance Program Requirements

4.1.1 QA Program

The Contractor shall have in effect at all times a QA Program which clearly establishes the authority and responsibility for all elements of the program. Persons performing quality functions shall have sufficient and well-defined responsibility and authority to enforce quality requirements, to identify, initiate, recommend, and provide solutions to quality problems, and to verify the effectiveness of the solutions. Submittal of this QA Program may be required.

4.1.2 Contractor's Responsibilities for Subsuppliers/ Subcontractors

The Contractor shall identify, in purchase documents to his subsuppliers/subcontractors, all applicable quality and QA requirements imposed by this Specification on the Contractor and shall ensure compliance thereto.

4.1.3 Notification Points.

The Purchaser shall have the right to establish notification points for which the Contractor shall be given prior notification.

In addition, the Purchaser may establish temporary notification points to ensure resolution of temporary quality problems. Notification points require receipt of notification at least 5 working days in advance of the scheduled time of performance. The Purchaser may require that activities performed without proper notification be repeated for Purchaser's Quality Control Representative (EQCR) observation at the Contractor's expense. The EQCR will witness the event or will authorize the Contractor to proceed without Purchaser's witnessing of the event.

4.1.4 Submittal of Manufacturing and Inspection Plan

After award of Contract, the Contractor shall submit copies of his Manufacturing and Inspection Plan to the Purchaser for his information and subsequent establishment of Notification Points.

As a minimum, the Manufacturing and Inspection Plan shall outline the basic manufacturing/production and field erection sequence and specific preplanned Contractor inspections that are required to be performed.

4.2 Tests

The Purchaser reserves the right to perform limited tests and inspection of heliostat components selected from Contractor's production lines to verify that key items perform to required specifications.

Every motor shall be given a routine factory test, including high-potential test, in accordance with NEMA MG1 (see 3.4.7.2.4).

4.2.1 Structural Steel

The following test shall be performed by the Engineers' Shop Inspector:

4.2.1.1 Painting

1. Surface Preparation Test - The surfaces of all steel to be coated shall be visually examined prior to the application of the coating. SSPC VIS 1, pictorial surface preparation standards for painting steel surfaces, shall be used to verify the degree of blast cleaning specified.

2. Film Thickness Test - For film thickness measurement, the requirements and recommended practices of SSPC-PA2, Method for Measurement of Dry Paint Thickness with Magnetic Gages, shall be followed. Readings shall be taken on smooth, regular surfaces.

The following tests shall be performed by the Contractor:

4.2.1.2 Welding

Twenty-five percent of all butt welds shall be radiographed in accordance with Section 6, Part B, Radiographic Testing of Welds

(AWS D1.1) or ultrasonically tested in accordance with Section 6, Part C (AWS D1.1) and a permanent record made of the results. Nondestructive test operators shall be qualified in accordance with SNT-TC-1A. Twenty-five percent of all fillet welds shall be tested in accordance with ASTM E709, practice for magnetic particle inspection. All welds shall satisfy the requirements of subsection 8.15, Quality of Welds (AWS D1.1). Welds found deficient by visual examination or by nondestructive testing shall be repaired in accordance with AWS D1.1.

4.3 Inspection

4.3.1 Structural Steel

The Engineer's Shop Inspector shall perform the following inspections:

4.3.1.1 Mill Test Reports

Verify by mill test reports that steel conforms to chemical and mechanical properties of the applicable specification covering the material to be furnished.

4.3.1.2 Qualification of Welders

Verify from shop records and welder's qualification records, that the Contractor is using qualified welders.

4.3.1.3 Weld Inspection

Perform required visual inspection of welds. If the visual inspection is satisfactory, nondestructive testing of welds shall be performed as described in Section 4.2.1.2, herein. Verify that weld tests have been properly performed and documented by the Contractor.

4.3.1.4 Fabrication Inspection

Perform random dimensional checks, using approved shop drawings, of completed fabricated components. Perform random check for straightness of completed components.

4.3.1.5 Protective Coatings Inspection

Witness the application of protective coatings on a random basis and verify that the protective coatings are applied in accordance with the coating manufacturer's application instructions and the Steel Structures Painting Council Specification SSPC-PA1; Shop, Field and Maintenance Painting. Perform visual inspection of the coated steel to ascertain that the coating entirely covers the surfaces without holidays, shadow-thru streaks, thin spots, sags, runs, and obvious surface defects.

4.3.2 Field Erection and Completion

The Engineer's shop inspector shall perform the following inspections:

4.3.2.1 Completed Heliostat

Inspection of assembled heliostat and pedestal for optical (mirrors), structural (mechanical), and electrical completeness.

4.3.2.2 Operational Heliostat

Inspection of assembled heliostat and pedestal during operational performance.

4.3.2.3 Partially Completed Heliostat

Inspection of partially completed heliostat can be made by field inspectors.

4.4 Documentation

4.4.1 Records System

A records system shall be established and maintained that provides for the identification and correlation of test and inspection records and certificates.

4.4.2 Document Submittals

This Specification requires specific documents to be formally submitted to the Engineers for information or review and approval. If these documents are changed subsequent to submittal, the supplier shall resubmit the revised document(s) to the Engineers for information or review and approval consistent with the original requirement. Any document required by this Specification which is produced by a subsupplier of the Contractor shall first be reviewed and noted as being approved by the Contractor and then submitted to the Engineers for review and approval. Contractors and subsuppliers who proceed to use unapproved documents do so at their own risk, and may be required to repeat activities that were performed if the document used is subsequently rejected by the Engineers.

4.4.3 Contractor's Documentation

QA documents are a deliverable item. The Contractor's QA shall approve them, then present them to the Purchaser. The Contractor shall assemble all QA records into two identical sets. Each page of each document submitted shall be clearly identified by the Purchaser's name, the station and unit, the Contract Number, the equipment description and specific identification, and the manufacturer's name and address. Each individual document shall be legible and shall have reproducible microform capability. No information shall be recorded closer than 5/8 in. to the binding edge or closer than 1/4 in. to any other edge of the paper.

Documents that have been submitted with a previous shipment on this order/contract shall not be duplicated. However, a statement shall be furnished to the Purchaser itemizing, by document, the documents previously furnished for each item of equipment and the date of that previous submittal.

4.4.4 Final Inspection and Check of Records

The Contractor shall be responsible for inspecting the item(s) and checking the applicable records, prior to shipment, to verify that all specification requirements have been complied with. Two complete sets of all documents required to comply with this specification shall be submitted to the Engineer. Acceptance of the completed sets of records does not relieve the Contractor of his responsibility for compliance with specification requirements. After completion but prior to submittal of these records, the Contractor shall complete and submit the Engineer's Certificate of Compliance. The Engineer's Certificate of Compliance supplied as part of this Specification is a document which certifies that the inspection(s) and test(s), required by the Specification, have been satisfactorily completed and the Contractor's documentation for that shipment conforms to the procurement document requirements, this Specification, and applicable codes and standards. The Certificate of Compliance shall be completed and signed by the Contractor's quality representative and submitted to the Purchaser, together with other documentation applicable to that shipment.

4.4.5 Shipping Release

A copy of the completed Certificate of Compliance must be included in each shipment. This requirement also applies to shipments from the Contractor's suppliers when item(s) are to be shipped directly to the Engineers or its clients.

4.4.6 Documentation by Contractor

The minimum documentation required to be furnished will be indicated at a later date.

All records required by this Specification, applicable regulations, codes and standards, or generated as a result of the Contractor's QA Program shall be retained in the Contractor's file for a period of (number of days) after the contract requirements for manufacture or installation have been complied with. At the expiration of this (number of days) period, the Purchaser or his authorized agent shall be provided the option of receipt and/or the Contractor's continued retention of the file contents. No QA records shall be destroyed or otherwise disposed of without written permission from the Purchaser.

5.0 PREPARATION FOR SHIPMENT

5.1 Packing and Packaging

Prior to packing, the Contractor shall apply all necessary preservatives required to protect the equipment from corrosion during shipment. All equipment shall be adequately packed, crated, boxed, skidded, or otherwise protected and prepared for shipment in such a manner as to prevent loss and damage and maintain the specified cleanliness during handling, transportation, and for a reasonable period of storage prior to use. Selection of the packing and packaging shall be the responsibility of the Contractor; however, the method employed shall conform to the information and recommendations furnished to the Purchaser.

5.2 Shipping Documents, Marks, and Forms

The Contractor must use proper identification, markings, and documentation records for shipment of the equipment to the jobsite.

1. Packing Lists

   Where applicable, two (2) packing lists must accompany each shipment.

   a. One fully itemized packing list must be inserted into a resealable waterproof envelope, and securely affixed to the exterior of the shipping container or piece of equipment adjacent to the shipment markings.

b. One fully itemized packing list must be placed within each shipping container.

2. <u>Marking, Labeling, and Identification</u>

a. All crates, boxes, cartons, or individual shipping containers must be marked or stenciled in waterproof ink, in clear legible characters in a visible location with the following <u>minimum</u> identification information:

1. Contractor's Name ______________________
2. Contract Number ______________________
3. Description of Item(s) ______________________
4. Mark Number ______________________
5. Quantity of Item(s) ______________________
6. Gross Weight ______________________
7. Net Weight ______________________
8. Shipment Number ______________________

b. All individual, skid mounted, or loose equipment must be marked or stenciled in waterproof ink or paint, in clear legible characters on the item or embossed on a metal tag securely fastened to the shipment in a visible location with the following minimum identification information:

1. Contractor's Name ____________________

2. Contract Number ____________________

3. Description of Item(s) ____________________

4. Mark Number ____________________

5. Gross Weight ____________________

6. Shipment Number ____________________

c. All shipping containers, individual skid mounted or loose equipment which weigh 10,000 lb or more must be marked with the following information in addition to the requirements of parts a and b above:

   1. The approximate shipping weight of the equipment.

   2. The calculated or actual center of gravity must be marked on the shipment or an accompanying loading diagram attached to the packing list.

d. All caution marks such as Fragile, This Side Up, etc, should be clearly visible and placed on at least two opposite sides of the shipping container or piece of equipment.

e. The shipment identification numbering system shall be established by the Contractor and used consistently for all equipment delivered to the site. No two shipments or pieces of equipment shall be assigned the same identification number.

5.3 Motor Bearing Lubricant

Oil filled bearings on motors shall be drained prior to shipment.

5.4 Provisions for Storage

Immediately upon receipt at the jobsite the Contractor shall receive, thoroughly inspect and determine that all equipment or material is in the as-shipped condition.

The Contractor shall assume all responsibility for the care, safeguarding, weather protection, fire protection, and temporary lay-up of all equipment and materials from the time of their receipt at the jobsite. Every effort shall be made to protect the equipment and materials at all times so that there is no deterioration that could in any way adversely affect the useful life or the suitableness of the equipment or material for the purpose for which it was furnished.

As a minimum, the Contractor shall provide indoor storage for the following:

1. Control panels
2. Control equipment - all types
3. Electrical devices - all types
4. Motors - electric and air
5. Motor starters

6. Spare parts

7. T-V equipment

All equipment stored outdoors shall be kept clean at all times, including during storage, handling, installation, and after installation until initial operation. In the storage yard, it shall be stored on sleepers or otherwise so it does not contact the earth.

The Contractor shall specify any special storage requirements for each shipment of equipment to the site.

6.0 SUPPLEMENTAL PROVISIONS

6.1 Conditions - Deviations and Nonconformances

No deviation or nonconformance from this Specification or applicable Federal, state, and local codes and standards invoked by this Specification shall be accepted until approved by the Purchaser. Deviations are considered departures from any requirement of this Specification. Uncorrectable nonconformances are considered to be conditions which cannot be corrected within the Specification requirements by rework or replacement.

The Contractor shall promptly document and notify the Engineer of all deviations and nonconformances from the Specification [such as deviations from applicable codes and/or drawings]. Further engineering, manufacturing, or fabrication after detection of any deviation or nonconformance prior to the Purchaser's approval shall be at the Contractor's risk. No departure from the Specification shall be binding on any party until an addendum or revision to the Specification has been issued by the Purchaser.

6.2 Subsuppliers/Subcontractors

Should the Contractor propose to purchase from a subsupplier/subcontractor any of the major pieces of equipment, material, or services specified herein, he shall identify in the proposal the subsupplier/subcontractor for the specific equipment, material, or services. These subsuppliers/subcontractors shall be subject to approval by the Purchaser.

To the extent that they apply, the Contractor shall impose on each of the subsuppliers/subcontractors the complete requirements of this specification. He shall be directly responsible that the subsuppliers/subcontractors are completely aware of all of these requirements, and that they abide thereby.

6.3 Furnished by the Purchaser

The Purchaser shall furnish the following equipment, materials, services, and finish painting:

The Purchaser shall provide a Master Process Control System to sense, detect, control, and monitor all parameters necessary to ensure safe and proper operation of the entire integrated repowered unit. The Master Control System will consist of a central computer, computer peripheral equipment, time code generator, control and display consoles, and solar/nonsolar electric power control interfaces and master control software.

In addition, the Purchaser shall furnish and install:

1. 480-V, 3 phase, 60 Hz power field wiring to the Contractor's equipment

2. Interconnecting wiring and cabling between the Master Control System and the Contractor's equipment

3. Field checkout and testing in addition to that provided by Contractor

4. Heliostat Foundations

5. Site grading

6.4 Furnished by Contractor

The Contractor shall design, fabricate, deliver, and install a solar collector system composed of an array of heliostats and supporting power and control elements designed to interact with the Purchaser's Master Control system. The collector subsystem components shall consist of the following:

1. Heliostats, including reflective surface, structural support, drive units, control sensors, and pedestals.

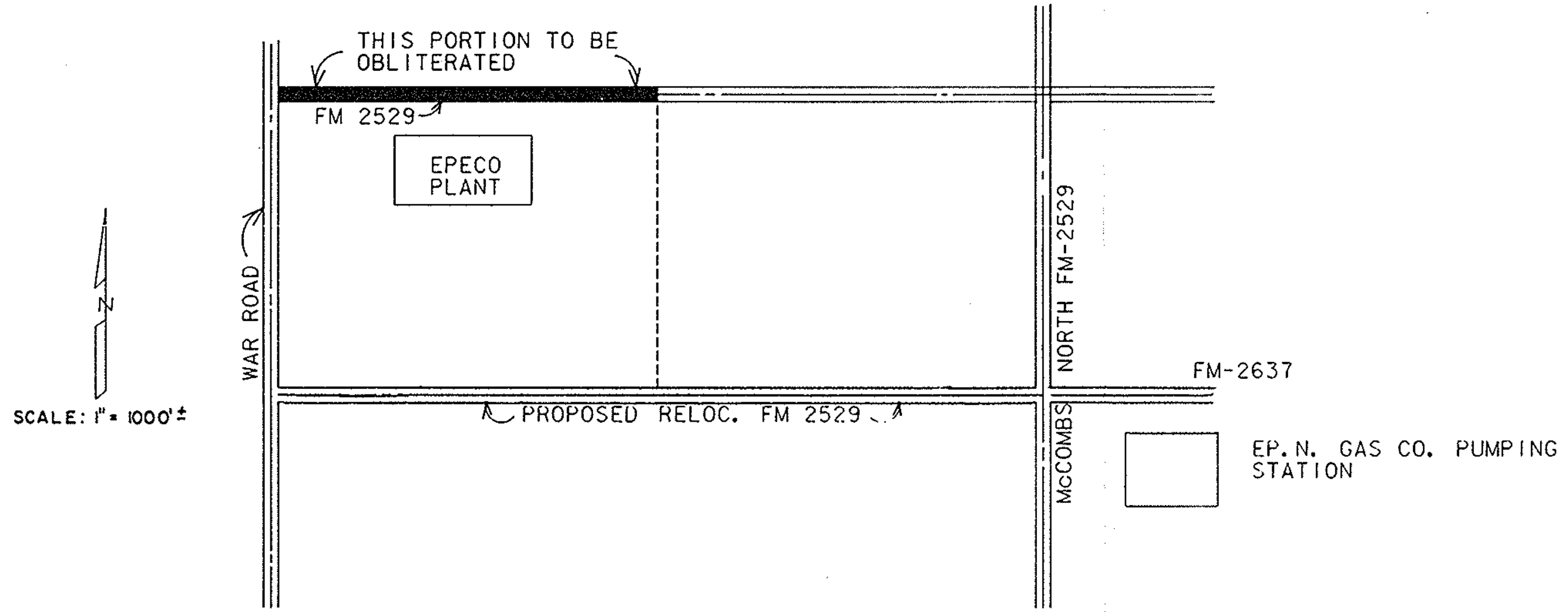
2. Electromechanical and electrical controllers, including individual heliostat, heliostat field, and heliostat array controllers, control system interface electronics, ac/dc power supplies, and beam characterization system components.

3. Interconnecting wiring and cabling between Contractor's components.

4. Software required for the safe and proper operation of the control system.

ROADWAY SUMMARY (FINANCED BY EL PASO ELECTRIC COMPANY)

ITEM	100	110	120	131	150	170	249	314	322				400	432	462			464	475		500	502	538
PLAN SHT. NO.	PREP ROW STA.	RD EXCAV (DENS CONT) CY	CHANNEL EXCAV (DENS CONT) CY	BORR (DEL) (DENS CONT) (TY A CL 3) CY	BLAD HR	OBLIT. ABAND. RD. STA.	FL BS (DEL) (DEN CON) (TyAGr4C14) (9 IN) SY	EMUL-ASPH (MS-2) OR (CSS-1H) GAL	AGGR (TyD, Gr3) CY	AGGR (TyD, Gr4) CY	AGGR (TY PD) GR. 4 CY	ASPH (AC-3, AC-5 AC-10 OR MC-800) GAL	STR EXCAV (CULV. LARGE) CY	RIPRAP (CONC) CL B CY	CONC BOX CULV. (4FT X 3FT) LF	CONC BOX CULV. (5FT X 3FT) LF	CONC BOX CULV. (6FT X 3FT) LF	R.C. PIPE ARCH CL-III DES 2 LF	CULV. WINGWALL (FW-N) EA	CULV. WINGWALL (MCW-FI) EA	MOBILIZATION LS	BARCD, SIGN AND TRAF HANDLING MO.	R. O. W. MARK TY II EA
9	60	7,883		5,650	5		26,719	5,344	243	90	134	16,032											9
10	45.7	4,492	468	9,500	5		20,440	4,088	186	68	103	12,264											2
11		285		450	5		2,444	449	23	9	13	1,467											5
12													74	1.74	63			132	2				
13													265			252			4	2			
14													88			116	58		2	2			
FIELD						53.7															1	7	
JOB TOTALS	105.7	12,660	468	15,600	15	53.7	49,603	9,881	452	167	250	29,763	427	1.74	63	368	58	132	8	4	1	7	16

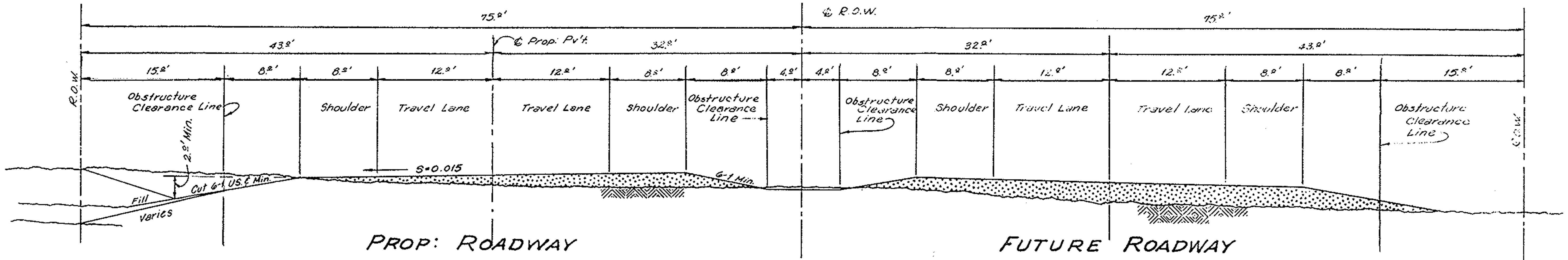


MAP OF THE PORTION OF
FM-2529 (TO BE OBLITERATED)

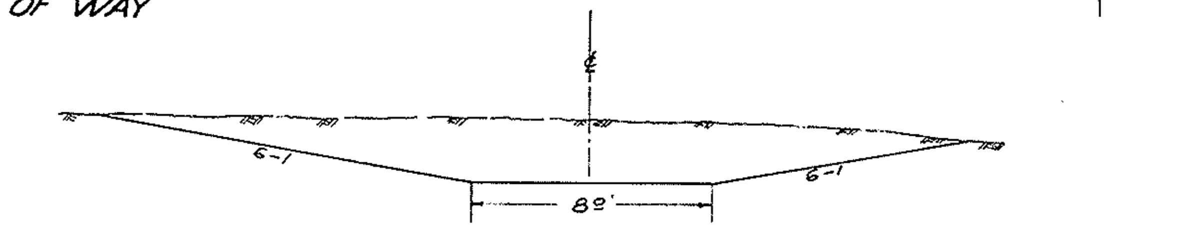
STATE DEPARTMENT OF HIGHWAYS AND PUBLIC TRANSPORTATION

RELOCATION FM-2529
ESTIMATE
SUMMARY

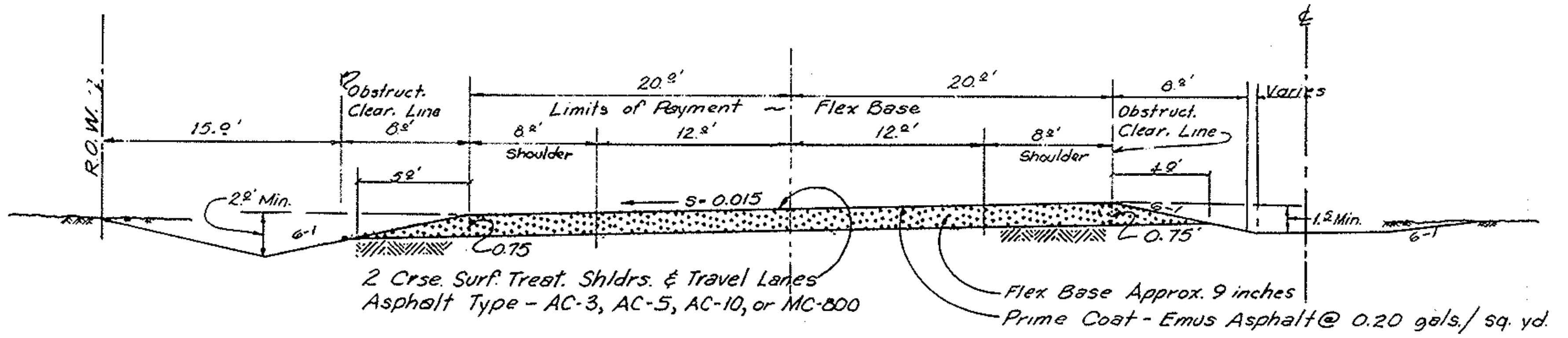
DN. • M. E. M.		STATE	STATE AID PROJECT NO.				SHEET NO.
CK. DN. • M. E. M.	8	TEXAS					6
DN. • A. J. P.							
CK. DN. • M. E. M.	STATE DIST. NO.	COUNTY		CONT. NO.	SEC. NO.	JOB NO.	HIGHWAY NO.
TR. • A. J. P.	24	EL PASO		3226	1	10	FM-2529
CK. TR. • M. E. M.							

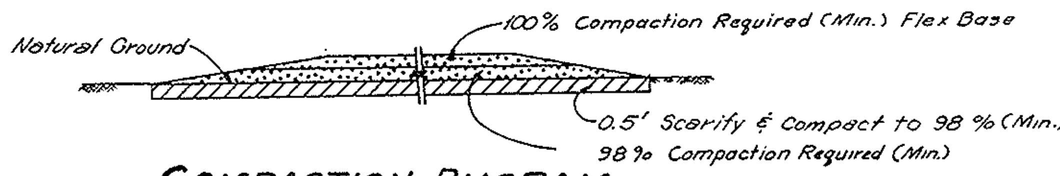


PROP: TYPICAL SECTION ~ ENTIRE RIGHT OF WAY



TYPICAL SECTION ~ Drainage Channel





COMPACTION DIAGRAM

First Application Full width
Asphalt - 0.25 Gals./s.y.
Aggregate Ty. D, Gr. 3, 1 c.y./110 s.y.

Second Application Travel Lanes
Asphalt @ 0.35 Gal./s.y.
Aggregate Ty. P.D., Gr. 4, 1 c.y./120 s.y.

Second Application Shoulders
Asphalt @ 0.35 Gal./s.y.
Aggregate Ty. D Gr. 4 @ 1 c.y./120 s.y.
Use contrasting color aggregate

TYPICAL SECTION

SUMMARY OF CULVERTS

STATION	PROP: STRUCTURE	LENGTH	HDWL. ~ TYPE	NO.
20+00	4x3 Box SC-NA	63'	FW-N	2
39+00	2~5x3 (MC 5-1)	63'/Ea. 126 L.F.	MCW-FI	2
55+00	5'x3' Box SC-NA	63	FW-N	2
79+00	5x3 Box SC-NA	63'	FW-N	2
92+50	2~5x3 (MC5-1)	58'/Ea. 116 L.F.	MCW-FI	2
108+00	6x3 Box SC NA	58	FWN	2
115+00	2- R.C.P. Arch-Des. 2	66'/Ea. 132 L.F.	Conc. Riprap Cl. B	

STATE DEPARTMENT OF HIGHWAYS AND PUBLIC TRANSPORTATION

TYPICAL SECTIONS
SUMMARY OF CULVERTS
RELOCATION OF FM 2529

STATE	COUNTY	CONT.	SECT.	JOB	SHEET NO.
TEXAS 24	EL PASO	2526	1	10	5 FM2529

I-3

IPE NO. 652

FED. RD. DIV. NO.	STATE	STATE PROJECT		SHEET NO.
6	TEXAS			1
STATE DIST. NO.	COUNTY		STATE CONTROL NO.	HIGHWAY NO.
24	EL PASO		2326-1-10	FM2529

STATE OF TEXAS

STATE DEPARTMENT OF HIGHWAYS AND PUBLIC TRANSPORTATION

PLANS OF PROPOSED

STATE HIGHWAY IMPROVEMENT

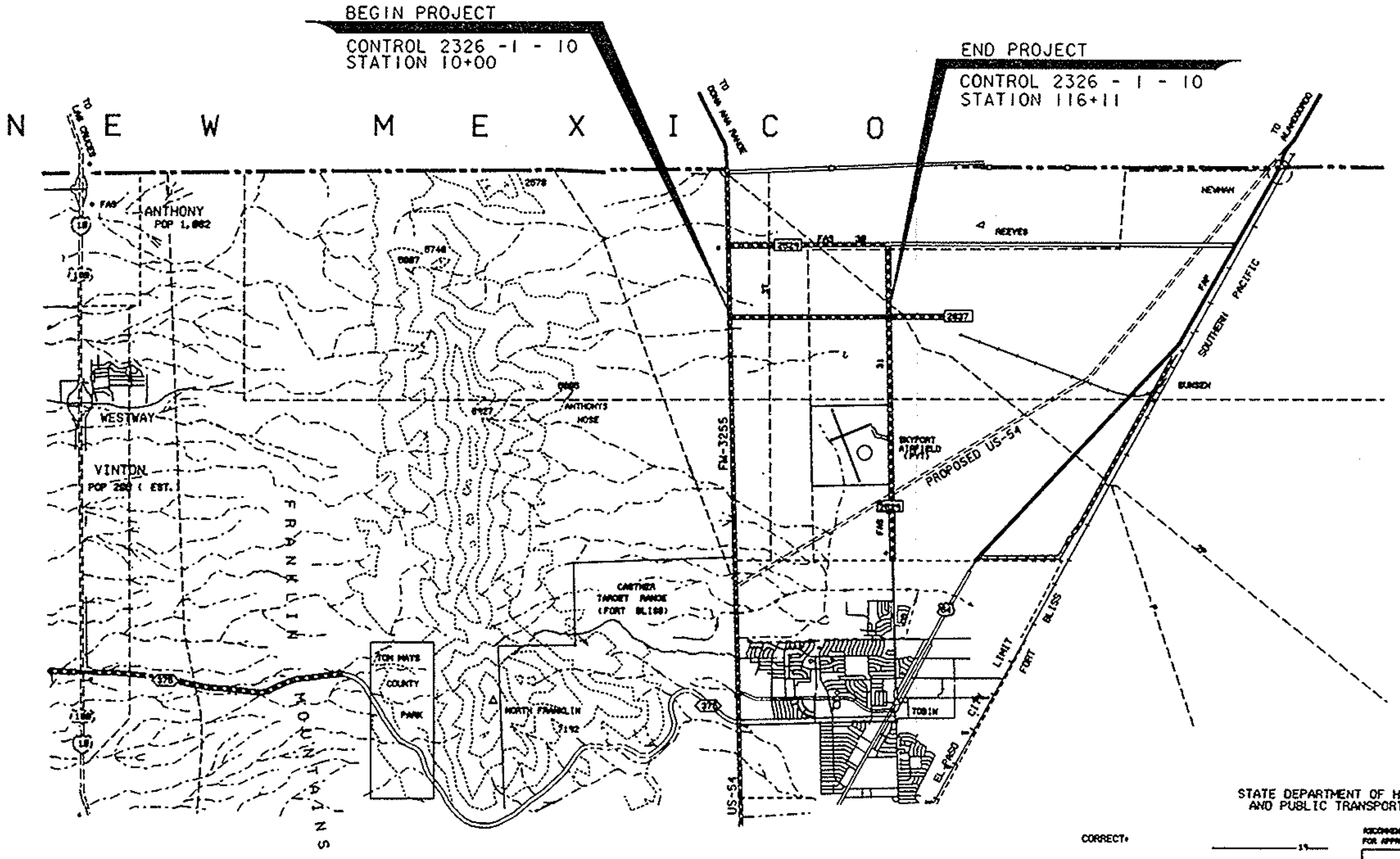
STATE PROJECT

SCALES: PLAN: 1 IN. = 100 FT.
PROFILE: 1 IN. HOR. = 100 FT., 1 IN. VERT. = 10 FT.
CROSS-SECTIONS: 1 IN. HOR. AND VERT. = 5 FT.
OTHERS AS NOTED.

NET LENGTH OF PROJECT= 10,611 FT.=2.009MI.

CITY OF EL PASO - EL PASO COUNTY
RELOCATION OF FM - 2529
FROM FM-3255 EAST TO FM-2637
GRADING, BASE, 2 CRSE SURF TREAT & STRUCTURES

INDEX OF SHEETS



FOR THE EL PASO ELECTRIC COMPANY

EXAMINED & APPROVED ________ DATE

TITLE: ________

COUNTY ________ PROJ. NO. ________
HWY. NO. ________ LETTING DATE ________
DATE ACCEPTED ________

CONVENTIONAL SIGNS
STATE OR NATIONAL LINE
CITY OR VILLAGE LINE
COUNTY LINE
BASE OR SURVEY LINE
RIGHT OF WAY LINE
RIGHT OF WAY MARKERS
FENCE LINE
RAILROAD
TRAVELLED WAY
CULVERT OR BRIDGE
POWER LINE
TELEGRAPH OR TELEPHONE

SPECIFICATIONS ADOPTED BY THE STATE HIGHWAY DEPARTMENT OF TEXAS, SEPTEMBER 1, 1982 AND SPECIFICATION ITEMS LISTED AND DATED AS FOLLOWS, SHALL GOVERN ON THIS PROJECT: SPECIAL LABOR PROVISIONS FOR STATE PROJECTS.

NOTE:
THE CONTRACTOR SHALL MAKE HIS OWN INVESTIGATION OF TRACKAGE FACILITIES AND ARRANGEMENTS FOR DELIVERY OF MATERIALS.

EXCEPTIONS: NONE
EQUATIONS: NONE
RAILROAD GRADE CROSSINGS: NONE
LAYOUT SCALE: 1 IN. =5000FT.

STATE DEPARTMENT OF HIGHWAYS AND PUBLIC TRANSPORTATION

CORRECT: ________ 19__

SUPERVISING DESIGN ENGINEER

RECOMMENDED FOR APPROVAL: ________ 19__

DISTRICT ENGINEER

RECOMMENDED FOR APPROVAL:

RECOMMENDED FOR APPROVAL:

APPROVED FOR LETTING:

CHIEF ENGINEER OF HIGHWAY DESIGN

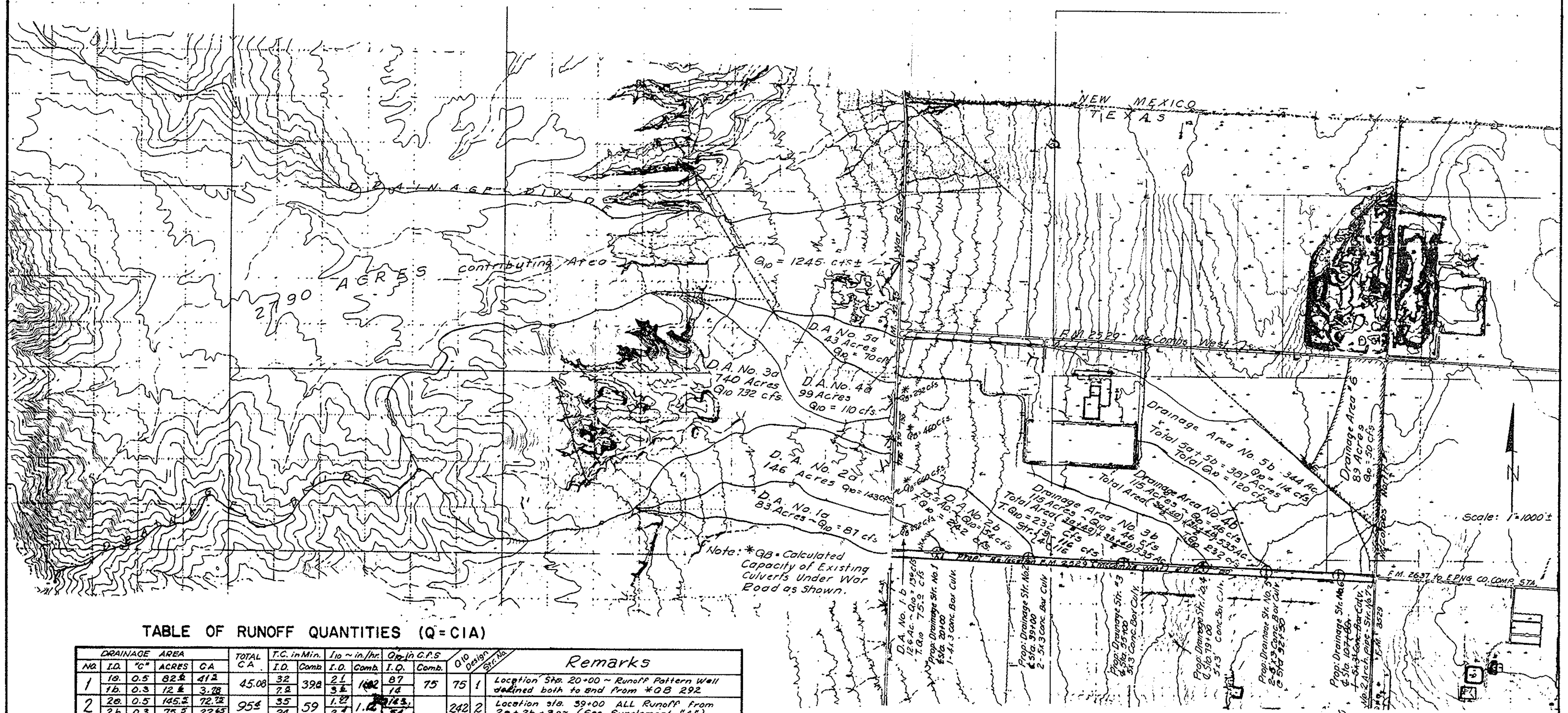


TABLE OF RUNOFF QUANTITIES (Q = CIA)

Drainage Area No.	I.D.	"C"	Acres	CA	Total C.A.	T.C. in Min. I.D.	T.C. in Min. Comb.	I_{10} ~ in./hr. I.D.	I_{10} ~ in./hr. Comb.	Q_{10} in C.F.S. I.D.	Q_{10} in C.F.S. Comb.	Q10 Design	Str. No.	Remarks
1	1a	0.5	82.5	41.3	45.08	32	39.8	2.1	1.02	87	75	75	1	Location Sta. 20+00 ~ Runoff Pattern Well defined both to and from *QB 292
	1b	0.3	12.6	3.78		7.2		3.5		14				
2	2a	0.5	145.5	72.75	95.4	35	59	1.27	1.2	143		242	2	Location Sta. 39+00 ALL Runoff from 2a + 2b + 3ax (See Supplement "A")
	2b	0.3	75.5	22.65		24		2.4		54				
3	3a	0.6	740	444	478.5	47	112	1.65	0.91	732		116	3	Location Sta. 55+00 & 79+00 ~ ¼ each of the combined Runoff D.A. 3 & 4. (See Suppl. "B")
	3b	0.3	115	34.5		65		1.33		46		116	4	
	3ax	0.6	142	85.2		47		1.65		140				Overflow from 3 to 2 (*QB 460 to *QB 660)
4	4a	0.5	99.8	49.9	84.4	30	95.0	2.2	1.02	110.		232	5	Location Sta. 92+50 ~ ½ of the combined Run off D.A. 3 & 4 ~ (See Supplement "B")
	4b	0.3	115	34.5		65		1.33		46				
5	5a	0.6	43	25.8	129	19	109	2.7	0.93	70	120	120	6	Location Sta. 108+00 ~ Drainage areas 3b, 4b, and 5b are sheet flow areas (no defined channels)
	5b	0.3	344	103.2		90		1.10		114				
6		0.3	89	26.7		39		1.85		50		50	7	Area-Flat No outside Contribution or defined channels, temporary build up equalized by 2 no. 2 RCP Arch's. at Sta. 115+00

SUPPLEMENTARY TABLES "A" & "B"

	I.D.	"C"	Acres	CA	Total C.A.	T.C. I.D.	T.C. Comb.	I_{10}	Q_{10}	Remarks
A	3ax	0.6	142	85.2	180.6	41	65	1.33	242	Note: Area 3ax is undefined within 3a but generates the 140 C.F.S. which overflows from QB-292 to QB 660 along the west side of War Road.
	2a	0.5	145.5	72.75		35				
	2b	0.3	75.5	22.65		24				
B	3a-3ax	0.6	598	358.8	478	39	104	0.97	464	Except 3ax, this Q is the combined runoff from areas 3 and 4, which by sheet flow across 3b and 4b, is distributed to structures 3, 4 and 5.
	3b+4b	0.3	230	69		65				
	4a	0.5	99.8	49.9		30				

SUMMARY OF CULVERT DESIGN/ANALYSIS BY THYSYS

Culv. I.D.	BBL Shape	BBLS	Wide	High	Long	Culv. Material	Type Inlet	Profile	Slope	Q C.F.S.	Calc. H.W.	Calc. Veloc.
1	Box	1	4	3	63	Conc.	Normal	straight	0.01%	75	3.56	10.66
▲2	Box	2	5	3	63	Conc.	Normal	straight	0.01%	242	4.56	11.65
3	Box	1	5	3	63	Conc.	Normal	straight	0.01	116	4.33	11.50
4	Box	1	5	3	63	Conc.	Normal	straight	0.01	116	4.33	11.50
▲5	Box	2	5	3	58	Conc.	Normal	straight	0.01	232	4.33	11.50
6	Box	1	6	3	60	Conc.	Normal	straight	0.01	120	3.76	11.20

▲ Based on Analysis for 1 Barrel.

STATE DEPARTMENT OF HIGHWAYS AND PUBLIC TRANSPORTATION

MAP OF DRAINAGE AREAS & RUNOFF TABULATIONS FOR EACH

RELOCATION OF FM 2529

Fed. Rd. Div. No.	State	State Project No.	Sheet No.
6	Texas		5

State Dist. No.	County	Cont.	Sect.	Job	Highway No.
24	El Paso	2526	1	10	FM 2529

5. Engineering services to perform final collector field analysis to characterize and optimize equipment arrangement and design and verify that the flux distribution meets the requirements of the receiver.

6.4.1 Materials and Services

The Contractor shall design, furnish, deliver, install, test, and place into commercial operation the heliostat field and associated equipment.

6.4.2 Tools

The Contractor shall provide the special tools or fixtures used only during erection/installation of the equipment. "Special" is defined as anything not normally or usually available in a power plant or readily available thereto. In addition, one complete set of special tools or fixtures required for maintenance and operation shall be furnished.

6.4.3 Spare Parts

The Contractor shall furnish all spare parts and expendable items (such as gaskets) that may be required during the preliminary operating period that precedes normal commercial operation. Also, a priced list of recommended spare parts for a longer term maintenance program after commercial operation shall be provided. When the spare parts order is placed, identify to the Purchaser any changes to codes/standards requirements referenced in the original purchase specification that must be complied with.

6.4.4 <u>Installation, Operating, and Maintenance Instructions</u>

Contractor shall send to the Purchaser 2 preliminary sets of installation, operating, and maintenance instructions no later than 6 months before intial shipment of equipment to the jobsite.

No later than 3 months before intial shipment of equipment to the jobsite, the Contractor shall submit to the Purchaser 20 bound copies as agreed and applicable of the installation, operation and maintenance instructions for the equipment furnished. One complete bound copy shall be sent to the Engineer.

One set of instructions, certified by the manufacturer, shall be packed with the equipment sent to the site. If "as-built" drawings or performance curves are not available when instruction books are required, a statement to this effect shall be prominently displayed therein, and provision shall be made for their addition when available but not later than 60 days after final shipment.

The operating instructions will be specific regarding the frequency of lubrication and the type of lubricants or equal to be used, which should include, but not be limited to, the following:

1. Total capacity of system

2. Recommended lubricant

3. Recommended operating pressure and temperatures

4. Adjustments, settings, and points requiring periodic maintenance and or inspection

All final instructions shall be certified by the manufacturer as applicable to the equipment furnished. Instruction manuals shall be on specific models of equipment purchased, not general information on the complete line or similar equipment. Information regarding equipment not purchased should not be shown. The equipment shall be specifically identified, such as by serial number, mark number, project number, project description, and Contract number.

A parts identification list shall be included with each set of instructions; the instructions shall include section and/or outline prints or illustrations marked to identify each numbered part and to locate it in relation to the equipment as a whole.

6.4.5 Data and Drawings

The Contractor shall submit all drawings in accordance with the agreed-upon schedule, which will be made part of the Contract. All drawings and data shall contain the following subject heading:

Contract No.

Heliostat Field - (plus additional description)

Newman Unit No. 1 Solar Repowering

El Paso Electric Company

The following shall be submitted by the Contractor:

6.4.5.1 All physical outlines, as required, to show the overall size and space requirements (including that for dismantling and maintenance) and the interrelationship of the various components. All outline drawings describing installed equipment shall include "north" arrows.

6.4.5.2 Cross sections and details, as required, to satisfy the Purchaser that all components are in conformance with the intent of the Specification and are satisfactory from the standpoint of design and physical arrangement

6.4.5.3 All information required by the Purchaser for the design and location of all connecting Purchaser-furnished structural, mechanical, or electrical items such as foundations, steel supports, piping, ducts, cables, conduit, etc

6.4.5.4 Wiring, elementary, and logic diagrams

6.4.5.5 Control equipment data sheets, instrument lists, pneumatic and electrical connections, outline and cutout drawings, and internal schematics to include data sheets with set points

6.4.5.6 Details of special features

6.4.5.7 Description of Contractor's recommended control systems/philosophy

6.4.5.8 An erection specification for the Contractor-furnished equipment that will be installed by others, detailing requirements for hauling, erecting, testing, and preparations for commercial operation.

6.4.5.9 Recommended procedures for cleaning

6.4.5.10 Recommended procedures for removal and reinstallation

6.4.5.11 Special storage requirements

All drawings submitted shall be in the form of two good, sharp, black and white, direct contact prints and one reproducible. The reproducible shall be on mylar film, unless the Contractor is unable to supply mylars, in which case he shall state in his proposal the type of reproducible he will supply. After review by the Purchaser, one print will be returned to the Contractor marked APPROVED or APPROVED AS REVISED. If marked APPROVED, the Contractor shall send one first generation silver microfilm aperture to the Purchaser. If marked APPROVED AS REVISED, the revisions indicated shall be made and clearly identified and drawings shall again be submitted to the Purchaser (in the manner indicated above), or the Purchaser shall be informed that the suggested changes cannot be made without prejudice to the Contractor's responsibility under warranty. Arrangements for production scheduling and the procurement of the necessary materials shall not be deferred, pending stamping of the drawings by the Purchaser.

6.4.6 Advisors

6.4.6.1 Advisors for unloading, placing into storage, erection, and start-up

The Contractor shall provide full-time coverage on a continuous basis, consisting of one or more advisors as required to provide a properly installed and operating unit. It is expected during the preliminary operation period advisors will be required on a sunlight only basis. The advisors shall not be withdrawn until the Contractor and Purchaser agree that their services are no longer required. Bidder will propose the number and duration of advisors that will be supplied.

6.4.7 Engineering Coordination Meeting

Upon Contract award, the Contractor shall arrange a meeting with the Engineers and Purchaser to discuss in detail those items pertaining to erection of specified equipment that may have an important effect upon engineering, design, the Contractor's planning, shipping sequence, shipping schedule, etc, such as:

1. Extent of shop fabrication as proposed by Contractor.

2. Size and weight of the major items handled during erection.

3. Method of lifting and placing the various items during erection.

4. Structural steel or concrete design concept, as it affects or is affected by erection requirements.

5. The sequence and timing of shipment of all components, so as to minimize storage at the site prior to erection.

6.4.8 Reliability and Maintenance (RAM) Program

The Contractor shall establish and maintain an effective RAM program that effectively and economically meets the RAM requirements of this Specification.

6.4.8.1 RAM Program Plan

One month after contract award, the Contractor shall submit a detailed RAM program plan. The final RAM report is due within one month of final shipment of the heliostats.

The Contractor's RAM Program Plan shall describe the methods of conducting and documenting the RAM Program in order to meet the RAM requirements of this Specification. The plan shall, as a minimum, contain those elements specified in Sections 6.5.5.4, 6.5.5.5, and 6.5.5.6.

6.4.8.2 Organization

The organization structure, capabilities, and responsibilities of the group responsible for fulfilling the RAM requirements of this Specification shall be described.

6.4.8.3 RAM Analysis

The purpose of this analysis is to demonstrate compliance with the RAM requirements of this Specification and to identify items that are critical to the proper operation of the heliostats. The Contractor shall describe the type of analysis performed, which may include, but not necessarily limited to the following:

a. Failure Modes and Effects Analysis (FMEA)

b. Fault Tree Analysis (FTA)

c. RAM Modeling techniques and predictions

Analyses previously performed shall be thoroughly revised to conform to the RAM requirements of this Specification. The sources and/or techniques used to derive MTBF and MTTR data shall be fully documented. The use of historical data is acceptable.

6.5 Furnished by the Bidder

6.5.1 Data and Drawings

The Bidder shall submit, with each copy of his proposal, one each of the following:

6.5.1.1 One copy of completed Technical Data Sheets

6.5.1.2 Outline drawings showing the general arrangement and approximate dimensions of the equipment proposed, including terminal points and clearances required for dismantling equipment. Also, an approach for determining the number and arrangement of heliostats (as described in Section 3.2).

6.5.1.3 List of all Contractor and subsupplier supplied motors required including horsepower and voltage

6.5.1.4 Description of Contractor's QA Program and copy of the proposed manufacturing and inspection plan

6.5.1.5 A list of all instruments and controls proposed including description and service. Also, confirmation of control approach or provision of an alternative concept that satisfies functional requirements. The bidder will supply control package or system cost separated from rest of quotation.

6.5.1.6 A description of the extent of shop fabrication modular construction included in the base proposal. Are other modular construction features available?

6.5.1.7 Frequency of BCS verification, time required to check and time required for realignment.

6.5.1.8 A list of power requirements for any heating/cooling equipment.

6.5.1.9 A list of requirements for the conversion and filtering equipment used by the heliostat control and drive equipment.

6.5.1.10 Times required to bring the heliostats from standby to Tracking mode.

6.5.1.11 A methodology for quantifying thermal power delivery by the heliostat field to the receiver aperature (as described in Section 3.8).

6.5.2 Provisions for Storage/Preventive Maintenance

As part of his proposal, the Bidder shall identify onsite storage requirements needed to maintain the equipment and material in the as-shipped condition. The Bidder shall also describe recommended cleaning methods and provide a plan for optimizing cleaning frequency. Failure to specify additional requirements with the proposal shall be considered as an indication that no additional requirements are necessary.

6.5.3 Reliability Data

As part of his proposal, the Bidder shall provide the following equipment qualification data in a Reliability Analysis Report:

6.5.3.1 Quantitative RAM (Reliability and Maintenance) Requirements

The Bidder shall provide estimates or data for the following, accompanied by a description of the basis for the values provided. These estimates or data shall be provided for the heliostat field as a whole, and for major subsystems and components.

1. Availability

2. Meantime to repair

3. Meantime between failures.

6.5.3.2 Documentation

A preliminary RAM program plan shall be included in the proposal.

NOTE: The following activities should not be included in the cost estimate provided by the Bidder:

1. Provision of detailed heliostat drawings identifying specific mounting and electrical interfaces.

2. Provision of a suggested optimized electrical power distribution one-line diagram for the heliostat field.

3. Provision of a specific description of suggested field control wiring architecture (control wiring should be integrated with power wiring).

4. Provision of a detailed definition of heliostat field operating modes and related control software requirements.

5. Provision of a detailed description of BCS hardware and software, and interfaces required with Master Control and other parts of plant. This also includes specific definition of electric power supply requirements.

6. Provision of motor and load list for heliostat field.

7. Provision of wiring diagrams and specific descriptions of power and control wiring connections at each interface point.

ATTACHMENT 1 - ENVIRONMENTAL CONDITIONS

1.0 GENERAL

1.1 Scope

This document lists representative environmental conditions for the Purchaser's Solar Repowered Newman Unit No. 1.

2.0 DOCUMENTS

The following documents form a part of this attachment to the extent stated herein:

MIL-STD-810B		Environmental Test Methods
Uniform Building Code	1979	International Conference of Building Officials
ANSI A58.1	1982	Minimum Design Loads for Building and Other Structures

3.0 ENVIRONMENT

Environmental conditions include winds and gusts, temperature extremes, rain, sleet, hail, snow, earthquakes, and soil conditions as follows.

3.1 Wind

The wind speed specifications during daylight hours at a reference height of 10 m (33 ft) shall be:

3.1.1 Speed Frequency

Wind power climatology was gathered from El Paso Airport, El Paso, Texas, over 32 years of data taking. The fastest wind speed recorded was 67 mph at 10 meters above ground. Miles per hour figures are over a 10 year period averaging.

100 year recurrence-71 mph

50 year recurrence-69 mph

25 year recurrence-66 mph

Speed:

m/s	MPH	Knots	Frequency Percentage
0.52 - 1.55	1.15 - 3.45	1 - 3	12.9
2.06 - 3.09	4.6 - 6.9	4 - 6	22.4
3.60 - 5.14	8.05 - 11.5	7 - 10	24.2
5.66 - 8.23	12.65 - 18.4	11 - 16	11.1
8.74 - 10.80	19.55 - 24.15	17 - 21	2.9
11.31 - 13.88	25.3 - 31.05	22 - 27	1.1
14.39 - 16.96	32.2 - 37.95	28 - 33	0.2
>17.48	>39.1	>34	<0.1

3.1.2 Wind Rise Rate

Under normal conditions, the maximum wind rise rate is 0.01 m/s^2 (0.02 mph/s). A maximum wind of 22 m/s (50 mph) from any direction may occur resulting from unusual rapid wind rise rates, such as severe thunderstorm gust fronts.

3.1.3 Survival Wind

A maximum wind speed, including gusts of 40 m/s (90 mph).

3.1.4 Dust Devils

Dust devils with wind speeds up to 17 m/s (38 mph).

3.1.5 Sandstorm Environment

Sandstorm limits within tests per MIL-STD-810B, Method 510.

3.2 Temperature

Ambient air temperatures range from -30°C to +50°C (-22°F to +122°F).

3.3 Precipitation

3.3.1 Rain

Average annual: 750 mm (30 in.) maximum 24-hr rate: 75 mm (3 in.).

3.3.2 Ice

Freezing rain and ice deposits in a layer up to 50 mm (2 in.) thick.

3.3.3 Hail

Diameter	25 mm (1 in.)
Specific Gravity	0.9
Terminal Velocity	23 m/s (75 ft/s)
Temperature	-6.7°C (20°F)

3.3.4 Snow

Maximum 24-hr rate: 0.3 m (1 ft); maximum loading: 250 Pa (5 lb/ft^2).

3.4 Insolation

3.4.1 Maximum Flux

Direct normal nominal insolation of 1100 Watts/square meter maximum at the plant site.

3.4.2 Rate of Change

The maximum rate of change of incident flux shall be assumed as that which would result from the passage of an opaque cloud across an otherwise clear sky where the sharp leading or trailing edges of the shadow move across the plant site at a velocity of 20 m/s (45 mph).

A-5

3.5 Soil Conditions

The soil conditions and preliminary foundation design recommendations are described in the Engineers' Report Number DE-FC-03-823F11677-2.

Specification No. 14380 - P201V

APPENDIX H

SPECIFICATION FOR

HELIOSTAT FIELD

NEWMAN UNIT 1 ADVANCED SOLAR REPOWERING
EL PASO ELECTRIC COMPANY
EL PASO, TEXAS

May 1983

CONTENTS

CONTENTS (Cont)

LIST OF TABLES

LIST OF FIGURES

Errata Sheet

Specification for Heliostat Field 14380-P201V

Based on review of the specification subsequent to its preparation and use, the following improvements and corrections have been identified.

Page/Section/Paragraph	Correction
3-33, 3.6.5.2, 4	(Add last sentence) Alternate systems will be permitted if all functional requirements are satisfied.
3-24, 3.6.1, 1	...The Heliostat control system (3.6.2) and electrical system (3.6.7) shall include all equipment necessary to safely control the heliostat during all modes of operation...
3-26, 3.6.1.1, 2	...Heliostat alignment shall take place on a periodic basis under the control...
3-37, 3.6.6, 1	(Add first sentence) The Contractor shall provide a test plan for checkout and verification of all operating modes of the heliostat.
3-39, 3.6.6, 2	... Motion from the stow to the standby position shall be controlled so as to prevent focusing of any portion of the array on anything that would cause a potential hazard.
3-40, 3.6.6.2, 1	...Again, as during startup, the array shall be moved in a way that precludes the focusing of any portion of it onto anything that would cause a potential hazard.
3-41, 3.6.6.2, 1	...This "Emergency Stow" mirror face-up position shall be used in this case because it constitutes the shortest travel time in elevation to achieve. Also, it permits a safe control of the reflected beams and the airspace involved... The "Emergency Standby" position shall be initiated manually by HAC or PCS operator command or automatically through power failure detectors, receiver failure, or turbine trip. "Emergency Shut-

	down" will take place if storm-early-warning devices are activated.
3-53, 3.7.7, 2	...Continuous fluxes on tower and normally unirradiated portions of the Receiver Subsystem are limited to (25) KW/M^2 (7880 BTU/ft^2hr). However, the use of radiation shields would permit a higher allowance of spillage.
3-54, 3.7.7, 2	...The heliostat field design, as well as all modes and transitions, shall be consistent with...
3-38, 3.6.6, 2	(Add sentence) The Beam Control Strategy and equipment shall protect personnel and property within and outside the plant facility including airspace. The characteristics relative to each mode...

1.0 SCOPE

This Specification covers the technical and quality assurance requirements for the design, fabrication, delivery, installation, testing, and checkout of the heliostat field including all auxiliary equipment necessary to achieve erection and field performance.

The Bidder will furnish data and drawings, provisions required for onsite storage, reliability data, and other information summarized in Section 6.5 and described in detail in Section 3.

Engineering by the Contractor during the Final Design Phase is not included in the scope of this specification, but will be covered under a separate procurement.

The Contractor shall also furnish data, drawings, installation and operating instructions, and recommended spare parts plus the detailed equipment, materials, and services as listed in Section 6.4 of this Specification.

The Purchaser will furnish information, services, and assistance as specified in Section 6.3 of this Specification.

2.0 APPLICABLE DOCUMENTS

The equipment, material, design, installation, checkout procedures, and construction of the heliostat field shall comply with all Federal, state, local, and user standards, regulations, codes, laws, and ordinances which are currently applicable for siting in El Paso, Texas and to the using utility, the El Paso Electric Company (Purchaser). These shall include, but are not to be limited to, the documents itemized below. If there is an overlap or conflict between the requirements in this Specification and the applicable Federal, state, county, or municipal codes, laws or ordinances, Stone & Webster Engineering Corporation, (Engineers) will resolve the issue. If there is, or seems to be, a conflict between this Specification and a referenced document, the matter shall be referred to the Engineers.

The following documents in effect as of the date of Contract, form a part of this Specification to the extent specified herein.

2.1 Standards

MIL-STD-454	1983	Standard General Requirements for Electrical Equipment
MIL-STD-1472	1983	Human Engineering Design Criteria

ANSI CI-1975	1983	American National Standards Institute
ANSI A58.1	1982	Minimum Design Loads for Buildings and Other Structures
NEMA	1983	National Electrical Manufacturer's Association Standards
Manual of Steel Construction 8th Edition	1980	American Institute of Steel Construction
Uniform Building Code 1979 Edition	1979	International Conference of Building Officials
ACI 318-77	1977	Building Code Requirement for Reinforced Concrete - American Concrete Institute
NFPA 70	1975	National Electrical Code
AWS D1.1	1982	Structural Welding Code - American Welding Society
SSPC	1982	Steel Structures Painting Council Systems And Specifications Volume II

SNT-TC-1A	1980	Recommended Practices, Nondestructive Testing, Personnel Qualification and Certification - American Society for Nondestructive Testing

2.2 <u>Other Publications</u>

Environmental Conditions (See Attachment 1)

OSHA Title 29, Part 1910 Occupational Safety and Health Standards

3.0 TECHNICAL REQUIREMENTS

3.1 Project Type and Location

The project includes a field of heliostats having a total reflective area of approximately 178,000 m^2 with guaranteed capability described in this Specification and all necessary auxiliary equipment.

The project is a 50 percent (41 MWe) solar repowering of Purchaser's Newman Station Unit 1 in El Paso, Texas. Newman Station consists of four electric generating units with a combined rating of 498 MWe. Newman Unit 1 is rated at 82 MWe (net). The site is accessible by road and by a railway siding located approximately 6 miles to the southeast of the plant.

This installation is identified as Solar Repowered Newman Unit 1 of the El Paso Electric Company and will be located in El Paso, Texas at and north of the existing Newman station. The site is near the intersection of War Highway (extension of the North-South Freeway) and Farm-to-Market Road 2529, northeast of El Paso, Texas.

3.2 Overall Project Design Requirements

A 160 degree arc collector field north of a single receiver tower will be utilized.

The tower will support a water/steam-cooled central receiver. The collector field will be designed so that 133 MWt of the redirected solar energy will impinge on the receiver at noon winter solstice with a normal insolation value of 1,000 W/m^2. The collector field shall be sized to allow 2 percent of the heliostats to be out of service for maintenance purposes while permitting the basis of design to be satisfied by the balance of the collector field. The Bidder may select either of the following approaches for determining the number and arrangement of required heliostats.

Approach 1

The Bidder may use the following information developed by Westinghouse Electric Corporation. Westinghouse, using the MIRVAL computer program, has estimated that 178,000 m^2 of reflective surface is required to satisfy receiver requirements (95 m^2 heliostat was assumed as a nominal value representative of state-of-the-art heliostats). This value includes a 2 percent allowance for spares to permit heliostats to be taken out of service for maintenance. Drawing 14067-FM-31B-SR "General Arrangement - Heliostat Field" shows a preliminary heliostat arrangement and exclusion areas for existing structures, rights-of-way, etc.

Approach 2

The Bidder may use his own in-house computer programs, etc, to estimate the number and arrangement of heliostats required based on the following information. Figure 3.2-1 shows the dimensions of the receiver. The receiver has an arc angle of 216 deg and is divided into segments as shown in Figure 3.2-2. Figure 3.2-3 shows the desired maximum vertical heat flux profile at design conditions. The peak flux, not to exceed 420 kW/m^2, should occur in the lower half of the main receiver. An aiming strategy for the receiver, should provide a smooth profile.

The heliostats shall generally redirect their image towards receiver vertical centerline. The vertical profile shape should remain similar for all receiver segments. It is desirable to try to provide uniform incident power on the largest number of segments. Any spillage beyond the boundary of the absorber surface shall not exceed 30 kW/m^2. Site interferences are listed as mathematical equations relative to true North and the location of the receiver towers in Table 3.2-1.

TABLE 3.2-1

EXCLUSION AREA BOUNDARIES

Exclusion	Excluded Area Boundary Equations
1. Gas Pipeline Right-of-Way	$y > -.810x + 863.1$ $y < -.810x + 937.7$
2. Transmission Lines	$Y < .0078x + 148.6$ $x < (y/35.0) - 71.6$
3. Gas Lines	$y < .0039x + 207.6$ $y > .0039x + 192.4$
4. East-West	$-772.4 > x > 772.4$
5. Included Angle	If $x > 0$, $y < 0.15838x$ If $x < 0$, $y < -0.15838x$
6. Road	$y < .0104x + 53.3$
7. Gas Meter	$153.3 < y < 181.9$ $5.7 < x < 39.1$
8. Well	$529.6 < x < 543.8$ $122.8 < y < 136.2$
9. Small Pipes or Roads	a. $y < 154.3$ $23.2 < x < 26.3$
	b. $y < 194.3$ $64.8 < x < 68.6$
	c. $136.2 < y < 194.3$ $535.3 < x < 537.2$

Where

x = positive in east direction, meters
y = positive in north direction, meters

Receiver is located at (0,0) and directions are based on true north.

External Receiver (Steam-Water)

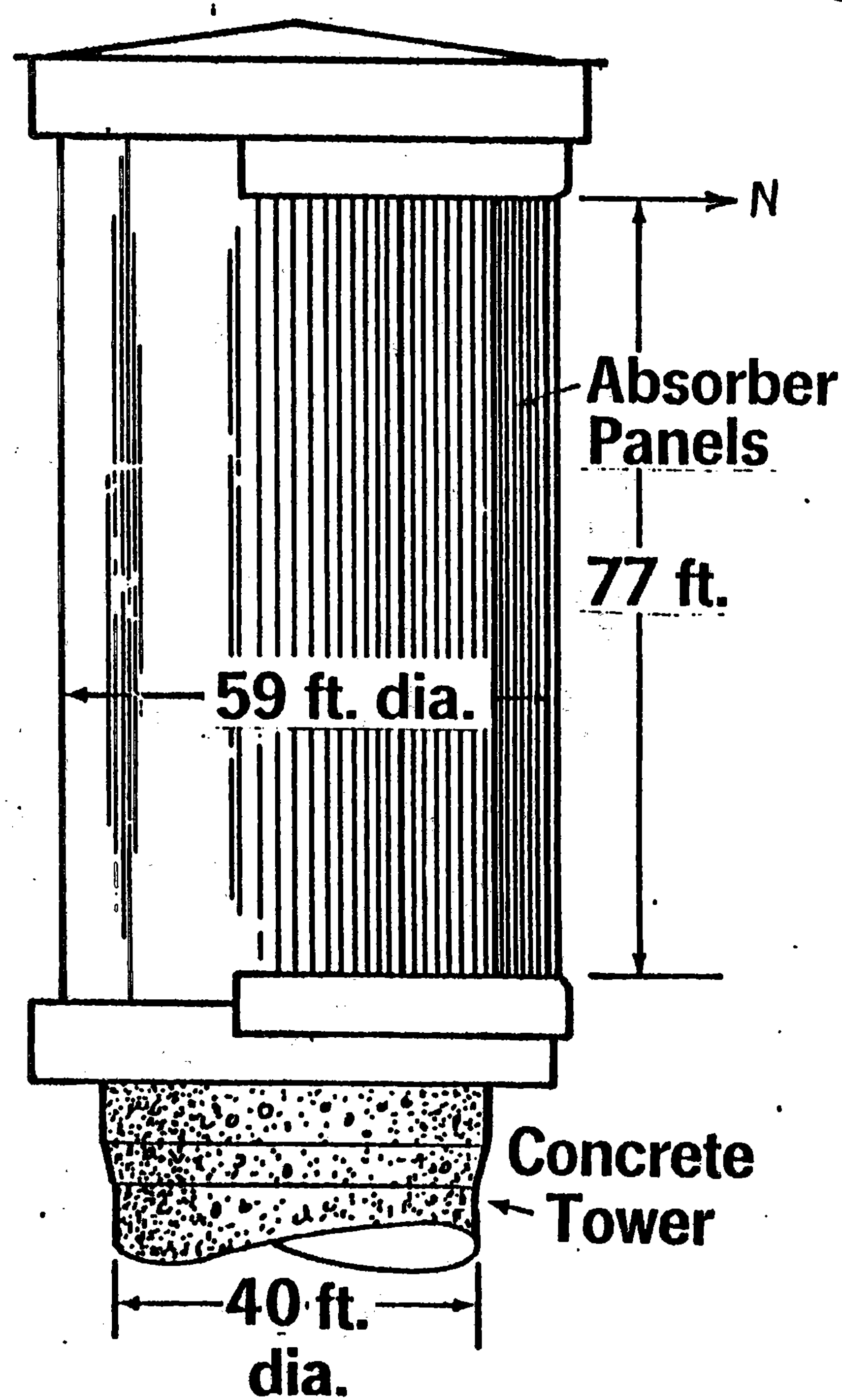
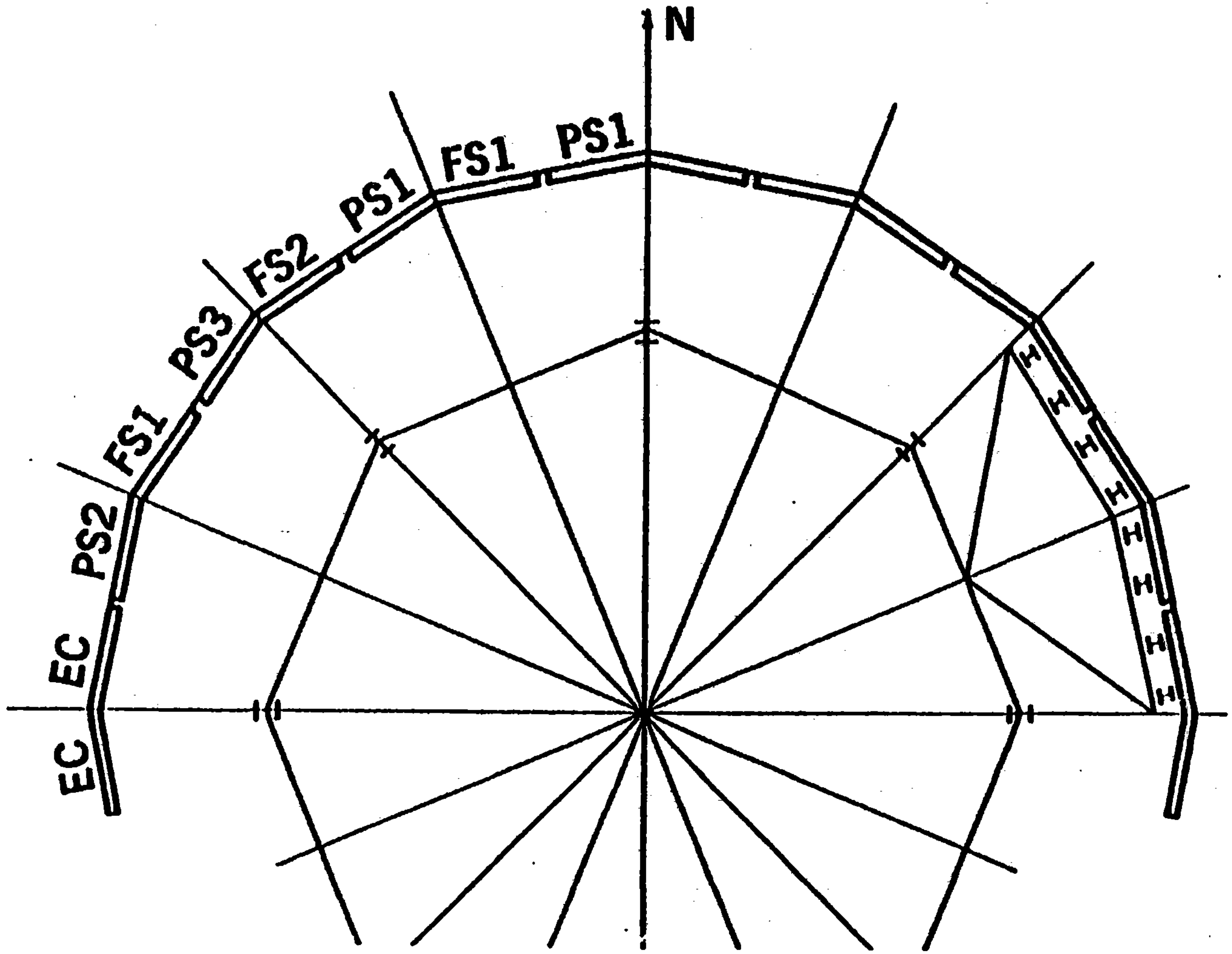


Fig. 3.2-1

RECEIVER DIMENSIONS

Interlaced panel arrangement around receiver periphery



PS = Primary Superheater
FS = Final Superheater

Fig. 3.2-2

Flow Diagram
Panel Arrangement

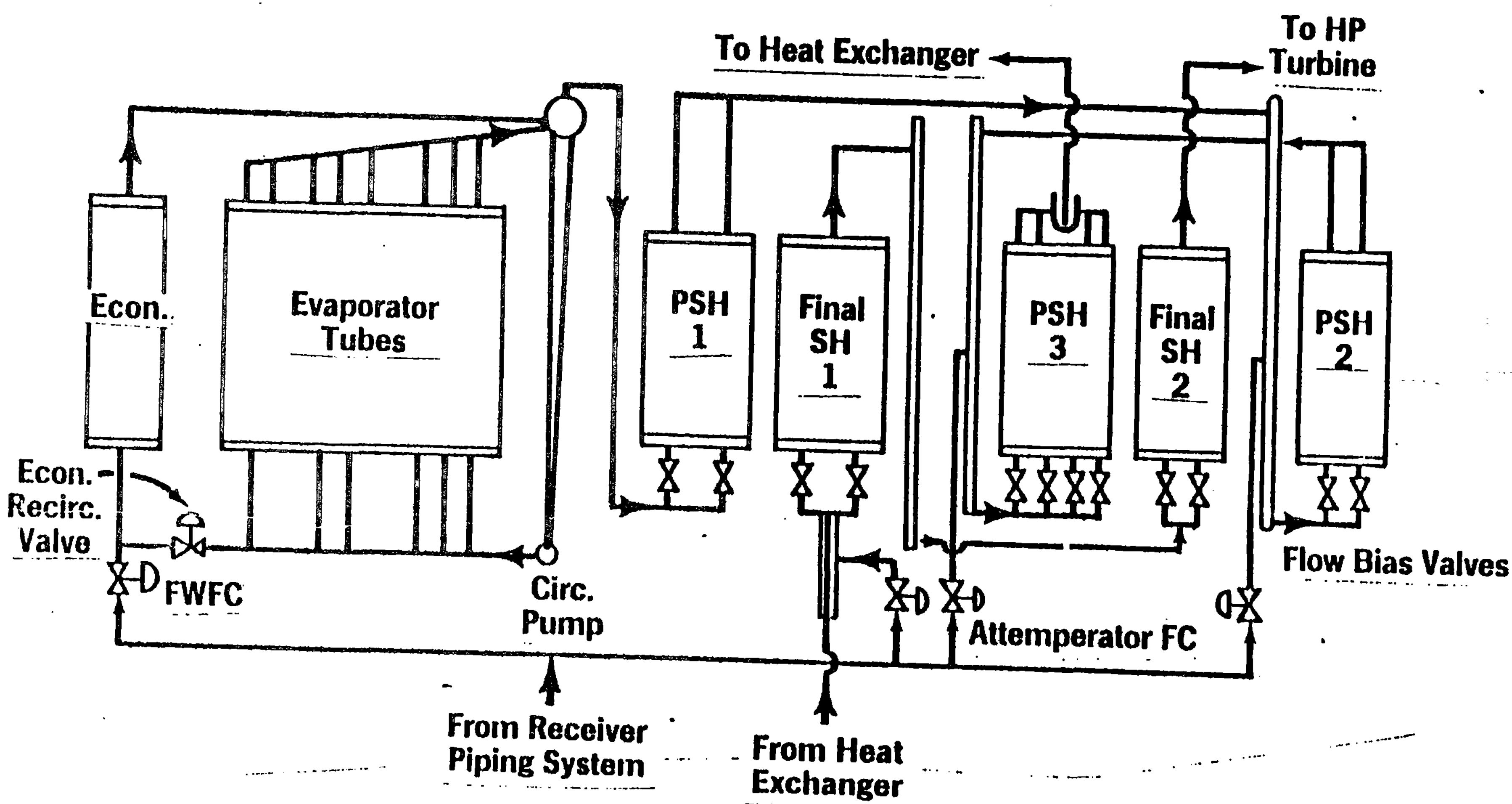


Fig. 3.2-3

H-11

HEAT FLUX PROFILE LIMIT
FOR INTERLACED TUBE DESIGN

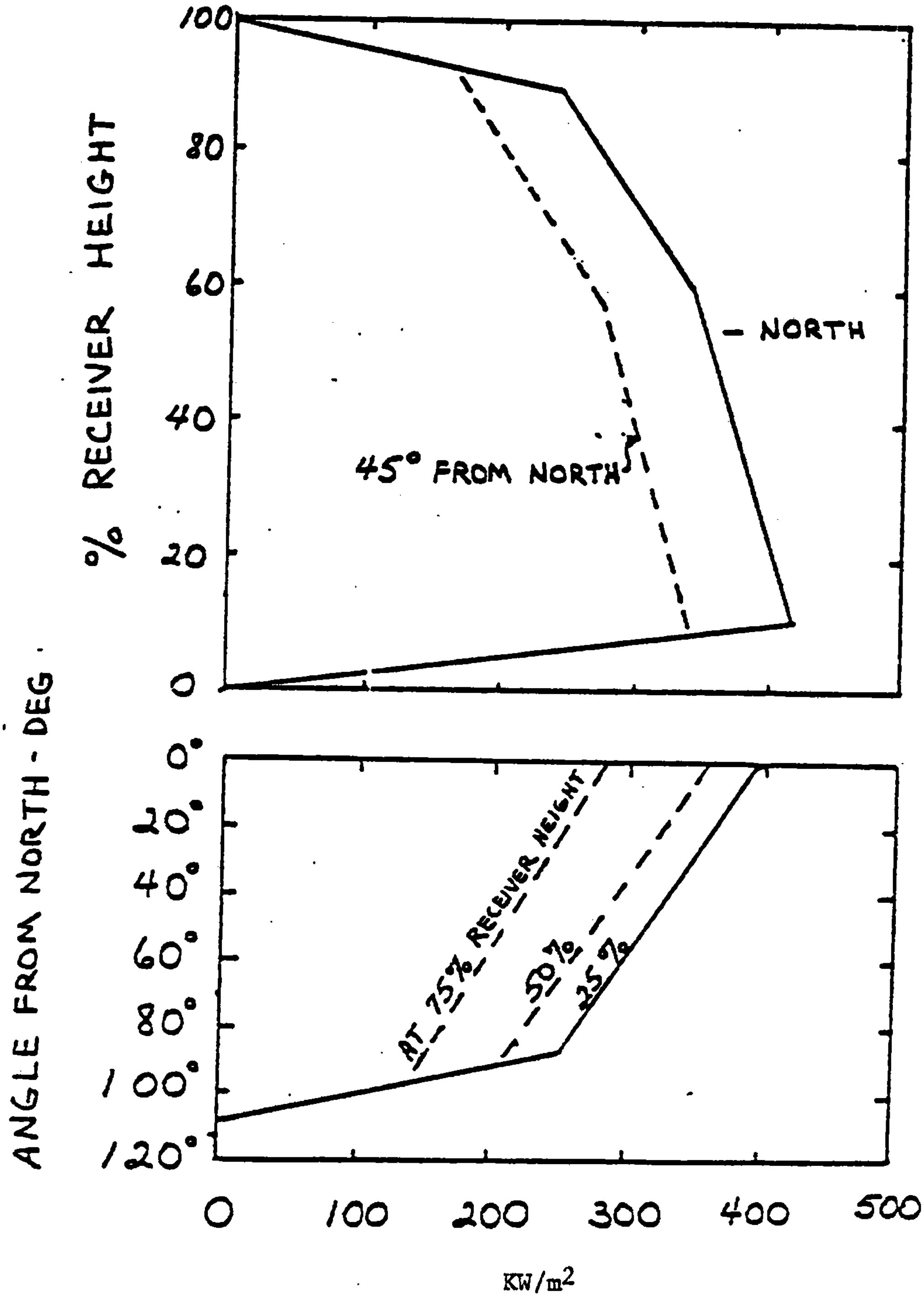


Fig. 3.2-4

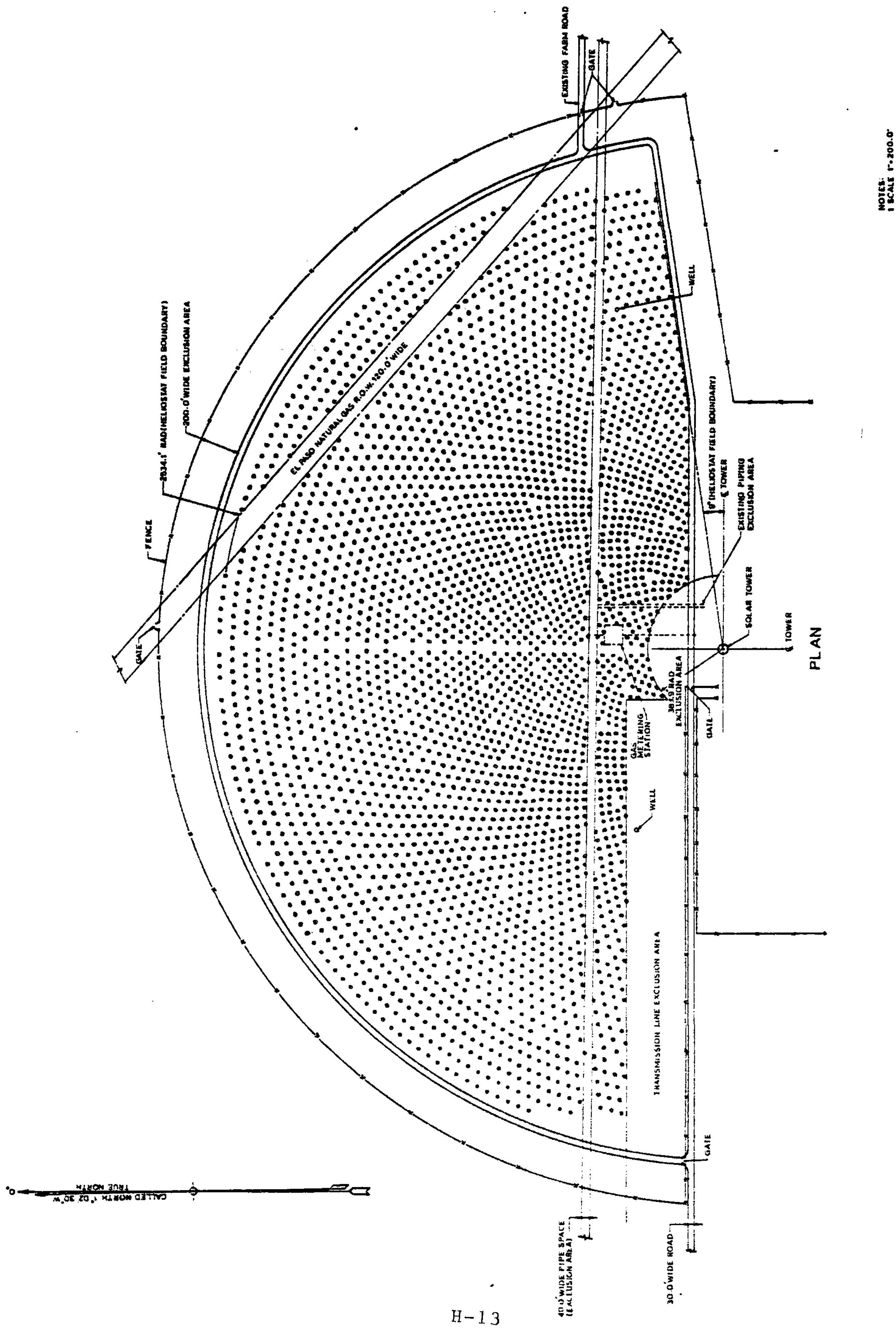


Fig. 3.2-5 Plot Plan

3.3 Heliostat Field Scope of Supplier Equipment

3.3.1 Scope

The heliostat array shall reflect solar radiation onto the elevated absorber (boiler/superheater) of the receiver system in a manner which satisfies receiver incident heat flux requirements. Deviations from this Specification are acceptable, with sufficient justification, to improve performance or cost-effectiveness. Performance shall be considered on an annual energy basis and costs include initial capital costs as well as operation and maintenance costs.

The heliostat array components shall be:

1. Heliostats
   - a. Mirror modules
     - Reflector
     - Mirror support substrate
   - b. Structural support
   - c. Drive units
   - d. Control sensors
   - e. Pedestal and mounting interface to foundation
   - f. Heliostat cabling and termination boxes (to interface points defined by Bidder)
     - Power
     - Signal

2. <u>Support Equipment and Procedures</u>

   a. Alignment

   b. Washing (optional)

   c. Operation and maintenance

   d. Repair and replacement

   e. Installation and removal

3.4 Functional Requirements

3.4.1 Optical Performance

In order to attain overall plant field performance such that at least 97 percent of the redirected energy shall impinge on the receiver with an incident angle of less then 60 deg, the following requirements have been established for designing and evaluating individual heliostats.

3.4.1.1 Beam Pointing Error

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

Wind - none

Temperature - 0° to 50°C (32°F to 122°F)

Gravity Effects - at all elevation and azimuth angles that could occur in a heliostat field.

Azimuth Angles - at all angles except during gimbal lock and during stow.

Sun Location - at least 0.26 rad above horizon, any time of year.

Individual 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). Beam pointing error shall be verified by the Beam Characterization System (BCS). Bidder shall identify frequency of BCS verification, time required to check and time required for realignment.

3.4.1.2 Beam Quality

Beam quality shall be such that a minimum of 90 percent 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 realigment. 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 azimuth angles that could occur in a heliostat field.

Sun Location - at least 0.26 rad above horizon, any time of year.

Heliostat Location - any position in the field and at any slant range.

Operating Mode - tracking on plant receiver or on a BCS calibration target.

Facet (Individual Mirror) Alignment - as planned by the Contractor.

Theoretical Beam Shape - the theoretical beam contour, determined by HELIOS (Computer model developed by and available from Sandia Laboratories for Heliostat field and beam design) is the isoflux contour that contains 90 percent of the total power. This isoflux contour will be increased by 1.4 mrad fringe.

Verification of beam quality shall be accomplished by the Beam Characterization System.

3.4.1.3 Reflective Surface Static Deflections

Overall structural support shall limit reflective surface static deflections to an effective 1.7 mrad standard deviation for a field of heliostats in a 12 m/s (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 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 are less than 1.7 mrad, the rms value of the slope errors taken over the entire reflective surface of an individual heliostat, computed under the worst conditions of wind and heliostat orientation (but excluding foundation 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 foundation deflection from the total surface slope error (1.7 - .5 = 1.2 mrad standard deviation x 3 = 3.6 mrad 3-sigma). The conditions under which this requirement applies are:

Wind, including gusts - 12 m/s (27 mph) at 10 m (33 ft) elevation

Temperature - 0° to 50°C (32° to 122°F)

Heliostat Location - any position in the field at any time of the year.

Gravity Effects - not included

Mirror Module Waviness - none

Facet Alignment Error - none

Contractor shall propose a verification technique for implementation during startup and/or operation of the facility.

3.4.1.4 <u>Receiver Size</u>

The heliostat array shall concentrate the redirected energy onto the receiver. The receiver is a vertical cylinder approximately

18.1m (59.4 ft) in diameter and 25.9m (85 ft) in length and the center is 155m (473 ft) above ground level.

3.4.2 Operational Control Specification

Operational control requirements are as follows:

1. The heliostats 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 with step changes no larger than 10 percent of the total heliostat field output.

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

3. Elevation and azimuth drives shall not drift from last commanded positions due to environmental loading.

4. Drive systems must be capable of resolving south field control singularity (i.e., "over-the-shoulder" limits or gimbal lock) within 15 minutes.

5. Drive systems shall provide for cost effective stowage of the reflective surface to minimize reflected beam safety hazards and dust or dirt buildup on the mirrors.

Heliostat orientation shall be available to master control at all times. Calculated gimbal angles are acceptable; orientation sensors are not required.

A typical heliostat configuration and field control configuration are shown in Figures 3.4-1 and 3.4-2, respectively.

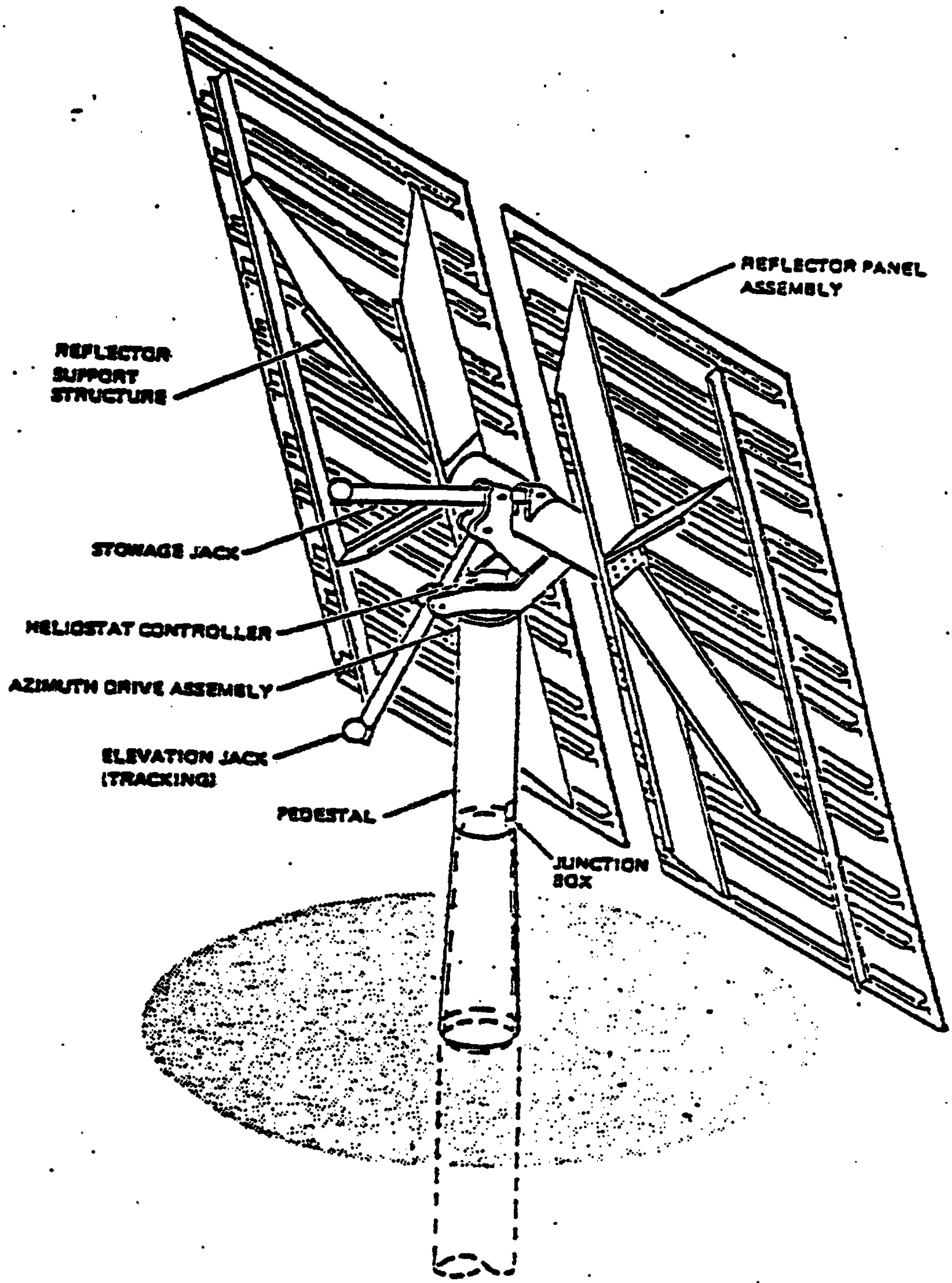


Fig. 3.4-1 Heliostat Configuration
BX214380-3

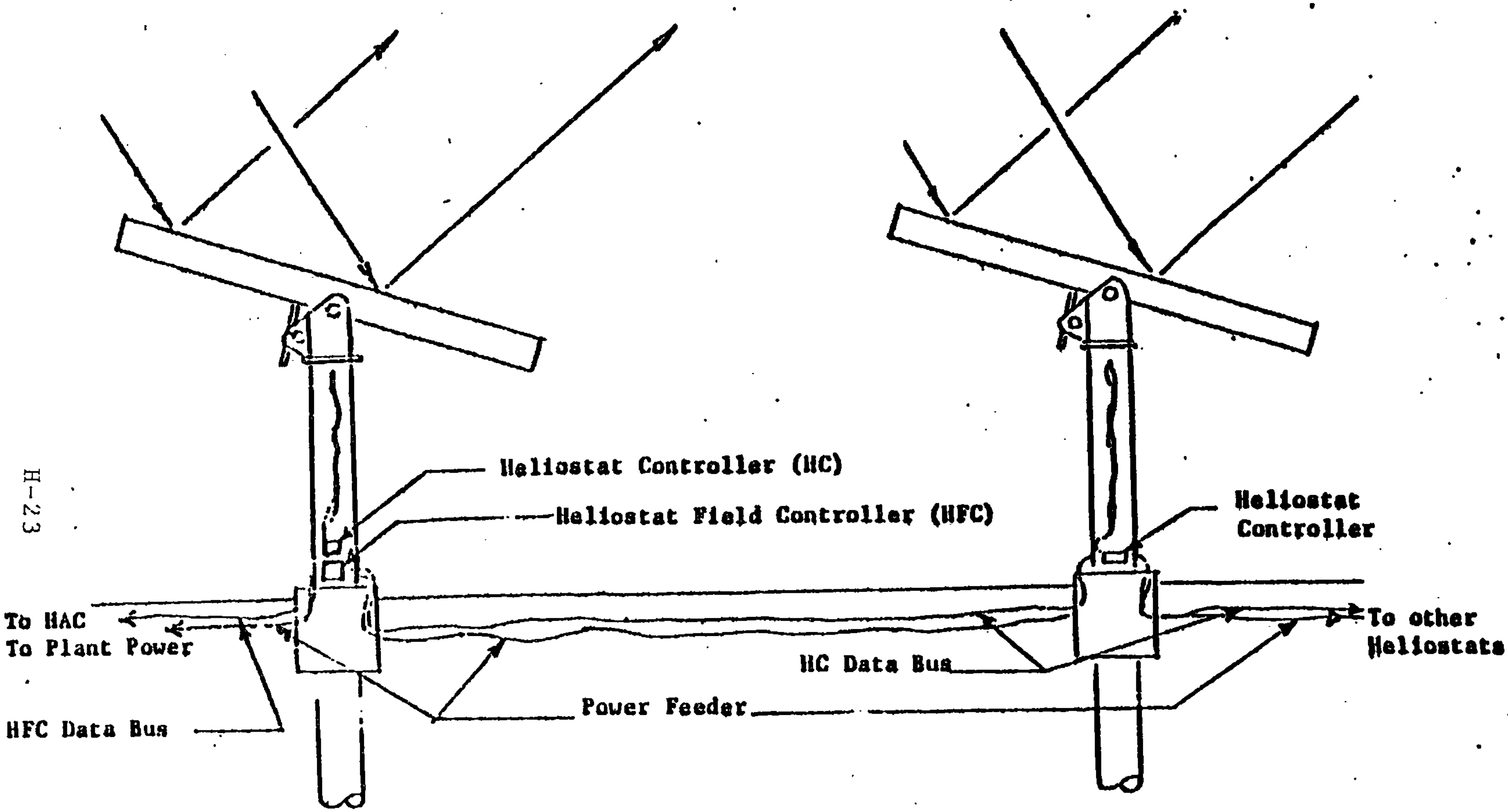


Fig. 3.4-2 Heliostat Field Control Configuration

3.5. Environmental Design Conditions

"Environmental Conditions" (Attachment 1) describes representative site conditions to be encountered and survived by the heliostat. The heliostat must maintain structural integrity in any applicable combination of these environments.

3.5.1 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 heliostat 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.

The heliostat shall be capable of operating in winds with a maximum speed, including gusts, of 16 m/s (35 mph). Performance requirements shall be met for winds with a maximum speed, including gusts, of 12 m/s (27 mph).

The heliostat, in any orientation, shall survive winds with a maximum speed, including gusts, of 22 m/s (50 mph), without damage. In the horizontal position, the heliostat shall survive winds with a maximum speed, including gusts, of 40.2 m/s (90 mph), without damage. A local wind vector variation of

+10 deg from the horizontal shall be assumed for the survival conditions.

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 ±10 deg from the horizontal.

3.5.2 Operational Limits

The heliostat and related equipment must meet performance requirements for the following conditions:

Environment	Level
Wind, including gusts	12 m/s maximum (27 mph)
Temperature	0 to 50°C (32°F to 122°F)
Gravity	All elevation angles

To achieve morning operational positioning or evening stow position, the heliostat will be required to function with ambient temperatures down to -9°C (16°F) and component temperatures that are colder or hotter than ambient temperatures due to thermal lag and/or absorption of direct insolation.

3.5.3 Stowage Initiation

The heliostats will continue to track the target with wind speeds up to 16 m/s (35 mph), but with degraded performance allowed, 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.

3.5.4 Hail

The heliostat, in any orientation, must survive 19 mm (0.75 in.) diameter, 0.9 specific gravity, hail impacting at 20 m/s (65 ft/s). In stowed position, the heliostat shall survive 25 mm (1 in.), 0.9 specific gravity, hail impacting at 23 m/s (75 ft/s) at a temperature of 6.7°C (22°F). The temperature of simulated hail shall be -6.7°C (20°F) for all tests.

3.5.5 Lightning

The heliostat field 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.

For design purposes, the maximum current in a lightning strike shall be limited to 200,000 amp.

3.5.6 Snow

The heliostat shall survive a static snow load of 250 Pa (5 lb/ft^2).

3.5.7 Rain

The heliostat shall survive rainfall conditions at a maximum rate of 75 mm (3 in.)/24 hrs, and 25 mm/hr (1 in./hr).

3.5.8 Ice

The heliostat shall survive freezing rain and ice deposits in a layer 50 mm (2 in.) thick.

3.5.9 Sandstorm Environment

The heliostat shall survive in fully operational condition after being exposed to flowing dust comparable to the conditions described by Methods 510 of the MIL-STD-810B.

3.5.10 Soil Conditions

The soil conditions at the site vary from very hard cemented soils which will support high structural loads to slightly cemented soils which essentially collapse upon saturation with water. These conditions are discussed along with preliminary foundation recommendations for the heliostats in the Preliminary Foundation Report prepared by the Engineers and issued in April 1983. Based upon this report, the heliostats will be founded upon 30 inch diameter reinforced concrete piers, 15 to 20 feet deep. Analyses, based upon preliminary design loading, indicate that these piers meet the requirements for rotation and tilting specified herein. Additional test borings and field and laboratory testing will be performed prior to final design to confirm these preliminary studies.

The drilled pier foundations will be furnished by others to a cut off grade 6 inches above the adjacent finished grade. The connection with the heliostat pedestal will be by anchor bolts or other similar means as mutually agreed between the Contractor and the Engineers.

The Contractor may propose an alternate foundation design which he considers better adapted to the configuration of his proposed heliostat pedestal or more cost-effective. Such alternates are subject to the approval of the Engineer and must meet the requirements for rotation and tiltng specified herein.

3.6 Heliostat Control and Electrical Requirements

Note: The following heliostat control concept is derived from the Barstow Solar One installation. Bidders are requested to confirm this approach or provide an alternative concept that satisfies functional requirements.

3.6.1 Scope

The heliostat control system (3.6.2) and electrical system (3.6.7) shall include all equipment necessary to position the heliostat field during all modes of operation, including startup, normal tracking, synthetic tracking, maintenance, emergency operation, and contingency operation. The major components of this system are the heliostat controllers (HC), heliostat field controllers (HFC), and the heliostat array controller (HAC).

3.6.1.1 Furnished by the Contractor

Redundant heliostat array controllers (HAC)

Heliostat controller peripherals:

CRT(s)

Keyboard(s)

Disk(s)

Printer(s)

Interconnecting Cables

Heliostat control software

Heliostat beam characterization equipment:

Television cameras

BCS targets

Meteorological and solar monitoring sensors

Heliostat Field Controllers (HFC)

Heliostat Controllers (HC)

Fiber optic cable, connectors, and connecting equipment, and supervisory personnel (if fiber optic data highways are used.)

Data highway and peripheral cable and connector/connections specifications (if coaxial or twisted shielded pair data highways are used).

Field receiving, storage, assembly, erection, and checkout including field supervision personnel and an operator training program. Bidder will quantify personnel requirements and describe a proposed operator training program.

3.6.1.2 Furnished by Purchaser

480 V, 3 phase, 60 Hz power supplies to termination points described by Bidder.

120 V, 60 Hz, 1 phase uninterruptible power supply for HAC and peripherals (Contractor to provide load requirements).

Data highways installation and supervision.

HAC installation.

Installation of BCS targets (as specified by Contractor).

Installation of peripheral equipment cable.

3.6.2 Heliostat Control System Description

Control of the heliostat array shall be through a three-level distributed microprocessor-based system (see Figure 3.6-1). The first level contains approximately 1875 HCs (based on 95 sq m heliostats) which provide closed-loop position maintenance control over the individual heliostats. The HCs also provide sun tracking control and heliostat position data acquisition on demand from the HFC.

The second level contains approximately 80 HFCs each providing control over approximately 25 HCs (one "cell" of heliostats). The HFCs perform the basic level of sun-tracking control and maintain a data base of their heliostat position information.

Communication between the HFCs is via a nonredundant data highway.

The third and highest level of heliostat control is the redundant HAC. Supervisory control of the heliostat array is performed by the HAC. The beam characterization system (BCS) control is resident in the HAC and provides automatic real time evaluation of any heliostat's quality of beam and pointing accuracy.

The HAC maintains communications with the HFCs via redundant data highways.

3.6.3 Heliostat Controller (HC)

3.6.3.1 Description

The heliostat controller shall be a single 16 bit microprocessor with programmable or erasable programmamble read only memory (PROM or EPROM) as well as random access memory (RAM). Additional components include input/output, isolation/drivers, and a data highway port with a 9600 baud rate. The HC shall be enclosed in a weathertight enclosure mounted on the heliostat.

3.6.3.2 Functional Requirements

The HC shall receive azimuth and elevation position data from the heliostat azimuth and elevation position encoder signals and output position control commands to the heliostat azimuth and elevation drive motors. The HC shall transmit the heliostat position data to the HFC on demand and receive the HFC sun-tracking and stow positions control commands. Communications with the HFC shall be via a nonredundant data highway port capable of serial transmission at 9600 baud.

No failure in the data highway, HFC, or other HCs on the data highway shall affect the closed-loop heliostat position maintenance control or the local control capabilities. Conversely, no failure within the HC shall affect the data highway, HFC, or other HCs. Local control shall be provided to perform maintenance on each heliostat.

Means shall also be provided to select remote or local control locking out whichever mode is not selected. Data on the mode (local/remote) shall be transmitted to the HAC.

3.6.3.3 Maintenance

Design of the HC shall be modular to facilitate ease of maintenance. No component shall obstruct the removal of any other component.

3.6.3.4 Environmental

The HC shall be designed to be operable in all modes without degradation due to the ambient environmental conditions as specified in Environmental Conditions (Attachment 1).

If supplemental heating/cooling is required to maintain proper operation, it shall be furnished by the Contractor. The Bidder shall identify the power requirements for any heating/cooling equipment.

3.6.3.5 Power Supplies

The Purchaser will supply a 480 V, 3 phase, 60 Hz, power supply or heliostat array controller (HAC) to each heliostat. The Contractor shall furnish any conversion equipment necessary to convert to proper voltage type and level required by the heliostat control and drive equipment, including any filtering equipment necessary to limit voltage spikes from power line drive motors from affecting the heliostat microprocessor equipment. The Bidder shall identify these equipment requirements. The Purchaser will provide power wiring between HACs and individual heliostats, if required.

3.6.3.6 Input/Output Interfaces

Solid state equipment shall be isolated from inputs by optical isolators. Outputs shall be isolated by relays with high cycle duty contacts rated for the azimuth and elevation drive motor maximum current and voltage.

3.6.3.7 Data Highway Interface

The HC shall interface with the HFC via a data highway port capable of serial transmission at a minimum of 9600 baud.

3.6.4 Heliostat Field Controller

3.6.4.1 Description

The HFC is a single 16 bit microprocessor with programmable or erasable programmer read only memory (PROM or EPROM), a minimum of 48K bytes of random access memory (RAM) and 32K of bubble memory. Additional components include I/O parts for interface with the HCs and the HAC. The HFC shall be enclosed in a weathertight enclosure mounted on selected heliostats.

3.6.4.2 Functional Requirements

The HFC shall be a nonredundant microprocessor-based controller. The HFC shall be capable of controlling and receiving data from a minimum of 25 HCs. The HFC shall interrogate each of the HCs for azimuth and elevation position as well as local remote control status and maintain this information in memory for subsequent transmission to the HAC upon demand. An open-loop, sun-tracking algorithm shall be performed by the HFC which will position the individual heliostats automatically via the data highway. The HFC shall receive individual heliostat position commands from the HAC for retransmission to the HCs. All detailed control algorithms for operation of the heliostats during the various operational modes (see Section 3.4.2) shall be stored in the bubble memory of the HFC.

3.6.4.3 Maintenance

Design of the HFC shall be modular to facilitate ease of maintenance. No component shall obstruct the removal of any other component.

3.6.4.4 Environmental

The HFC shall be designed to be operable in all modes without degradation due to the ambient environmental conditions as specified in Environmental Conditions (Attachment 1).

If supplemental heating/cooling is required to maintain proper operation, it shall be furnished by the Contractor. The Contractor shall state the power requirements for any heating/cooling equipment.

3.6.4.5 Data Highway Interfaces

The HFC shall contain a single data highway port for serial communication to its HCs at a minimum of 9600 bAUD.

The HFC shall contain redundant data highway ports for serial data transmission to/from the HAC at a minimum of 9600 bAUD. Isolation between the redundant HAC communication ports shall be provided to prevent failure of one port from affecting transmission on the redundant port.

3.6.5 Heliostat Array Controller (HAC)

3.6.5.1 Description

The HAC shall be a minicomputer system with redundant central processing units (CPU) and 256K bytes of resident memory. The HAC shall include peripherals such as cathode ray tubes (CRT), line printer, disk unit for long-time storage, and a keyboard or touch sensitive CRT overlay or similar as recommended by the heliostat Vendor. The HAC shall contain redundant data links to the redundant process computer system portion of the main control subsystem (MCS). Also, the HAC shall contain data highway ports in accordance with redundant HAC to communicate with the HFCs via redundant data highways. These data highway ports shall be capable of serial data transmission at 9600 bAUD minimum.

The HAC shall contain I/O ports for the BCS, resident in software, within one of the redundant HACs. These ports shall communicate with the three field-mounted television cameras, the three calibration targets, and the meteorological and solar data monitoring equipment which are a part of the heliostat control system.

The Contractor shall be responsible to provide the interface between the HAC and the Process Computer System (PCS) based on the protocol furnished by the PCS manufacturer.

3.6.5.2 Functional Requirements

The HAC shall communicate with each of the heliostat sectors simultaneously.

In order to further increase the flexibility of the collector array, the control system shall be designed to operate without the HAC with respect to the main modes of operation.

The HAC shall be needed only to coordinate certain maintenance and alignment operations (it shall direct, for example, a given heliostat to track its beam onto the calibration target) and to update or modify the normal control sequence for any sector, field, or single heliostat as desired by the operator. Since the HAC shall fully interface with the process computer system, the above functions shall, at the request of the operator (or automatically), be initiated at the HAC or be relayed to and from the PCS.

The beam characterization system shall be a software-based system resident within one of the redundant HACs. The BCS also consists of three heliostat field-mounted television cameras and three calibration targets mounted on the receiver tower with its own interface at the HAC to provide the necessary heliostat data and control for beam quality and accuracy measurements.

The purpose of the system is to permit automatic real-time evaluation of quality of the beam and pointing accuracy provided by any heliostat. The whole operation shall be under software control and require no operator intervention. At any one time, three heliostats, one from each third of the array, shall be directed to deflect their beams from the receiver to their respective calibration target. Beam size, shape, centroid, flux distribution, and power shall then be measured for each heliostat. This shall be a passive process made possible by use of video cameras aimed at the calibration targets. Their output shall be digitized, calibrated, and processed. Software modules shall detect any abnormality and provide the operator or maintenance personnel, through the interface with the PCS, with data necessary to perform any eventual heliostat beam adjustment. Pointing information shall be delivered to the HAC for use in performing automatic realignment.

Each remotely controlled camera shall be permanently installed in the field. Temperature stablizer, environmental enclosure, and camera filters shall be part of the field installation.

Calibration targets shall have a Lambertian high temperature surface paint with remotely controlled pyrheliometers for absolute flux measurements. The output of the sensors shall be transmitted to the BCS computer. Camera output shall also be transmitted to the BCS computer where a video switch shall select each camera in turn. Central processing units, CRT displays, keyboards, printers, video digitizers, and data recorders shall be utilized to extract needed data. The Heliostat contractor shall supply meteorological data and solar irradiance data inputs to the BCS computer shall be used to close the loop on evaluation of heliostat beam characteristics.

The BCS computer and the HAC shall work in direct communication, under PCS supervision, in selection of the heliostats to be aligned and calibrated. Once a heliostat is selected, the BCS shall give the instructions to the HAC to direct the heliostat beam from the receiver to the standby position and then to the calibration target to perform the measurements. The operator shall be able to intervene at any time to modify or take active part in the operation.

The BCS shall also be capable of operating on its own, without the connection to the PCS, in its basic interactions with the collector system through the HAC. Total failure of the HAC or the BCS computer may interrupt the beam characterization process. Failure of the BCS shall not immediately affect the actual performance of the heliostats; no redundant BCS system is required. The unit operator shall be alerted so that he can take necessary action to restore normal conditions.

The HAC shall be capable of modifying or updating the routines in the HFCs by downloading new routines through the same communication network utilized for control of the array. Status of each heliostat or set of heliostats shall be available at all times at the request of the HAC operator.

Heliostat control arrangement shall be designed to achieve intended performance at all levels with a minimum of human intervention. All modes of operation shall be selectable by a single operator by controlling the execution of appropriate instructions or set of routines, which shall be permanently stored in the computer software. Although operation routines shall be permanently stored, the ability shall exist to modify or update them at any time using the standard computer system software without affecting the hardware. Provisions shall be included to enable manual intervention in any function by the operator.

Heliostat alignment shall take place on a continuous basis under the control of the HAC utilizing calibration targets. The PCS and the BCS take part in this operation through their respective interfaces with the HAC.

Alignment data and control commands for heliostats undergoing alignment shall be exchanged with the BCS while the entire procedure occurs under the PCS supervision. One heliostat from each third of the field shall be commanded, in sequence, to reflect the suns's image onto the assigned calibration target. Heliostat beam pointing data from the BCS shall be transmitted through the HAC to the HFCs serving the applicable heliostats. At the same time, the HAC shall select the field of heliostats (served by a HFC) that must undergo alignment. The HFC then produces necessary commands to verify correct aiming at the calibration target and to make necessary adjustments for each heliostat under its control. Any biases necessary to make the calibration signal satisfy the alignment requirements are stored in the bubble memory of the HFC and are used in subsequent operation to correct the heliostat pointing. The HFC notifies the HAC that alignment of its set of heliostats has been completed so that the HAC can switch to the next set of heliostats. The entire procedure is to be under software control with provisions for manual operator intervention.

3.6.5.3 Power Supplies

The Purchaser will furnish a 120 V, 1 phase, 60 Hz, uniterruptible power supply for the HAC and peripheral equipment. All filtering and module power distribution shall be supplied by the Contractor.

3.6.5.4 Environmental

The HAC and its peripheral equipment (CRT's, printer, disk, etc) will be located in a controlled environment. The Contractor shall provide the environmental limits specifications including estimated heat load.

3.6.6 Heliostat Operational Modes

The following is a list of the heliostat modes of operation which can be implemented:

- Startup
- Shutdown
- Track
- Standby
- Align
- Manual
- Stow
- Communication

The characteristics relative to each mode are described in the following sections:

3.6.6.1 Startup

The heliostat array shall be normally in the stowed position prior to startup. The power supply units for the heliostat array controller (HAC), heliostat field controllers (HFCs), and heliostat controllers (HCs) may or may not be energized. If they are deenergized, the first operation at startup shall be to apply electrical power to the entire array and load the control software into the HAC random access memory (RAM). Upon power-up, the HFC software shall be automatically loaded into the HFC RAM from the resident magnetic bubble memory extension. The HC software shall be permanently stored in erasable programmable read only memory (EPROM) and shall not need to be loaded. Within a few seconds from the application of power, all software shall be loaded and the array shall be ready to respond to commands (from either a dedicated operator or from the unit's process computer system).

The first command shall be the Communications command, aimed at polling all heliostats and obtaining a response which indicates their operational status. The HAC cathode ray tube (CRT) displays shall provide a summary of the conditions relative to the respective heliostats. The Communication command shall also initialize the day and the time routines at each HFC so that appropriate sun position calculations can be performed at the cell level. Subsequently, the HAC shall transmit the first sun vector in order to calibrate the HFC sun position algorithm. At this point the startup procedure shall proceed with the issuance of the Standby command. All heliostats, or any portion as commanded, shall move so as to reflect the sun's image onto the standby point(s) (adjacent to, and away from the receiver) which shall complete the startup procedure. The heliostats shall, sequentially on command from the PCS, be switched from the Standby to the Track position (beam on the receiver) and vice versa at a rate dictated by the Master Control System. Motion from the Stow to the Standby position shall be controlled so as to prevent focusing of any portion of the array onto anything other than the Standby point(s). Bidder shall identify the amount of time required to bring heliostats from Standby to Tracking mode.

3.6.6.2 Shutdown

Shutdown is the operation that removes the beam from the receiver, and, eventually, places the array in a stowed position so that the next day's startup operation if facilitated. The Shutdown command shall start a sequence of actions at the HAC. The first action shall remove the beam from the receiver and put the array in Standby. Once the Standby position is reached, the array shall be moved from Standby to the Stow position. Again, as during startup, the array shall be moved in a way that precludes the focusing of any portion of it onto anything other than the Standby point(s).

There shall be two types of Shutdown operation: Normal Shutdown (used at sunset, etc) and Emergency Shutdown, (used prior to an unsafe condition such as a wind storm). During Normal Shutdown, the heliostats shall be Stowed with some predetermined orientation, facilitating Standby operation the next morning. A Normal Shutdown shall be initiated either by the operator (at the HAC or PCS) or automatically when the sun's elevation goes below a predetermined value.

An Emergency Shutdown shall move all heliostats to the Stowed position in the least amount of time possible. The initial emergency command shall move only the azimuth of the heliostats so as to remove the beam from the receiver and place it at an approximate Standby position. Subsequently, the heliostats shall be Stowed with the mirror facing up. This "Emergency Stow" mirror face-up position shall be used in this case because it constitutes the shortest travel time in elevation to achieve. When the emergency conditions disappear, the array shall be commanded to resume Normal operation or assume a Normal Shutdown position. The Emergency Shutdown operation shall be initiated manually by HAC or PCS operator command or automatically through power failure detectors, storm-early-warning devices, receiver failure, or turbine trip.

3.6.6.3 Track

The Track command shall be given for any number of heliostats through the HAC. At this command the heliostats shall be switched from standby target tracking to receiver tracking. The number of heliostats to be moved in accordance with unit time shall be determined by the PCS. The basic sun receiver tracking algorithm shall be resident in the HFC software. A more detailed algorithm shall be resident in the HAC software which periodically shall transmit a reference sun vector to the HFCs for calibration.

3.6.6.4 Standby

The Standby command shall be indentical to the Track command, except that in Standby the heliostats shall focus on a volume adjacent to the receiver, in free space. Sun position and pointing angle evaluations shall be carried out on a continuous basis to maintain the focus away from the receiver. The number of heliostats on Standby and number on Track shall be constantly varied by the PCS to maintain the desired steam pressure and temperature at the output of the reciver. The Standby mode of operation shall be selected automatically during Startup and Shutdown and shall constitute the intermediate step for the beginning or termination of power generation.

The data necessary for pointing angle evaluation shall be available at the HFC/HC at all times so that only the Standby or Track command need be issued together with the identification of the number of heliostats involved. As for any mode of operation, this command shall be issued either automatically by the control system software or manually by the HAC or PCS operator.

3.6.6.5 Align

Align operation shall take place on a continuous basis under the control of the HAC utilizing the beam characterization system (BCS). The PCS and BCS shall take part in this operation through their respective interfaces with the HAC. The purpose of the operation shall be to permit the automatic real-time evaluation of the quality of the beam and pointing accuracy provided by a heliostat. Each heliostat shall be commanded, individually in sequence, to reflect the sun's image onto the calibration target. Beam size, shape, centroid, flux distribution, and power shall be measured for each heliostat. These data shall be evaluated and made available to the HAC and the PCS operator. Pointing data (beam centroid) shall be used by the HAC to perform the necessary correction to the specific heliostat angles. The correction biases shall be stored in the HFC to update and maintain accurate pointing of the heliostats. Data relative to beam quality shall be used by the PCS operator to determine the need for mirror facet canting adjustment and/or mirror washing. The whole operation shall be under software control and require no operator intervention.

Initial alignment shall be performed following the installation of the heliostat to determine pointing biases caused by installation irregularities (such as nonperfect leveling of the foundation, orthogonality errors between vertical and horizontal rotational axes, etc). This initial alignment operation shall be repeated several times during an initializing 24-hour period. The pointing biases relative to each alignment shall be stored in the HFC for the specific heliostat. At the completion of the 24-hour alignment cycle, a special software routine shall be executed on the accumulated biases. Correction coefficients shall be evaluated so that the encoder reading (or motor count signal) of the respective heliostat shall be compensated for leveling and other mechanical installation errors.

Alignment shall also be performed on a regular basis during normal operation. Regular aligment shall not take more than approximately 1 minute to execute. The HAC software for the regular alignment sequence shall require one heliostat from each cell polled for alignment before the next heliostat from the same cell is selected to ensure that any problem associated with an HFC is readily identified. The operator shall be able to intervene at any time to modify the sequence or to perform alignment on any heliostat upon command.

3.6.6.6 Manual

The manual mode of operation shall be initiated from either the HAC or the PCS and shall be used to move the specified number of heliostats in any direction, both in azimuth and in elevation. In addition, individual heliostat local control shall be provided at the HC. Safeguards shall be provided to avoid excessive concentration of multiple heliostat beams at unacceptable targets during manual control.

3.6.6.7 Stow

The Stow operation shall place the specified number of heliostats in a position where the mirror facets are horizontal or vertical (or nearly so). This command shall be issued automatically during the Startup and Shutdown sequences as well as manually at the HAC or PCS. The heliostats to be Stowed are always on Standby as a starting mode. The features associated with this operation in normal or emergency conditions are described in the preceding Shutdown Section.

3.6.6.8 Communication

The Communication mode transfers data between the HAC, HFCs, and HCs, as needed, in the bi-directional communication links. Also, the HFC software shall be downloadable from the HAC when the array is installed, including initial downloading of data relative to the heliostat target coordinates (Track and Standby points), Stow positions, and alignment biases via the Communication mode.

Data relative to the array shall be collected in this mode. The communication mode shall not affect any other operating mode of the array. This mode shall coexist with any other previously established mode and shall be used only to permit the exchange of any data among the various computers in the control network.

3.6.7 Electrical System Requirements

3.6.7.1 Applicable Documents

National Electrical Manufacturer's Association, NEMA MG1-1978, Motors and Generators.

3.6.7.2 Motors

General

All motors shall conform to NEMA MG1, Section II, Parts 2, 10, 11, 12, and 14 with respect to materials, workmanship, design, and routine tests except as specified herein.

3.6.7.2.1 Electrical Design

A 480 V, 3 phase, 60 Hz power source will be brought to each heliostat. Each heliostat shall contain its own integral transformation or rectification equipment if motors are rated other than 480 V, 3 phase, 60 Hz.

Motors shall be NEMA Design B unless load torques require motors with special characteristics.

The full load current when operating at ±10 percent of rated voltage shall not exceed 1.15 times rated full load current.

3.6.7.2.2 Mechanical Design

Motors shall be totally enclosed, nonventilated (TENV) with nonhygroscopic insulation and shall be suitable for the service conditions specified in Section 3.5 of this specification.

Motors shall have antifriction bearings with suitable seals to prevent leakage of lubricant in either direction along the shaft.

Grease lubricated bearings shall be lubricated prior to shipment.

Bearings requiring periodic regreasing shall have provisions for inservice positive lubrication with means to prevent damage due to overgreasing.

Bearings of the completely sealed or the prelubricated type shall not have provisions for inservice lubrication.

3.6.7.2.3 Motor Data

The Contractor shall provide a filled-in motor data sheet, for each type of motor being supplied.

3.6.7.2.4 Tests

Every motor shall be given a routine factory test, including high-potential test, in accordance with NEMA MG1.

3.6.7.2.5 Documentation

Five copies of a certified routine test and high-potential test of five motors of each type, picked at random from the assembly line, shall be provided.

3.6.7.3 Interfaces

The heliostat field controller (HFC) and heliostat control (HC) power compartments/junction boxes shall be provided with suitable terminal boards to accept incoming control and power cables. The compartments/junction boxes shall be watertight, NEMA Type 4 or equivalent. Provision shall be made for fastening a NO. 4/0 bare copper ground wire to the base of the heliostat.

MOTOR DATA SHEET

(Data to be Furnished)

Client

Project

Mark or Item No.

Make ______________________

Frame NO. ______________________

Horsepower ______________________

Voltage ______________________

Service ______________________

Full load, rpm ______________________

Full load, amp ______________________

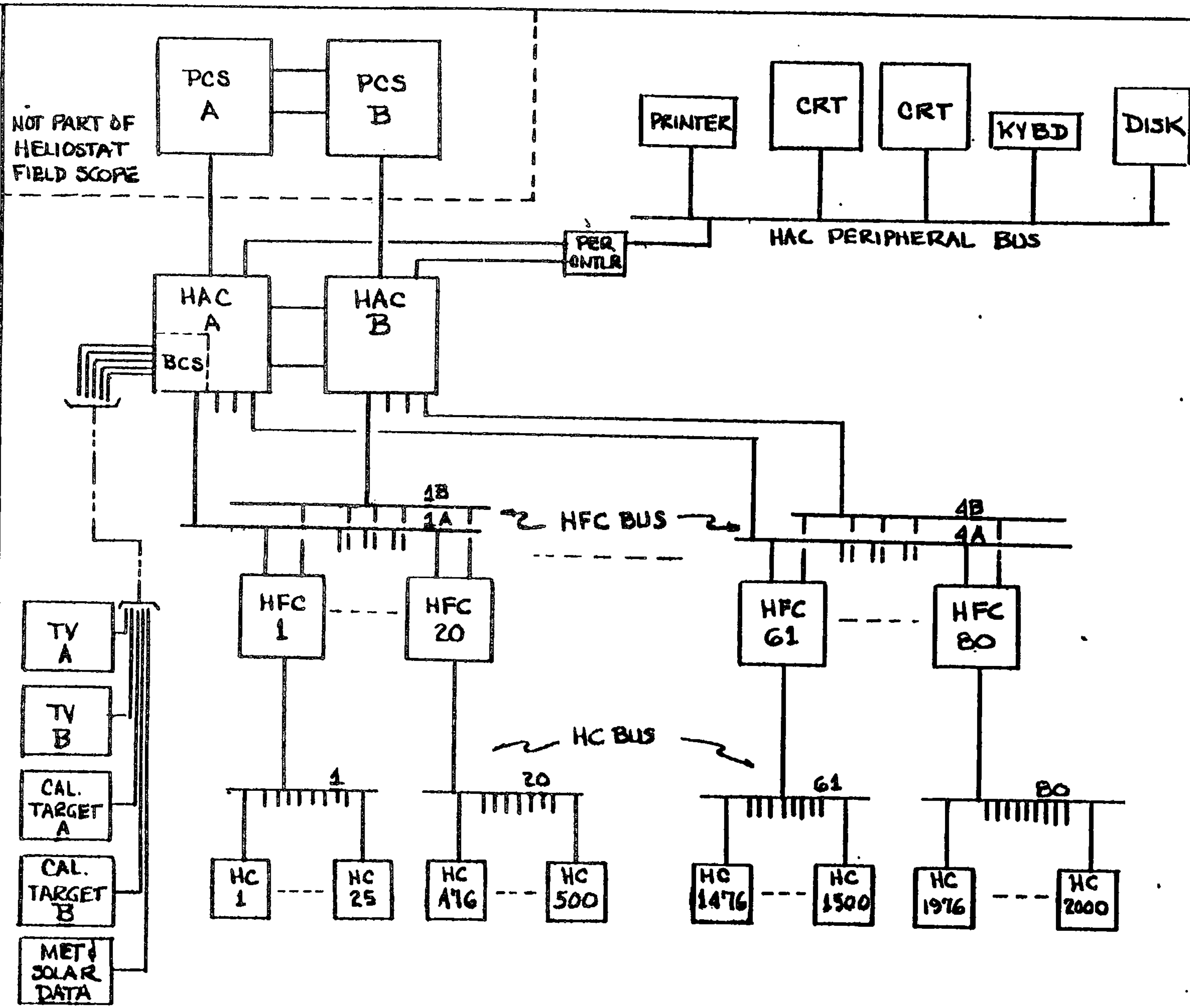
Locked rotor, amp ______________________

Bearing manufacturer and model

Outboard ______________________

Inboard ______________________

Lubrication ______________________



TITLE: FIGURE 3.6-1
HELIOSTAT CONTROL FUNCTIONAL BLOCK DIAGRAM

REF:

SKETCH

DATE	PREP.	CHECK	APPR.
		5	
		4	
		3	
		2	
		1	

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3.7 General Design, Fabrication, and Erection Requirements

Commercial design and construction standards shall be employed. Where applicable, the Uniform Building Code (1979 Edition), ANSI A58.1 - 1982, ACI 318-77, and the AISC Manual of Steel Construction (8th Edition) shall be used. For electrical components, the National Electrical Code (ANSI C1), the National Electrical Manufacturer's 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 heliostat life.

3.7.1 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 noncommercially available parts shall be defined and documented in deliverable documents.

3.7.2 Electromagnetic Radiation

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

3.7.3 Flammability

In a high temperature, low humidity environment of a typical desert, the heliostat field shall not be vulnerable to extensive fire damage.

Given that a fire exists in any part of the heliostat field, the fire should not damage any heliostats that are not directly adjacent to the fire due to burning of a heliostat or any heliostat wiring. If a heliostat or any part of a heliostat burns for any reason the heliostat fire should not spread to other parts of the field due to blowing winds, component explosions, or any other means.

3.7.4 Nameplate and Product Marking

See Section 5.2

3.7.5 Quality

The level of quality shall conform to practices defined in the codes, standards, and specifications applicable to the plant site and the using utility. 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.

3.7.6 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. Heliostats do not need to be interchangeable within the array; however, the number of noninterchangeable types shall be limited to the most economic choice.

3.7.7 Safety

The heliostat field 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.

Operational safety requirements are as follows:

1. The heliostat shall be capable of emergency defocusing upon command to reduce peak incident radiation on the receiver to less than 3 percent of initial value within 120 sec.

2. Heat fluxes on tower and normally unirradiated portions 1 of the Receiver Subsystem are limited to (25) kW/m^2 (7880 Btu/ft^2 hr).

3. Beam control strategy and equipment shall protect personnel and property within and outside the plant facility including air space.

4. The heliostat field design shall be consistent with safety criteria identified for the Barstow Pilot Plant. The supplier of the Heliostats shall identify any deviations from these design criteria which affect safety. (Reference: 10 MWe Solar Thermal Central Receiver Pilot Plant System Safety Analysis, December 1980, SAN/0499-55).

3.7.8 Human Engineering

The Heliostat shall be designed to facilitate manual operation, adjustment, and maintenance as needed and to provide the optimum allocation of functions between personnel and automatic control. The heliostat 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. MIL-STD-1472, "Human Engineering Design Criteria", 1
shall be used as a guide in designing equipment.

3.7.9 Welding 1

All welding, welding procedures and qualifications, and welder 1
qualifications shall be in accordance with the Structural Welding 1
Code, D1.1-82, of the American Welding Society.

3.7.10 Cleaning

Bidder shall describe recommended cleaning methods and provide a plan for optimizing cleaning frequency.

3.7.11 Surface Preparation and Painting

All steel shall be cleaned and shop coated. Cleaning, coating materials, application methods and inspection procedures shall conform to the specifications, referred to herein, of the Steel Structures Painting Manual, Volume 2, "Systems and Specifications" by the Steel Structures Painting Council.

Prior to coating, all steel shall be blast cleaned after fabrication in accordance with SSPC-SP10, Near-White Blast Cleaning. All petroleum-based contaminents shall be cleaned from the surface prior to blast cleaning.

An organic zinc-rich primer shall be used. The topcoat shall be a vinyl copolymer enamel which provides excellent intercoat adhesion to itself and to the primer. The topcoat must withstand long-term exposure with negligible fading and chalking. The total system dry thickness shall be a minimum of 6 mils. The primer or the topcoat shall be a minimum of 2.5 mils. While maintaining the 6 mil total system thickness. The interior surfaces of the pedestal will not require painting.

3.7.12 Transportability

Heliostat components or assemblies shall be designed for transportability by highway handling equipment within applicable federal and state regulations.

3.7.13 Maintenance

The system shall be designed so that potential maintenance points can be easily reached and components such as electronic units, motor drivers, etc, can be readily replaced. Elements subject to wear and damage, such as supporting wheels, gears, etc, shall be identified for service or replacement. Items with a common function shall be provided with standard tolerances and connector locations to permit service interchangeability.

3.7.14 Service Life

The system shall be designed for a 30-year service life.

3.7.15 Standard Usage

Commercial design and construction standards relevant to the system's intended use shall be employed.

3.7.16 Component Availability

Standard materials and off-the-shelf components shall be used to the maximum extent possible.

3.8 Performance Measurement Methodology

Bidder shall propose a methodology for quantifying thermal power delivery by the heliostat field to the receiver aperture. This methodology should utilize beam pointing error and beam shape information from the Beam Characterization System, reflectivity measurements, direct normal insolation measurements, and flux measurements (at the BCS targets) if available. A formula will be developed that will be used to determine whether performance of the heliostat field satisfies design requirements. These periodic performance measurements shall be used to enforce performance guarantee conditions and penalties.

The methodology for heliostat performance measurement will require review and approval by the Purchaser, Engineers, and receiver supplier. The calculated flux delivery to the receiver is also intended to provide a basis for evaluating receiver performance.

4.0 QUALITY ASSURANCE

4.1 Quality Assurance Program Requirements

4.1.1 QA Program

The Contractor shall have in effect at all times a QA Program which clearly establishes the authority and responsibility for all elements of the program. Persons performing quality functions shall have sufficient and well-defined responsibility and authority to enforce quality requirements, to identify, initiate, recommend, and provide solutions to quality problems, and to verify the effectiveness of the solutions. Submittal of this QA Program may be required.

4.1.2 Contractor's Responsibilities for Subsuppliers/ Subcontractors

The Contractor shall identify, in purchase documents to his subsuppliers/subcontractors, all applicable quality and QA requirements imposed by this Specification on the Contractor and shall ensure compliance thereto.

4.1.3 Notification Points.

The Purchaser shall have the right to establish notification points for which the Contractor shall be given prior notification.

In addition, the Purchaser may establish temporary notification points to ensure resolution of temporary quality problems. Notification points require receipt of notification at least 5 working days in advance of the scheduled time of performance. The Purchaser may require that activities performed without proper notification be repeated for Purchaser's Quality Control Representative (EQCR) observation at the Contractor's expense. The EQCR will witness the event or will authorize the Contractor to proceed without Purchaser's witnessing of the event.

4.1.4 Submittal of Manufacturing and Inspection Plan

After award of Contract, the Contractor shall submit copies of his Manufacturing and Inspection Plan to the Purchaser for his information and subsequent establishment of Notification Points.

As a minimum, the Manufacturing and Inspection Plan shall outline the basic manufacturing/production and field erection sequence and specific preplanned Contractor inspections that are required to be performed.

4.2 Tests

The Purchaser reserves the right to perform limited tests and inspection of heliostat components selected from Contractor's production lines to verify that key items perform to required specifications.

Every motor shall be given a routine factory test, including high-potential test, in accordance with NEMA MG1 (see 3.4.7.2.4).

4.2.1 Structural Steel

The following test shall be performed by the Engineers' Shop Inspector:

4.2.1.1 Painting

1. Surface Preparation Test - The surfaces of all steel to be coated shall be visually examined prior to the application of the coating. SSPC VIS 1, pictorial surface preparation standards for painting steel surfaces, shall be used to verify the degree of blast cleaning specified.

2. Film Thickness Test - For film thickness measurement, the requirements and recommended practices of SSPC-PA2, Method for Measurement of Dry Paint Thickness with Magnetic Gages, shall be followed. Readings shall be taken on smooth, regular surfaces.

The following tests shall be performed by the Contractor:

4.2.1.2 Welding

Twenty-five percent of all butt welds shall be radiographed in accordance with Section 6, Part B, Radiographic Testing of Welds

(AWS D1.1) or ultrasonically tested in accordance with Section 6, Part C (AWS D1.1) and a permanent record made of the results. Nondestructive test operators shall be qualified in accordance with SNT-TC-1A. Twenty-five percent of all fillet welds shall be tested in accordance with ASTM E709, practice for magnetic particle inspection. All welds shall satisfy the requirements of subsection 8.15, Quality of Welds (AWS D1.1). Welds found deficient by visual examination or by nondestructive testing shall be repaired in accordance with AWS D1.1.

4.3 Inspection

4.3.1 Structural Steel

The Engineer's Shop Inspector shall perform the following inspections:

4.3.1.1 Mill Test Reports

Verify by mill test reports that steel conforms to chemical and mechanical properties of the applicable specification covering the material to be furnished.

4.3.1.2 Qualification of Welders

Verify from shop records and welder's qualification records, that the Contractor is using qualified welders.

4.3.1.3 Weld Inspection

Perform required visual inspection of welds. If the visual inspection is satisfactory, nondestructive testing of welds shall be performed as described in Section 4.2.1.2, herein. Verify that weld tests have been properly performed and documented by the Contractor.

4.3.1.4 Fabrication Inspection

Perform random dimensional checks, using approved shop drawings, of completed fabricated components. Perform random check for straightness of completed components.

4.3.1.5 Protective Coatings Inspection

Witness the application of protective coatings on a random basis and verify that the protective coatings are applied in accordance with the coating manufacturer's application instructions and the Steel Structures Painting Council Specification SSPC-PA1; Shop, Field and Maintenance Painting. Perform visual inspection of the coated steel to ascertain that the coating entirely covers the surfaces without holidays, shadow-thru streaks, thin spots, sags, runs, and obvious surface defects.

4.3.2 Field Erection and Completion

The Engineer's shop inspector shall perform the following inspections:

4.3.2.1 Completed Heliostat

Inspection of assembled heliostat and pedestal for optical (mirrors), structural (mechanical), and electrical completeness.

4.3.2.2 Operational Heliostat

Inspection of assembled heliostat and pedestal during operational performance.

4.3.2.3 Partially Completed Heliostat

Inspection of partially completed heliostat can be made by field inspectors.

4.4 Documentation

4.4.1 Records System

A records system shall be established and maintained that provides for the identification and correlation of test and inspection records and certificates.

4.4.2 Document Submittals

This Specification requires specific documents to be formally submitted to the Engineers for information or review and approval. If these documents are changed subsequent to submittal, the supplier shall resubmit the revised document(s) to the Engineers for information or review and approval consistent with the original requirement. Any document required by this Specification which is produced by a subsupplier of the Contractor shall first be reviewed and noted as being approved by the Contractor and then submitted to the Engineers for review and approval. Contractors and subsuppliers who proceed to use unapproved documents do so at their own risk, and may be required to repeat activities that were performed if the document used is subsequently rejected by the Engineers.

4.4.3 Contractor's Documentation

QA documents are a deliverable item. The Contractor's QA shall approve them, then present them to the Purchaser. The Contractor shall assemble all QA records into two identical sets. Each page of each document submitted shall be clearly identified by the Purchaser's name, the station and unit, the Contract Number, the equipment description and specific identification, and the manufacturer's name and address. Each individual document shall be legible and shall have reproducible microform capability. No information shall be recorded closer than 5/8 in. to the binding edge or closer than 1/4 in. to any other edge of the paper.

Documents that have been submitted with a previous shipment on this order/contract shall not be duplicated. However, a statement shall be furnished to the Purchaser itemizing, by document, the documents previously furnished for each item of equipment and the date of that previous submittal.

4.4.4 Final Inspection and Check of Records

The Contractor shall be responsible for inspecting the item(s) and checking the applicable records, prior to shipment, to verify that all specification requirements have been complied with. Two complete sets of all documents required to comply with this specification shall be submitted to the Engineer. Acceptance of the completed sets of records does not relieve the Contractor of his responsibility for compliance with specification requirements. After completion but prior to submittal of these records, the Contractor shall complete and submit the Engineer's Certificate of Compliance. The Engineer's Certificate of Compliance supplied as part of this Specification is a document which certifies that the inspection(s) and test(s), required by the Specification, have been satisfactorily completed and the Contractor's documentation for that shipment conforms to the procurement document requirements, this Specification, and applicable codes and standards. The Certificate of Compliance shall be completed and signed by the Contractor's quality representative and submitted to the Purchaser, together with other documentation applicable to that shipment.

4.4.5 Shipping Release

A copy of the completed Certificate of Compliance must be included in each shipment. This requirement also applies to shipments from the Contractor's suppliers when item(s) are to be shipped directly to the Engineers or its clients.

4.4.6 Documentation by Contractor

The minimum documentation required to be furnished will be indicated at a later date.

All records required by this Specification, applicable regulations, codes and standards, or generated as a result of the Contractor's QA Program shall be retained in the Contractor's file for a period of (number of days) after the contract requirements for manufacture or installation have been complied with. At the expiration of this (number of days) period, the Purchaser or his authorized agent shall be provided the option of receipt and/or the Contractor's continued retention of the file contents. No QA records shall be destroyed or otherwise disposed of without written permission from the Purchaser.

5.0 PREPARATION FOR SHIPMENT

5.1 Packing and Packaging

Prior to packing, the Contractor shall apply all necessary preservatives required to protect the equipment from corrosion during shipment. All equipment shall be adequately packed, crated, boxed, skidded, or otherwise protected and prepared for shipment in such a manner as to prevent loss and damage and maintain the specified cleanliness during handling, transportation, and for a reasonable period of storage prior to use. Selection of the packing and packaging shall be the responsibility of the Contractor; however, the method employed shall conform to the information and recommendations furnished to the Purchaser.

5.2 Shipping Documents, Marks, and Forms

The Contractor must use proper identification, markings, and documentation records for shipment of the equipment to the jobsite.

1. Packing Lists

   Where applicable, two (2) packing lists must accompany each shipment.

   a. One fully itemized packing list must be inserted into a resealable waterproof envelope, and securely affixed to the exterior of the shipping container or piece of equipment adjacent to the shipment markings.

b. One fully itemized packing list must be placed within each shipping container.

2. <u>Marking, Labeling, and Identification</u>

a. All crates, boxes, cartons, or individual shipping containers must be marked or stenciled in waterproof ink, in clear legible characters in a visible location with the following <u>minimum</u> identification information:

1. Contractor's Name ____________________
2. Contract Number ____________________
3. Description of Item(s) ____________________
4. Mark Number ____________________
5. Quantity of Item(s) ____________________
6. Gross Weight ____________________
7. Net Weight ____________________
8. Shipment Number ____________________

b. All individual, skid mounted, or loose equipment must be marked or stenciled in waterproof ink or paint, in clear legible characters on the item or embossed on a metal tag securely fastened to the shipment in a visible location with the following minimum identification information:

1. Contractor's Name________________________

2. Contract Number________________________

3. Description of Item(s) ________________________

4. Mark Number________________________

5. Gross Weight ________________________

6. Shipment Number________________________

c. All shipping containers, individual skid mounted or loose equipment which weigh 10,000 lb or more must be marked with the following information in addition to the requirements of parts a and b above:

1. The approximate shipping weight of the equipment.

2. The calculated or actual center of gravity must be marked on the shipment or an accompanying loading diagram attached to the packing list.

d. All caution marks such as Fragile, This Side Up, etc, should be clearly visible and placed on at least two opposite sides of the shipping container or piece of equipment.

e. The shipment identification numbering system shall be established by the Contractor and used consistently for all equipment delivered to the site. No two shipments or pieces of equipment shall be assigned the same identification number.

5.3 Motor Bearing Lubricant

Oil filled bearings on motors shall be drained prior to shipment.

5.4 Provisions for Storage

Immediately upon receipt at the jobsite the Contractor shall receive, thoroughly inspect and determine that all equipment or material is in the as-shipped condition.

The Contractor shall assume all responsibility for the care, safeguarding, weather protection, fire protection, and temporary lay-up of all equipment and materials from the time of their receipt at the jobsite. Every effort shall be made to protect the equipment and materials at all times so that there is no deterioration that could in any way adversely affect the useful life or the suitableness of the equipment or material for the purpose for which it was furnished.

As a minimum, the Contractor shall provide indoor storage for the following:

1. Control panels
2. Control equipment - all types
3. Electrical devices - all types
4. Motors - electric and air
5. Motor starters

6. Spare parts

7. T-V equipment

All equipment stored outdoors shall be kept clean at all times, including during storage, handling, installation, and after installation until initial operation. In the storage yard, it shall be stored on sleepers or otherwise so it does not contact the earth.

The Contractor shall specify any special storage requirements for each shipment of equipment to the site.

6.0 SUPPLEMENTAL PROVISIONS

6.1 Conditions - Deviations and Nonconformances

No deviation or nonconformance from this Specification or applicable Federal, state, and local codes and standards invoked by this Specification shall be accepted until approved by the Purchaser. Deviations are considered departures from any requirement of this Specification. Uncorrectable nonconformances are considered to be conditions which cannot be corrected within the Specification requirements by rework or replacement.

The Contractor shall promptly document and notify the Engineer of all deviations and nonconformances from the Specification [such as deviations from applicable codes and/or drawings]. Further engineering, manufacturing, or fabrication after detection of any deviation or nonconformance prior to the Purchaser's approval shall be at the Contractor's risk. No departure from the Specification shall be binding on any party until an addendum or revision to the Specification has been issued by the Purchaser.

6.2 Subsuppliers/Subcontractors

Should the Contractor propose to purchase from a subsupplier/subcontractor any of the major pieces of equipment, material, or services specified herein, he shall identify in the proposal the subsupplier/subcontractor for the specific equipment, material, or services. These subsuppliers/ subcontractors shall be subject to approval by the Purchaser.

To the extent that they apply, the Contractor shall impose on each of the subsuppliers/subcontractors the complete requirements of this specification. He shall be directly responsible that the subsuppliers/subcontractors are completely aware of all of these requirements, and that they abide thereby.

6.3 Furnished by the Purchaser

The Purchaser shall furnish the following equipment, materials, services, and finish painting:

The Purchaser shall provide a Master Process Control System to sense, detect, control, and monitor all parameters necessary to ensure safe and proper operation of the entire integrated repowered unit. The Master Control System will consist of a central computer, computer peripheral equipment, time code generator, control and display consoles, and solar/nonsolar electric power control interfaces and master control software.

In addition, the Purchaser shall furnish and install:

1. 480-V, 3 phase, 60 Hz power field wiring to the Contractor's equipment

2. Interconnecting wiring and cabling between the Master Control System and the Contractor's equipment

3. Field checkout and testing in addition to that provided by Contractor

4. Heliostat Foundations

5. Site grading

6.4 Furnished by Contractor

The Contractor shall design, fabricate, deliver, and install a solar collector system composed of an array of heliostats and supporting power and control elements designed to interact with the Purchaser's Master Control system. The collector subsystem components shall consist of the following:

1. Heliostats, including reflective surface, structural support, drive units, control sensors, and pedestals.

2. Electromechanical and electrical controllers, including individual heliostat, heliostat field, and heliostat array controllers, control system interface electronics, ac/dc power supplies, and beam characterization system components.

3. Interconnecting wiring and cabling between Contractor's components.

4. Software required for the safe and proper operation of the control system.

5. Engineering services to perform final collector field analysis to characterize and optimize equipment arrangement and design and verify that the flux distribution meets the requirements of the receiver.

6.4.1 Materials and Services

The Contractor shall design, furnish, deliver, install, test, and place into commercial operation the heliostat field and associated equipment.

6.4.2 Tools

The Contractor shall provide the special tools or fixtures used only during erection/installation of the equipment. "Special" is defined as anything not normally or usually available in a power plant or readily available thereto. In addition, one complete set of special tools or fixtures required for maintenance and operation shall be furnished.

6.4.3 Spare Parts

The Contractor shall furnish all spare parts and expendable items (such as gaskets) that may be required during the preliminary operating period that precedes normal commercial operation. Also, a priced list of recommended spare parts for a longer term maintenance program after commercial operation shall be provided. When the spare parts order is placed, identify to the Purchaser any changes to codes/standards requirements referenced in the original purchase specification that must be complied with.

6.4.4 Installation, Operating, and Maintenance Instructions

Contractor shall send to the Purchaser 2 preliminary sets of installation, operating, and maintenance instructions no later than 6 months before intial shipment of equipment to the jobsite.

No later than 3 months before intial shipment of equipment to the jobsite, the Contractor shall submit to the Purchaser 20 bound copies as agreed and applicable of the installation, operation and maintenance instructions for the equipment furnished. One complete bound copy shall be sent to the Engineer.

One set of instructions, certified by the manufacturer, shall be packed with the equipment sent to the site. If "as-built" drawings or performance curves are not available when instruction books are required, a statement to this effect shall be prominently displayed therein, and provision shall be made for their addition when available but not later than 60 days after final shipment.

The operating instructions will be specific regarding the frequency of lubrication and the type of lubricants or equal to be used, which should include, but not be limited to, the following:

1. Total capacity of system

2. Recommended lubricant

3. Recommended operating pressure and temperatures

4. Adjustments, settings, and points requiring periodic maintenance and or inspection

All final instructions shall be certified by the manufacturer as applicable to the equipment furnished. Instruction manuals shall be on specific models of equipment purchased, not general information on the complete line or similar equipment. Information regarding equipment not purchased should not be shown. The equipment shall be specifically identified, such as by serial number, mark number, project number, project description, and Contract number.

A parts identification list shall be included with each set of instructions; the instructions shall include section and/or outline prints or illustrations marked to identify each numbered part and to locate it in relation to the equipment as a whole.

6.4.5 Data and Drawings

The Contractor shall submit all drawings in accordance with the agreed-upon schedule, which will be made part of the Contract. All drawings and data shall contain the following subject heading:

Contract No.

Heliostat Field - (plus additional description)

Newman Unit No. 1 Solar Repowering

El Paso Electric Company

The following shall be submitted by the Contractor:

6.4.5.1 All physical outlines, as required, to show the overall size and space requirements (including that for dismantling and maintenance) and the interrelationship of the various components. All outline drawings describing installed equipment shall include "north" arrows.

6.4.5.2 Cross sections and details, as required, to satisfy the Purchaser that all components are in conformance with the intent of the Specification and are satisfactory from the standpoint of design and physical arrangement

6.4.5.3 All information required by the Purchaser for the design and location of all connecting Purchaser-furnished structural, mechanical, or electrical items such as foundations, steel supports, piping, ducts, cables, conduit, etc

6.4.5.4 Wiring, elementary, and logic diagrams

6.4.5.5 Control equipment data sheets, instrument lists, pneumatic and electrical connections, outline and cutout drawings, and internal schematics to include data sheets with set points

6.4.5.6 Details of special features

6.4.5.7 Description of Contractor's recommended control systems/philosophy

6.4.5.8 An erection specification for the Contractor-furnished equipment that will be installed by others, detailing requirements for hauling, erecting, testing, and preparations for commercial operation.

6.4.5.9 Recommended procedures for cleaning

6.4.5.10 Recommended procedures for removal and reinstallation

6.4.5.11 Special storage requirements

All drawings submitted shall be in the form of two good, sharp, black and white, direct contact prints and one reproducible. The reproducible shall be on mylar film, unless the Contractor is unable to supply mylars, in which case he shall state in his proposal the type of reproducible he will supply. After review by the Purchaser, one print will be returned to the Contractor marked APPROVED or APPROVED AS REVISED. If marked APPROVED, the Contractor shall send one first generation silver microfilm aperture to the Purchaser. If marked APPROVED AS REVISED, the revisions indicated shall be made and clearly identified and drawings shall again be submitted to the Purchaser (in the manner indicated above), or the Purchaser shall be informed that the suggested changes cannot be made without prejudice to the Contractor's responsibility under warranty. Arrangements for production scheduling and the procurement of the necessary materials shall not be deferred, pending stamping of the drawings by the Purchaser.

6.4.6 Advisors

6.4.6.1 Advisors for unloading, placing into storage, erection, and start-up

The Contractor shall provide full-time coverage on a continuous basis, consisting of one or more advisors as required to provide a properly installed and operating unit. It is expected during the preliminary operation period advisors will be required on a sunlight only basis. The advisors shall not be withdrawn until the Contractor and Purchaser agree that their services are no longer required. Bidder will propose the number and duration of advisors that will be supplied.

6.4.7 Engineering Coordination Meeting

Upon Contract award, the Contractor shall arrange a meeting with the Engineers and Purchaser to discuss in detail those items pertaining to erection of specified equipment that may have an important effect upon engineering, design, the Contractor's planning, shipping sequence, shipping schedule, etc, such as:

1. Extent of shop fabrication as proposed by Contractor.

2. Size and weight of the major items handled during erection.

3. Method of lifting and placing the various items during erection.

4. Structural steel or concrete design concept, as it affects or is affected by erection requirements.

5. The sequence and timing of shipment of all components, so as to minimize storage at the site prior to erection.

6.4.8 Reliability and Maintenance (RAM) Program

The Contractor shall establish and maintain an effective RAM program that effectively and economically meets the RAM requirements of this Specification.

6.4.8.1 RAM Program Plan

One month after contract award, the Contractor shall submit a detailed RAM program plan. The final RAM report is due within one month of final shipment of the heliostats.

The Contractor's RAM Program Plan shall describe the methods of conducting and documenting the RAM Program in order to meet the RAM requirements of this Specification. The plan shall, as a minimum, contain those elements specified in Sections 6.5.5.4, 6.5.5.5, and 6.5.5.6.

6.4.8.2 Organization

The organization structure, capabilities, and responsibilities of the group responsible for fulfilling the RAM requirements of this Specification shall be described.

6.4.8.3 RAM Analysis

The purpose of this analysis is to demonstrate compliance with the RAM requirements of this Specification and to identify items that are critical to the proper operation of the heliostats. The Contractor shall describe the type of analysis performed, which may include, but not necessarily limited to the following:

a. Failure Modes and Effects Analysis (FMEA)

b. Fault Tree Analysis (FTA)

c. RAM Modeling techniques and predictions

Analyses previously performed shall be thoroughly revised to conform to the RAM requirements of this Specification. The sources and/or techniques used to derive MTBF and MTTR data shall be fully documented. The use of historical data is acceptable.

6.5 Furnished by the Bidder

6.5.1 Data and Drawings

The Bidder shall submit, with each copy of his proposal, one each of the following:

6.5.1.1 One copy of completed Technical Data Sheets

6.5.1.2 Outline drawings showing the general arrangement and approximate dimensions of the equipment proposed, including terminal points and clearances required for dismantling equipment. Also, an approach for determining the number and arrangement of heliostats (as described in Section 3.2).

6.5.1.3 List of all Contractor and subsupplier supplied motors required including horsepower and voltage

6.5.1.4 Description of Contractor's QA Program and copy of the proposed manufacturing and inspection plan

6.5.1.5 A list of all instruments and controls proposed including description and service. Also, confirmation of control approach or provision of an alternative concept that satisfies functional requirements. The bidder will supply control package or system cost separated from rest of quotation.

6.5.1.6 A description of the extent of shop fabrication modular construction included in the base proposal. Are other modular construction features available?

6.5.1.7 Frequency of BCS verification, time required to check and time required for realignment.

6.5.1.8 A list of power requirements for any heating/cooling equipment.

6.5.1.9 A list of requirements for the conversion and filtering equipment used by the heliostat control and drive equipment.

6.5.1.10 Times required to bring the heliostats from standby to Tracking mode.

6.5.1.11 A methodology for quantifying thermal power delivery by the heliostat field to the receiver aperature (as described in Section 3.8).

6.5.2 Provisions for Storage/Preventive Maintenance

As part of his proposal, the Bidder shall identify onsite storage requirements needed to maintain the equipment and material in the as-shipped condition. The Bidder shall also describe recommended cleaning methods and provide a plan for optimizing cleaning frequency. Failure to specify additional requirements with the proposal shall be considered as an indication that no additional requirements are necessary.

6.5.3 Reliability Data

As part of his proposal, the Bidder shall provide the following equipment qualification data in a Reliability Analysis Report:

6.5.3.1 Quantitative RAM (Reliability and Maintenance) Requirements

The Bidder shall provide estimates or data for the following, accompanied by a description of the basis for the values provided. These estimates or data shall be provided for the heliostat field as a whole, and for major subsystems and components.

1. Availability

2. Meantime to repair

3. Meantime between failures.

6.5.3.2 Documentation

A preliminary RAM program plan shall be included in the proposal.

NOTE: The following activities should not be included in the cost estimate provided by the Bidder:

1. Provision of detailed heliostat drawings identifying specific mounting and electrical interfaces.

2. Provision of a suggested optimized electrical power distribution one-line diagram for the heliostat field.

3. Provision of a specific description of suggested field control wiring architecture (control wiring should be integrated with power wiring).

4. Provision of a detailed definition of heliostat field operating modes and related control software requirements.

5. Provision of a detailed description of BCS hardware and software, and interfaces required with Master Control and other parts of plant. This also includes specific definition of electric power supply requirements.

6. Provision of motor and load list for heliostat field.

7. **Provision of wiring diagrams and specific descriptions of power and control wiring connections at each interface point.**

ATTACHMENT 1 - ENVIRONMENTAL CONDITIONS

1.0 GENERAL

1.1 Scope

This document lists representative environmental conditions for the Purchaser's Solar Repowered Newman Unit No. 1.

2.0 DOCUMENTS

The following documents form a part of this attachment to the extent stated herein:

MIL-STD-810B		Environmental Test Methods
Uniform Building Code	1979	International Conference of Building Officials
ANSI A58.1	1982	Minimum Design Loads for Building and Other Structures

3.0 ENVIRONMENT

Environmental conditions include winds and gusts, temperature extremes, rain, sleet, hail, snow, earthquakes, and soil conditions as follows.

3.1 Wind

The wind speed specifications during daylight hours at a reference height of 10 m (33 ft) shall be:

3.1.1 Speed Frequency

Wind power climatology was gathered from El Paso Airport, El Paso, Texas, over 32 years of data taking. The fastest wind speed recorded was 67 mph at 10 meters above ground. Miles per hour figures are over a 10 year period averaging.

100 year recurrence–71 mph

50 year recurrence–69 mph

25 year recurrence–66 mph

Speed:

m/s	MPH	Knots	Frequency Percentage
0.52 - 1.55	1.15 - 3.45	1 - 3	12.9
2.06 - 3.09	4.6 - 6.9	4 - 6	22.4
3.60 - 5.14	8.05 - 11.5	7 - 10	24.2
5.66 - 8.23	12.65 - 18.4	11 - 16	11.1
8.74 - 10.80	19.55 - 24.15	17 - 21	2.9
11.31 - 13.88	25.3 - 31.05	22 - 27	1.1
14.39 - 16.96	32.2 - 37.95	28 - 33	0.2
>17.48	>39.1	>34	<0.1

3.1.2 Wind Rise Rate

Under normal conditions, the maximum wind rise rate is 0.01 m/s² (0.02 mph/s). A maximum wind of 22 m/s (50 mph) from any direction may occur resulting from unusual rapid wind rise rates, such as severe thunderstorm gust fronts.

3.1.3 Survival Wind

A maximum wind speed, including gusts of 40 m/s (90 mph).

3.1.4 Dust Devils

Dust devils with wind speeds up to 17 m/s (38 mph).

3.1.5 Sandstorm Environment

Sandstorm limits within tests per MIL-STD-810B, Method 510.

3.2 Temperature

Ambient air temperatures range from -30°C to +50°C (-22°F to +122°F).

3.3 Precipitation

3.3.1 Rain

Average annual: 750 mm (30 in.) maximum 24-hr rate: 75 mm (3 in.).

3.3.2 Ice

Freezing rain and ice deposits in a layer up to 50 mm (2 in.) thick.

3.3.3 Hail

Diameter	25 mm (1 in.)
Specific Gravity	0.9
Terminal Velocity	23 m/s (75 ft/s)
Temperature	-6.7°C (20°F)

3.3.4 Snow

Maximum 24-hr rate: 0.3 m (1 ft); maximum loading: 250 Pa (5 lb/ft^2).

3.4 Insolation

3.4.1 Maximum Flux

Direct normal nominal insolation of 1100 Watts/square meter maximum at the plant site.

3.4.2 Rate of Change

The maximum rate of change of incident flux shall be assumed as that which would result from the passage of an opaque cloud across an otherwise clear sky where the sharp leading or trailing edges of the shadow move across the plant site at a velocity of 20 m/s (45 mph).

A-5

3.5 Soil Conditions

The soil conditions and preliminary foundation design recommendations are described in the Engineers' Report Number DE-FC-03-823F11677-2.

APPENDIX I

APPENDIX I

The following drawings were prepared by the Texas State Department of Highways and Public Transportation to illustrate the relocation of Farm-to-Market Road 2529.

Page	Drawing Number	Drawing Title
I-2	IPE 652 SH 1	Plans of Proposed State Highway Improvement-Relocation of FM 2529
I-3	IPE 652 SH 5	Typical Sections - Summary of Culverts
I-4	IPE 652 SH 6	Estimate Summary
I-5	IPE 652 SH 15	Map of Drainage Areas and Runoff Tabulations for Each

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APPENDIX J

APPENDIX J

The following flow diagrams, electrical diagrams, piping and instrumentation diagrams, and sketches are included in Appendix J:

Page	Drawing Number	Drawing Title
J-2	14380-Legend	Symbols for P&I Diagrams - Solar Repowering
J-3	14380-PID-3-1A-SR	P&I Diagram - Solar Repowering Main and High Pressure Steam Systems
J-4	14380-PID-3-1B-SR	P&I Diagram - Solar Repowering Main and High Pressure Steam Systems
J-5	14380-PID-3-2-SR	P&I Diagram - Solar Repowering Cold and Hot Reheat System
J-6	14380-PID-3-4-SR	P&I Diagram - Solar Repowering Extraction Steam System
J-7	14380-PID-6-1A-SR	P&I Diagram - Solar Repowering Feedwater System
J-8	14380-PID-6-1B-SR	P&I Diagram - Solar Repowering Feedwater System
J-9	14380-PID-6-1C-SR	P&I Diagram - Solar Repowering Feedwater System
J-10	14380-PID-6-6-SR	P&I Diagram - Solar Repowering Solar Heater Drain, Vent, and Relief System
J-11	14380-PID-11-3A-SR	P&I Diagram - Solar Repowering Boiler Blowdown, Vent, and Drain System
J-12	14380-PID-11-3B-SR	P&I Diagram - Solar Repowering Boiler Blowdown, Vent, and Drain System
J-13	14380-FSK-3-8-SR	Flow Diagram - Solar Repowering Fossil Boiler/Solar Recirculation Startup System
J-14	14380-EW-1A-1	Main One Line Diagram - Solar Repowering System
J-15	14380-EW-3A-1	One Line Diagram - 480 V Motor Control Centers
J-16	14380-FM-2A-SR-1	Flow Diagram - Main, Reheat, and Extraction Steam Lines
J-17	14380-FM-3A-SR-1	Flow Diagram - Boiler Feed Pump Suction and Discharge Lines
J-18	14380-WT-1	Sketch - Condensate Polishing System

HORIZONTAL CENTRIFUGAL PUMP
U - TUBE HEATER
FIXED TUBE HEATER
SOLAR SUPERHEATER PANEL
DESH DESUPERHEATER
GATE VALVE
GLOBE VALVE
VALVE NORMALLY CLOSED
CHECK VALVE
NON-RETURN VALVE
MOTOR OPERATED VALVE
L.C. LOCKED CLOSED VALVE
L.O. LOCKED OPEN VALVE
PRESSURE RELIEF OR SAFETY VALVE
S SOLENOID OPERATED VALVE
AIR OPERATED VALVE
T - STRAINER
FLANGE
BLIND FLANGE
REDUCER
MULTIPLE PRESSURE RESTRICTING ORIFICE

FIXED RESTRICTING ORIFICE
FLOW NOZZLE
CONTROL VALVE WITH HAND JACK
DEAERATOR
CL. 151 DISSIMILAR WELD AT CLASS CHANGE
STRAINER
T STEAM TRAP
E POWER OPERATED SAFETY VALVE
NEEDLE VALVE

FS FLOW SWITCH
FE FLOW ELEMENT
FI FLOW INDICATOR
FT FLOW TRANSMITTER
LT LEVEL TRANSMITTER
RO RESTRICTION ORIFICE
PI PRESSURE INDICATOR
PS PRESSURE SWITCH
PIS PRESSURE INDICATING SWITCH
PT PRESSURE TRANSMITTER
PIT PRESSURE INDICATING TRANSMITTER
TE TEMPERATURE ELEMENT
TI TEMPERATURE INDICATOR
TS TEMPERATURE SWITCH
TIS TEMPERATURE INDICATING SWITCH
TT TEMPERATURE TRANSMITTER
TW THERMOWELL
AOV AIR OPERATED VALVE
LY LEVEL TRANSDUCER
LOGIC INTEGRAL TO DCS
LOGIC INTEGRAL TO DCS(OPERATOR ACCESSIBLE)
SHARED DISPLAY
TY TEMPERATURE TRANSDUCER

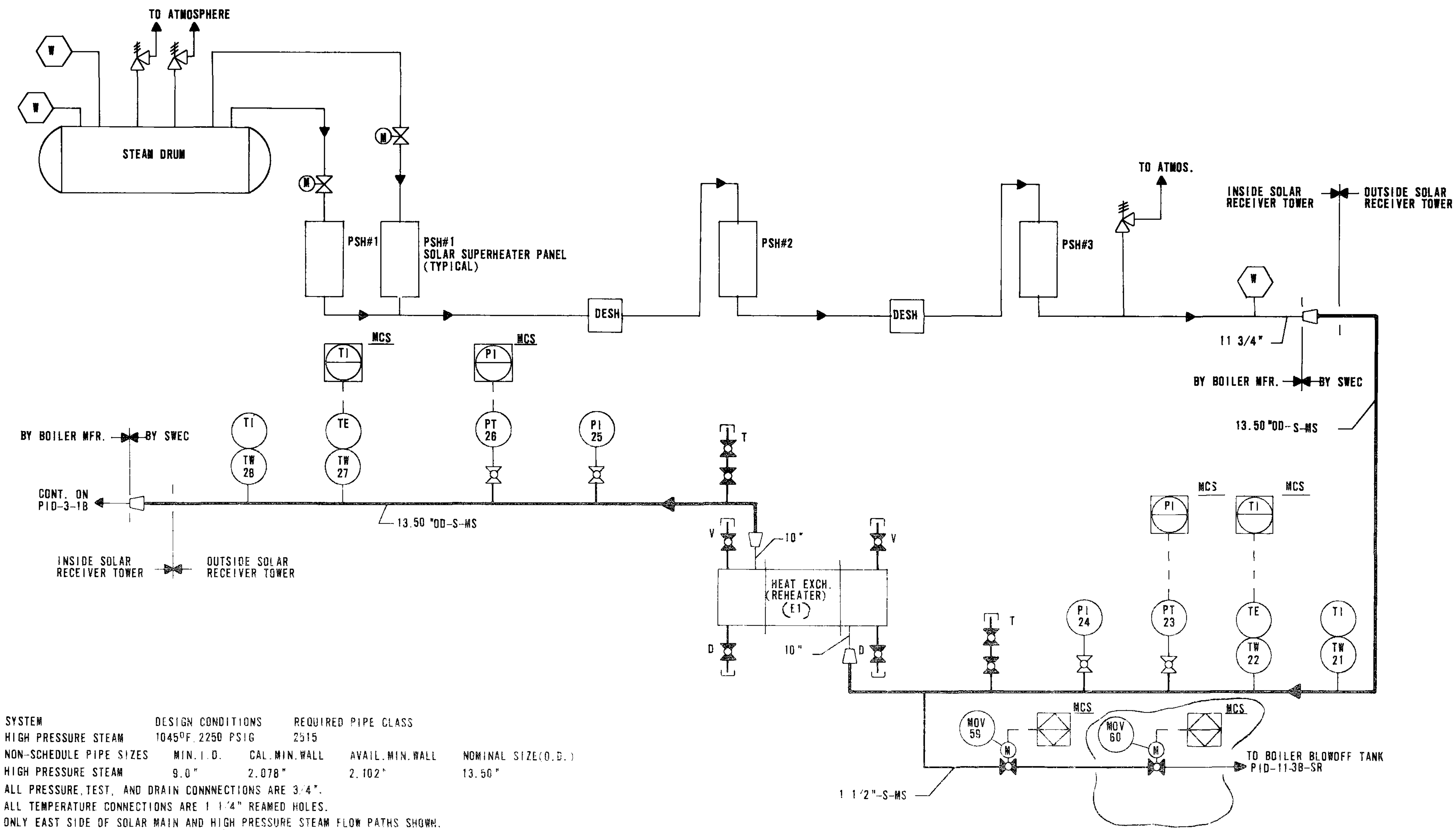
FV FLOW CONTROL VALVE
LV LEVEL CONTROL VALVE
TV TEMPERATURE CONTROL VALVE
RV RELIEF VALVE
SV SAFETY VALVE
NRV NON-RETURN VALVE
I/P CURRENT TO PNEUMATIC CONVERTER
ATV AUTOMATIC TRIP VALVE
MOV MOTOR OPERATED VALVE
SOV SOLENOID OPERATED VALVE
ZS POSITION SWITCH
MCS MASTER CONTROL SYSTEM
SRCS SOLAR RECEIVER CONTROL SYSTEM
BCS BOILER CONTROL SYSTEM
TCS TURBINE CONTROL SYSTEM
AIR LINE
I INTERCONNECTING LOGIC
FY FLOW TRANSDUCER
CBV CONTINUOUS BLOWDOWN VALVE
W WEST SIDE OF SOLAR RECEIVER

PSH PRIMARY SUPERHEATER
BD BOILER DRAIN
FSH FINAL SUPERHEATER
L.O. LOCKED OPEN
L.C. LOCKED CLOSED
W WATER
S STEAM
FW FEEDWATER
MS MAIN & HIGH PRESSURE STEAM
CR COLD REHEAT
HR HOT REHEAT
ES EXTRACTION STEAM
HD HEATER DRAIN
FO FAIL OPEN ON LOSS OF AIR
FC FAIL CLOSED ON LOSS OF AIR
PTF TUBING STANDARD FOR ANSI B31.1
STRT TEMPORARY STRAINER
DCS DISTRIBUTED CONTROL SYSTEM
T TEST CONNECTION
V VENT CONNECTION
D DRAIN CONNECTION

4	3	2	1	ISSUE
		SC	SC	PREP
		RR	RR	REVIEW
		BMJ	BMJ	APP
		9-27-83	7-22-83	DATE

SYMBOLS FOR P & I DIAGRAM
SOLAR REPOWERING
UNIT NO. 1 - NEWMAN POWER STATION
EL PASO ELECTRIC COMPANY
STONE & WEBSTER ENGINEERING CORPORATION
14380—LEGEND
J-2

DESCRIPTION NUMBER	SIZE	NUMBER OF VALVES
MOV-VOS250-F	1 1/2"	(2)
VOS250-F	3/4"	12



NOTES

1. SYSTEM — DESIGN CONDITIONS — REQUIRED PIPE CLASS
   HIGH PRESSURE STEAM — 1045°F, 2250 PSIG — 2515
2. NON-SCHEDULE PIPE SIZES — MIN. I.D. — CAL. MIN. WALL — AVAIL. MIN. WALL — NOMINAL SIZE (O.D.)
   HIGH PRESSURE STEAM — 9.0" — 2.078" — 2.102" — 13.50"
3. ALL PRESSURE, TEST, AND DRAIN CONNNECTIONS ARE 3/4".
4. ALL TEMPERATURE CONNECTIONS ARE 1 1/4" REAMED HOLES.
5. ONLY EAST SIDE OF SOLAR MAIN AND HIGH PRESSURE STEAM FLOW PATHS SHOWN.
   WEST SIDE FLOW PATH INDICATED BY ⟨W⟩
6. UPON COMPLETION OF PIPING DRAWINGS LOCAL VENT, DRAIN, AND TRAP CONNECTIONS SHALL BE INCORPORATED AS REQUIRED.
7. ALL GLOBE VALVES 2" AND SMALLER CL. 2515 ARE VOS250-F.
8. ALL EQUIPMENT AND INSTRUMENTS TO BE PREFIXED WITH "MS" EXCEPT WHERE A DIFFERENT PREFIX IS SHOWN.
9. REFER TO B & W DRAWING NOS. 164095D, 164096D, & 164097D FOR SOLAR RECEIVER INSTRUMENTATION.

ALL LINE SIZES ARE PRELIMINARY

4	3	2	1	ISSUE
		SC DRL	SC DRL	PREP
		RR / GH	RR / RWT	REVIEW
		BMJ	BMJ	APP
		9-27-83	7-22-83	DATE

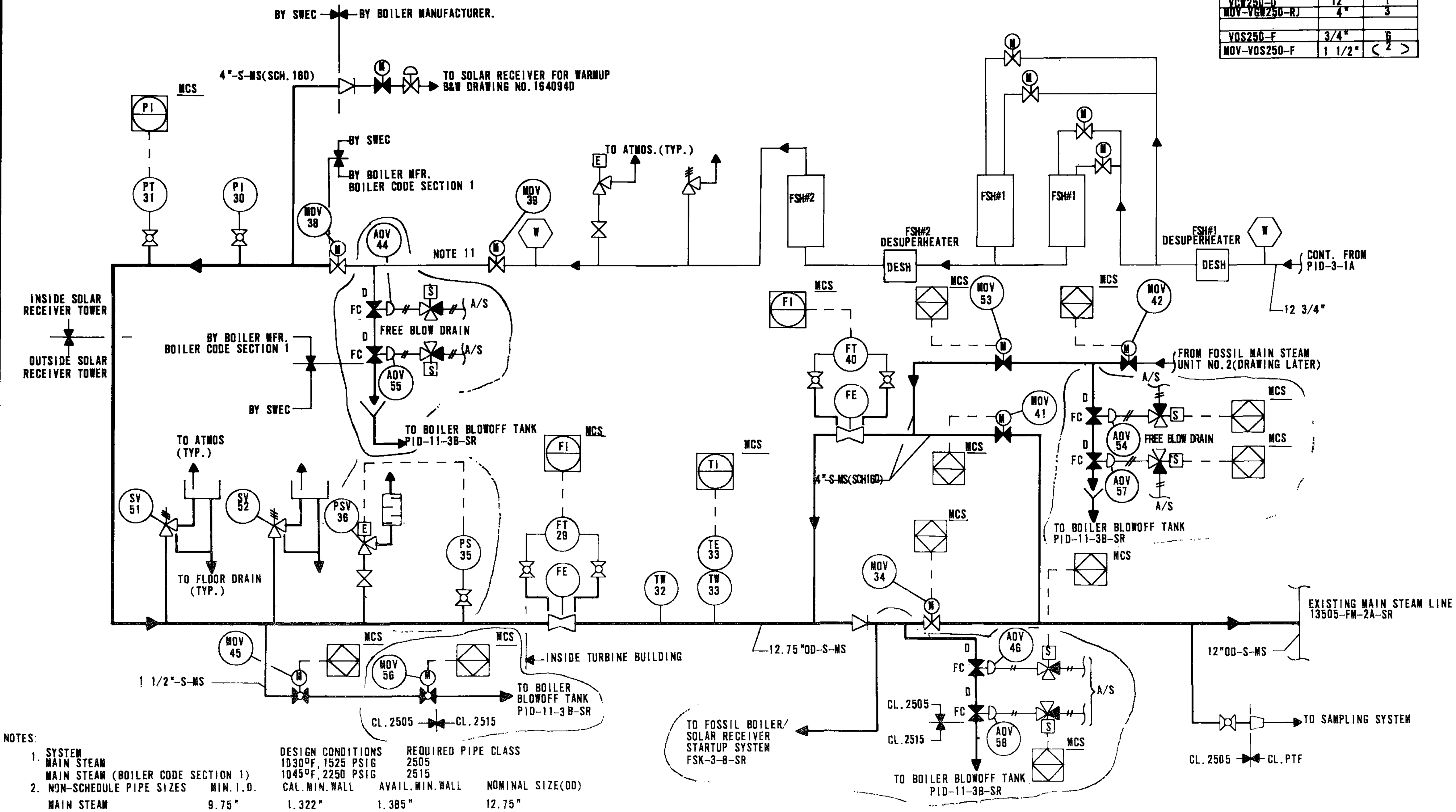
P & I DIAGRAM - SOLAR REPOWERING
MAIN & HIGH PRESSURE STEAM SYSTEMS
UNIT NO. 1 - NEWMAN POWER STATION
EL PASO ELECTRIC COMPANY

STONE & WEBSTER ENGINEERING CORPORATION

14380-PID-3-1A-SR

J-3

DESCRIPTION NUMBER	SIZE	NO. OF VALVES
MOV-VGW250-RJ	12"	3
VCW250-D	12"	1
MOV-VGW250-RJ	4"	3
VOS250-F	3/4"	6
MOV-VOS250-F	1 1/2"	2



NOTES:

1. SYSTEM — DESIGN CONDITIONS — REQUIRED PIPE CLASS
   MAIN STEAM — 1030°F, 1525 PSIG — 2505
   MAIN STEAM (BOILER CODE SECTION 1) — 1045°F, 2250 PSIG — 2515
2. NON-SCHEDULE PIPE SIZES

NON-SCHEDULE PIPE SIZES	MIN.I.D.	CAL.MIN.WALL	AVAIL.MIN.WALL	NOMINAL SIZE(OD)
MAIN STEAM	9.75"	1.322"	1.385"	12.75"

3. ALL PRESSURE, TEST, AND DRAIN CONNECTIONS ARE 3/4".
4. ALL TEMPERATURE CONNECTIONS ARE 1 1/4" REAMED HOLES.
5. ONLY EAST SIDE OF SOLAR MAIN AND HIGH PRESSURE STEAM FLOW PATH SHOWN. WEST SIDE FLOW PATH INDICATED BY ⟨W⟩ .
6. UPON COMPLETION OF PIPING DRAWINGS, LOCAL VENT, DRAIN AND TRAP CONNECTIONS SHALL BE INCORPORATED.
7. ALL GLOBE VALVES 2" AND SMALLER CL.2505 ARE VOS250-F.
8. ALL GATE VALVES 2 1/2" AND LARGER CL.2505 ARE VGW250-RJ.
9. REFER TO B&W DRAWING NOS. 164095D, 164096D, AND 164097D FOR SOLAR RECEIVER INSTRUMENTATION.
10. ALL CHECK VALVES 2 1/2" AND LARGER CL.2505 ARE VCW250-D.
11. MOV38, MOV39, AOV44, AOV55, SOV44, &SOV55 TO BE SUPPLIED BY SWEC
12. ALL EQUIPMENT AND INSTRUMENT NUMBERS TO BE PREFIXED WITH "MS" EXCEPT WHERE A DIFFERENT PREFIX IS SHOWN.

ALL LINE SIZES ARE PRELIMINARY

4	3	2	1	ISSUE
		SC DPL	SC DPL	PREP
		RR / EHH	QR / RWJ	REVIEW
		BMJ	BMJ	APP
		7-27-83	7-22-83	DATE

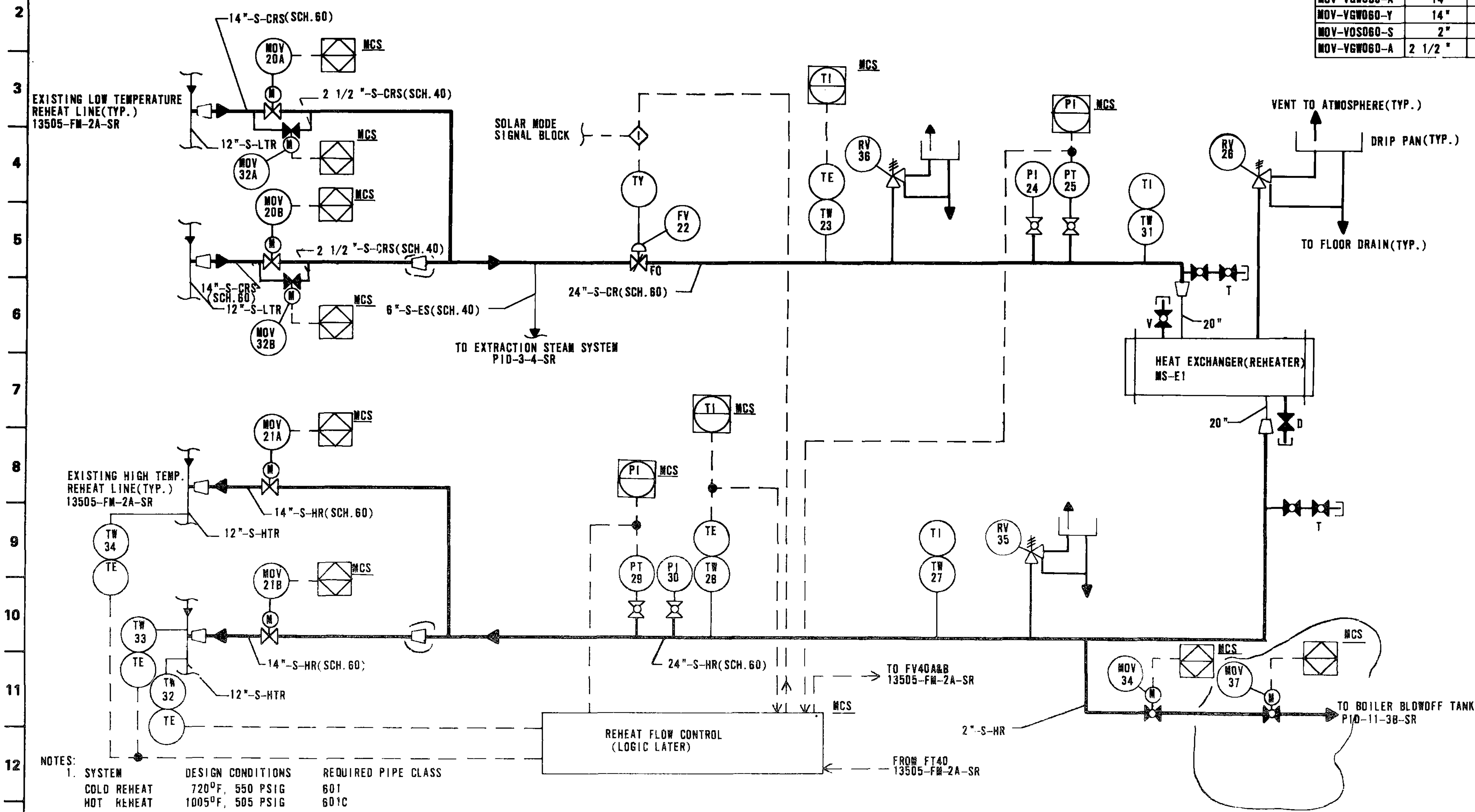
P & I DIAGRAM – SOLAR REPOWERING
MAIN & HIGH PRESSURE STEAM SYSTEMS
UNIT NO.1 – NEWMAN POWER STATION
EL PASO ELECTRIC COMPANY

STONE & WEBSTER ENGINEERING CORPORATION

RET 14380–PID–3–1B–SR

J-4

DESCRIPTION NUMBER	SIZE	NO. OF VALVES
VOS060-C	3/4"	5
VOS060-S	3/4"	4
VGS060-S	3/4"	1
MOV-VGW060-A	14"	2
MOV-VGW060-Y	14"	2
MOV-VOS060-S	2"	2
MOV-VGW060-A	2 1/2 "	2



NOTES:

1. SYSTEM — DESIGN CONDITIONS — REQUIRED PIPE CLASS

SYSTEM	DESIGN CONDITIONS	REQUIRED PIPE CLASS
COLD REHEAT	720°F, 550 PSIG	601
HOT REHEAT	1005°F, 505 PSIG	601C

2. ALL PRESSURE, TEST, AND DRAIN CONNECTIONS ARE 3/4"
3. ALL TEMPERATURE CONNECTIONS ARE 1 1/4"S.W. FOR COLD REHEAT LINE, AND 1 1/2" REAMED HOLES FOR HOT REHEAT LINE.
4. UPON COMPLETION OF PIPING DRAWINGS, LOCAL VENT, DRAIN, AND TRAP CONNECTIONS SHALL BE INCORPORATED AS REQUIRED.
5. ALL GLOBE VALVES 2" AND SMALLER CL.601 AND CL.601C ARE VOS060-C AND VOS060-S RESPECTIVELY.
6. ALL GATE VALVES 2" AND SMALLER CL.601C ARE VGS060-S.
7. ALL GATE VALVES 2 1/2" AND LARGER CL.601 AND 601C ARE VGW060-A AND VGW060-Y RESPECTIVELY.
8. ALL INSTRUMENT AND EQUIPMENT NUMBERS TO BE PREFIXED WITH "HR" OR "CR" EXCEPT WHERE A DIFFERENT PREFIX IS SHOWN.

ALL PIPE SIZES ARE PRELIMINARY

4	3	2	1	ISSUE
		SC	SC	PREP
				REVIEW
				APP
		9-29-83	7-22-83	DATE

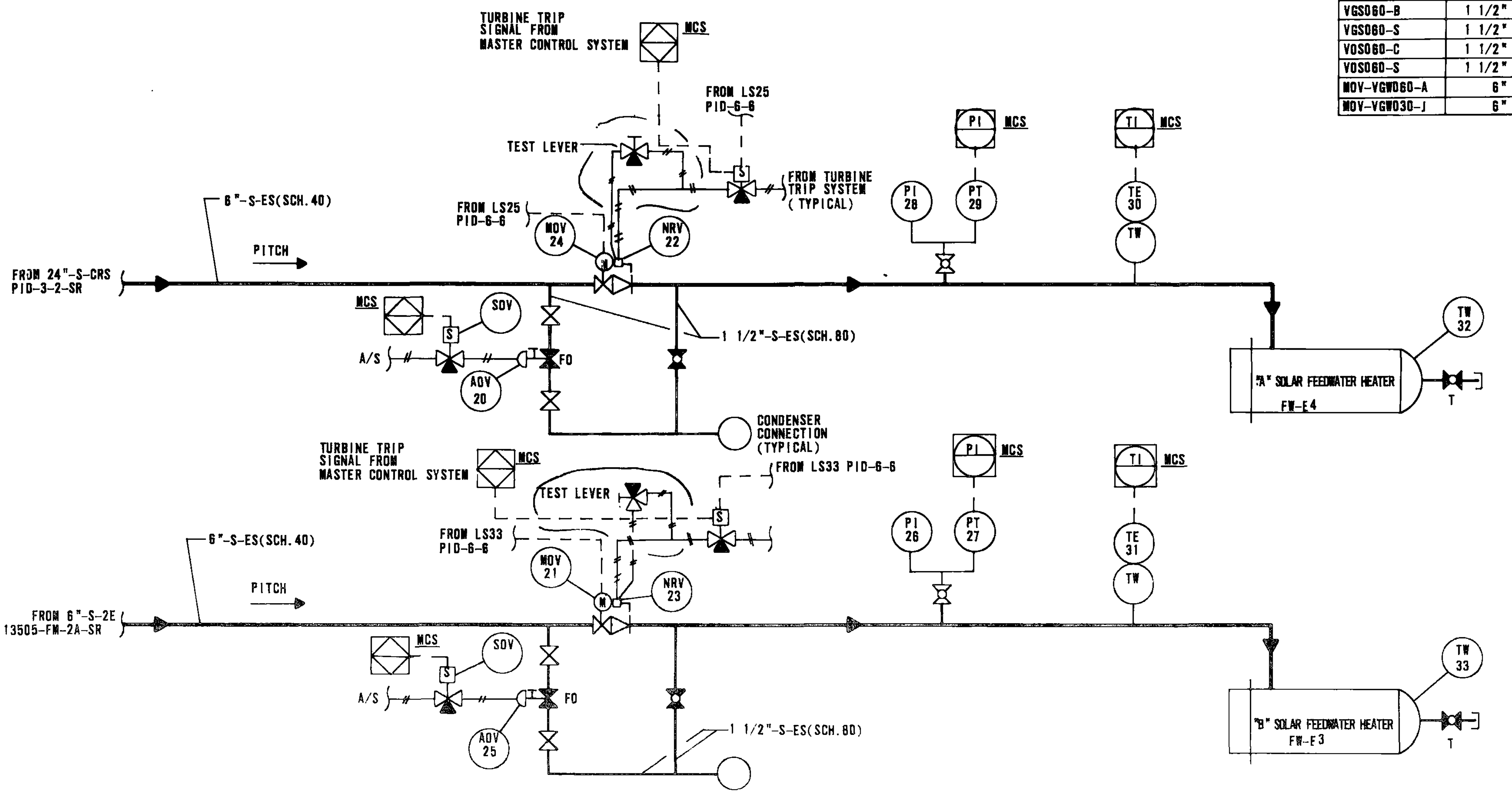
P&I DIAGRAM-SOLAR REPOWERING
COLD AND HOT REHEAT SYSTEM
UNIT NO.1 - NEWMAN POWER STATION
EL PASO ELECTRIC COMPANY

STONE & WEBSTER ENGINEERING CORPORATION

14380-PID-3-2-SR

J-5

DESCRIPTION NUMBER	SIZE	NO. OF VALVES
VOS060-C	3/4"	2
VOS060-S	3/4"	2
VGS060-B	1 1/2"	2
VGS060-S	1 1/2"	2
VOS060-C	1 1/2"	1
VOS060-S	1 1/2"	1
MOV-VGW060-A	6"	1
MOV-VGW030-J	6"	1



NOTES:

1. SYSTEM — DESIGN CONDITIONS — REQUIRED PIPE CLASS

SYSTEM	DESIGN CONDITIONS	REQUIRED PIPE CLASS
"A" SOLAR HEATER EXTRACTION	720°F, 550PSIG/FULL VAC.	601
"B" SOLAR HEATER EXTRACTION	790°F, 250PSIG/FULL VAC	301C

2. ALL PRESSURE AND TEST CONNECTIONS ARE 3/4".
3. ALL TEMPERATURE CONNECTIONS ARE 1 1/4" S.W.
4. UPON COMPLETION OF PIPING DRAWINGS, DRAIN LINES TO BE PROVIDED AT THE BOTTOM OF VERTICAL PIPE RUNS.
5. ALL GLOBE VALVES 2" AND SMALLER CL.601 AND 301C ARE VOS060-C AND VOS060-S RESPECTIVELY.
6. ALL GATE VALVES 2" AND SMALLER CL.601 AND 301C ARE VGS060-B AND VGS060-S RESPECTIVELY.
7. ALL GATE VALVES 2 1/2" AND LARGER CL.601 AND 301C ARE VGW060-A AND VGW030-J RESPECTIVELY.
8. ALL INSTRUMENT AND EQUIPMENT NUMBERS TO BE PREFIXED WITH "ES" EXCEPT WHERE A DIFFERENT PREFIX IS SHOWN.

ALL LINE SIZES ARE PRELIMINARY

4	3	2	1	ISSUE
		SC	SC	PREP
				REVIEW
		BMJ	BMJ	APP
		4-29-83	7-22-83	DATE

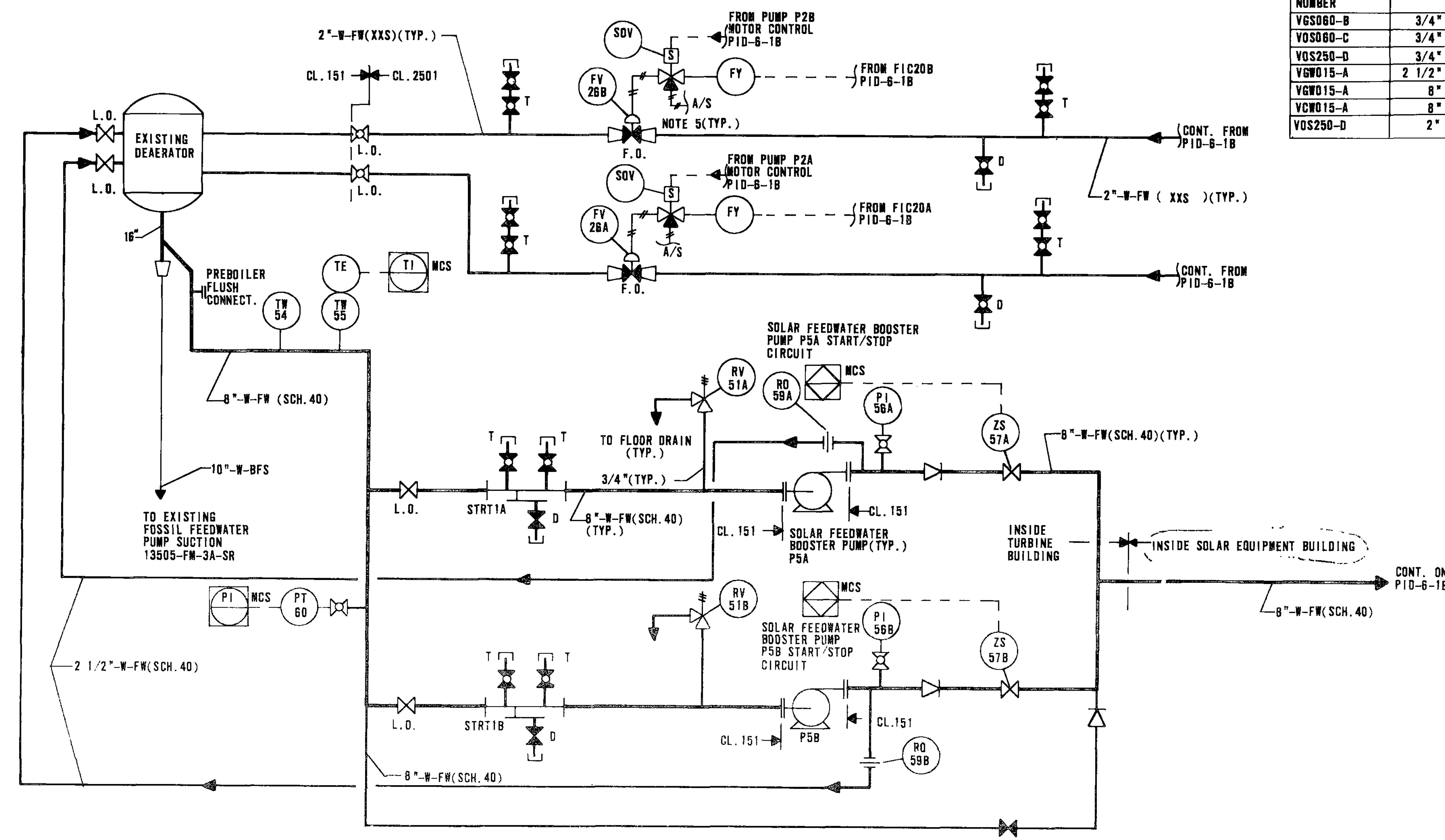
P & I DIAGRAM - SOLAR REPOWERING EXTRACTION STEAM SYSTEM
UNIT NO. 1 - NEWMAN POWER STATION
EL PASO ELECTRIC COMPANY

STONE & WEBSTER ENGINEERING CORPORATION

14380-PID-3-4-SR

J-6

DESCRIPTION NUMBER	SIZE	NO. OF VALVES
VGS060-B	3/4"	2
VOS060-C	3/4"	7
VOS250-D	3/4"	10
VGW015-A	2 1/2"	2
VGW015-A	8"	5
VCW015-A	8"	3
VOS250-D	2"	2



NOTES:

1. SYSTEM

SYSTEM	DESIGN CONDITIONS	REQUIRED PIPE CLASS
SOLAR FEEDWATER BOOSTER PUMP SUCTION	308°F, 95 PSIG	CL.151
SOLAR FEEDWATER BOOSTER PUMP DISCHARGE	308°F, 130 PSIG	CL.151

2. ALL LOCAL PRESSURE, TEST, AND DRAIN CONNECTIONS ARE 3/4"
3. ALL TEMPERATURE CONNECTIONS ARE 1 1/4" S.W.
4. UPON COMPLETION OF PIPING DRAWINGS, LOCAL VENTS AND DRAINS WILL BE INCORPORATED AS REQUIRED.
5. RECIRCULATION CONTROL VALVE TO BE LOCATED AS CLOSE AS PRACTICAL TO THE DEAERATOR.
6. ALL GATE VALVES 2" AND SMALLER CL.151 ARE VGS060-B.
7. ALL GLOBE VALVES 2" AND SMALLER CL.151 AND CL.2501 ARE VOS060-C AND VOS250-D RESPECTIVELY.
8. ALL GATE VALVES 2 1/2" AND LARGER CL.151 ARE VGW015-A.
9. ALL CHECK VALVES 2 1/2" AND LARGER CL.151 ARE VCW015-A.
10. ALL INSTRUMENT AND EQUIPMENT NUMBERS TO BE PREFIXED WITH "FW-" EXCEPT WHERE A DIFFERENT PREFIX IS SHOWN.

ALL LINE SIZES ARE PRELIMINARY

4	3	2	1	ISSUE
		SC	SC	PREP
			RWJ	REVIEW
		BMJ	BMS	APP
		9-27-83	7-22-83	DATE

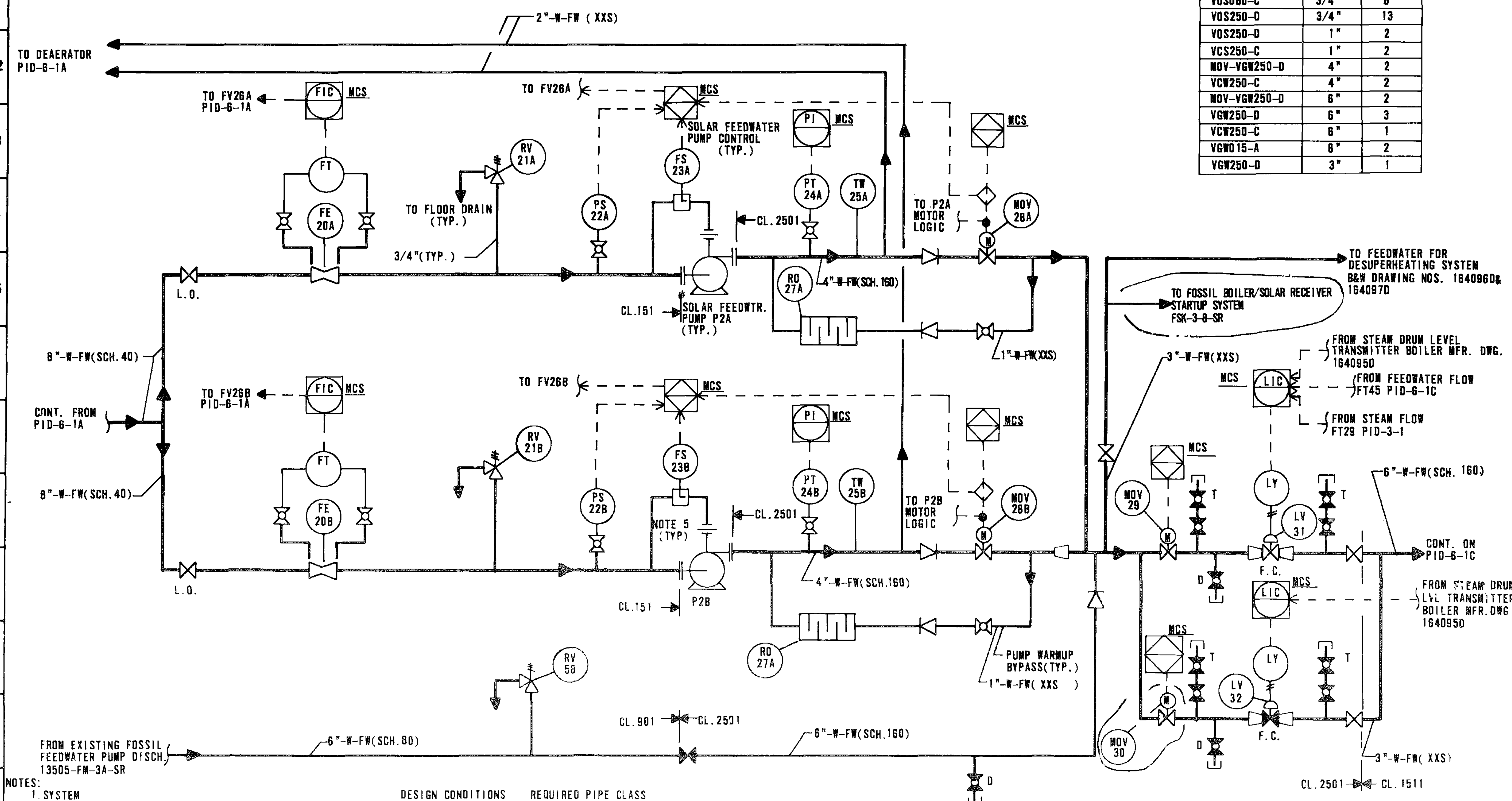
P & I DIAGRAM- SOLAR REPOWERING
FEEDWATER SYSTEM
UNIT NO.1 - NEWMAN POWER STATION
EL PASO ELECTRIC COMPANY

STONE & WEBSTER ENGINEERING CORPORATION

14380-PID-6-1A-SR

J-7

DESCRIPTION NUMBER	SIZE	NO. OF VALVES
VOS060-C	3/4"	6
VOS250-D	3/4"	13
VOS250-D	1"	2
VCS250-C	1"	2
MOV-VGW250-D	4"	2
VCW250-C	4"	2
MOV-VGW250-D	6"	2
VGW250-D	6"	3
VCW250-C	6"	1
VGW015-A	8"	2
VGW250-D	3"	1



NOTES:

1. SYSTEM

	DESIGN CONDITIONS	REQUIRED PIPE CLASS
SOLAR FEEDWATER PUMP DISCHARGE TO CONTROL STATION DOWNSTREAM BLOCK VALVE	315°F, 3710 PSIG	CL.2501
SOLAR FEEDWATER PUMP DISCHARGE TO CONTROL STATION DOWNSTREAM BLOCK VALVE(PIPING ONLY)	315°F, 3100 PSIG	CL.2501

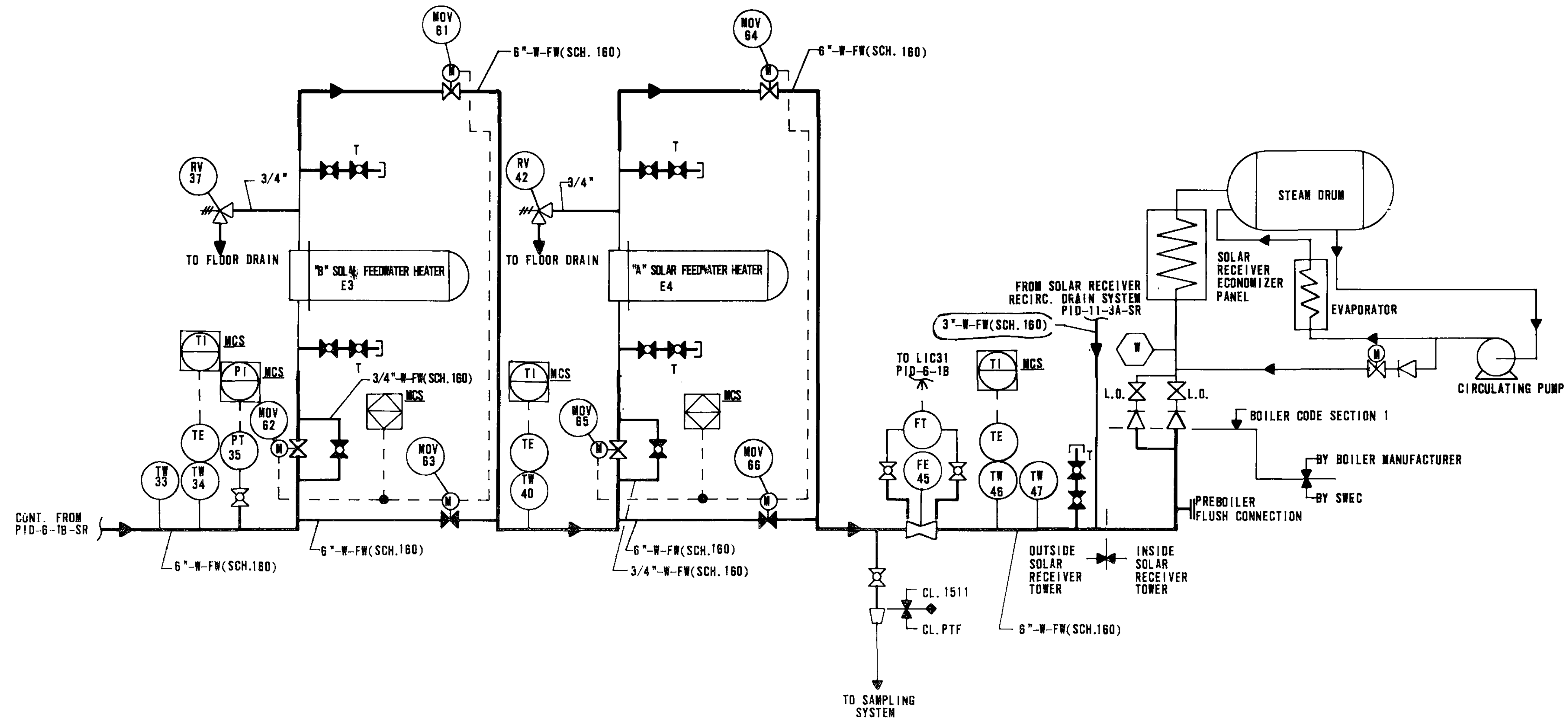
2. ALL LOCAL PRESSURE, TEST, AND DRAIN CONNECTIONS ARE 3/4".
3. ALL TEMPERATURE CONNECTIONS ARE 1 1/4" REAMED HOLES.
4. UPON COMPLETION OF PIPING DRAWINGS, LOCAL VENTS AND DRAINS WILL BE INCORPORATED AS REQUIRED.
5. BALANCE DRUM LEAKOFF LINE TO BE PROVIDED IF REQUIRED BY PUMP MANUFACTURER.
6. ALL GLOBE VALVES 2" AND SMALLER CL.151 AND CL.2501 ARE VOS060-C AND VOS250-D RESPECTIVELY.
7. ALL CHECK VALVES 2" AND SMALLER CL.2501 ARE VCS250-C.
8. ALL GATE VALVES 2 1/2" AND LARGER CL.151 AND CL.2501 ARE VGW015-A AND VGW250-D RESPECTIVELY.
9. ALL CHECK VALVES 2 1/2" AND LARGER CL.2501 ARE VCW250-C.
10. ALL INSTRUMENT AND EQUIPMENT NUMBERS TO BE PREFIXED WITH "FW-" EXCEPT WHERE A DIFFERENT PREFIX IS SHOWN.

ALL LINE SIZES ARE PRELIMINARY

4	3	2	1	ISSUE	
		SC	SC	PREP	P & I DIAGRAM - SOLAR REPOWERING FEEDWATER SYSTEM
				REVIEW	UNIT NO.1 - NEWMAN POWER STATION EL PASO ELECTRIC COMPANY
		BMJ	BMJ	APP	STONE & WEBSTER ENGINEERING CORPORATION
		9-27-83	7-22-83	DATE	14380-PID-6-1B-SR

J-8

DESCRIPTION NUMBER	SIZE	NO. OF VALVES
VOS150-G	3/4"	16
MOV-VGW150-F	6"	6



NOTES:

1. SYSTEM

SYSTEM	DESIGN CONDITIONS	REQUIRED PIPE CLASS
HEATER "B" INLET	315°F, 2630 PSIG	CL. 1511
HEATER "B" OUTLET TO HEATER "A" INLET	407°F, 2630 PSIG	CL. 1511
HEATER "A" OUTLET TO ECONOMIZER INLET	480°F, 2630 PSIG	CL. 1511

2. ALL LOCAL PRESSURE, TEST, SAMPLE AND DRAIN CONNECTIONS ARE 3/4".
3. ALL TEMPERATURE CONNECTIONS ARE 1 1/4" REAMED HOLES.
4. UPON COMPLETION OF PIPING DRAWINGS, LOCAL VENTS AND DRAINS SHALL BE INCORPORATED AS REQUIRED.
5. ONLY EAST SIDE OF SOLAR FEEDWATER FLOW PATH SHOWN IN SOLAR RECEIVER. WEST SIDE FLOW PATH INDICATED BY ⟨W⟩.
6. ALL GLOBE VALVES 2" AND SMALLER CL. 1511 ARE VOS150-G.
7. ALL GATE VALVES 2 1/2" AND LARGER CL. 1511 ARE VGW150-F.
8. REFER TO B&W DRAWING NO. 164095D FOR SOLAR RECEIVER INSTRUMENTATION.
9. ALL INSTRUMENT AND EQUIPMENT NUMBERS TO BE PREFIXED WITH "FW" EXCEPT WHERE A DIFFERENT PREFIX IS SHOWN.

ALL LINE SIZES ARE PRELIMINARY

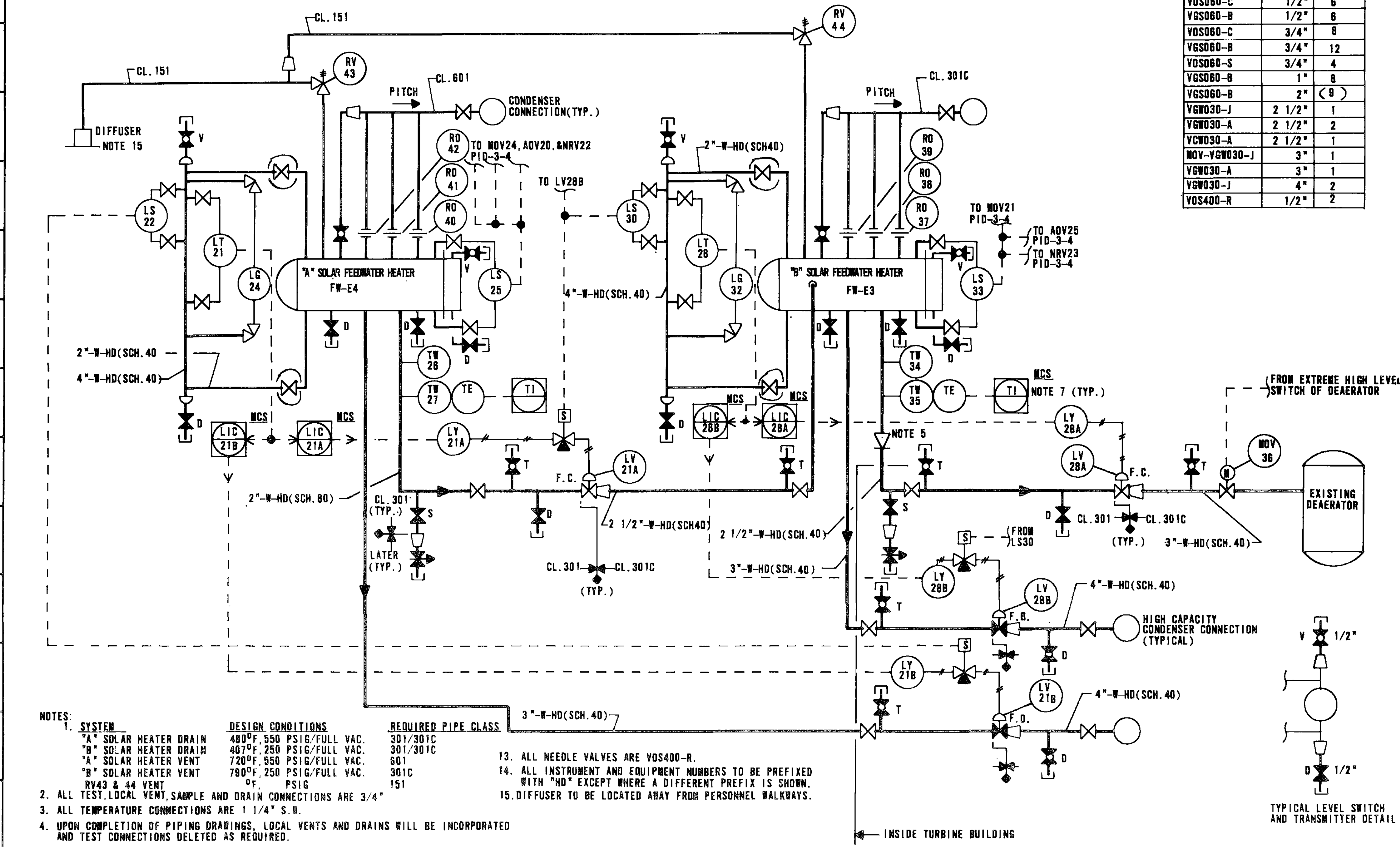
4	3	2	1	ISSUE
		SC	SC	PREP
				REVIEW
				APP
		7-27-83	7-22-83	DATE

P & I DIAGRAM - SOLAR REPOWERING FEEDWATER SYSTEM
UNIT NO. 1 - NEWMAN POWER STATION
EL PASO ELECTRIC COMPANY
STONE & WEBSTER ENGINEERING CORPORATION

14380-PID-6-1C-SR

J-9

DESCRIPTION NUMBER	SIZE	NO. OF VALVES
VOS060-C	1/2"	6
VGS060-B	1/2"	6
VOS060-C	3/4"	8
VGS060-B	3/4"	12
VOS060-S	3/4"	4
VGS060-B	1"	8
VGS060-B	2"	(9)
VGW030-J	2 1/2"	1
VGW030-A	2 1/2"	2
VCW030-A	2 1/2"	1
MOV-VGW030-J	3"	1
VGW030-A	3"	1
VGW030-J	4"	2
VOS400-R	1/2"	2



NOTES:

1. SYSTEM / DESIGN CONDITIONS / REQUIRED PIPE CLASS

SYSTEM	DESIGN CONDITIONS	REQUIRED PIPE CLASS
"A" SOLAR HEATER DRAIN	480°F, 550 PSIG/FULL VAC.	301/301C
"B" SOLAR HEATER DRAIN	407°F, 250 PSIG/FULL VAC.	301/301C
"A" SOLAR HEATER VENT	720°F, 550 PSIG/FULL VAC.	601
"B" SOLAR HEATER VENT	790°F, 250 PSIG/FULL VAC.	301C
RV43 & 44 VENT	°F, PSIG	151

2. ALL TEST, LOCAL VENT, SAMPLE AND DRAIN CONNECTIONS ARE 3/4"
3. ALL TEMPERATURE CONNECTIONS ARE 1 1/4" S.W.
4. UPON COMPLETION OF PIPING DRAWINGS, LOCAL VENTS AND DRAINS WILL BE INCORPORATED AND TEST CONNECTIONS DELETED AS REQUIRED.
5. LOCATE CHECK VALVE NEAR HEATER
6. LS PIPING IS 1", LC AND LT PIPING IS 2".
7. INSTRUMENTS BOXED IN ARE SHARED WITHIN THE DISTRIBUTED CONTROL SYSTEM
8. ALARMS, COMPUTER POINTS, AND REDUNDANCY OMIT FOR CLARITY.
9. ALL GATE VALVES 2" AND SMALLER CL.301 ARE VGS060-B.
10. ALL GLOBE VALVES 2" AND SMALLER CL.301 AND CL.301C ARE VOS060-C AND VOS060-S RESPECTIVELY.
11. ALL GATE VALVES 2 1/2" AND LARGER CL.301 AND CL.301C ARE VGW030-A AND VGW030-J RESPECTIVELY.
12. ALL CHECK VALVES 2 1/2" AND LARGER CL.301 ARE VCW030-A.
13. ALL NEEDLE VALVES ARE VOS400-R.
14. ALL INSTRUMENT AND EQUIPMENT NUMBERS TO BE PREFIXED WITH "HD" EXCEPT WHERE A DIFFERENT PREFIX IS SHOWN.
15. DIFFUSER TO BE LOCATED AWAY FROM PERSONNEL WALKWAYS.

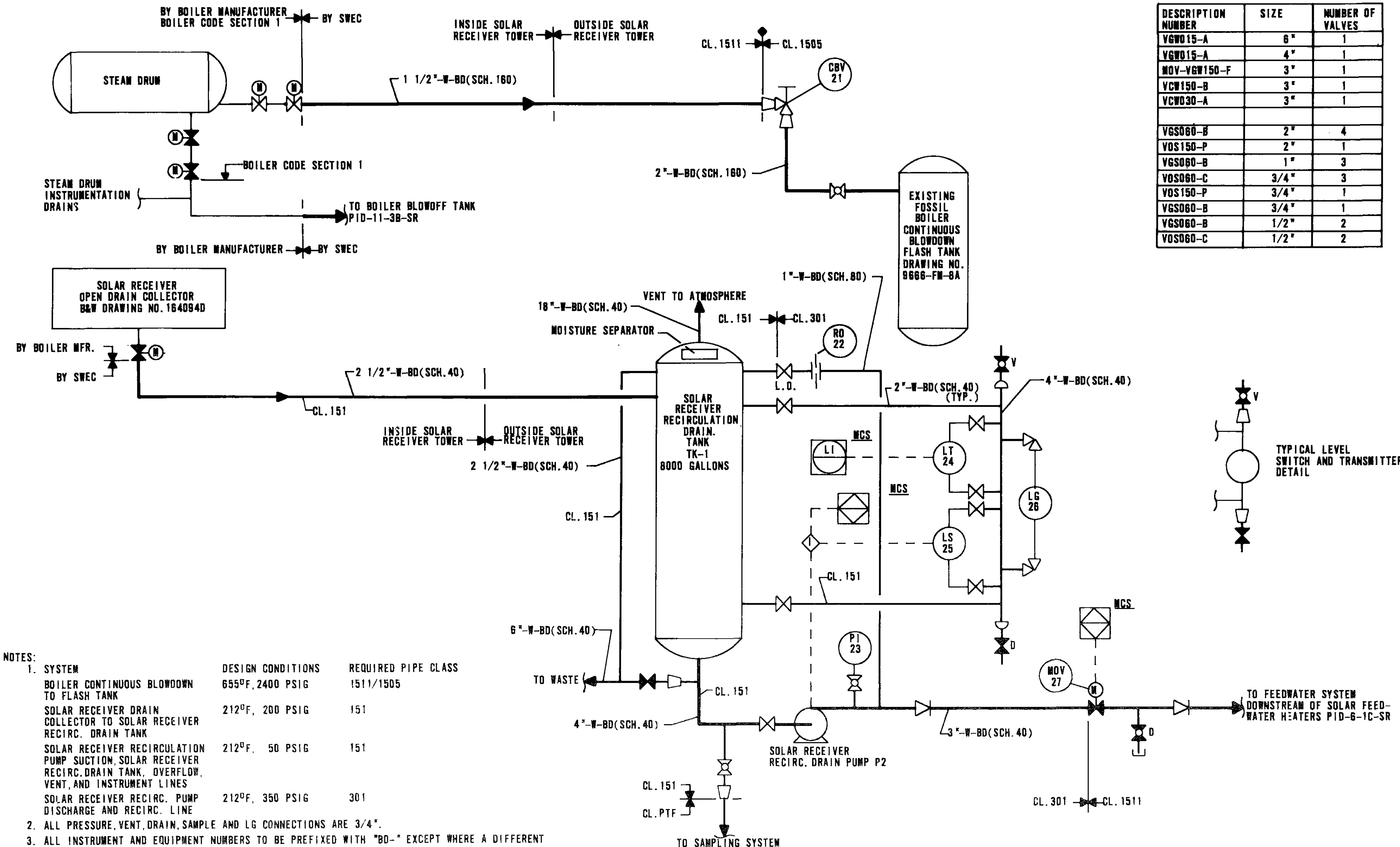
ALL LINE SIZES ARE PREMINARY

4	3	2	1	ISSUE
		SC	SC	PREP
			RWJ	REVIEW
		BMJ	BMJ	APP
		9-27-83	7-22-83	DATE

P & I DIAGRAM-SOLAR REPOWERING
SOLAR HEATER DRAIN, VENT, & RELIEF SYST.
UNIT NO. 1 - NEWMAN POWER STATION
EL PASO ELECTRIC COMPANY

STONE & WEBSTER ENGINEERING CORPORATION

14380-PID-6-6-SR



DESCRIPTION NUMBER	SIZE	NUMBER OF VALVES
VGW015-A	6"	1
VGW015-A	4"	1
MOV-VGW150-F	3"	1
VCW150-B	3"	1
VCW030-A	3"	1
VGS060-B	2"	4
VOS150-P	2"	1
VGS060-B	1"	3
VOS060-C	3/4"	3
VOS150-P	3/4"	1
VGS060-B	3/4"	1
VGS060-B	1/2"	2
VOS060-C	1/2"	2

NOTES:

1. SYSTEM

SYSTEM	DESIGN CONDITIONS	REQUIRED PIPE CLASS
BOILER CONTINUOUS BLOWDOWN TO FLASH TANK	655°F, 2400 PSIG	1511/1505
SOLAR RECEIVER DRAIN COLLECTOR TO SOLAR RECEIVER RECIRC. DRAIN TANK	212°F, 200 PSIG	151
SOLAR RECEIVER RECIRCULATION PUMP SUCTION, SOLAR RECEIVER RECIRC. DRAIN TANK, OVERFLOW, VENT, AND INSTRUMENT LINES	212°F, 50 PSIG	151
SOLAR RECEIVER RECIRC. PUMP DISCHARGE AND RECIRC. LINE	212°F, 350 PSIG	301

2. ALL PRESSURE, VENT, DRAIN, SAMPLE AND LG CONNECTIONS ARE 3/4".
3. ALL INSTRUMENT AND EQUIPMENT NUMBERS TO BE PREFIXED WITH "BD-" EXCEPT WHERE A DIFFERENT PREFIX IS SHOWN.
4. LS PIPING IS 1" AND LT PIPING IS 2".
5. UPON COMPLETION OF PIPING DRAWINGS, LOCAL VENT AND DRAIN CONNECTIONS WILL BE INCORPORATED AS REQUIRED.
6. ALL GATE VALVES 2" AND SMALLER CL.151 AND CL.301 ARE VGS060-B.
7. ALL GLOBE VALVES 2" AND SMALLER CL.151, CL.301, CL.1511 AND CL.1505 ARE VOS060-C, VOS060-C, VOS150-G AND VOS150-P RESPECTIVELY.
8. ALL GATE VALVES 2 1/2" AND LARGER CL.151 & 1511 ARE VGW015-A AND VGW150-F RESPECTIVELY.
9. ALL CHECK VALVES 2 1/2" AND LARGER CL.301 AND CL.1511 ARE VCW030-A AND VCW150-B RESPECTIVELY.

ALL LINE SIZES ARE PRELIMINARY

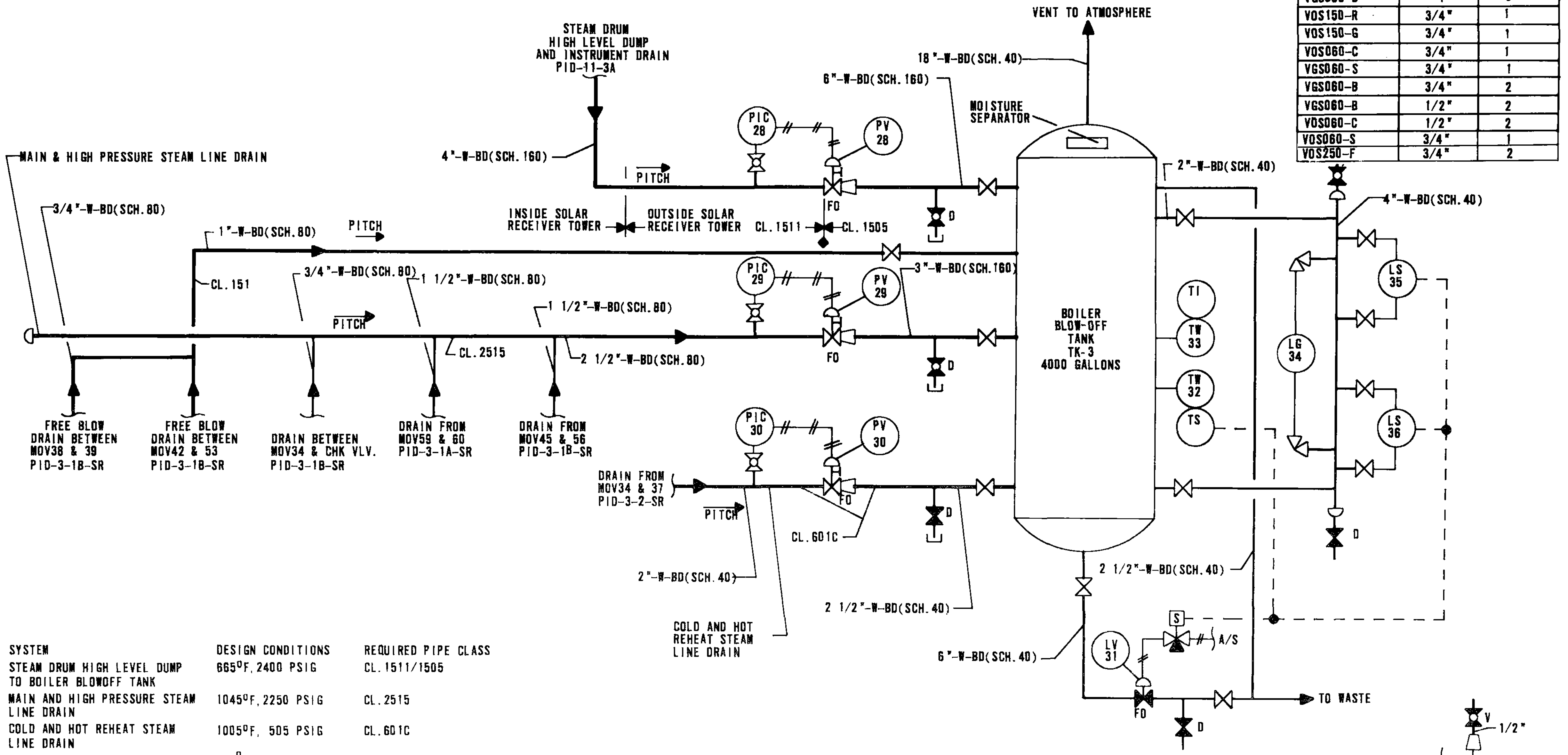
4	3	2	1	ISSUE
			SC	PREP
				REVIEW
			BMK	APP
			9-27-83	DATE

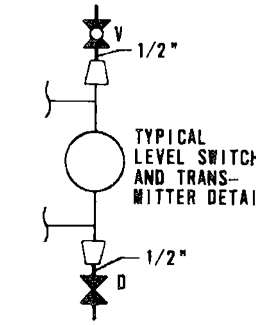
P & I DIAGRAM - SOLAR REPOWERING
BOILER BLOWDOWN, VENT AND DRAIN SYSTEM
UNIT NO.1 - NEWMAN POWER STATION
EL PASO ELECTRIC COMPANY

STONE & WEBSTER ENGINEERING CORPORATION

14380-PID-11-3A-SR

VALVE DESCRIPTION	SIZE	NUMBER OF VALVES
VGW150-A	6"	1
VGW015-A	6"	2
VGW250-RJ	3"	1
VGW060-Y	2 1/2"	1
VGW060-B	2"	2
VGS060-B	1"	5
VOS150-R	3/4"	1
VOS150-G	3/4"	1
VOS060-C	3/4"	1
VGS060-S	3/4"	1
VGS060-B	3/4"	2
VGS060-B	1/2"	2
VOS060-C	1/2"	2
VOS060-S	3/4"	1
VOS250-F	3/4"	2





NOTES:

1. SYSTEM

SYSTEM	DESIGN CONDITIONS	REQUIRED PIPE CLASS
STEAM DRUM HIGH LEVEL DUMP TO BOILER BLOWOFF TANK	665°F, 2400 PSIG	CL.1511/1505
MAIN AND HIGH PRESSURE STEAM LINE DRAIN	1045°F, 2250 PSIG	CL.2515
COLD AND HOT REHEAT STEAM LINE DRAIN	1005°F, 505 PSIG	CL.601C
BOILER BLOWOFF TANK DRAIN, OVERFLOW, VENT, INSTRUMENT LINES & FREE BLOW DRAINS	212°F, 50 PSIG	CL.151

2. ALL PRESSURE, VENT, DRAIN, AND LG CONNECTIONS ARE 3/4".
3. ALL INSTRUMENT AND EQUIPMENT NUMBERS TO BE PREFIXED WITH "BD-" EXCEPT WHERE A DIFFERENT PREFIX IS SHOWN.
4. LS PIPING IS 1".
5. ALL GLOBE VALVES 2" AND SMALLER CL.1505, CL.1511, CL.601C, CL.2515, AND CL.151 ARE VOS150-R, VOS150-G, VOS060-S, VOS250-F & VOS060-C RESPECTIVELY.
6. ALL GATE VALVES 2" AND SMALLER CL.601C AND CL.151 ARE VGS060-S & VGS060-B RESPECTIVELY.
7. ALL GATE VALVES 2 1/2" AND LARGER CL.1505, CL.2515, CL.601C, AND CL.151 ARE VGW150-A, VGW250-RJ, VGW060-Y AND VGW015-A RESPECTIVELY.

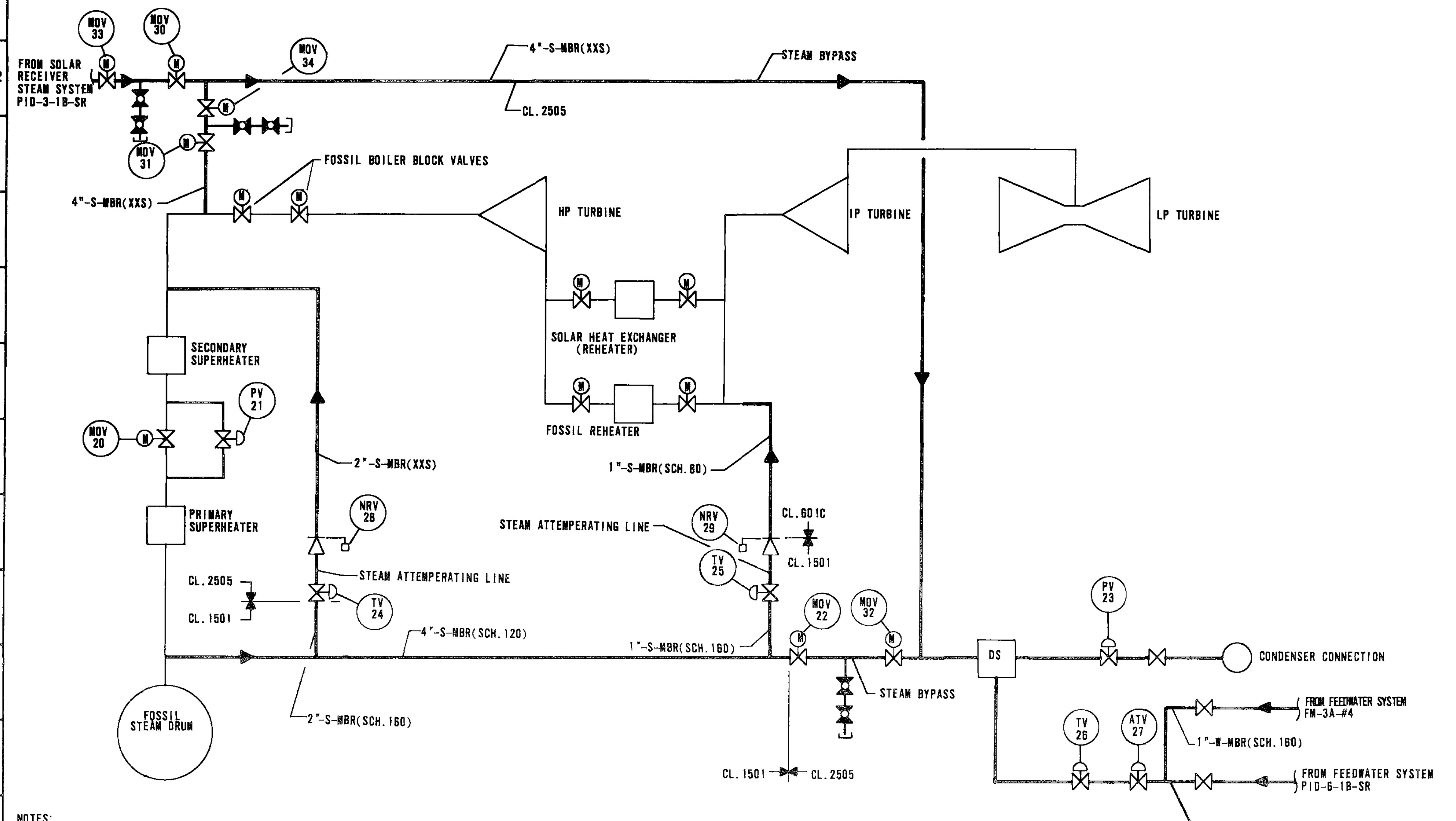
ALL LINE SIZES ARE PRELIMINARY

4	3	2	1	ISSUE
			SC	PREP
				REVIEW
				APP
			9-27-83	DATE

P & I DIAGRAM - SOLAR REPOWERING
BOILER BLOWDOWN VENT AND DRAIN SYSTEM
UNIT NO.1 - NEWMAN POWER STATION
EL PASO ELECTRIC COMPANY

STONE & WEBSTER ENGINEERING CORPORATION

14380-PID-11-3B-SR



NOTES:
1. ALL EQUIPMENT AND INSTRUMENT NUMBERS TO BE PREFIXED WITH "MBR" EXCEPT WHERE A DIFFERENT PREFIX IS SHOWN.

ALL LINE SIZES ARE PRELIMINARY

4	3	2	1	ISSUE
			SC	PREP
				REVIEW
				APP
			1-29-83	DATE

FLOW DIAGRAM - SOLAR REPOWERING
FOSSIL BOILER/SOLAR REC.-STARTUP SYSTEM
UNIT NO.1 - NEWMAN POWER STATION
EL PASO ELECTRIC COMPANY

STONE & WEBSTER ENGINEERING CORPORATION

14380-FSK-3-8-SR

A 5010.28

STONE & WEBSTER ENGINEERING CORPORATION

CALCULATION SHEET

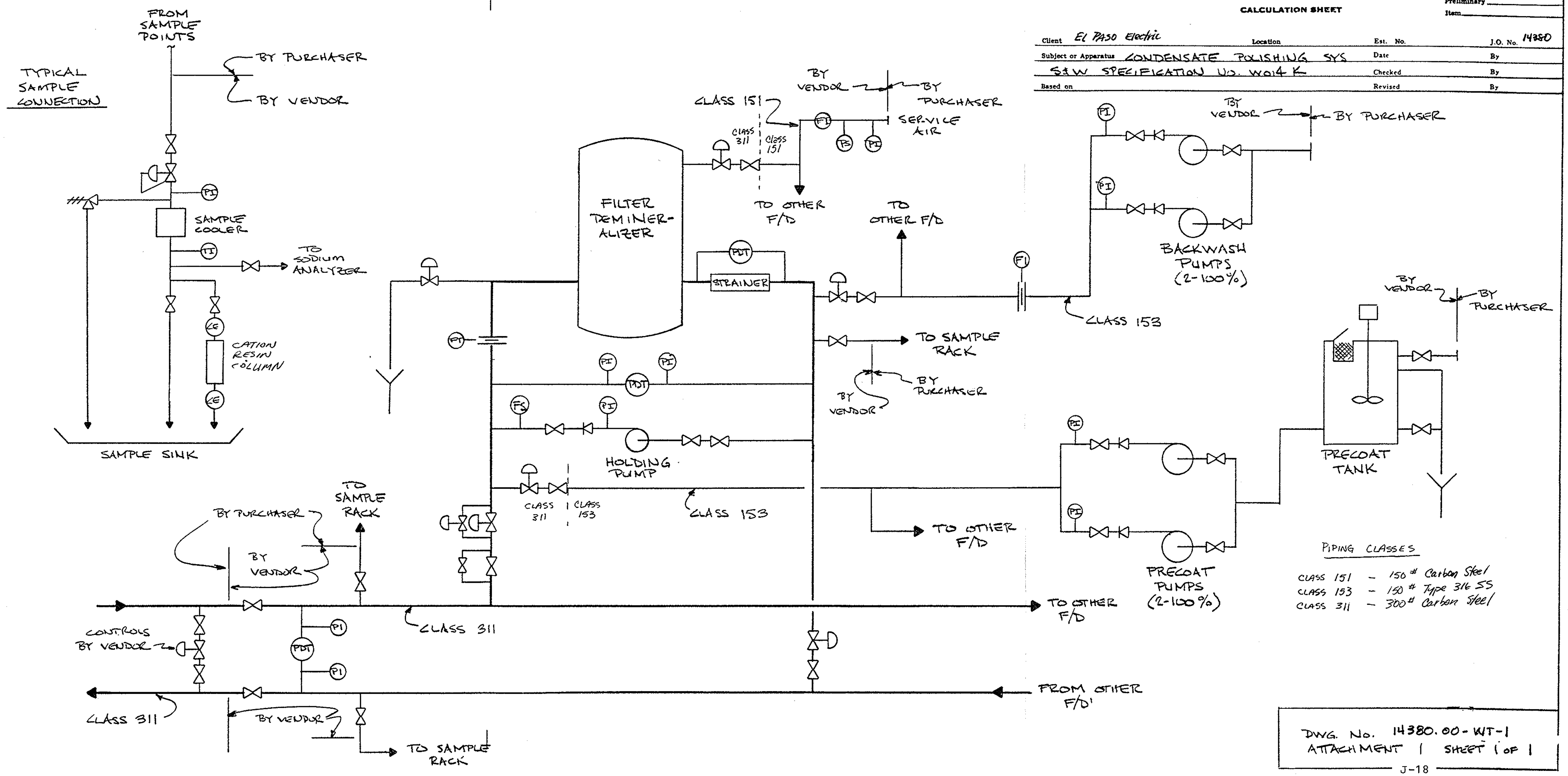
Page No. ______
Preliminary ______
Item ______

Client: El Paso Electric — Location: — Est. No.: — J.O. No. 14380

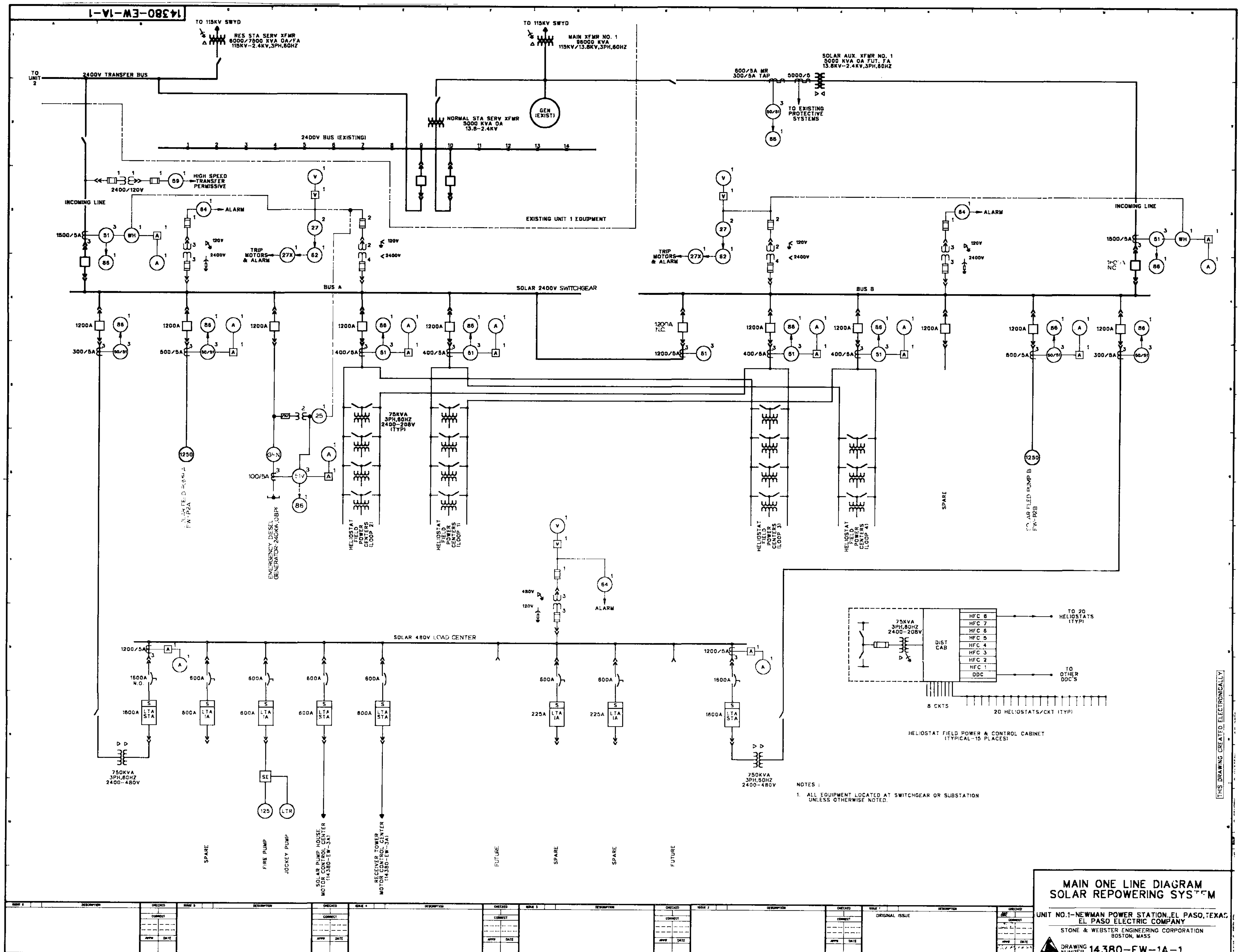
Subject or Apparatus: CONDENSATE POLISHING SYS — Date: — By:

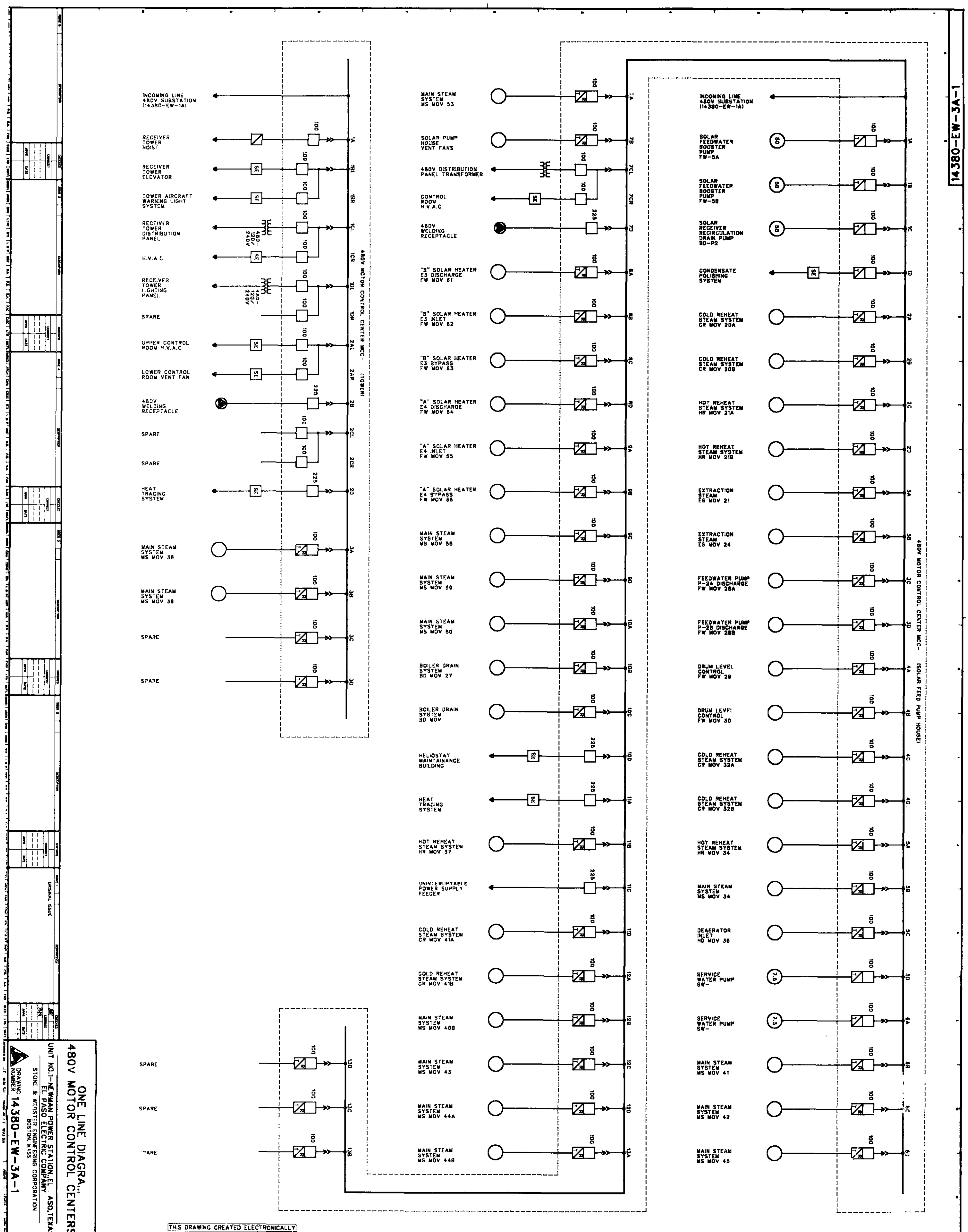
S&W SPECIFICATION NO. W014K — Checked: — By:

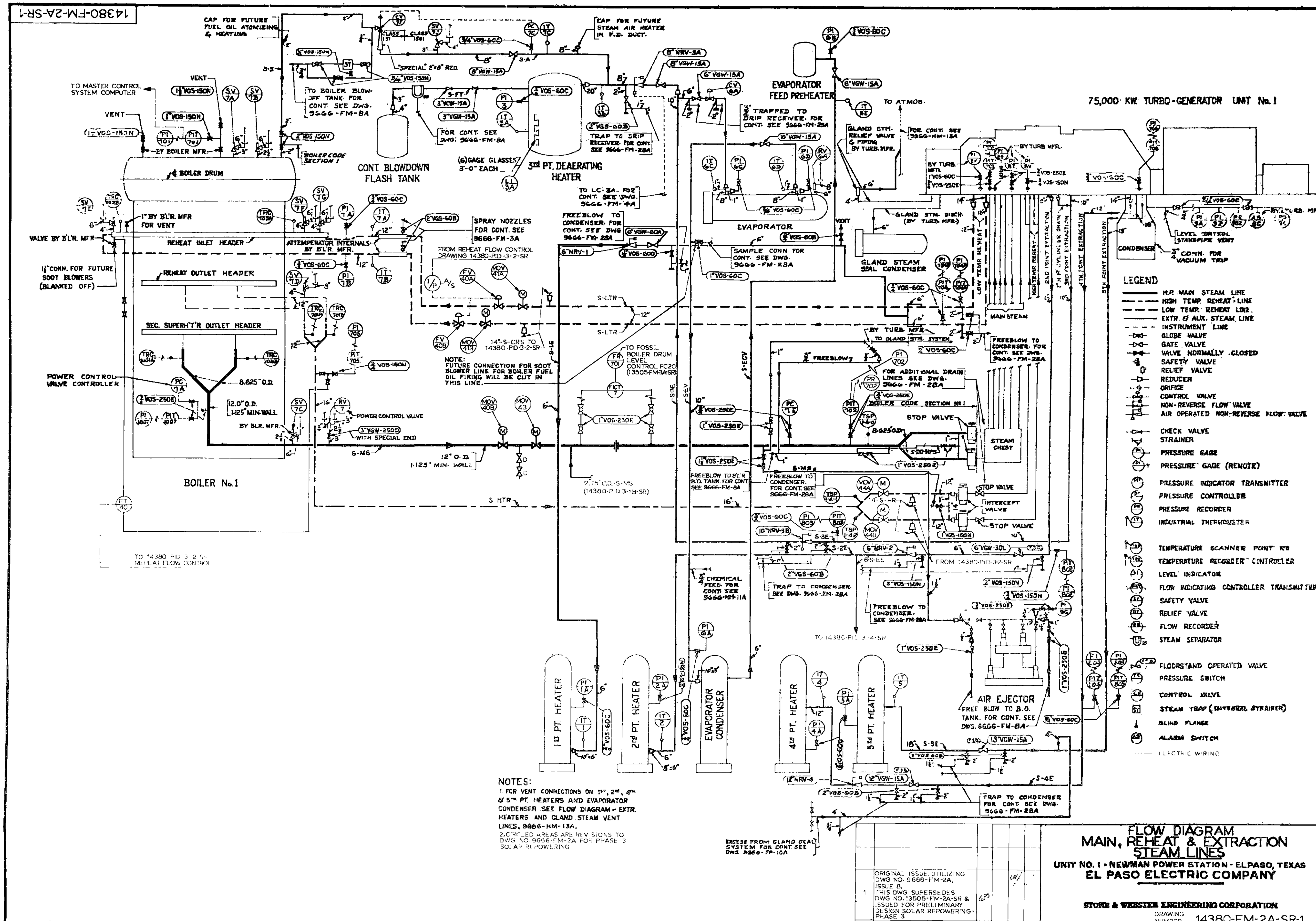
Based on: — Revised: — By:

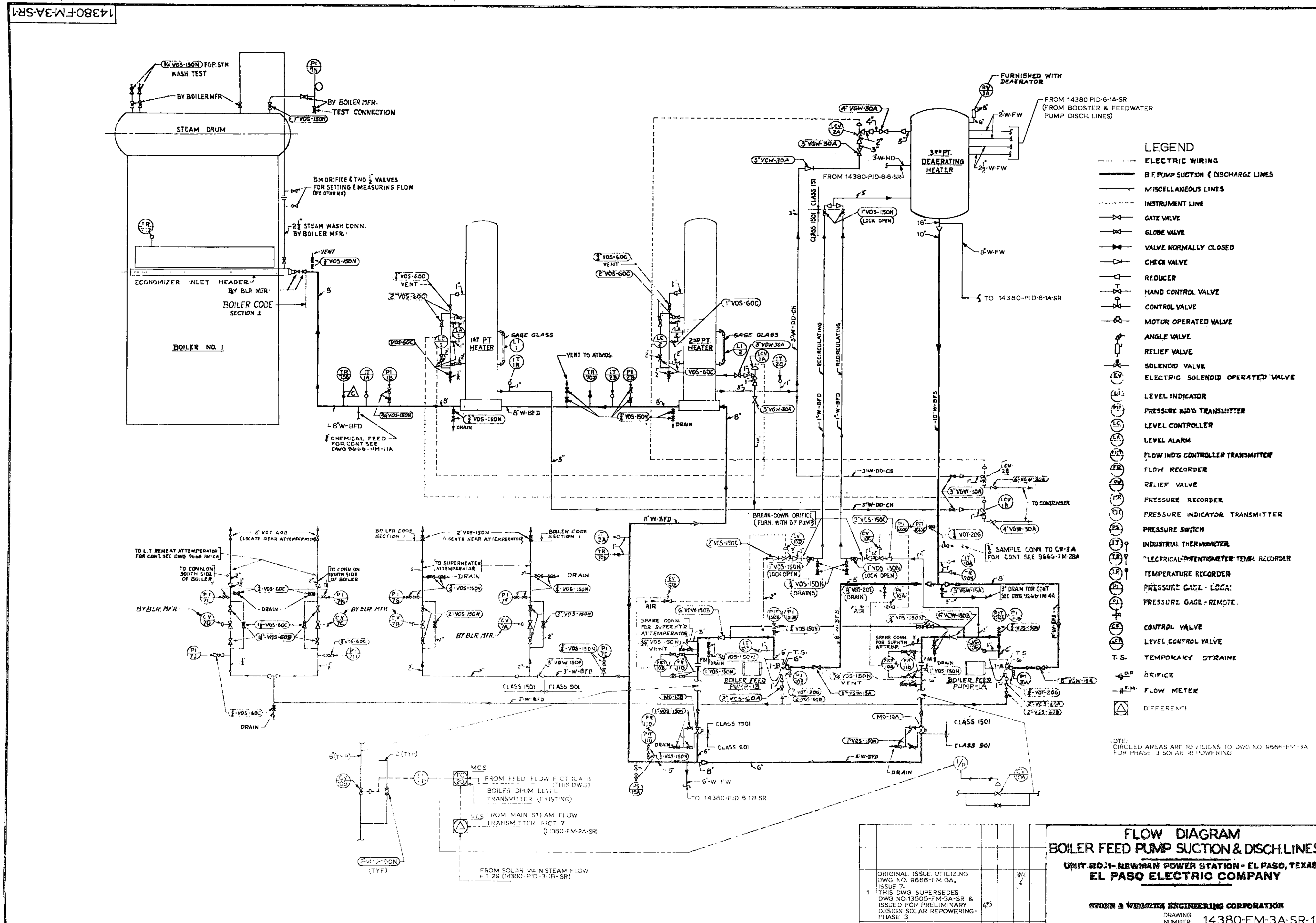


DWG. No. 14380.00-WT-1
ATTACHMENT 1 SHEET 1 OF 1


14380-EW-1A-1
TO 115KV SWYD
RES STA SERV XFMR 6000/7500 KVA OA/FA 115KV-2.4KV,3PH,60HZ
MAIN XFMR NO. 1 85000 KVA 115KV/13.8KV,3PH,60HZ
SOLAR AUX. XFMR NO. 1 5000 KVA OA FUT. FA 13.8KV-2.4KV,3PH,60HZ
TO UNIT 2
2400V TRANSFER BUS
NORMAL STA SERV XFMR 5000 KVA OA 13.8-2.4KV
GEN (EXIST)
2400V BUS (EXISTING)
TO EXISTING PROTECTIVE SYSTEMS
HIGH SPEED TRANSFER PERMISSIVE
2400/120V
INCOMING LINE
EXISTING UNIT 1 EQUIPMENT
ALARM
TRIP MOTORS & ALARM
BUS A
SOLAR 2400V SWITCHGEAR
BUS B
75KVA 3PH,60HZ 2400-208V (TYP)
EMERGENCY DIESEL GENERATOR 240KW,0BPH
HELIOSTAT FIELD POWER CENTERS (LOOP 2)
HELIOSTAT FIELD POWER CENTERS (LOOP 1)
HELIOSTAT FIELD POWER CENTERS (LOOP 3)
HELIOSTAT FIELD POWER CENTERS (LOOP 4)
SPARE
SOLAR 480V LOAD CENTER
750KVA 3PH,60HZ 2400-480V
SPARE
FIRE PUMP
JOCKEY PUMP
SOLAR PUMP HOUSE MOTOR CONTROL CENTER (14380-EW-3A)
RECEIVER TOWER MOTOR CONTROL CENTER (14380-EW-3A)
FUTURE
SPARE
SPARE
FUTURE
75KVA 3PH,60HZ 2400-208V
DIST CAB
HFC 8
HFC 7
HFC 6
HFC 5
HFC 4
HFC 3
HFC 2
HFC 1
DDC
TO 20 HELIOSTATS (TYP)
TO OTHER DDC'S
8 CKTS
20 HELIOSTATS/CKT (TYP)
HELIOSTAT FIELD POWER & CONTROL CABINET (TYPICAL-15 PLACES)
NOTES :
1. ALL EQUIPMENT LOCATED AT SWITCHGEAR OR SUBSTATION UNLESS OTHERWISE NOTED.
THIS DRAWING CREATED ELECTRONICALLY
MAIN ONE LINE DIAGRAM
SOLAR REPOWERING SYSTEM
UNIT NO.1-NEWMAN POWER STATION,EL PASO,TEXAS
EL PASO ELECTRIC COMPANY
STONE & WEBSTER ENGINEERING CORPORATION BOSTON, MASS
ORIGINAL ISSUE
DRAWING NUMBER 14380-EW-1A-1


ONE LINE DIAGRAM
480V MOTOR CONTROL CENTERS
UNIT NO.1-NEWMAN POWER STATION, EL PASO, TEXAS
EL PASO ELECTRIC COMPANY
STONE & WEBSTER ENGINEERING CORPORATION
BOSTON, MASS.
DRAWING NUMBER 14380-EW-3A-1
14380-EW-3A-1
THIS DRAWING CREATED ELECTRONICALLY
ORIGINAL ISSUE
480V MOTOR CONTROL CENTER MCC- (TOWER)
480V MOTOR CONTROL CENTER MCC- (SOLAR FEED PUMP HOUSE)
INCOMING LINE 480V SUBSTATION (14380-EW-1A)
RECEIVER TOWER HOIST
RECEIVER TOWER ELEVATOR
TOWER AIRCRAFT WARNING LIGHT SYSTEM
RECEIVER TOWER DISTRIBUTION PANEL
H.V.A.C.
RECEIVER TOWER LIGHTING PANEL
SPARE
UPPER CONTROL ROOM H.V.A.C.
LOWER CONTROL ROOM VENT FAN
480V WELDING RECEPTACLE
HEAT TRACING SYSTEM
MAIN STEAM SYSTEM MS MOV 38
MAIN STEAM SYSTEM MS MOV 39
MAIN STEAM SYSTEM MS MOV 53
SOLAR PUMP HOUSE VENT FANS
480V DISTRIBUTION PANEL TRANSFORMER
CONTROL ROOM H.V.A.C.
"B" SOLAR HEATER E3 DISCHARGE FW MOV 61
"B" SOLAR HEATER E3 INLET FW MOV 62
"B" SOLAR HEATER E3 BYPASS FW MOV 63
"A" SOLAR HEATER E4 DISCHARGE FW MOV 64
"A" SOLAR HEATER E4 INLET FW MOV 65
"A" SOLAR HEATER E4 BYPASS FW MOV 66
MAIN STEAM SYSTEM MS MOV 58
MAIN STEAM SYSTEM MS MOV 59
MAIN STEAM SYSTEM MS MOV 60
BOILER DRAIN SYSTEM BD MOV 27
BOILER DRAIN SYSTEM BD MOV
HELIOSTAT MAINTAINANCE BUILDING
UNINTERUPTABLE POWER SUPPLY FEEDER
HOT REHEAT STEAM SYSTEM HR MOV 37
COLD REHEAT STEAM SYSTEM CR MOV 41A
COLD REHEAT STEAM SYSTEM CR MOV 41B
MAIN STEAM SYSTEM MS MOV 40B
MAIN STEAM SYSTEM MS MOV 43
MAIN STEAM SYSTEM MS MOV 44A
MAIN STEAM SYSTEM MS MOV 44B
SOLAR FEEDWATER BOOSTER PUMP FW-5A
SOLAR FEEDWATER BOOSTER PUMP FW-5B
SOLAR RECEIVER RECIRCULATION DRAIN PUMP BD-P2
CONDENSATE POLISHING SYSTEM
COLD REHEAT STEAM SYSTEM CR MOV 20A
COLD REHEAT STEAM SYSTEM CR MOV 20B
HOT REHEAT STEAM SYSTEM HR MOV 21A
HOT REHEAT STEAM SYSTEM HR MOV 21B
EXTRACTION STEAM ES MOV 21
EXTRACTION STEAM ES MOV 24
FEEDWATER PUMP P-2A DISCHARGE FW MOV 28A
FEEDWATER PUMP P-2B DISCHARGE FW MOV 28B
DRUM LEVEL CONTROL FW MOV 29
DRUM LEVEL CONTROL FW MOV 30
COLD REHEAT STEAM SYSTEM CR MOV 32A
COLD REHEAT STEAM SYSTEM CR MOV 32B
HOT REHEAT STEAM SYSTEM HR MOV 34
MAIN STEAM SYSTEM MS MOV 34
DEAERATOR INLET HD MOV 36
SERVICE WATER PUMP SW-
MAIN STEAM SYSTEM MS MOV 41
MAIN STEAM SYSTEM MS MOV 42
MAIN STEAM SYSTEM MS MOV 45


14380-FM-2A-SR-1
75,000 KW TURBO-GENERATOR UNIT No. 1
BOILER No. 1
BOILER DRUM
REHEAT INLET HEADER
REHEAT OUTLET HEADER
SEC. SUPERH'T'R OUTLET HEADER
CONT. BLOWDOWN FLASH TANK
3rd PT. DEAERATING HEATER
EVAPORATOR FEED PREHEATER
EVAPORATOR
GLAND STEAM SEAL CONDENSER
STEAM CHEST
STOP VALVE
INTERCEPT VALVE
CONDENSER
AIR EJECTOR
1st PT. HEATER
2nd PT. HEATER
EVAPORATOR CONDENSER
4th PT. HEATER
5th PT. HEATER
TO MASTER CONTROL SYSTEM COMPUTER
POWER CONTROL VALVE CONTROLLER
ATTEMPERATOR INTERNALS BY B'L'R MFR.
SPRAY NOZZLES FOR CONT. SEE 9666-FM-3A
FROM REHEAT FLOW CONTROL DRAWING 14380-PID-3-2-SR
NOTE: FUTURE CONNECTION FOR SOOT BLOWER LINE FOR BOILER FUEL OIL FIRING WILL BE CUT IN THIS LINE.
TO FOSSIL BOILER DRUM LEVEL CONTROL FC20 (13505-FM3A-SR)
LEGEND
H.P. MAIN STEAM LINE
HIGH TEMP. REHEAT LINE
LOW TEMP. REHEAT LINE
EXTR. & AUX. STEAM LINE
INSTRUMENT LINE
GLOBE VALVE
GATE VALVE
VALVE NORMALLY CLOSED
SAFETY VALVE
RELIEF VALVE
REDUCER
ORIFICE
CONTROL VALVE
NON-REVERSE FLOW VALVE
AIR OPERATED NON-REVERSE FLOW VALVE
CHECK VALVE
STRAINER
PRESSURE GAGE
PRESSURE GAGE (REMOTE)
PRESSURE INDICATOR TRANSMITTER
PRESSURE CONTROLLER
PRESSURE RECORDER
INDUSTRIAL THERMOMETER
TEMPERATURE SCANNER POINT
TEMPERATURE RECORDER CONTROLLER
LEVEL INDICATOR
FLOW INDICATING CONTROLLER TRANSMITTER
SAFETY VALVE
RELIEF VALVE
FLOW RECORDER
STEAM SEPARATOR
FLOORSTAND OPERATED VALVE
PRESSURE SWITCH
CONTROL VALVE
STEAM TRAP (INTEGRAL STRAINER)
BLIND FLANGE
ALARM SWITCH
ELECTRIC WIRING
NOTES:
1. FOR VENT CONNECTIONS ON 1st, 2nd, 4th & 5th PT. HEATERS AND EVAPORATOR CONDENSER SEE FLOW DIAGRAM - EXTR. HEATERS AND GLAND STEAM VENT LINES, 9666-HM-13A.
2. CIRCLED AREAS ARE REVISIONS TO DWG NO. 9666-FM-2A FOR PHASE 3 SOLAR REPOWERING
EXCESS FROM GLAND SEAL SYSTEM FOR CONT. SEE DWG. 9666-FP-10A
1 ORIGINAL ISSUE UTILIZING DWG NO. 9666-FM-2A, ISSUE 8. THIS DWG SUPERSEDES DWG NO. 13505-FM-2A-SR & ISSUED FOR PRELIMINARY DESIGN SOLAR REPOWERING-PHASE 3
ISSUE | DESCRIPTION | CHKD | INSP | CORR | APPR
FLOW DIAGRAM
MAIN, REHEAT & EXTRACTION STEAM LINES
UNIT NO. 1 - NEWMAN POWER STATION - ELPASO, TEXAS
EL PASO ELECTRIC COMPANY
STONE & WEBSTER ENGINEERING CORPORATION
DRAWING NUMBER 14380-FM-2A-SR-1


14380-FM-3A-SR-1
STEAM DRUM
BOILER NO. 1
ECONOMIZER INLET HEADER
BOILER CODE SECTION 1
1ST PT HEATER
2ND PT HEATER
3RD PT. DEAERATING HEATER
FURNISHED WITH DEAERATOR
FROM 14380-PID-6-1A-SR (FROM BOOSTER & FEEDWATER PUMP DISCH. LINES)
FROM 14380-PID-6-6-SR
TO 14380-PID-6-1A-SR
TO CONDENSER
BOILER FEED PUMP-1B
BOILER FEED PUMP-1A
TO 14380-PID-5-1B-SR
LEGEND
ELECTRIC WIRING
B.F. PUMP SUCTION & DISCHARGE LINES
MISCELLANEOUS LINES
INSTRUMENT LINE
GATE VALVE
GLOBE VALVE
VALVE NORMALLY CLOSED
CHECK VALVE
REDUCER
HAND CONTROL VALVE
CONTROL VALVE
MOTOR OPERATED VALVE
ANGLE VALVE
RELIEF VALVE
SOLENOID VALVE
ELECTRIC SOLENOID OPERATED VALVE
LEVEL INDICATOR
PRESSURE IND'G TRANSMITTER
LEVEL CONTROLLER
LEVEL ALARM
FLOW IND'G CONTROLLER TRANSMITTER
FLOW RECORDER
RELIEF VALVE
PRESSURE RECORDER
PRESSURE INDICATOR TRANSMITTER
PRESSURE SWITCH
INDUSTRIAL THERMOMETER
ELECTRICAL POTENTIOMETER TEMP. RECORDER
TEMPERATURE RECORDER
PRESSURE GAGE - LOCAL
PRESSURE GAGE - REMOTE
CONTROL VALVE
LEVEL CONTROL VALVE
T.S. TEMPORARY STRAINER
ORIFICE
FLOW METER
DIFFERENCE
NOTE: CIRCLED AREAS ARE REVISIONS TO DWG NO. 9666-FM-3A FOR PHASE 3 SOLAR REPOWERING
1 ORIGINAL ISSUE UTILIZING DWG NO. 9666-FM-3A, ISSUE 7. THIS DWG SUPERSEDES DWG NO. 13505-FM-3A-SR & ISSUED FOR PRELIMINARY DESIGN SOLAR REPOWERING-PHASE 3
ISSUE DESCRIPTION CHKD INSP CORR APPR
FLOW DIAGRAM
BOILER FEED PUMP SUCTION & DISCH. LINES
UNIT NO. 1 - NEWMAN POWER STATION - EL PASO, TEXAS
EL PASO ELECTRIC COMPANY
STONE & WEBSTER ENGINEERING CORPORATION
DRAWING NUMBER 14380-FM-3A-SR-1

APPENDIX K

APPENDIX K

K.1 INTRODUCTION

The following system descriptions were prepared for the Newman Unit 1 Solar Repowering Preliminary Design:

The purpose of these documents is to provide detailed definition of system requirements, system design, system limitations, and control system set points. Table K.1-1 is a sample Table of Contents for these system descriptions. Due to the large size and same inherent redundancy within these documents, only excerpts are included in this Appendix, as indicated by an asterisk (*) in Table K.1-1. System Flow Diagrams corresponding to these system descriptions are provided in Appendix J; piping drawings are included in Appendix L.

TABLE K.1-1

TYPICAL SYSTEM DESCRIPTION

TABLE OF CONTENTS

APPENDICES

NOTE:

* Excerpts included in Appendix L.

K.2

EXCERPTS FROM SYSTEM DESCRIPTION NO. 3-1,

MAIN AND HIGH PRESSURE STEAM SYSTEM

SUMMARY

The high pressure steam system conducts superheated steam from the primary superheater outlet header of the solar receiver through a horizontal straight tube heat exchanger (reheater) to the final superheater inlet header of the solar receiver. The high pressure (HP) steam is on the tube side of the heat exchanger and the HP turbine exhaust steam is on the shell side of the heat exchanger. The function of the heat exchanger is to reheat the HP turbine exhaust steam to a specific temperature before the steam enters the intermediate pressure turbine.

The main steam system conducts superheated steam from the final superheater outlet header of the receiver to the turbine stop valves via the existing fossil boiler main steam line.

The steam from the primary superheater outlet header of the receiver is transported in a single lead to the heat exchanger (reheater). The steam from the outlet of the reheater is transported in a single lead to the final superheater inlet header of the receiver. The steam from the final superheater outlet header of the receiver is transported in a single lead to existing fossil boiler main steam lead.

The receiver piping has safety valves and desuperheaters. The safety valves shall provide pressure relief for the steam drum, superheaters, and HP steam piping. The desuperheaters (attemperators) are used to control steam temperature at the outlet of primary and final superheaters before the steam enters the HP turbine. The desuperheaters in the primary superheater section of the receiver also control the hot reheat steam temperature before the steam enters the intermediate pressure turbine by controlling HP steam temperature.

The main steam lead has spring loaded safety valves, a check valve, and motor-operated block valves. The safety valves provide pressure relief protection. The check valve prevents reverse flow of steam from the fossil boiler in the event of depressurization of receiver due to cloud cover during combined /fossil mode of plant operation. The motor-operated block valves are used for receiver isolation, initial steam line blowout and warmup of the receiver and steam piping by fossil boiler steam.

2.0 SYSTEM DESIGN

2.1 DETAILED DESIGN DESCRIPTION

Refer to the detailed P&I diagram PID-3-1A and B, which are included in Appendix A.2-1, to follow this design description.

The high pressure superheated steam from the primary superheater outlet header of the solar receiver shall be transported in a single lead to the reheater. The steam from the heat exchanger outlet shall be transported in a single lead to the receiver final superheater inlet header. The steam from the final superheater outlet header shall be transported in a single lead to the existing fossil boiler main steam lead.

The main steam lead contains motor-operated block valves (MOVs). Motor-operated valve (MOV 34) is located as close as practical to the existing fossil boiler main steam lead. Two other motor-operated valves (MOVs 38 and 39) are located at the outlet of the final superheater outlet header in accordance with ASME Section 1 to minimize the length of piping under jurisdiction of ASME 1.

During prewarm operation, MOVs 34, 38, and 39 shall be closed and the main steam from the fossil boilers shall be admitted to the solar receiver by opening either MOV 41 which is installed in the warmup steam supply line from Unit 1 fossil boiler or MOVs 42 and 53 which are installed in the warmup steam supply line from Unit 2 fossil boiler in accordance with the requirement of ASME Section 1 (see paragraph 1.2.3.1.4) and the condensate shall be removed through drain system. These MOVs 34, 38, and 39 also allow positive isolation of the receiver during all fossil mode of plant operation. The main steam lead also contains a check valve to prevent reverse flow of steam from the fossil boiler in the event of depressurization of the receiver due to cloud transient during combined solar/fossil mode of plant operation.

The safety valves are mounted on the main steam line to prevent overpressurization of the system upon failure of HP turbine stop/intercept valve and motor-operated block valves. Safety valves shall satisfy the total relief capacity requirement without exceeding the maximum allowable flow per valve. Drain connections are provided for draining the condensed steam from the high pressure and main steam system during warmup operation and shutdown.

Sample nozzle is installed in the main steam piping to ensure representative samples. Vents at all system high points and drains at all system low points provide the ability to fill, drain, and hydrotest.

Instrument connections for flow, temperature, and pressure sensing devices are provided on the main and high pressure steam system.

The design pressure and temperature of the main steam system, based on the Requirements Section 1.2.2.1, are 10.51 MPa gauge (1525 psig), 554°C (1030°F).

The design pressure and temperature of the high pressure steam system, based on the Requirements Section 1.2.2.1 are 15.51 MPa gauge (2250 psig), 563°C (1045°F).

2.2 ARRANGEMENT

The reheat heat exchanger (reheater) is located outside the receiver tower at elevation 1238.5 m (4063 ft 6 in.). The interface point for tower piping and receiver piping, specifically the primary superheater outlet, final superheater inlet, and final superheater outlet are located at elevation 1376 m (4514 ft 6 in.). The high pressure steam lead from the primary superheater outlet header of the receiver is directed down the tower to the heat exchanger (reheater). The steam lead from the heat exchanger (reheater) is directed back up the tower to the final superheater inlet header of the receiver. The main steam lead from the final superheater outlet header of the receiver is again directed down the tower to the turbine throttle valves. The arrangement of main and high pressure steam is shown in the piping drawings in Appendix L.

2.3 SYSTEM OPERATION

The following sections present a summary of the operation of the main and high pressure steam system.

The main turbine operation and receiver operation procedures will be provided by the vendor's technical manuals. They will both be warmed up and operated in accordance with their respective operating procedures.

The start-up or warm-up of the receiver and steam piping can be accomplished by either solar generated steam or main steam from fossil Unit 1 or Unit 2. This system description describes only start-up utilizing main steam from either Unit 1 or Unit 2.

2.3.1 Start-Up

Prior to prewarming the receiver and steam piping, the condensate trapped between the closed MOV 34 and upstream check valve, closed MOVs 38 and 39 and the closed MOVs 53 and 42 shall be drained by opening the air-operated drain valves.

The receiver, main and high pressure steam piping upstream of the MOV 34 shall be prewarmed by main steam from Unit 1 or 2 prior to start-up of the receiver. During the prewarm operation, MOVs 34, 38, and 39 shall be closed and the fossil main steam shall be admitted to the receiver by opening either MOV 41 or MOVs 42 and 53. The condensate shall be removed through receiver drain traps and valves and through MOVs 59, 60, 45, and 56 in the main and high pressure steam piping.

Start-up of the main and high pressure steam system will begin when the receiver is being brought up to operating pressure, and the steam turbine is ready to receive main steam. If the main steam for startup is from Unit 2, the main steam lead downstream of the MOV 34 will be warmed up to operating temperature slowly. This will be accomplished by admitting steam via the partially open main steam block valve, MOV 34, with drain lines open.

When the main steam lead downstream of MOV 34 has been brought up to temperature, the main steam block valve will be opened fully, prior to admitting steam to the turbine via the turbine stop valves.

2.3.2 Normal Operation

During solar and solar/fossil combined mode of operation the main steam block valve remains open, and the main steam system conducts steam from the final superheaters outlet header to the turbine via the turbine stop valves.

2.3.3 Shutdown

The main and high pressure steam system is shut down during a receiver trip, a turbine trip, or in the normal course of bringing the unit off the line. At low pressure, the main and high pressure steam drain valves open automatically to allow any condensate to be returned to the boiler blowoff tank.

K.3

EXCERPTS FROM SYSTEM DESCRIPTION NO. 3-2

COLD AND HOT REHEAT SYSTEM

SUMMARY

The cold reheat system conducts steam from the outlet of the high pressure (HP) turbine to the shell side of the reheat heat exchanger (reheater). The cold reheat system also provides steam for the extraction steam to the solar feedwater heater "A".

The exhaust steam from the HP turbine is transported in double leads to the existing fossil boiler. Then the cold reheat leads tie into the existing leads which combine into a single lead terminating at the shell side of the reheater. The cold reheat single lead has a safety valve for protection of cold reheat piping. The cold reheat single lead also provides steam to the solar feedwater heater "A".

The solar cold reheat single lead, as well as the fossil cold reheat single lead, have flow control valves for splitting cold reheat steam flow between fossil and solar reheaters during solar/fossil combined mode of operation. Flow control provides the capability of increasing fossil boiler reheat temperature by reducing cold reheat steam flow to the fossil boiler.

The function of the reheater is to reheat the HP turbine exhaust to a higher temperature by utilizing high pressure steam from the outlet of primary superheaters of the receiver before the exhaust steam enters the intermediate pressure (IP) turbine. The high pressure steam is on the tube side of the heat exchanger and the cold and hot reheat are on the shell side of the reheater.

The hot reheat system conducts superheated steam from the shell side of the reheater to the IP turbine.

The superheated steam from the reheater is transported in a single lead which branches into double leads to provide connections to two existing fossil hot reheat leads. The hot reheat single lead has a safety valve for the protection of hot reheat piping.

2.0 SYSTEM DESIGN

2.1 DETAILED DESIGN DESCRIPTION

Refer to the detailed P&I diagram PID-3-2 which is included as Appendix J to follow this design description.

The HP turbine exhaust steam leads from the existing cold reheat double leads are combined into a single lead and transported to the reheat heat exchanger (reheater) for reheating. The cold reheat steam is heated in the shell side of the reheater by high pressure steam (see System Description 3-1) to reach 535°C (995°F). The superheated reheat steam from the reheater is transported in a single lead which branches into double leads to provide connections to two fossil hot reheat leads.

The cold reheat single lead contains a flow control valve used for fossil and solar mixed reheat temperature control.

The motor operated block valves are provided for isolation of the system during fossil mode of operation of the plant.

The safety relief valves are mounted on the cold reheat, hot reheat, and reheater to prevent overpressurization due to heat exchanger tube rupture and failure of intercept valve and motor-operated valves.

Vents at all system high points and drains at all system low points provide the ability to fill, drain, and hydrotest.

A bypass line with a motor-operated valve is provided for the cold reheat steam block valve to warm up the cold and hot reheat piping prior to start-up. A drain connection with a motor operated valve is provided at the system low point downstream of the reheater for draining condensate to the boiler blowoff tank.

Instrument connections for temperature and pressure sensing devices used for reheat steam temperature control are also provided on the cold and hot reheat piping.

The design temperature and pressure of the cold reheat system are 382°C (720°F) and 3.79 MPa (550 psig), respectively.

The design temperature and pressure of hot reheat system are 540.5°C (1005°F) and 3.48 MPa (505 psig), respectively.

2.2 ARRANGEMENT

The reheater is located outside the receiver tower at el 1238.5 m (4,063 ft 6 in.) near the base of the tower. The arrangement of the cold and hot reheat system is shown in the general arrangement and piping drawings referenced in Appendix L.

2.3 SYSTEM OPERATION

The following sections present a summary of the modes of operation provided for in the design of the cold and hot reheat system. Refer to PID 3-2 to follow the operations summarized below.

2.3.1 Startup

The cold and hot reheat system shall be warmed up by opening motor-operated cold reheat bypass valves around the motor operated block valves in the cold reheat system. The motor operated condensate drain valve will be operated to drain condensate to the boiler blowoff tank.

2.3.2 Normal Operation

During normal operation the cold reheat system transports steam to the reheat heat exchanger (reheater). A branch connection from cold reheat line provides steam to the extraction steam system. The reheater outlet temperature is controlled at 535°C (995°F) by spraying feedwater into the solar receiver high pressure steam (System Description 3-1) piping through the desuperheater. During normal operation, the hot reheat system transports steam from the reheater to the intermediate pressure turbine stop/intercept valves. Instruments in the inlet and outlet of the reheater transmit a control signal to the reheat steam temperature control system.

2.3.3 Shutdown

When the solar receiver is shut down, the hot and cold reheat system is shut down and the drain line valves open automatically.

K.4 EXCERPTS FROM

SYSTEM DESCRIPTION NO. 3-4

EXTRACTION STEAM SYSTEM

SUMMARY

The extraction steam system conducts steam from the cold reheat line and intermediate pressure turbine to the solar feedwater heaters. The extraction steam is required for feedwater heating to increase cycle efficiency.

2.0 SYSTEM DESIGN

2.1 DETAILED DESIGN DESCRIPTION

Refer to the detailed P&I diagrams PID-3-4, which are included as Appendix J, to follow this design description.

The extraction point for the Solar Feedwater Heater "A" is taken from the cold reheat lead.

The extraction point for the Solar Feedwater Heater "B" is taken from the extraction line to the 2nd point fossil feedwater heater.

The extraction lines have motor-operated valves (MOVs) for automatic shutoff when actuated by an extreme high level in the feedwater heater. The required speed of operation of these valves depends on the mass balance of water flowing to the heater and the volume between the extreme high level alarm and the motor-operated valves.

Immediately following the MOV is a swing check nonreturn valve which is primarily used for fast action closing to limit turbine overspeed due to entrained energy in the extraction system and affords some protection from a water induction standpoint. The nonreturn valves are power assisted in the closed direction in the event of extreme high heater level or turbine trip.

Automatic drains to the condenser are provided upstream of the motor-operated valves and at system low points. These drain valves open automatically on heater extreme high water level or on a turbine trip.

The following tables summarize the design pressures and temperatures of the extraction steam system. Refer to the structural requirements Section 1.2.2 for determining design pressure and temperature.

The design temperatures and pressures for the extraction steam system are:

Extraction Point	Design Pressure* MPa gauge/mm	Design Pressure* psig/in. Hg Vac	Temperature °C	Temperature °F
Solar feedwater heater "A"	3.79/762	550/30	382	(720)
Solar feedwater heater "B"	1.72/762	250/30	421	(790)

2.2 ARRANGEMENT

The motor-operated valves (MOVs) and the nonreturn valves (NRVs) in the Heater "B" extraction line are located only in horizontal runs of piping and as close as practical to the turbine to minimize the energy entrained in the extraction system piping upstream of these valves. The MOV and the NRV in the Heater "A" extraction line are located as close as practical to the cold reheat lead to minimize the energy entrained in the extraction system piping upstream of these valves. These arrangements increase the volume between the extreme high level alarm and the MOVs which allows more time for these valves to close after receiving a close signal.

The extraction piping is arranged to be self draining away from the turbine to the drain connections upstream of the MOVs.

For additional details of system arrangement, see the arrangement drawing in Appendix L.

2.3 SYSTEM OPERATION

The following sections present a summary of the operations provided for in the design of the extraction steam system, refer to P&I diagrams, PID-3-4, Appendix J.

2.3.1 Startup

The extraction steam system is prepared for operation after the generator is synchronized and minimum load applied. At this time the motor-operated block valves may be opened on each line with the associated NRVs released to swing freely. The extraction steam line drains to the condenser and the heater drains to the condenser will be open prior to admitting steam to the turbine (see Heater Drains System Description 6-6).

2.3.2 Normal Operation

During normal operation, all extraction MOVs are in the wide open position. All NRVs are free to swing open and all extraction line automatic drain valves are closed.

2.3.3 Shutdown

The extraction steam system is automatically shut down upon a turbine trip, via closure of the nonreturn NRVs. This will prevent turbine overspeed upon a turbine trip.

2.3.4 Infrequent Operation

If an extreme high level occurs in the heaters, the motor-operated isolation valve for that extraction line feed will close automatically and the NRVs valves will be power assisted in the closed direction.

If a solar heater is to be taken out of service during normal operation, its extraction line MOV will be closed, and its extraction line drains to the condenser should be opened.

K.5

MINISYSTEM DESCRIPTION NO. 3-8
FOSSIL BOILER/SOLAR RECEIVER - STARTUP SYSTEM

MINISYSTEM DESCRIPTION

FOSSIL BOILER/SOLAR RECEIVER - STARTUP SYSTEM

SWEC Drawing 14380-FSK-3-8-SR (See Appendix J)

The function of the fossil boiler/solar receiver startup system is:

1. Turbine startup with fossil boiler only

2. Turbine startup with solar receiver only

3. Fossil boiler operating with solar receiver startup

4. Solar receiver operating with fossil boiler startup

Turbine Startup with Fossil Boiler Only

This system description describes only the cold start of the fossil boiler. During turbine startup with fossil boiler only, MBR-MOV30, 31, 33, and 34 shall remain closed throughout the operating procedure. The positions of other valves are described as follows:

The cold start is defined as the unit startup from no drum pressure or no furnace gas temperature above ambient. Once firing commences, the amount of heat input to the boiler shall be kept at a desired maximum. Therefore, all bypass system valves (MBR-MOV20, MBR-PV21, MBR-TV24, MBR-TV25, MBR-MOV22, MBR-PV23) shall be closed for drum pressure buildup. The turbine can be rolled at the lowest pressure permitted by the turbine manufacturer, using MBR-PV21 to control throttle pressure, MBR-MOV22 and 32 and MBR-PV23 to control drum pressure, and MBR-TV24 to maintain the desired steam temperature to turbine metal temperature match. The desuperheating water, supplied from the feedwater system, shall be controlled by MBR-TV26 and MBR-ATV27. Once HP turbine exhaust steam passes through the reheater, hot reheat steam temperature shall be maintained relative to turbine metal temperature by use of MBR-TV25. If the steam temperature is less than the allowable turbine metal temperature matching tolerance, steam attemperation shall be removed, followed by increased firing to raise steam temperature. Excess drum pressure shall be relieved through MBR-MOV22 and 32 and MBR-PV23.

After turbine snychronization, MBR-PV21 shall be used to control throttle pressure. The turbine throttle valves shall be completely open. Load shall then be increased by opening MBR-PV21 as required.

Above approximately 10 percent load, the steam attemperators become less effective and MBR-TV24 and 25 may be closed as conditions warrant. The water attemperators shall be used as needed when load shall be increased. Above 15 percent load, MBR-MOV22 and 32, MBR-TV24 and 25, and MBR-PV23 shall be closed. Load shall be continuously increased until 70 percent load, when MBR-PV21 shall be essentially open. To further increase load, MBR-MOV20 shall be automatically pushed open, allowing time for the turbine throttle valves to adjust as required. After MBR-MOV20 shall be wide open. MBR-PV21 may be left open or closed as desired.

Turbine Startup with Solar Receiver Only

During turbine startup with solar receiver only, MBR-MOV30 and 33, MBR-PV23, MBR-TV26, and MBR-ATV27 shall remain closed throughout the operating procedure. Refer to Section 5.3.6 and Section 2.3, "System Operation," of Main and High Pressure Steam System Description No. 3-1.

Fossil Boiler Operating with Solar Receiver Startup

During fossil boiler operating with receiver startup, MBR-MOV22, 31, 32, and MBR-TV24 and 25 shall remain closed throughout the operating procedure. Refer to Section 5.3.6 and Section 2.3, "System Operation," of Main and High Pressure Steam System Description No. 3-1 to warmup solar receiver main and high pressure steam piping up to MS-MOV40 (PID-3-1-SR), and Section 2.3, "System Operation", of Cold and Hot Reheat Steam System Description No. 3-2 to warmup the cold and hot reheat piping. The main steam block valve in the solar main steam system, MS-MOV34 shall be closed, and receiver generated steam shall be bypassed to the condenser by opening MBR-MOV30 and 33 and MBR-PV23. The desuperheating water, supplied from the feedwater system, shall be controlled by MBR-TV26 and MBR-ATV27. When receiver generated steam temperature shall match with the fossil boiler generated steam temperature, MBR-MOV30 and 33 and MBR-PV23 shall be closed and MS-MOV34 (PID-3-1-SR) shall be opened.

Solar Receiver Operating with Fossil Boiler Startup

During receiver operation with fossil boiler startup, MBR-MOV30 and 33, and MBR-TV24 and 25, MBR-PV21 shall remain closed throughout the operating procedure. Once firing commences, the amount of heat input to the boiler shall be kept at a desired maximum. Therefore, all bypass system valves (MBR-MOV20, MBR-PV21, MBR-TV24, MBR-TV25, MBR-MOV22, MBR-MOV32 and MBR-PV23) shall be closed for drum pressure buildup. After drum pressure buildup, MBR-MOV22 and 32 and MBR-PV23 shall be opened to the control drum pressure. Valves MBR-MOV20, 31, and 34 shall be opened to bypass steam to the condenser in order to warmup the primary and secondary superheaters and main steam piping up to the main steam block valves in the fossil main steam system. When fossil boiler generated steam temperature matches with the receiver generated steam temperature, MBR-MOV22 and 32, MBR-PV23, MBR-MOV31 and 34 shall be closed and the main steam block valves in the fossil main steam system shall be opened.

K.6 EXCERPTS FROM

SYSTEM DESCRIPTION NO. 6-1

FEEDWATER SYSTEM

SUMMARY

The feedwater system receives partially heated feedwater from the deaerator. It provides additional regenerative feedwater heating and raises its pressure to the value required to feed the solar receiver.

Feedwater flows by gravity and deaerator pressure to the suction of two 100 percent capacity motor-driven solar feedwater booster pumps. The booster pumps discharge to the suction of two 50 percent capacity solar feedwater pumps. The solar feedwater pumps discharge to a common header which contains the feedwater control valves. The header also receives flow from the fossil feedwater system when the solar feedwater pump bypass line is utilized to fill the system. The feedwater control valves are positioned by a signal from the feedwater control system.

Two stages of regenerative feedwater heating are provided by the solar feedwater heaters "A" and "B".

The solar feedwater heaters "A" and "B" are in series downstream of the feedwater control valves. The heater piping after the solar heater "A" divides into two separate connections at the economizer inlet. The discharge piping contains a flow element and a temperature element which are utilized by the feedwater control system.

2.0 SYSTEM DESIGN

2.1 DETAILED DESIGN DESCRIPTION

Refer to the detailed piping and instrument diagrams PID-6-1A through 1C which are included as Appendix J.

The feedwater system contains two parallel booster and solar feedwater pumps, each driven by a constant speed motor. Each booster pump is capable of full system capacity. Each solar feedwater pump is capable of one-half system capacity. The booster pumps take suction from the deaerator and discharge through check valves, and discharge isolation valves to a common header which transports feedwater to the suction of solar feedwater pumps. The check valves prevent backflow through idle pump and reverse rotation of the pump motor. The discharge and suction valves of the booster pumps provide isolation for pump maintenance. A minimum continuous flow recirculation line between the pump and the check valve is installed for each booster pump and protects against undue heat buildup and vibration in the pump during pump startup with closed discharge valve or other low flow operation. A relief valve is provided in the booster pump suction lines to prevent overpressurization through check valve leakage when the suction valve is closed. A temporary strainer is installed in the booster pump suction to protect the pump during system flush. The solar feedwater pumps discharge through check valves and motor-operated discharge valves to a common header. The check valves prevent backflow through idle pump and reverse rotation of the pump motor. The discharge and suction valves of the solar feedwater pumps provide isolation for pump maintenance. A relief valve is provided in the solar feedwater pump suction lines to prevent overpressurization through the pump warming line or through check valve leakage when the suction valve is closed. A minimum flow recirculation line and control valve for each solar feedwater pump protects against undue heat buildup and vibration in the pump at reduced loads. The control valves in the recirculation lines are located as close as practical to the deaerator in order to minimize the length of pipe which may be subject to two phase flow. A pump bypass line from the fossil feedwater system is provided to permit filling of the solar receiver prior to start-up from cold shutdown. A small warm-up bypass with multiple breakdown orifice, check valve and globe valve in series is provided around the check valve and isolation valve in each discharge line of the solar feedwater pump to permit a gradual warming and to prevent thermal shock during start-up of a pump which has been out of service.

The feedwater flows from the common pump discharge header through the feedwater control valves to the solar feedwater heaters and to the connections at the economizer. The feed pump discharge header has a connection to the high pressure desuperheating system for controlling the temperature of the superheated steam to the main and high pressure steam system and also provides feedwater to the fossil boiler/solar receiver start-up system desuperheater for controlling temperature of the bypass steam to the condenser. The solar feedwater heaters can be isolated for maintenance by motor operated valves on the inlet and outlet of each heater and a motor operated valve in the bypass lines. The bypass lines are sized to allow 100 percent feedwater flow with the heater isolated. The motor operated valves are interlocked to prevent simultaneous closure of the heater isolation and bypass valves.

The feedwater enters the piping to the economizers by two connections to minimize the probablity of inadvertent closure of both economizer isolation block valves which would subject the feedwater piping and components located downsteam of the control valve isolation valves to the pump shut-off pressure.

The solar feedwater heater "A" discharge header contains a flow element with associated flow transmitter which provides the feedwater flow signal used in the feedwater control system. The feedwater control valves are automatically positioned by a signal from the feedwater control system. The feedwater control valve maintains steam drum level during steady state and transient operations.

The feedwater control valves consists of a 100 percent main control valve for normal operation and a 25 percent low load control valve for loads less than 25 percent for start-up.

The minimum flow recirculation valves are controlled by the flow elements in the solar feedwater pump suction lines.

The following table summarizes the design pressures and temperatures of the feedwater system. Refer to the structural requirements, Section 1.2.2, for determining design pressure and temperature.

PIPING

Portion of System	Design Pressure MPa Gauge	(psig)	Design Temperature °C	(°F)
Solar Feedwater Booster Pump Suction	.65	(95)	153.3	(308)
Solar Feedwater Booster Pump Discharge	.90	(130)	153.3	(308)
Solar Feedwater Pump Discharge to Control Station Downstream Block Valve	25.58	(3,710)	157.2	(315)

Portion of System	Design Pressure MPa Gauge	(psig)	Design Temperature °C	(°F)
Solar Feedwater Pump Discharge to Control Station Downstream Block Valve (Piping only)	21.37	(3,100)	157.2	(315)
Downstream of the Control Station Downstream Block Valve to Solar Heater "B" Inlet	18.13	(2,630)	157.2	(315)
Solar Heater "B" Outlet to Solar Heater "A" Inlet	18.13	(2,630)	208.3	(407)
Solar Heater "A" Outlet to Economizer Inlet	18.13	(2,630)	248.9	(480)

2.2 ARRANGEMENT

The two solar feedwater booster pumps are located on the ground floor of the turbine building at elevation 4,065 ft. The two solar feedwater pumps are located on the ground floor of the solar equipment building at elevation 4,065 ft. The solar feedwater heaters "A" and "B" are located on the second floor of the solar equipment building at elevation 4,079 ft.

For additional details of system arrangement, see the machine location and piping drawings referenced in Appendix L.

2.3 SYSTEM OPERATION

The following sections present a summary of the modes of operation provided for in the design of the feedwater system. Refer to PID-6-1A through C, Appendix J, to follow the operations described below.

2.3.1 System Fill

The feedwater system from the solar feedwater pump's discharge valve to the solar receiver economizer inlet header is filled by the fossil feed pumps through the solar feed pump bypass line. The rest of the system, from the deaerator to the solar pump discharge valve, is filled by gravity from the deaerator. This procedure allows the feedwater pumps to start with a full feedwater system. Valves should be aligned as shown on PID-6-1 except that the pump discharge valves are closed and the control valves are manually opened. All systems, controls, and power supplies should be available to support the operation of the feedwater system in accordance with their respective operating procedure.

With the level in the deaerator in the normal operating range and the fossil feed pump operating, the feedwater system high point vents and component vents will be opened in sequential order the direction of flow to remove entrapped air. Each vent valve shall remain open until entrapped air is vented and then will be closed.

2.3.2 Start Up

Prior to starting up the feedwater system, the following prerequisites should be established:

1. Condensate system in operation, and condenser vacuum established.

2. Valve positioned as shown on PID-6-1 except that the low load feedwater control valve isolation valves are open and the low load feedwater control valve is in operation.

3. Deaerator level in the normal operating range and deaerator supplied with pegging steam.

To start up the feedwater system

1. With the discharge valve closed, start the solar feedwater booster pump through the Master Control System (MCS) touch sensitive CRT in the control room.

2. The solar feedwater booster pump will recirculate water back to the deaerator through the minimum flow recirculation line. When the pump is warmed as recommended by the manufacturer, the pump discharge valve will be opened through the MCS and the solar feedwater pump will be started through the MCS with the discharge valve closed.

3. The solar feedwater pump will recirculate water back to the deaerator through the minimum flow recirculation line. When the pump is warmed as recommended by the manufacturer, the pump discharge valve will be opened also through the MCS CRT.

   The MCS is provided with logic and set points to prevent out of sequence or improper operation. An automatic startup program will perform the above steps for a normal daily startup when initiated by the operator.

   NOTE: In the event that the solar receiver was not previously filled utilizing the fossil feed pumps, establish a normal operating level with the solar feedwater pump via the feedwater low load control valve.

2.3.3 Normal Operation

During normal operation, the feedwater system supplies feedwater to the solar receiver. The two solar feedwater booster pumps and the two solar feedwater pumps are in operation discharging through one of the feedwater control valves and through the feedwater heaters. The feedwater control valves (one modulating at low load condition and the other at high load condition) maintain solar receiver drum level within a predetermined operating range. Refer to PID-6-1 (Appendix J) for flow path and valve positions. During operation at some fraction of design flow and below, only one solar feedwater pump will be operated. The idle feed pump will be kept warm by utilizing the pump's warmup line. This line recirculates a small portion of the operating pump's discharge flow back through the idle pump's warming line.

Proper system operation is verified by monitoring the following parameters:

1. Deaerator water level

2. Solar feedwater pump's discharge pressure

3. System flow

4. Feedwater heater outlet temperatures

5. Water chemistry within proper specification

6. Solar receiver drum level

2.3.4 Shutdown

The feedwater system operation can be shut down when the following conditions have been established:

1. The solar receiver is not in operation.

2. The system is not being used to make up for the water contraction in the solar receiver during cooldown.

The system is shut down by stopping the feed pump in accordance with manufacturer's recommendations. The pumps' discharge valves will close automatically when the pump is shut down.

2.3.5 Infrequent Operations

2.3.5.1 Solar Receiver Fill

Prior to start-up from a shutdown condition, normal solar receiver drum level must be established. If the solar receiver requires filling, the fossil feed pumps transfer water from the deaerator to the solar receiver via the solar feedwater system. During solar receiver fill, valves will be aligned as shown on PID-6-1 (Appendix J), except that the feed pump discharge valves will be closed and the low load feedwater control valve isolation valve will be open.

2.3.5.2 Operating With A Feedwater Heater Bypassed and Isolated

In the event a feedwater heater needs to be taken out of service, it will be isolated.

The shell side of solar feedwater heaters "A" and "B" can be isolated as follows:

1. Close the extraction line isolation valve.

2. Close the drain line isolation valves in the normal and high capacity drain lines, and cascading drain lines entering the heater, if any.

3. Close the heater vents to the condenser.

Isolating feedwater (tubeside) to solar feedwater heaters "A" and "B" is accomplished as follows:

1. Open the heaters motor operated bypass valve.

2. Close the heaters motor operated inlet and outlet isolation valves.

With a heater or heaters bypassed, the turbine manufacturer's guidelines on load reduction should be followed, and plant efficiency is affected.

2.3.5.3 Returning a Feedwater Heater to Service During Plant Operation

Returning heaters "A" and "B" to service requires care to prevent excessive thermal shocks. The shell side vent valves should be closed, and the channel side vent valves open. Ensure that the drain control valve block valve is open, and the control valve is in the automatic mode. The procedure is as follows:

1. Admit steam to the shell by slowly opening the extraction line motor-operated valve. Gradually

increase the pressure until the shell side temperature equals the feedwater inlet temperature.

2. Open the feedwater inlet isolation valve bypass valve to gradually fill the channel side, and equalize pressure across the outlet isolation valve.

3. Close the channel side vent when all air has been purged.

4. Open the feedwater outlet valve to establish flow through the heater.

5. Open the feedwater inlet isolation valve and close the heater bypass valve and the inlet isolation valve bypass valve, to establish full feedwater flow through the heater.

6. Open the shell start-up vent valve, and continue opening the extraction block valve, bringing the heater to full operating pressure.

7. Close the shell start-up vent, and open incoming cascading drain lines, if any.

K.7

EXCERPTS FROM SYSTEM DESCRIPTION NO. 6-6

SOLAR FEEDWATER HEATER DRAIN, VENT AND RELIEF

SUMMARY

The solar feedwater heater drains system consists of an arrangement of piping and valving which transports the heater drains from the shell side of the solar feedwater heaters to the condensate system.

The solar feedwater heater string consists of two full-size heaters which are designated as the solar feedwater heater "A" and solar feedwater heater "B" in the feedwater system.

The normal drains from the solar feedwater heater "A" cascade to solar feedwater heater "B" where both heater drains are collected and cascaded to the deaerator where the drains are collected and stored prior to entering the feedwater system. Drains are cascaded to the heaters to extract an optimum amount of heat from the drains for feedwater heating.

Both solar feedwater heaters have individual high capacity drain lines which dump the drains directly to the condenser in the event of a high level in the associated heater.

The solar feedwater heater shell operating vent system provides continuous removal of noncondensable gases from the heater shells to prevent a blanketing of the heater tubes by these gases which would result in a decrease in the heat transfer between the extraction steam and the feedwater. During normal operation, the solar feedwater heaters are vented to the condenser.

Both solar feedwater heaters have startup vents which are piped to the condenser.

The solar feedwater heaters have relief valve (RV) vent systems to prevent heater overpressure. The RV vents are piped to diffusers.

2.0 SYSTEM DESIGN

2.1 DETAILED DESIGN DESCRIPTION

Refer to detailed Piping and Instrumentation diagram PID-6-6 which is included in Appendix J, to follow this design description.

2.1.1 Heater Drain System

Two full-size solar feedwater heaters are used to heat feedwater which is pumped from the deaerator through the tube side of the heaters. The normal drain from the solar feedwater heater "A" is cascaded to the shell of the solar feedwater heater "B" via a control valve which maintains a level in the shell of the solar feedwater heater "A". The combined drains from the shell of the solar feedwater heater "B" is then cascaded to the deaerator. By cascading the drains to the solar feedwater heater and deaerator and maintaining a level in the solar feedwater heaters "A" and "B", an efficient amount of heat can be extracted from the condensed extraction steam.

Because of the severity of damage that can occur due to water entering the turbine from a solar feedwater heater, a redundant means of draining the solar feedwater heaters to prevent water induction is provided so that no individual failure of equipment results in water entering the turbine. A high capacity drain system is utilized as a defense against water induction for the solar feedwater heaters. This drain consists of a high capacity drain line and a high level control valve which passes the drains from each heater shell directly to the condenser. The control valves in both the normal and high capacity drain lines are controlled by level in the heater shell. The normal drain valve modulates to maintain a normal level and the high capacity drain valve modulates when a high level occurs. The high capacity drain valve is also used when the normal drain valve is out of service.

If the level in the heater reaches a high level (above high level control range), the high capacity drain valve will be fully opened by a separate signal and, in addition, cascaded drains from the upstream heater will be automatically isolated. If extreme high level exists in any heater, the isolation valve and the nonreturn valve in the extraction line will be automatically closed and extraction drain valves opened. The independent controls for the automatic drain valves and the automatic extraction steam isolation valves will minimize the possibility of water induction into the turbine. For further information refer to System Description 3-4, Extraction Steam.

The following table summarizes the design pressures and temperature of the solar feedwater heater drains system. Refer to the structural requirements, Section 1.2.2, for design pressure and temperature.

Heater Drain	Pressure MPa Gauge (psig)	Temperature (°F)
Solar Feedwater Heater "A"	3.79 (550)	249 (480)
Solar Feedwater Heater "B"	1.72 (250)	208 (407)

2.1.2 Heater Vent and Relief System

Two full-size solar feedwater heaters (solar heater "A" and solar heater "B") are vented to the condenser during startup and normal operation. The startup vent line(s) and the operating vent lines from each heater are manifolded downstream of the startup vent isolation valve(s) and the restricting orifices respectively, into a single vent line which is piped to the condenser shell for elimination of noncondensables by the condenser air removal system.

Each operating vent line from a solar feedwater heater is equipped with a restricting orifice, unless an internal orifice is provided by the heater manufacturer.

Relief valves are installed on all solar feedwater heater shells to protect the shell from overpressure due to tube rupture. Solar feedwater heater relief valve vent lines terminate inside a diffuser. The diffuser is located in an area remote from personnel traffic.

An isolation valve is installed in each manifold vent line running from heater to the condenser for isolation during condenser hydro testing and is located close to the condenser.

The following table summarizes the design pressures and temperatures of heater relief and vent system. Refer to the structural requirements, Section 1.2.2, for design pressure and temperature.

Feedwater Heater Vents	Pressure		Temperature	
	MPa gauge/mm	psig/in. Hg vac	°C	(°F)
Solar Feedwater Heater "A"	3.79/762	550/30	382	(720)
Solar Feedwater Heater "B"	1.72/762	250/30	421	(790)

2.2 ARRANGEMENT

The solar feedwater heater drains, vent and relief system is located inside the solar equipment building and in the turbine building. The high capacity drain line control valve stations are located adjacent to the condenser.

The restricting orifices (external) are installed in the vertical operating vent piping and are self-draining to the heaters. The restricting orifices in the heater vent piping are located close to the feedwater heater vent connections. A minimum length of straight pipe on either side of the orifice is required to obtain the calculated pressure drop in the flow through the orifice. Beyond the required length of straight pipe downstream of the orifice, the vents are manifolded into a common pipe.

All horizontal piping before the orifice shall pitch to the heater and after the orifice shall pitch to the condenser.

Startup vent vertical piping is self-draining to the heater. Startup vent horizontal piping is pitched and drained to the condenser. Relief valve vents are piped from the heaters to a diffuser.

2.3 SYSTEM OPERATION

2.3.1 Heater Drain System

The following sections present a summary of the modes of operation provided for in the design of the solar feedwater heater drain system. Refer to P&I diagram 6-6 (Appendix J) to follow the operations summarized below.

2.3.1.1 Startup

Prior to starting the solar heater drains system, ensure the following systems are operational:

1. Condensate System

2. Solar Feedwater System

3. Solar Extraction System

The solar feedwater heater drain system is placed in operation by aligning the system valves as shown in PID-6-6 (Appendix J).

As extraction steam entering the solar feedwater heaters is condensed, the water level in those heaters will rise. At a predetermined water level in the heaters, the normal drain control valves will automatically modulate to maintain normal water level (NWL) in their respective heaters.

2.3.1.2 Normal Operation

During normal operation, all of the normal solar feedwater heater drain flow paths are in operation. Water levels in the solar feedwater heater "A" and solar feedwater heater "B" are automatically maintained at predetermined normal operating levels by the normal drain valves.

2.3.1.3 Shutdown

The solar heater drain system will cease operation after the turbine has been tripped and feedwater heater level has decreased below the set point where the normal drain control valve closes.

2.3.1.4 Infrequent Operation

At low loads the pressure difference between heaters may be too small to completely drain the heaters through the normal drain lines. If the water level in the solar heater reaches 6 in. above normal water level, the high capacity drain valve will modulate, directing the heater drains to the condenser, to limit the further rise in water level. At 305 mm (12 in.) above NWL, the high capacity drain valve goes to the full open position and at the same time the upstream cascading drain valve is isolated. If an extreme high level occurs in the heater, the extraction steam isolation valve and nonreturn valve will close automatically (see System Description 3-4, Extraction Steam System).

In the event that a heater is isolated, returning that heater or string of heaters to service is accomplished in accordance with procedures described in System Description 6-1, Feedwater.

2.3.2 Heater Vent and Relief System

The following section presents a summary of the operations provided for in the design of the heater relief and vents system (refer to P&I diagram 6-6, Appendix J, to follow the operation summarized below).

2.3.2.1 Startup

The feedwater heater vent system is prepared for operation by opening the high and low pressure heater startup vents to remove noncondensables via the condenser air removal system.

2.3.2.2 Normal Operation

During normal operation, the startup vents are closed and the venting from each heater flows through the operating vent lines.

2.3.2.3 Shutdown

During shutdown, the venting arrangement is the same as for normal operation. When a heater is isolated for maintenance, the shell can be drained through the local drains provided.

2.3.2.4 Infrequent Operation

A heater may be isolated from the system when high water level reaches a predetermined point in the heater. When a heater is taken out of service for maintenance, the shell must be drained. When a heater is brought back into service, the startup vent and normal operation vent isolation valve must be opened to remove noncondensables.

K.8
MINISYSTEM DESCRIPTION NO. 11-3
BOILER BLOWDOWN, VENT AND DRAIN

MINI-SYSTEM DESCRIPTION

BOILER BLOWDOWN, VENT AND DRAIN SYSTEM

SWEC Drawing 14380-PID-11-3A-SR (See Appendix J)

A continuous blowdown line is provided from the receiver steam drum to the existing Unit 1 fossil boiler continuous blowdown flash tank. The hand operated pressure reducing blowdown valve (CBV21) and the pipe downstream of the continuous blowdown valve are constructed of chrome-moly steel.

The receiver open drain collector is located at the top of the receiver tower. The drain collector will collect water from the drum, evaporator, economizer and associated piping when the solar receiver is shut down due to low water temperature, in the range of 4.5-15.5°C (40-60°F), to prevent freeze-up. All vent and drain lines from the drum, economizer, evaporator, primary superheaters and final superheaters are directed to the open drain collector.

During startup/warmup of the solar receiver by fossil boiler steam (Unit 1 or 2), the hot pressurized condensate from the drum, economizer evaporator, primary superheaters and final superheaters shall be drained to the open drain collector and shall flash to steam at atmospheric pressure. The motor operated valve (MOV) at the discharge of the drain collector shall remain closed during the prewarm operation to prevent entry of flashed steam into the drain line from the drain collector to the carbon steel recirculation drain tank. After prewarming the solar receiver, the water shall be drained from the drain collector to the receiver recirculation drain tank. Tank water chemistry shall be checked and, if permitting, water shall be pumped back to the drum by the receiver recirculation drain pump before receiver startup, otherwise, it will be drained to waste. A minimum continuous flow recirculation line between the pump and the check valve is installed to start the pump with closed discharge valve. A check and a motor-operated gate valve are installed where the pipe class changes from CL301 to CL511. The pump shall be started manually from the control room and shall be stopped on low level signal from the level switch (LS25).

SWEC Drawing 14380-PID-11-3B-SR (See Appendix J)

In order to maintain normal drum level during cloud transient, a 4-in. carbon steel dump line is provided to drain drum high level water to the boiler blowoff tank. Pressure control valve (PV28 should be located as close as possible to the blowoff tank to prevent two-phase flow upstream of the control valve. Piping downstream of the control valve is one size larger and made of chrome-moly steel.

Drains from the main and high pressure steam system and from the cold and hot reheat steam system shall be directed to the boiler blowoff tank separately to avoid mixing drains of different pressure. Pressure control valves (PV29 and PV30) are installed near the boiler blowoff tank to prevent two-phase flow upstream of the pressure control valves. Piping is constructed of chrome-moly steel.

Hot pressurized water shall flash downstream of the pressure control valves and in the boiler blowoff tank. Steam shall be vented to atmosphere and hot water shall be collected in the tank. Tank level control valve (LV31) shall open and water drained to waste when the water temerature is 60°C (140°F) or level switch (LS35) senses high water level.

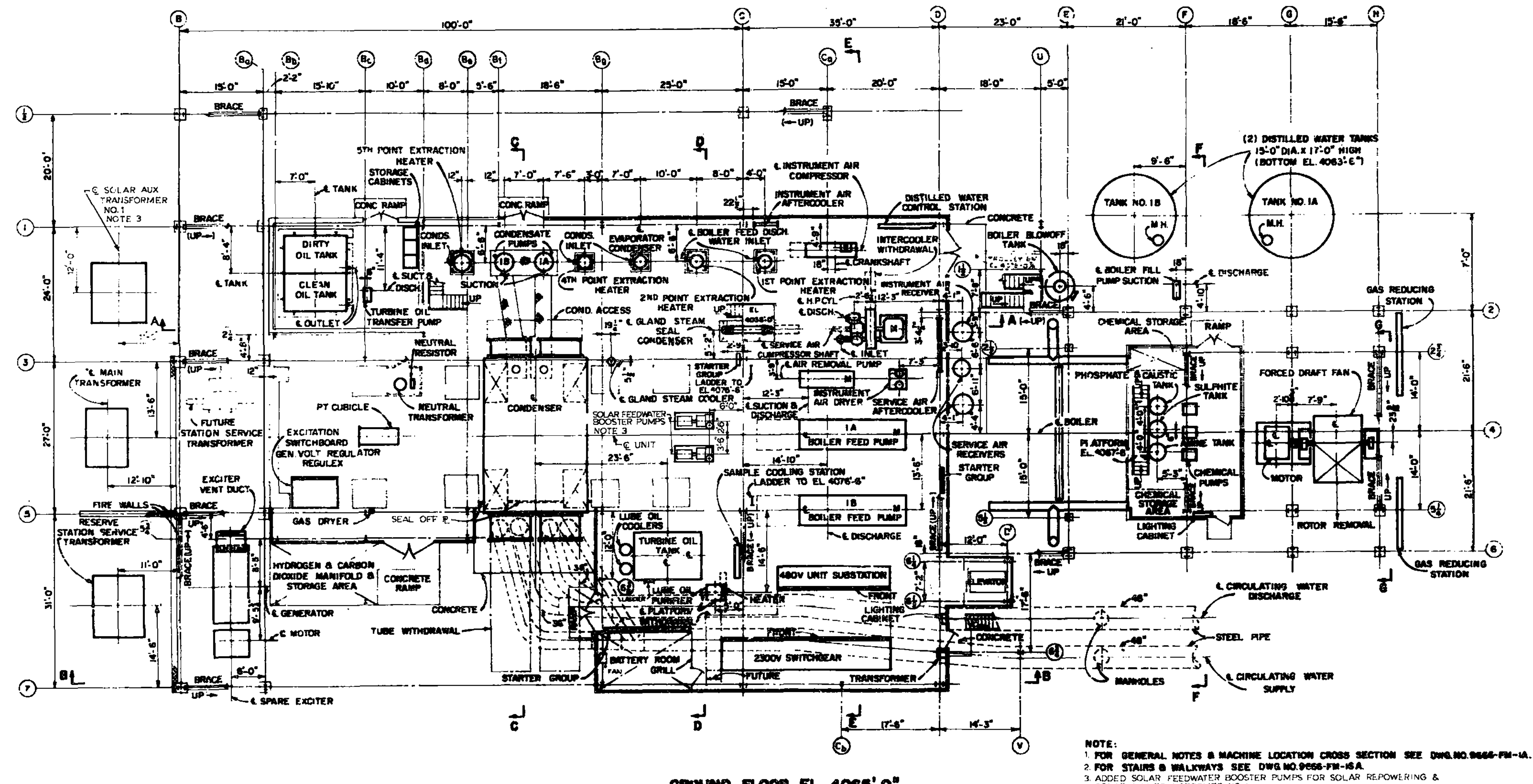
APPENDIX L

APPENDIX L

The following drawings are included in Appendix L:

Page	Drawing Number	Drawing Title
L-3	14380-EM-201C-SR-1	General Arrangement - Turbine Building Plan Ground Floor
L-4	14380-EM-201E-SR-1	General Arrangement - Turbine Building - Section
L-5	14380-EM-231A-SR-1	Plot Plan - Solar Repowering Arrangement
L-6	14380-EM-231B-SR-1	General Arrangement - Heliostat Field
L-7	14380-EM-232A-SR-2	General Arrangement - Solar Tower and Solar Equipment Building - Plan
L-8	14380-EM-232B-SR-1	General Arrangement - Solar Tower and Solar Equipment Building - Section
L-9	14380-EP-601A-SR-1	Study - Solar Main Steam Piping Turbine Building
L-10	14380-EP-602A-SR-1	Study - Solar Hot Reheat Steam Piping Turbine Building
L-11	14380-EP-603A-SR-1	Study - Cold Reheat Steam Piping Turbine Building
L-12	14380-EP-607A-SR-1	Study - Solar 2nd Point Extraction Steam Piping Turbine Building
L-13	14380-EP-659A-SR-1	Area Piping - Existing Turbine Building to Solar Tower - Plan-Sh 1
L-14	14380-EP-659B-SR-1	Area Piping - Existing Turbine Building to Solar Tower - Sect-Sh 2
L-15	14380-EP-659C-SR-2	Area Piping - Existing Turbine Building to Solar Tower - Plan-Sh 3
L-16	14380-EP-660A-SR-1	Study - Solar Feedwater Booster Piping Turbine Building

Page	Drawing Number	Drawing Title
L-17	14380-FY-3A-SR-8	Lot Plan
L-18	14380-EC-601A-SR	Receiver Tower and Foundation
L-19	14380-EC-601B-SR	Receiver Tower and Foundation
L-20	14380-SSK-1A	Heliostat Foundation



GROUND FLOOR EL. 4065'-0"

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

NOTE:
1. FOR GENERAL NOTES & MACHINE LOCATION CROSS SECTION SEE DWG. NO. 9666-FM-1A.
2. FOR STAIRS & WALKWAYS SEE DWG. NO. 9666-FM-16A.
3. ADDED SOLAR FEEDWATER BOOSTER PUMPS FOR SOLAR REPOWERING & SOLAR AUX TRANSFORMER NO. 1

REFERENCE DRAWINGS
1. GENERAL ARRGT TURBINE BLDG SECTION 14380-EM-201E

NOT TO BE USED FOR CONSTRUCTION

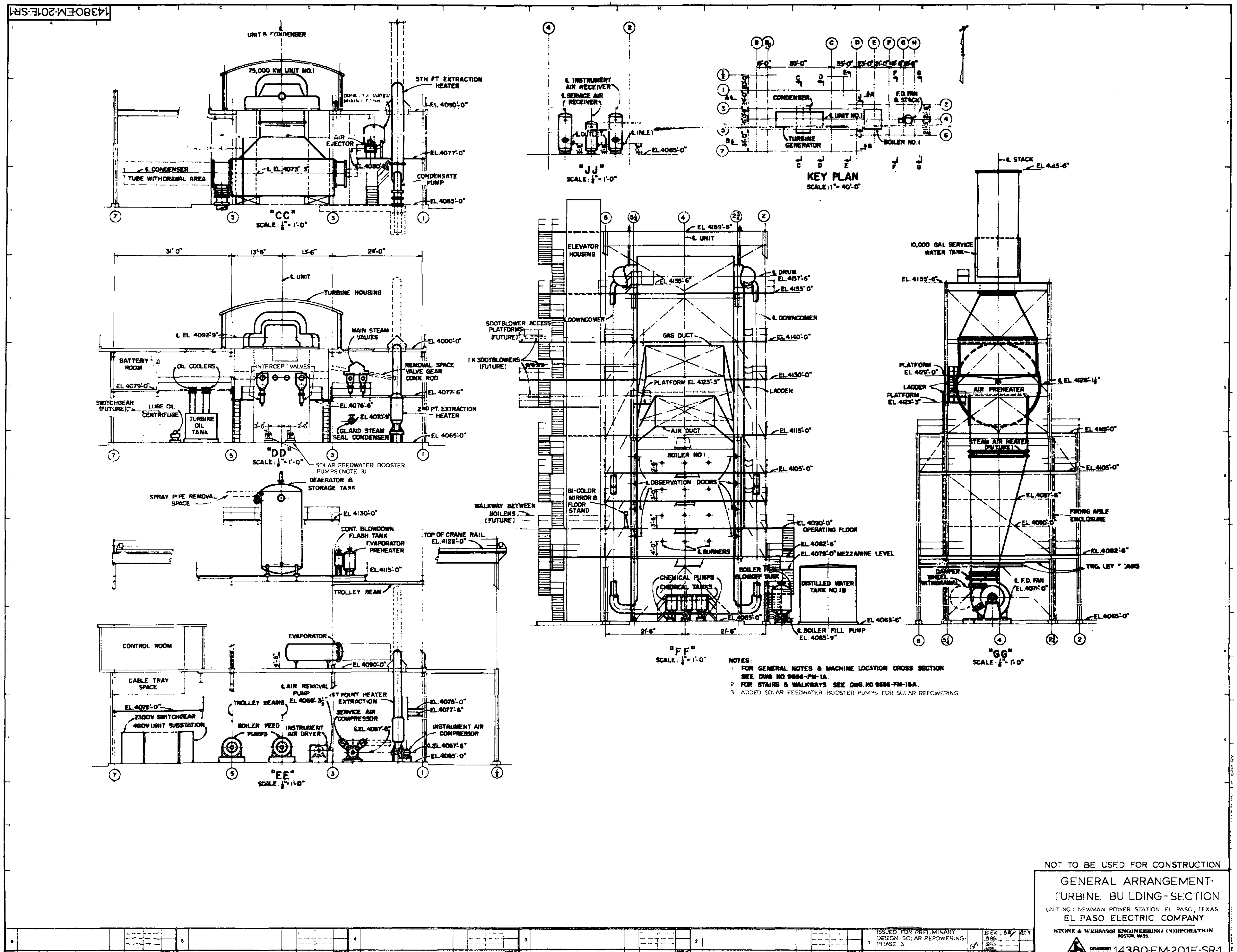
GENERAL ARRANGEMENT
TURBINE BUILDING
PLAN GROUND FLOOR

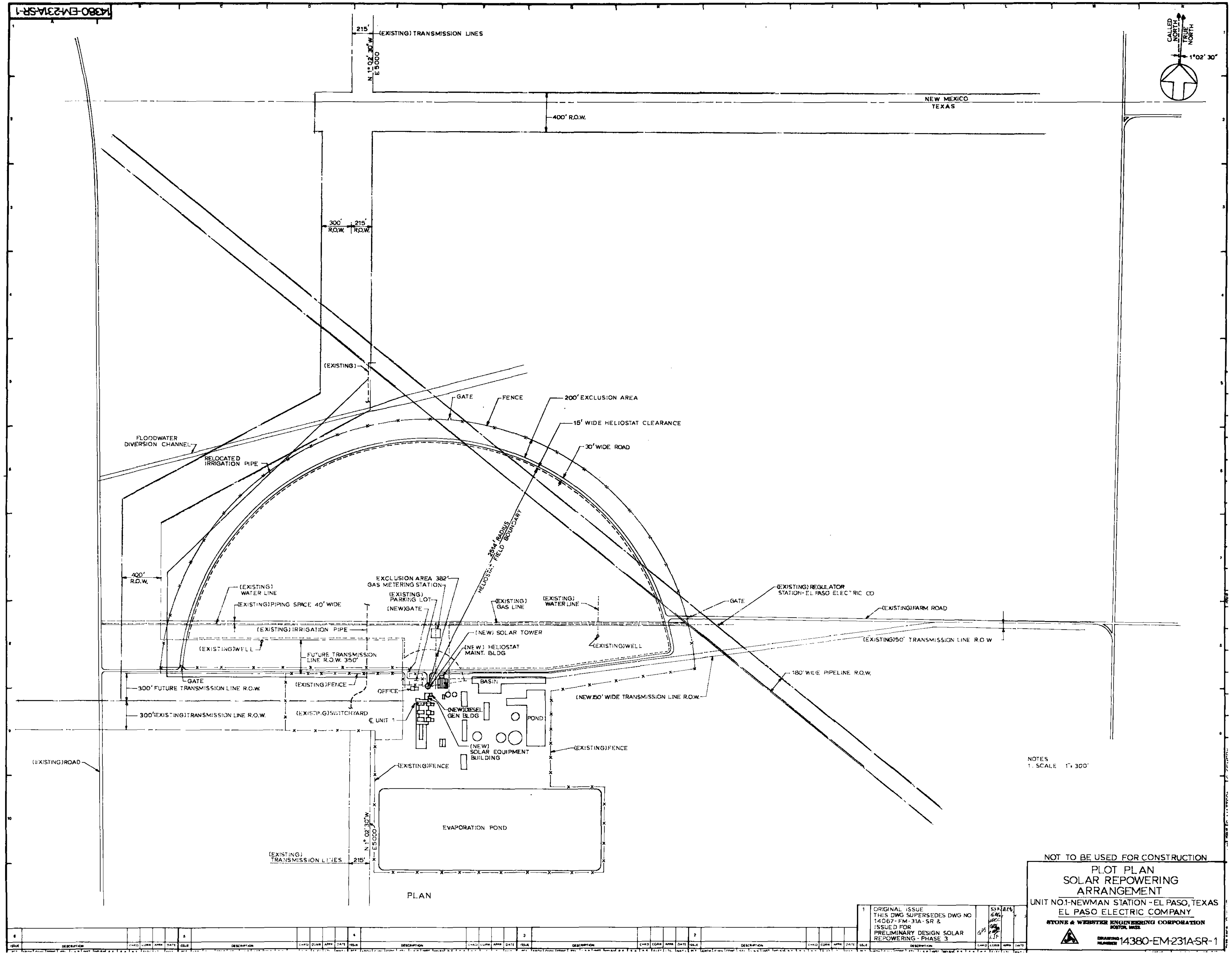
UNIT NO. 1 - NEWMAN POWER STATION - EL PASO, TEXAS
EL PASO ELECTRIC COMPANY

STONE & WEBSTER ENGINEERING CORPORATION
BOSTON, MASS.

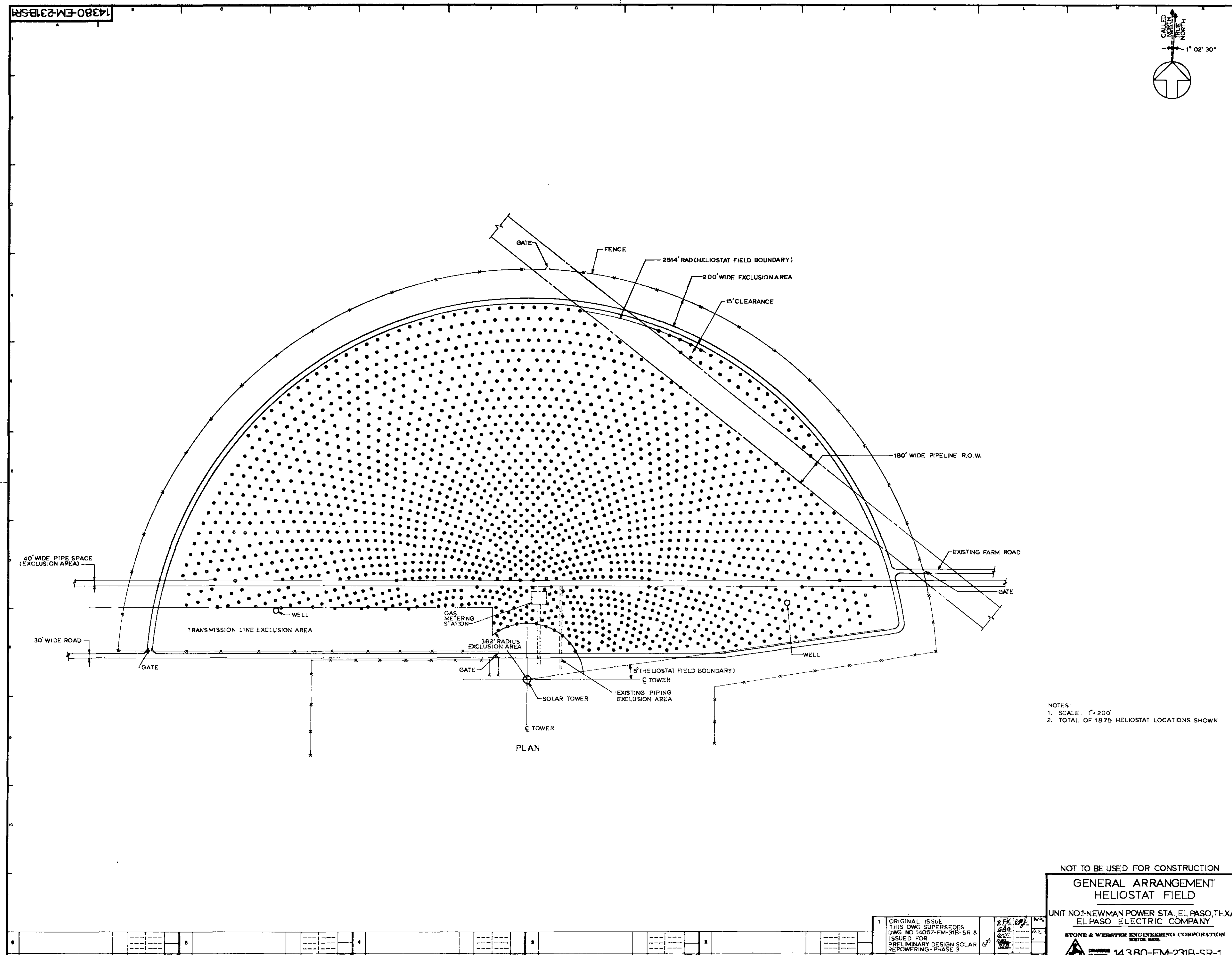
DRAWING NUMBER 14380-EM-201C-SR-1

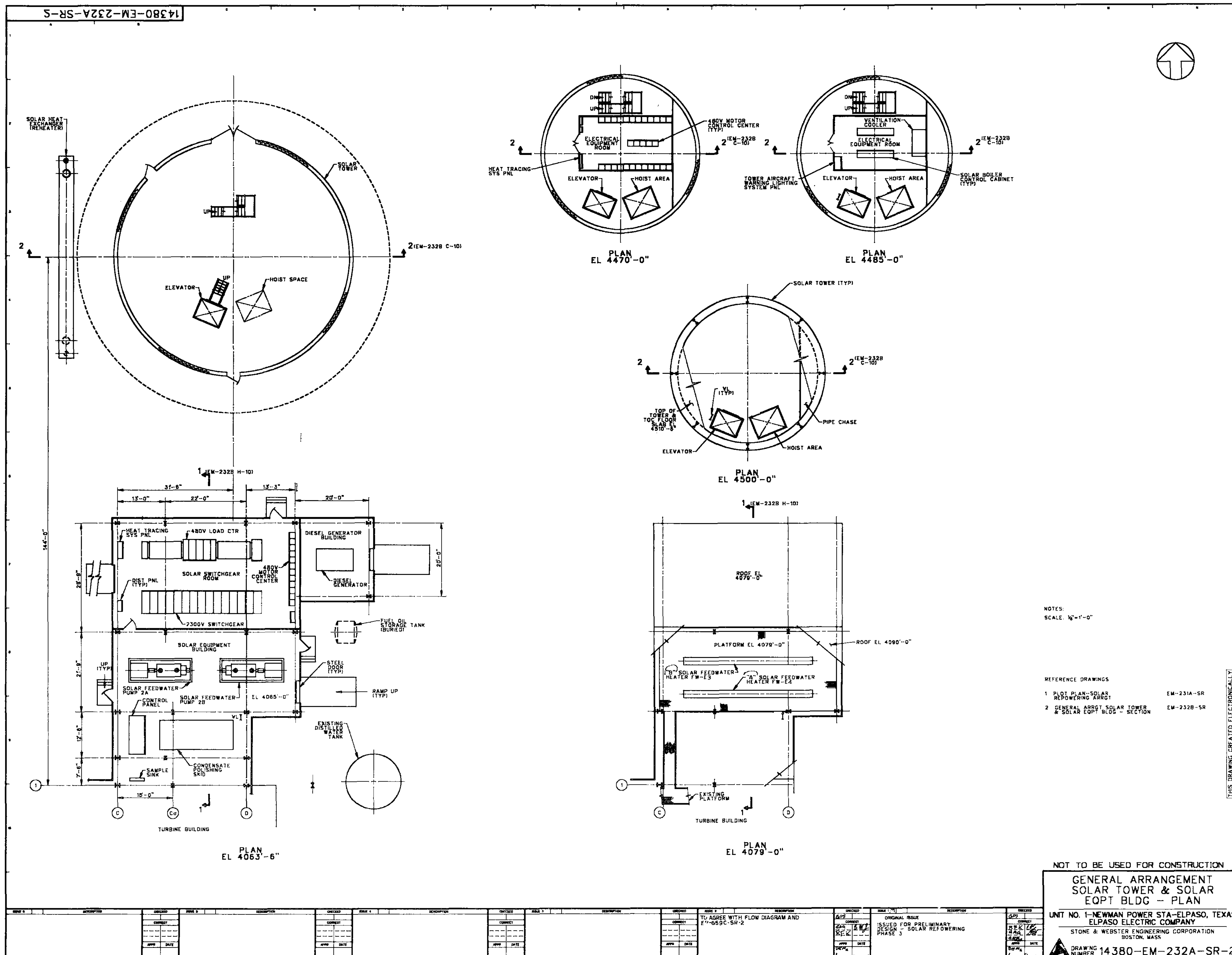
1 ISSUED FOR PRELIMINARY DESIGN SOLAR REPOWERING - PHASE 3

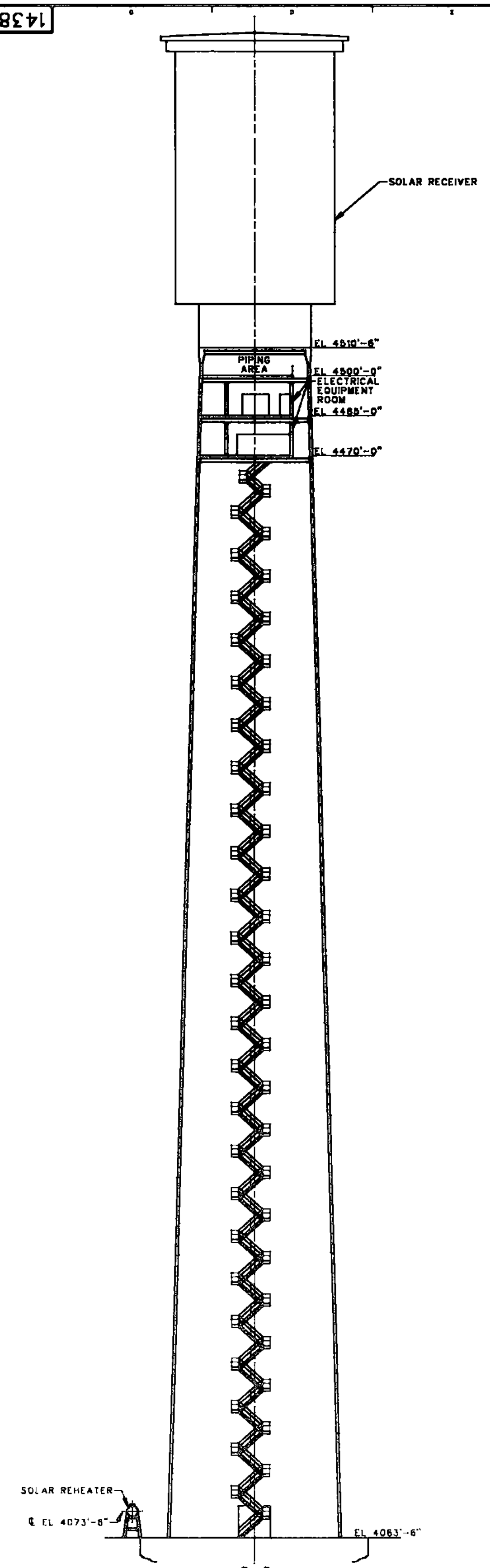

14380-EM-201E-SR1
"CC"
SCALE: 1/8" = 1'-0"
75,000 KW UNIT NO.1
5TH PT EXTRACTION HEATER
AIR EJECTOR
CONDENSATE PUMP
TUBE WITHDRAWAL AREA
"DD"
SCALE: 1/8" = 1'-0"
TURBINE HOUSING
MAIN STEAM VALVES
BATTERY ROOM
OIL COOLERS
INTERCEPT VALVES
SWITCHGEAR (FUTURE)
LUBE OIL CENTRIFUGE
TURBINE OIL TANK
GLAND STEAM SEAL CONDENSER
2ND PT. EXTRACTION HEATER
SOLAR FEEDWATER BOOSTER PUMPS (NOTE 3)
DEAERATOR & STORAGE TANK
SPRAY PIPE REMOVAL SPACE
CONT. BLOWDOWN FLASH TANK
EVAPORATOR PREHEATER
TOP OF CRANE RAIL EL. 4122'-0"
TROLLEY BEAM
CONTROL ROOM
CABLE TRAY SPACE
EVAPORATOR
2300V SWITCHGEAR
480V UNIT SUBSTATION
TROLLEY BEAMS
BOILER FEED PUMPS
INSTRUMENT AIR DRYER
SERVICE AIR COMPRESSOR
INSTRUMENT AIR COMPRESSOR
"EE"
SCALE: 1/8" = 1'-0"
"JJ"
SCALE: 1/8" = 1'-0"
KEY PLAN
SCALE: 1" = 40'-0"
CONDENSER
TURBINE GENERATOR
BOILER NO. 1
F.D. FAN & STACK
ELEVATOR HOUSING
DOWNCOMER
SOOTBLOWER ACCESS PLATFORMS (FUTURE)
GAS DUCT
LADDER
AIR DUCT
BOILER NO. 1
OBSERVATION DOORS
BI-COLOR MIRROR & FLOOR STAND
WALKWAY BETWEEN BOILERS (FUTURE)
BURNERS
CHEMICAL PUMPS
CHEMICAL TANKS
BOILER BLOWOFF TANK
DISTILLED WATER TANK NO.1B
BOILER FILL PUMP
OPERATING FLOOR
MEZZANINE LEVEL
"FF"
SCALE: 1/8" = 1'-0"
STACK
10,000 GAL SERVICE WATER TANK
AIR PREHEATER
STEAM AIR HEATER (FUTURE)
FIRING AISLE ENCLOSURE
DAMPER WHEEL WITHDRAWAL
F.D. FAN
"GG"
SCALE: 1/8" = 1'-0"
NOTES:
1. FOR GENERAL NOTES & MACHINE LOCATION CROSS SECTION SEE DWG NO. 9886-FM-1A.
2. FOR STAIRS & WALKWAYS SEE DWG NO 9886-FM-16A.
3. ADDED SOLAR FEEDWATER BOOSTER PUMPS FOR SOLAR REPOWERING
NOT TO BE USED FOR CONSTRUCTION
GENERAL ARRANGEMENT-
TURBINE BUILDING-SECTION
UNIT NO 1 NEWMAN POWER STATION EL PASO, TEXAS
EL PASO ELECTRIC COMPANY
STONE & WEBSTER ENGINEERING CORPORATION
BOSTON, MASS.
ISSUED FOR PRELIMINARY DESIGN SOLAR REPOWERING PHASE 3
14380-EM-201E-SR-1



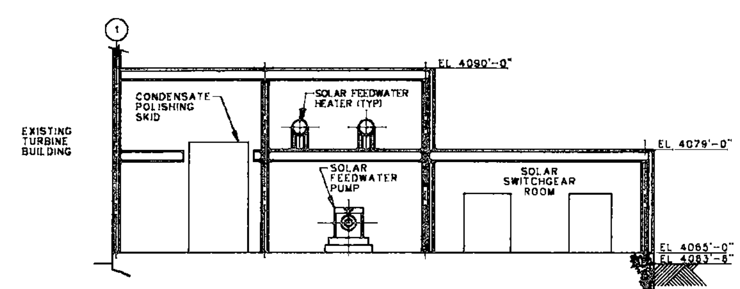
14380-EM-231A-SR-1
215'
(EXISTING) TRANSMISSION LINES
N 1°02' 30" W
E5000
NEW MEXICO
TEXAS
400' R.O.W.
CALLED NORTH
TRUE NORTH
1°02' 30"
300' R.O.W.
215' R.O.W.
(EXISTING)
GATE
FENCE
200' EXCLUSION AREA
15' WIDE HELIOSTAT CLEARANCE
30' WIDE ROAD
FLOODWATER DIVERSION CHANNEL
RELOCATED IRRIGATION PIPE
2314' RADIUS HELIOSTAT FIELD BOUNDARY
400' R.O.W.
(EXISTING) WATER LINE
(EXISTING) PIPING SPACE 40' WIDE
EXCLUSION AREA 382'
GAS METERING STATION
(EXISTING) PARKING LOT
(NEW) GATE
(EXISTING) GAS LINE
(EXISTING) WATER LINE
(EXISTING) REGULATOR STATION - EL PASO ELECTRIC CO
GATE
(EXISTING) FARM ROAD
(EXISTING) IRRIGATION PIPE
(NEW) SOLAR TOWER
(EXISTING) WELL
(NEW) HELIOSTAT MAINT. BLDG
(EXISTING) WELL
FUTURE TRANSMISSION LINE R.O.W. 350'
(EXISTING) 50' TRANSMISSION LINE R.O.W.
GATE
300' FUTURE TRANSMISSION LINE R.O.W.
(EXISTING) FENCE
OFFICE
BASIN
180' WIDE PIPELINE R.O.W.
(NEW) 150' WIDE TRANSMISSION LINE R.O.W.
300' (EXISTING) TRANSMISSION LINE R.O.W.
(EXISTING) SWITCHYARD
℄ UNIT 1
(NEW) DIESEL GEN BLDG
POND
(NEW) SOLAR EQUIPMENT BUILDING
(EXISTING) FENCE
(EXISTING) ROAD
(EXISTING) FENCE
EVAPORATION POND
N 1° 02' 30" W
E5000
(EXISTING) TRANSMISSION LINES
215'
PLAN
NOTES
1. SCALE 1" = 300'
NOT TO BE USED FOR CONSTRUCTION
PLOT PLAN
SOLAR REPOWERING
ARRANGEMENT
UNIT NO.1-NEWMAN STATION - EL PASO, TEXAS
EL PASO ELECTRIC COMPANY
STONE & WEBSTER ENGINEERING CORPORATION
BOSTON, MASS.
14380-EM-231A-SR-1
1 ORIGINAL ISSUE
THIS DWG SUPERSEDES DWG NO 14067-FM-31A-SR &
ISSUED FOR PRELIMINARY DESIGN SOLAR REPOWERING - PHASE 3
ISSUE
DESCRIPTION


14380-EM-231B-SR
CALLED NORTH
TRUE NORTH
1° 02' 30"
GATE
FENCE
2514' RAD (HELIOSTAT FIELD BOUNDARY)
200' WIDE EXCLUSION AREA
15' CLEARANCE
180' WIDE PIPELINE R.O.W.
EXISTING FARM ROAD
GATE
40' WIDE PIPE SPACE (EXCLUSION AREA)
WELL
GAS METERING STATION
TRANSMISSION LINE EXCLUSION AREA
30' WIDE ROAD
382' RADIUS EXCLUSION AREA
GATE
GATE
8' (HELIOSTAT FIELD BOUNDARY)
℄ TOWER
EXISTING PIPING EXCLUSION AREA
SOLAR TOWER
WELL
℄ TOWER
PLAN
NOTES:
1. SCALE: 1"=200'
2. TOTAL OF 1875 HELIOSTAT LOCATIONS SHOWN
NOT TO BE USED FOR CONSTRUCTION
GENERAL ARRANGEMENT
HELIOSTAT FIELD
UNIT NO.1-NEWMAN POWER STA., EL PASO, TEXAS
EL PASO ELECTRIC COMPANY
STONE & WEBSTER ENGINEERING CORPORATION
BOSTON, MASS.
14380-EM-231B-SR-1
1 ORIGINAL ISSUE THIS DWG SUPERSEDES DWG NO 14067-FM-31B-SR & ISSUED FOR PRELIMINARY DESIGN SOLAR REPOWERING-PHASE 3
DESCRIPTION
CHKD
CORRECT


14380-EM-232A-SR-2
SOLAR HEAT EXCHANGER (REHEATER)
SOLAR TOWER
UP
ELEVATOR
HOIST SPACE
2 (EM-232B C-10)
DN
UP
480V MOTOR CONTROL CENTER (TYP)
ELECTRICAL EQUIPMENT ROOM
HEAT TRACING SYS PNL
ELEVATOR
HOIST AREA
PLAN
EL 4470'-0"
VENTILATION COOLER
ELECTRICAL EQUIPMENT ROOM
TOWER AIRCRAFT WARNING LIGHTING SYSTEM PNL
SOLAR BOILER CONTROL CABINET (TYP)
PLAN
EL 4485'-0"
SOLAR TOWER (TYP)
VL (TYP)
TOP OF TOWER & TOC FLOOR SLAB EL 4510'-0"
PIPE CHASE
ELEVATOR
HOIST AREA
PLAN
EL 4500'-0"
1 (EM-232B H-10)
31'-6"
13'-0"
22'-0"
13'-3"
20'-0"
HEAT TRACING SYS PNL
480V LOAD CTR
DIESEL GENERATOR BUILDING
SOLAR SWITCHGEAR ROOM
480V MOTOR CONTROL CENTER
DIST PNL (TYP)
DIESEL GENERATOR
2300V SWITCHGEAR
FUEL OIL STORAGE TANK (BURIED)
SOLAR EQUIPMENT BUILDING
STEEL DOOR (TYP)
UP (TYP)
SOLAR FEEDWATER PUMP 2A
SOLAR FEEDWATER PUMP 2B
EL 4065'-0"
RAMP UP (TYP)
CONTROL PANEL
EXISTING DISTILLED WATER TANK
CONDENSATE POLISHING SKID
SAMPLE SINK
15'-0"
TURBINE BUILDING
PLAN
EL 4063'-6"
ROOF EL 4079'-0"
PLATFORM EL 4079'-0"
ROOF EL 4090'-0"
"B" SOLAR FEEDWATER HEATER FW-E3
"A" SOLAR FEEDWATER HEATER FW-E4
EXISTING PLATFORM
TURBINE BUILDING
PLAN
EL 4079'-0"
NOTES:
SCALE: 1/8"=1'-0"
REFERENCE DRAWINGS
1 PLOT PLAN-SOLAR REPOWERING ARRGT EM-231A-SR
2 GENERAL ARRGT SOLAR TOWER & SOLAR EQPT BLDG - SECTION EM-232B-SR
THIS DRAWING CREATED ELECTRONICALLY
NOT TO BE USED FOR CONSTRUCTION
GENERAL ARRANGEMENT
SOLAR TOWER & SOLAR
EQPT BLDG - PLAN
UNIT NO. 1-NEWMAN POWER STA-ELPASO, TEXAS
ELPASO ELECTRIC COMPANY
STONE & WEBSTER ENGINEERING CORPORATION
BOSTON, MASS
DRAWING NUMBER 14380-EM-232A-SR-2
TO AGREE WITH FLOW DIAGRAM AND EM-659C-SR-2
ORIGINAL ISSUE
ISSUED FOR PRELIMINARY DESIGN - SOLAR REPOWERING PHASE 3



2-2
(EM-232A)
SCALE:1"=20'-0"



1-1
(EM-232A)
SCALE:1/8"=1'-0"

NOTES:

1. SCALE: AS NOTED.

REFERENCE DRAWINGS

1. GENERAL ARRGT SOLAR TOWER & SOLAR EQPT BLDG - PLAN — EM-232A- SR

THIS DRAWING CREATED ELECTRONICALLY

ORIGINAL ISSUE
ISSUED FOR PRELIMINARY DESIGN - SOLAR REPOWERING PHASE 3

NOT TO BE USED FOR CONSTRUCTION

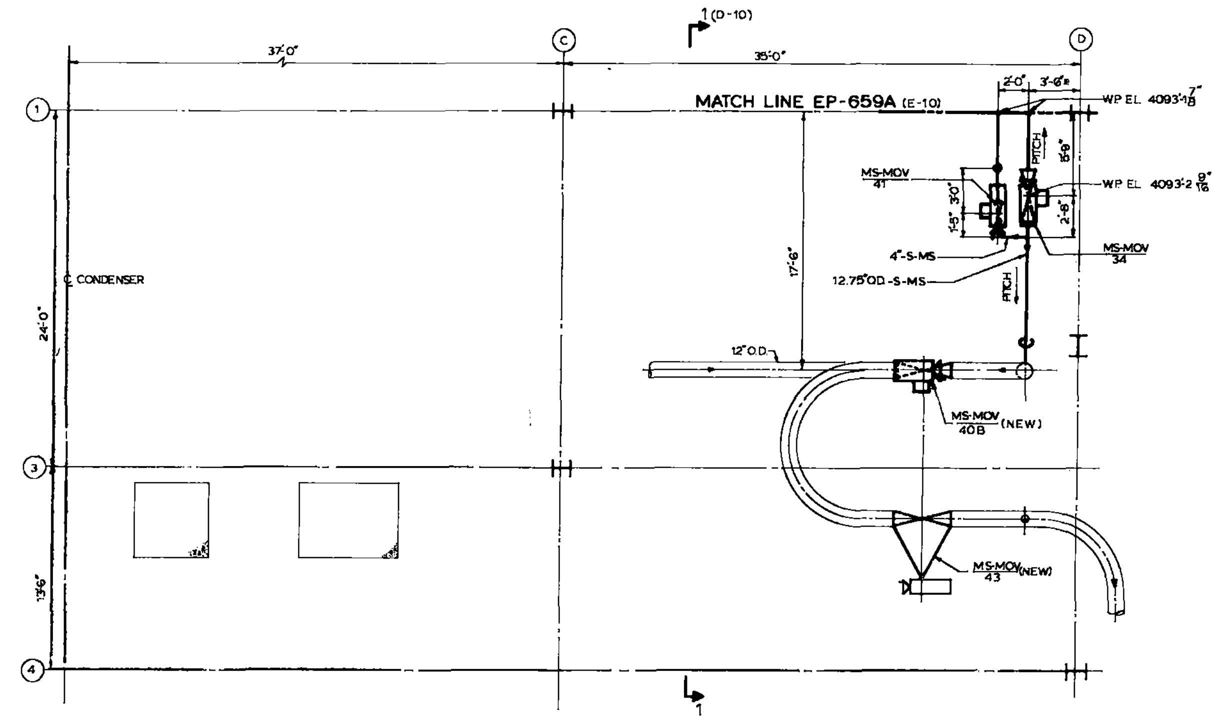
GENERAL ARRANGEMENT SOLAR TOWER & SOLAR EQPT BLDG - SECTION

UNIT NO. 1-NEWMAN POWER STA-ELPASO, TEXAS
ELPASO ELECTRIC COMPANY

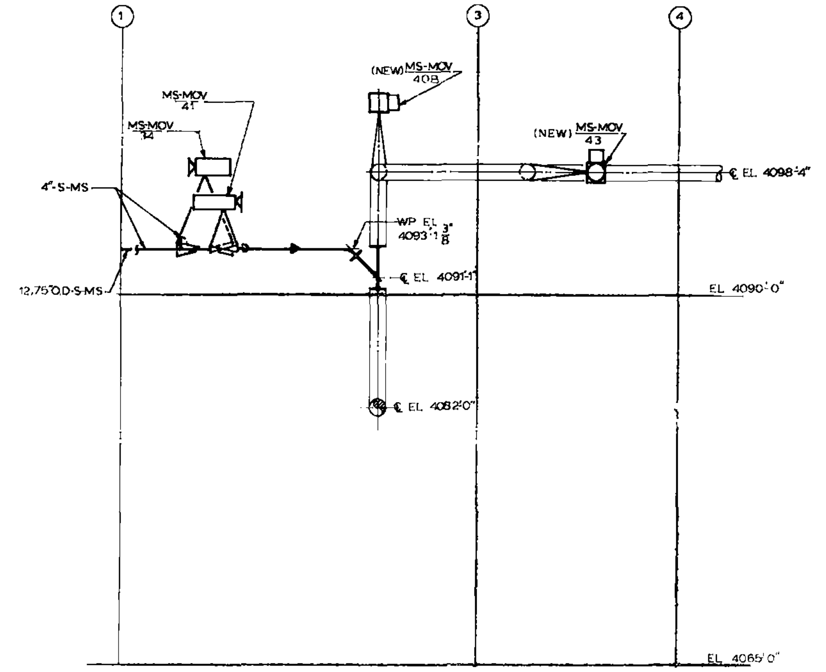
STONE & WEBSTER ENGINEERING CORPORATION
BOSTON, MASS.

DRAWING NUMBER 14380-EM-232B-SR-1

14380-EP-601A-SR-1



PLAN EL 4090'-0"



1-1
(F-1)

NOTES
1 SCALE 1/4"=1'-0"
2 ⊞ INDICATES HOT DIMENSION

REFERENCE DRAWINGS
1 DIAG - SOLAR REPOWERING MN & HP ST SYS PID-3-1B-SR
2 EXST MACH LOC PLAN EL 4090'-0" 9666-FM-1B
3 EXST MN ST 9666-FP-1A

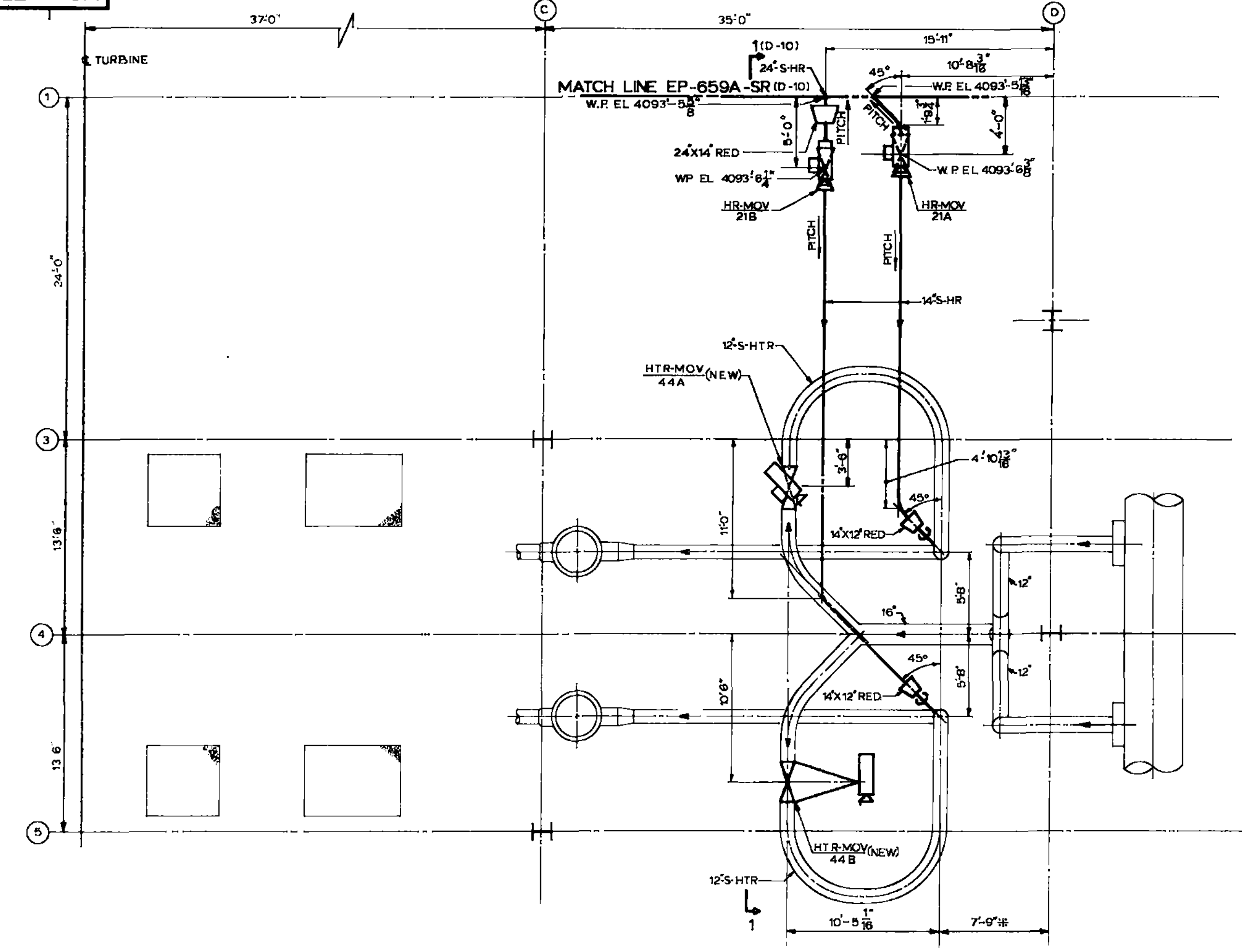
ISSUE	DESCRIPTION	CHKD	CORRECT	APPR DATE
1	ORIGINAL ISSUE. THIS DWG SUPERSEDES DWG NO. 13505-FP-1A-SR & ISSUED FOR PRELIMINARY DESIGN SOLAR REPOWERING - PHASE 3	GPS	RFK DAG WCC	

NOT TO BE USED FOR CONSTRUCTION

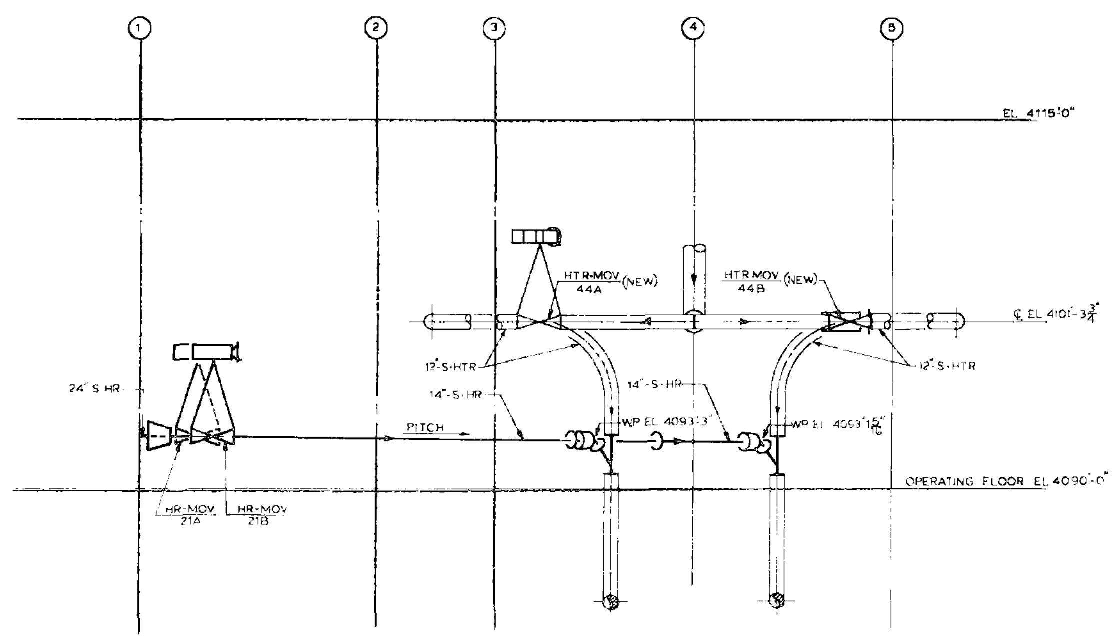
STUDY
SOLAR MAIN STEAM PIPING
TURBINE BUILDING

UNIT NO 1 - NEWMAN POWER STATION - EL PASO, TEXAS
EL PASO ELECTRIC COMPANY

DRAWING NUMBER 14380-EP-601A-SR-1



PLAN EL 4065'-0"



1-1
(F-1)

NOTES:
1. SCALE $\frac{1}{4}$"=1'-0"
2. ✱ INDICATES HOT DIMENSION.

REFERENCE DRAWINGS:

1. P&ID COLD AND HOT REHEAT SYSTEM	14380-PID-3-2-SR
2. FLOW DIAGRAM-MAIN REHEAT & EXTRACTION STEAM LINE	14380-FM-2A-SR
3. HIGH TEMP REHEAT STEAM LINE-SH1	9666-FP-2A
4. HIGH TEMP REHEAT STEAM LINE SH2	9666-FP-2B

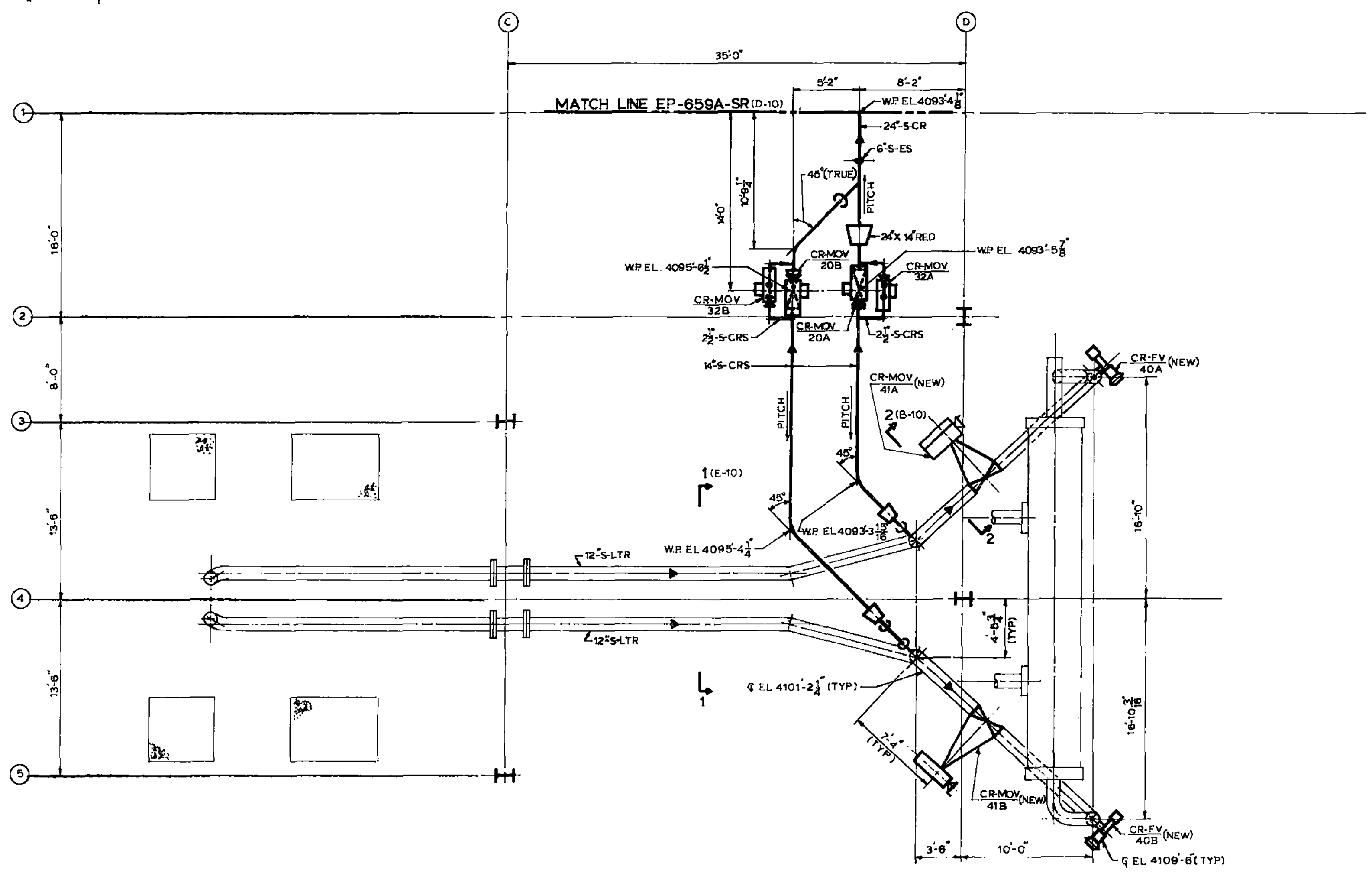
ISSUE	DESCRIPTION	CHKD	CORRECT
1	ORIGINAL ISSUE. THIS DWG SUPERSEDES DWG NO. 13505-FP-2A-SR & ISSUED FOR PRELIMINARY DESIGN SOLAR REPOWERING - PHASE 1		RFK SAG WCC

NOT TO BE USED FOR CONSTRUCTION

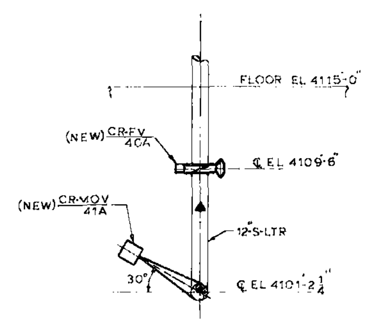
STUDY
SOLAR HOT REHEAT STEAM PIPING
TURBINE BUILDING

UNIT NO 1 - NEWMAN POWER STATION - EL PASO TEXAS
EL PASO ELECTRIC COMPANY

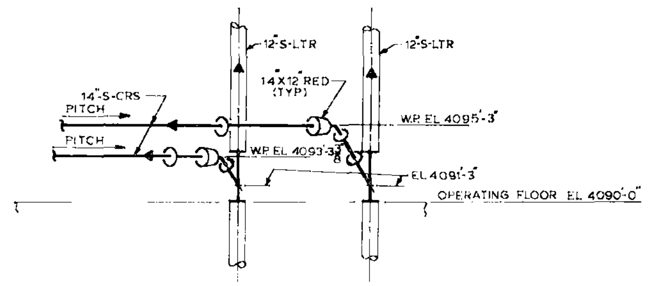
DRAWING NUMBER 14380-EP-602A-SR-1



PLAN



2-2
(G-4)



1-1
(F-4)

NOTES:
1. SCALE. ¼" = 1'-0"

REFERENCE DRAWINGS:

1. DIAG-SOLAR REPOWERING-COLD & HOT REHEAT SYS	PID-3-2-SR
2. LOW TEMP REHEAT STEAM LINE - SHT 1	9666-FP-3A
3. LOW TEMP REHEAT STEAM LINE - SHT 2	9666-FP-3B

NOT TO BE USED FOR CONSTRUCTION

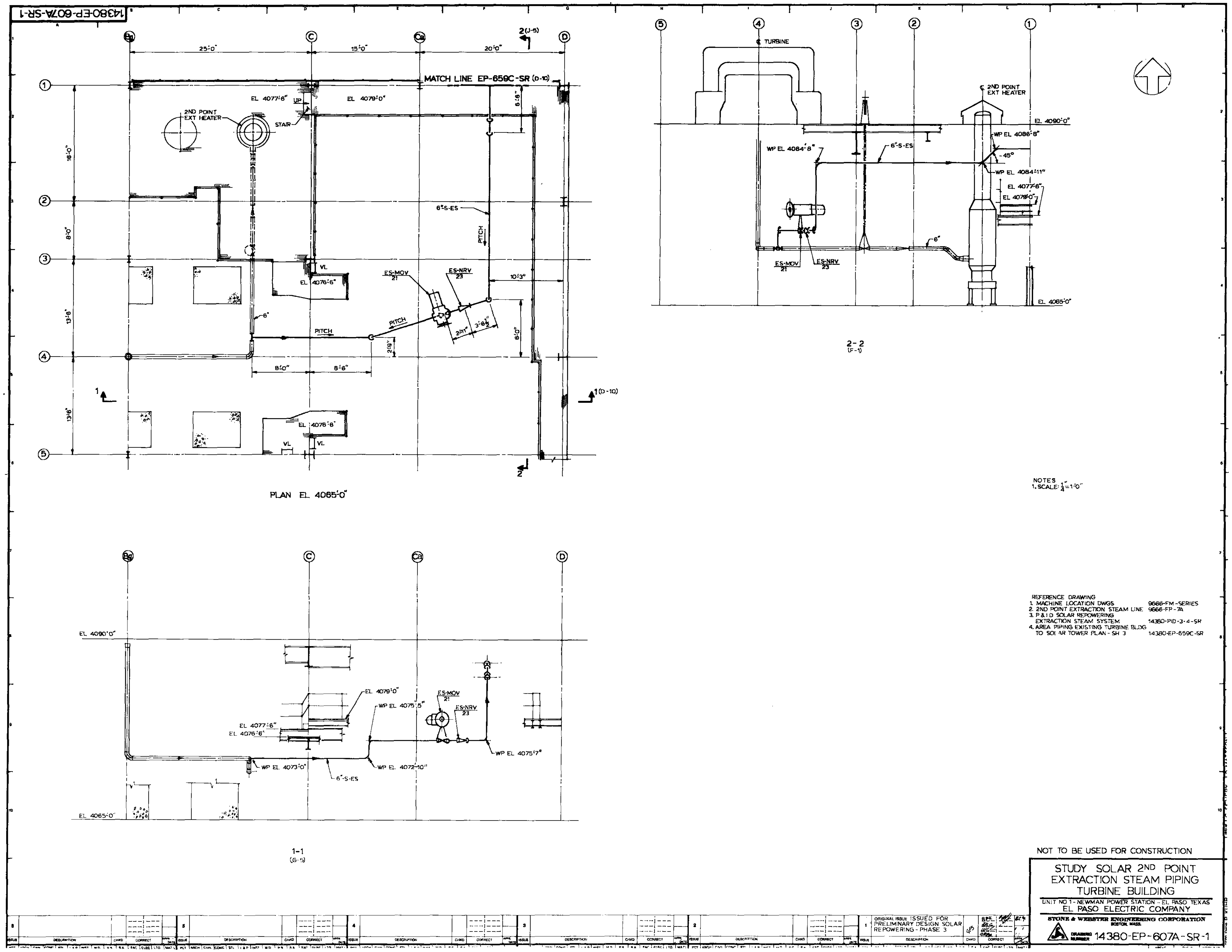
ISSUE	DESCRIPTION	CHKD	CORRECT	APPR DATE
1	ORIGINAL ISSUE THIS DWG SUPERSEDES DWG NO 13505-FP-3A-SR & ISSUED FOR PRELIMINARY DESIGN SOLAR REPOWERING - PHASE 3		RPK GAG WCC	

STUDY-COLD REHEAT STEAM PIPING-TURBINE BLDG

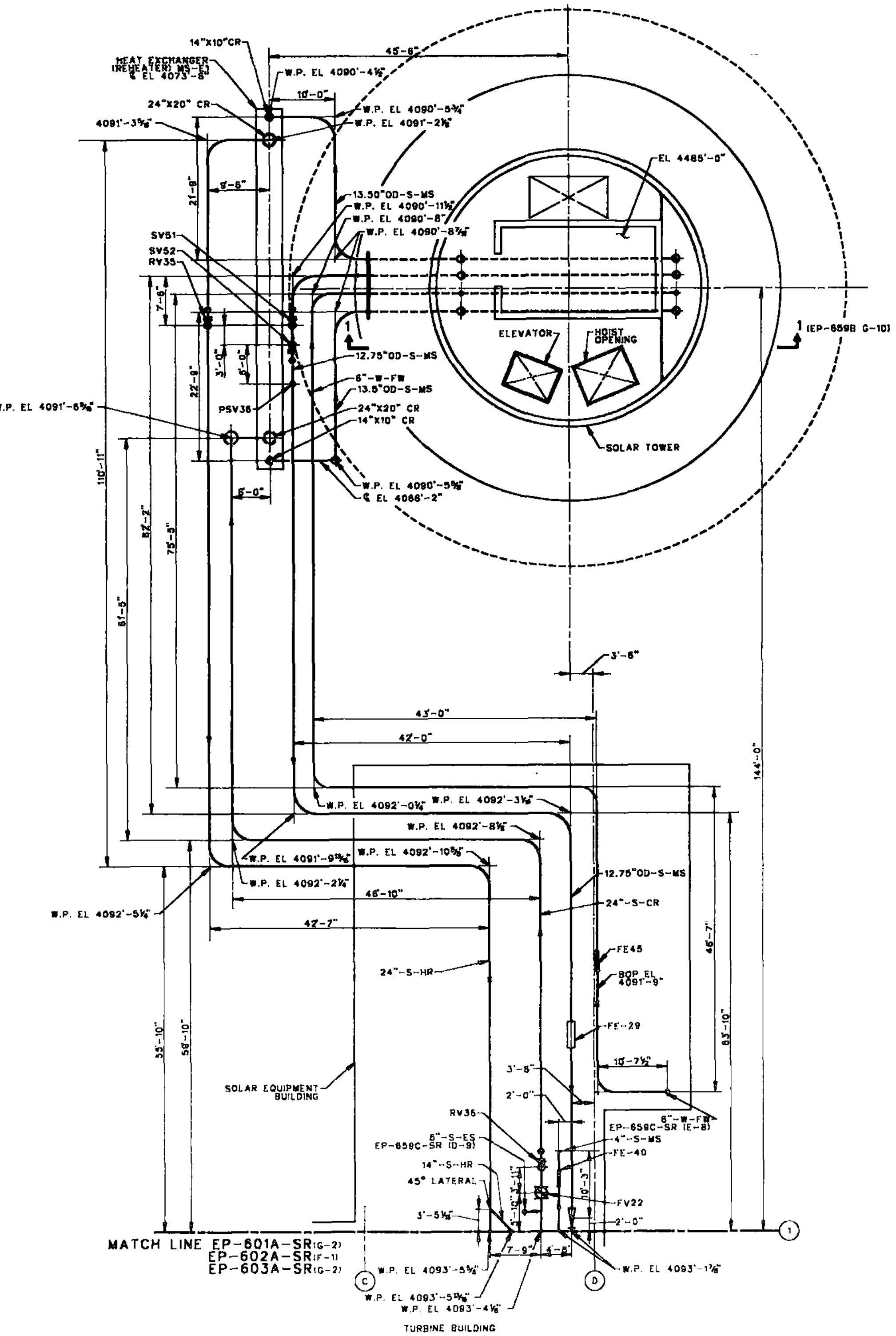
UNIT NO 1 - NEWMAN POWER STATION - EL PASO TEXAS
EL PASO ELECTRIC COMPANY

STONE & WEBSTER ENGINEERING CORPORATION
BOSTON, MASS

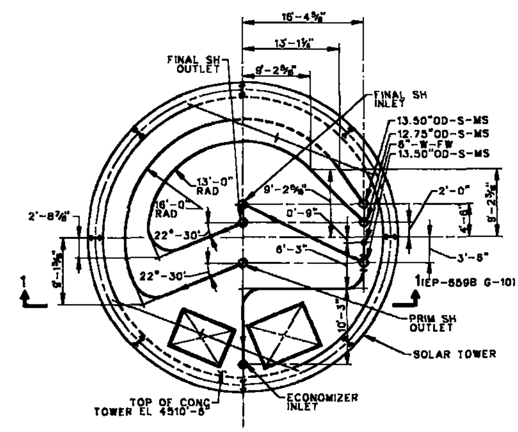
DRAWING NUMBER 14380-EP-603A-SR-1



MATCH LINE EP-659C-SR (D-10)
2ND POINT EXT HEATER
STAIR
EL 4077'-8"
EL 4079'-0"
6"-S-ES
PITCH
ES-MOV 21
ES-NRV 23
EL 4076'-6"
EL 4078'-6"
VL
PLAN EL 4065'-0"
TURBINE
2ND POINT EXT HEATER
EL 4090'-0"
WP EL 4088'-8"
WP EL 4084'-8"
WP EL 4084'-11"
45°
EL 4065'-0"
2-2
NOTES
1. SCALE: 1/4"=1'-0"
WP EL 4073'-0"
WP EL 4072'-10"
WP EL 4075'-5"
WP EL 4075'-7"
1-1
REFERENCE DRAWING
1. MACHINE LOCATION DWGS 9666-FM-SERIES
2. 2ND POINT EXTRACTION STEAM LINE 9666-FP-7A
3. P & I D SOLAR REPOWERING EXTRACTION STEAM SYSTEM 14380-PID-3-4-SR
4. AREA PIPING EXISTING TURBINE BLDG TO SOLAR TOWER PLAN - SH 3 14380-EP-659C-SR
NOT TO BE USED FOR CONSTRUCTION
STUDY SOLAR 2ND POINT EXTRACTION STEAM PIPING TURBINE BUILDING
UNIT NO 1 - NEWMAN POWER STATION - EL PASO TEXAS
EL PASO ELECTRIC COMPANY
STONE & WEBSTER ENGINEERING CORPORATION
BOSTON, MASS.
DRAWING NUMBER 14380-EP-607A-SR-1
ORIGINAL ISSUE ISSUED FOR PRELIMINARY DESIGN SOLAR REPOWERING - PHASE 3



PLAN



DETACHED PLAN
EL 4500'-0"

NOTES:

1. SCALE: 1/8"=1'-0"

REFERENCE DRAWINGS

1	STUDY-AREA PIPING-TURBINE BUILDING TO SOLAR TOWER-SHEET 2	EP-659B-SR
2	STUDY-AREA PIPING-TURBINE BUILDING TO SOLAR TOWER-SHEET 3	EP-659C-SR
3	STUDY-SOLAR MAIN STEAM PIPING TURBINE BUILDING	EP-601A-SR
4	STUDY-SOLAR HOT REHEAT STEAM PIPING-TURBINE BLDG	EP-602A-SR
5	STUDY-SOLAR COLD REHEAT STEAM PIPING-TURBINE BLDG	EP-603A-SR
6	STUDY-SOLAR 2ND POINT EXTRACTION STEAM PIPING-TURBINE BLDG	EP-607A-SR
7	STUDY-SOLAR FEEDWATER BOOSTER PIPING-TURBINE BLDG	EP-660A-SR
8	GENERAL ARRAGEMENT-SOLAR TOWER & SOLAR EQUIPMENT BLDG	EM-232A & B

FLOW DIAGRAMS

1	MAIN & HIGH PRESSURE STEAM SYSTEM	PID-3-1A-SR
2	MAIN & HIGH PRESSURE STEAM SYSTEM	PID-3-1B-SR
3	COLD & HOT REHEAT SYSTEM	PID-3-2-SR
4	EXTRACTION STEAM SYSTEM	PID-3-4-SR
5	FEEDWATER SYSTEM	PID-6-1B-SR
7	FEEDWATER SYSTEM	PID-6-1C-SR

THIS DRAWING CREATED ELECTRONICALLY

ORIGINAL ISSUE

THIS DWG SUPERSEDES DWG NO. 13505 & 14067-FP-59A-SR ISSUED FOR PRELIMINARY DESIGN-SOLAR REPOWERING PHASE 3

NOT TO BE USED FOR CONSTRUCTION

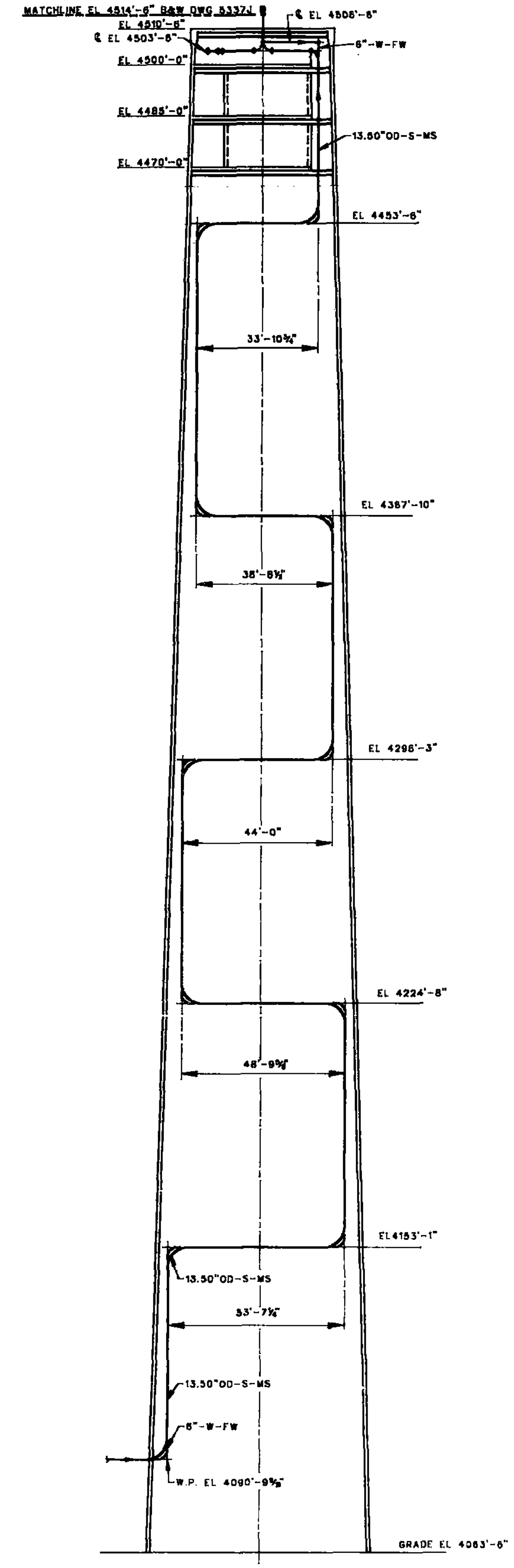
AREA PIPING-EXISTING TURBINE BUILDING TO SOLAR TOWER PLAN SH 1

UNIT NO. 1-NEWMAN POWER STA-ELPASO, TEXAS
ELPASO ELECTRIC COMPANY

STONE & WEBSTER ENGINEERING CORPORATION
BOSTON, MASS.

DRAWING NUMBER 14380-EP-659A-SR-1

14380-EP-659B-SR-1



1-1

(EP-659A-SR F-4)
(EP-659A-SR J-4)

NOTES:
1. SCALE: 1/16"=1'-0"
2. REFERENCE DRAWING EP-659A-SR

THIS DRAWING CREATED ELECTRONICALLY

NOT TO BE USED FOR CONSTRUCTION

AREA PIPING-EXISTING TURBINE BUILDING TO SOLAR TOWER-SECT-SH 2

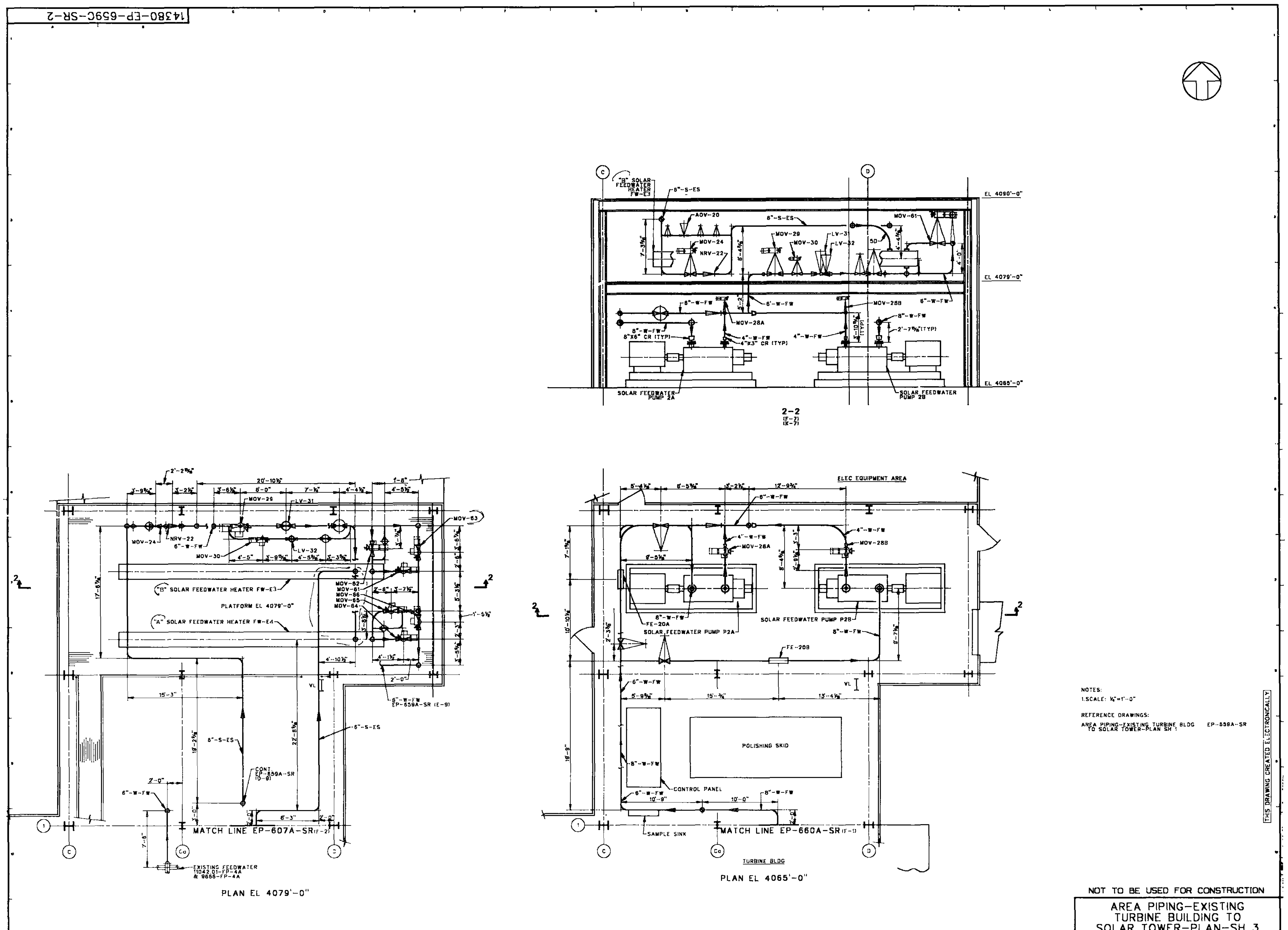
UNIT NO. 1-NEWMAN POWER STA-ELPASO, TEXAS
ELPASO ELECTRIC COMPANY

STONE & WEBSTER ENGINEERING CORPORATION
BOSTON, MASS.

DRAWING NUMBER 14380-EP-659B-SR-1

ORIGINAL ISSUE
THIS DWG SUPERSEDES DWG NO. 135 & 14087-FP-59B-SR ISSUED FOR PRELIMINARY DESIGN SOLAR REPOWERING-PHASE 3

DESIGNED BY H CLEMENS DRAWN BY H CLEMENS



NOTES:
1. SCALE: ¼"=1'-0"

REFERENCE DRAWINGS:
AREA PIPING-EXISTING TURBINE BLDG TO SOLAR TOWER-PLAN SH 1 EP-659A-SR

THIS DRAWING CREATED ELECTRONICALLY

NOT TO BE USED FOR CONSTRUCTION

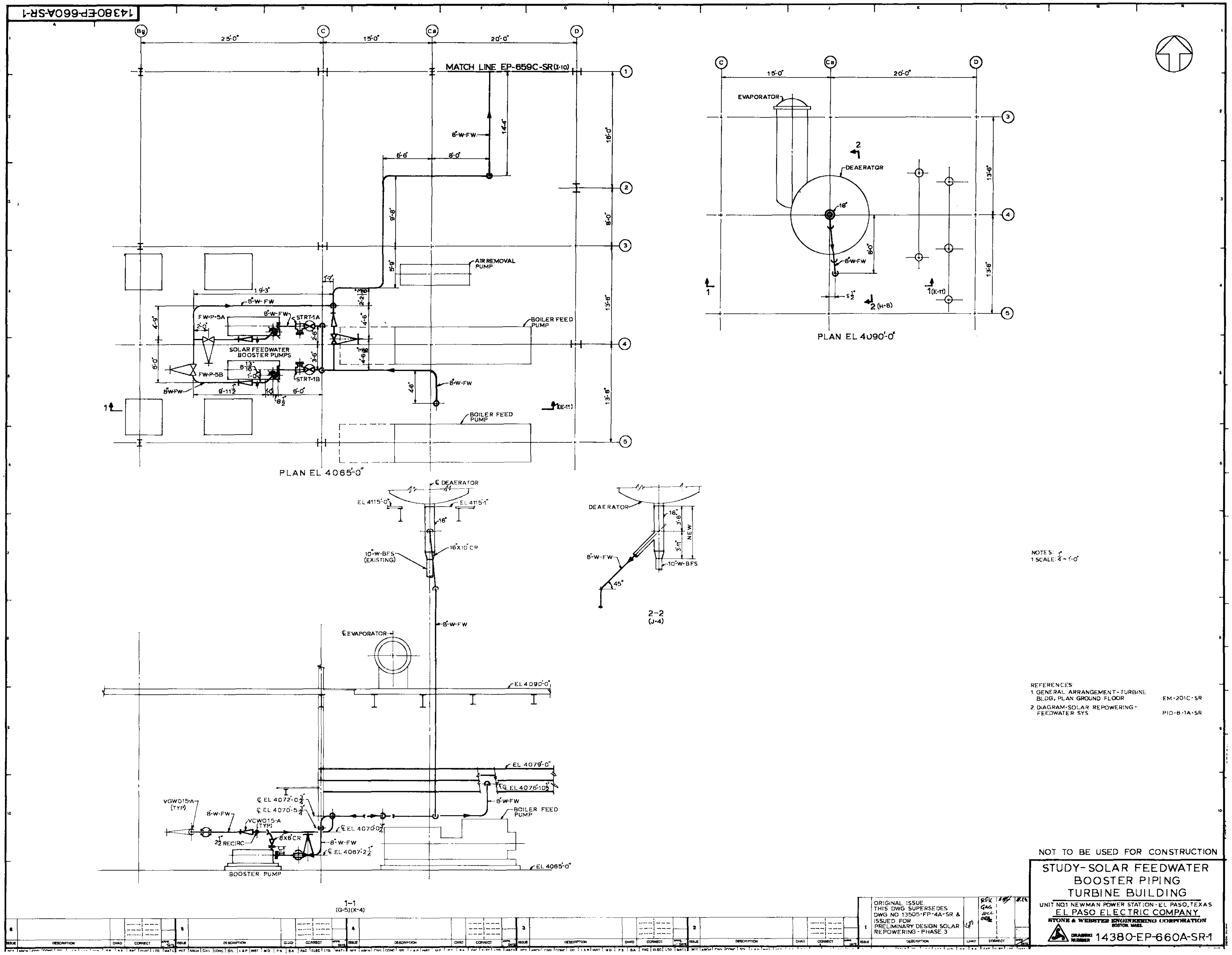
AREA PIPING-EXISTING TURBINE BUILDING TO SOLAR TOWER-PLAN-SH 3

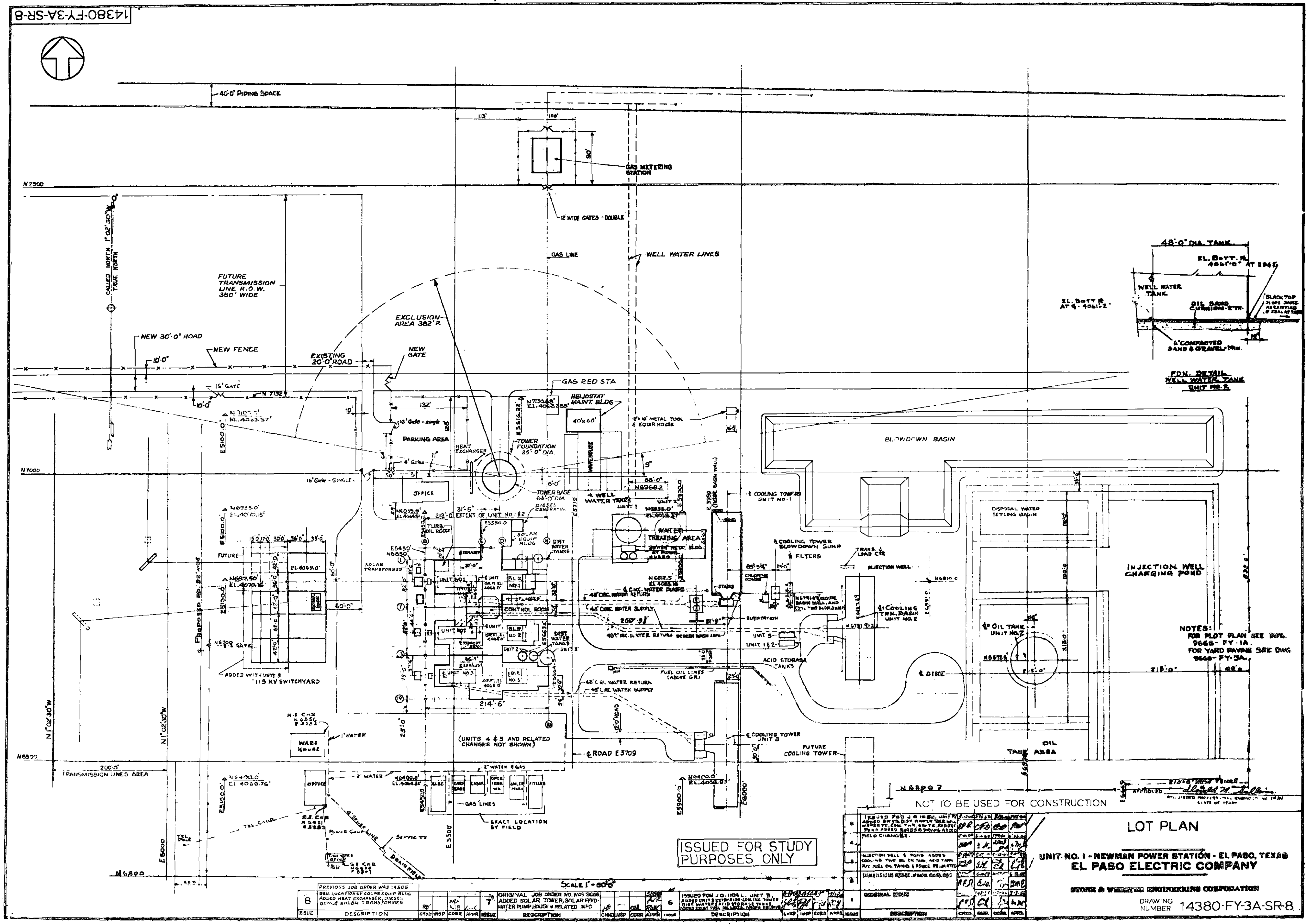
UNIT NO. 1-NEWMAN POWER STA-ELPASO, TEXAS
ELPASO ELECTRIC COMPANY

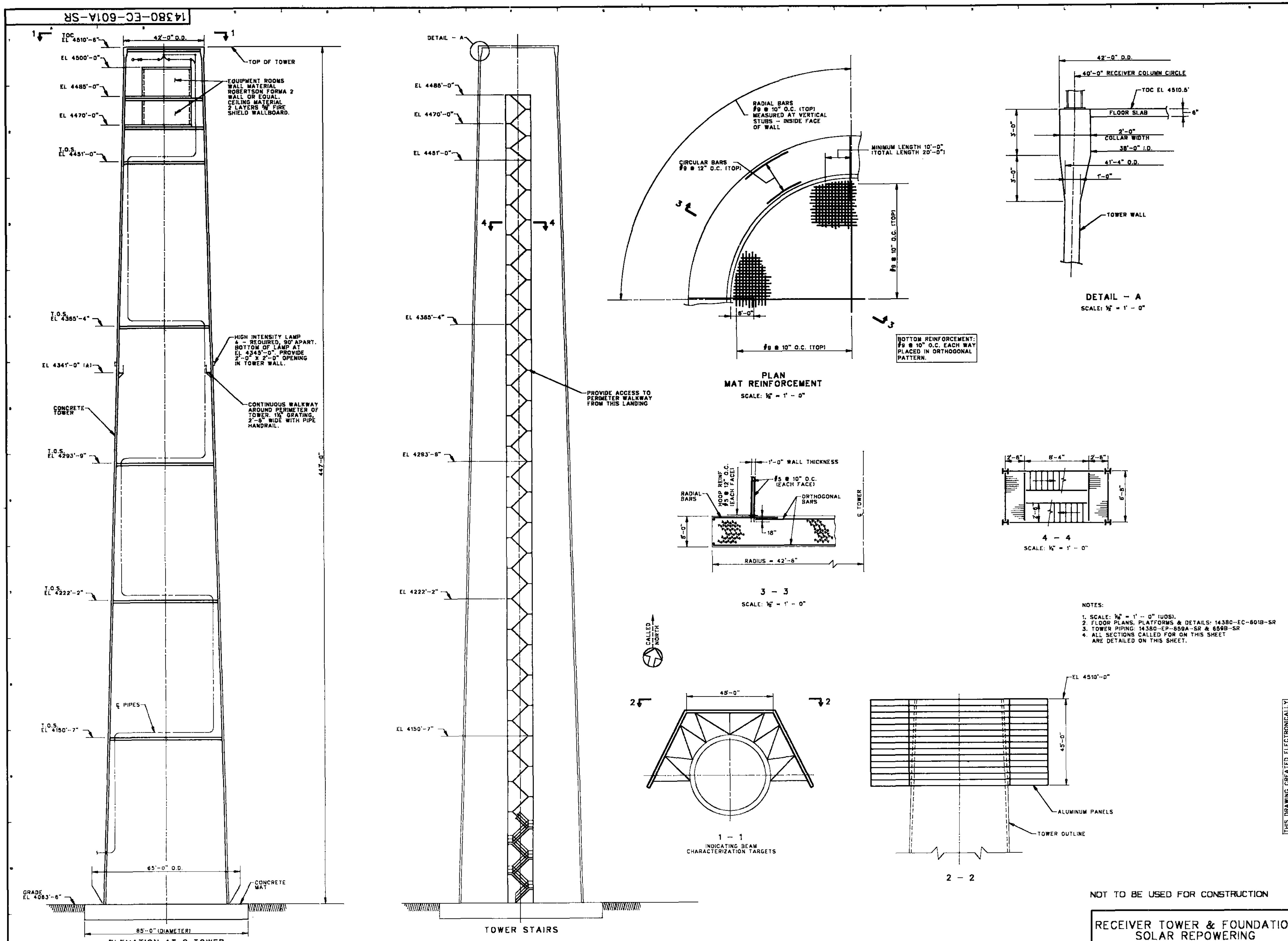
STONE & WEBSTER ENGINEERING CORPORATION
BOSTON, MASS.

DRAWING NUMBER 14380-EP-659C-SR-2

ISSUE	DESCRIPTION
	ORIGINAL ISSUE
	ISSUED FOR PRELIMINARY DESIGN-SOLAR REPOWERING PHASE 3
	REVISED TO AGREE WITH FLOW DIAGRAM


14380-EP-660A-SR-1
MATCH LINE EP-659C-SR(I-10)
AIR REMOVAL PUMP
BOILER FEED PUMP
SOLAR FEEDWATER BOOSTER PUMPS
FW-P-5A
FW-P-5B
STRT-1A
STRT-1B
8"-W-FW
PLAN EL 4065'-0"
EVAPORATOR
DEAERATOR
PLAN EL 4090'-0"
℄ DEAERATOR
EL 4115'-0"
EL 4115'-1"
16X10 CR
10"-W-BFS (EXISTING)
℄ EVAPORATOR
EL 4090'-0"
EL 4079'-0"
BOOSTER PUMP
1-1 (G-5)(K-4)
DEAERATOR
NEW
10"-W-BFS
2-2 (J-4)
NOTES:
1 SCALE: ¼" = 1'-0"
REFERENCES
1. GENERAL ARRANGEMENT - TURBINE BLDG, PLAN GROUND FLOOR EM-201C-SR
2. DIAGRAM-SOLAR REPOWERING-FEEDWATER SYS PID-6-1A-SR
NOT TO BE USED FOR CONSTRUCTION
ORIGINAL ISSUE. THIS DWG SUPERSEDES DWG NO 13505-FP-4A-SR & ISSUED FOR PRELIMINARY DESIGN SOLAR REPOWERING - PHASE 3
STUDY-SOLAR FEEDWATER BOOSTER PIPING TURBINE BUILDING
UNIT NO.1 NEWMAN POWER STATION - EL PASO, TEXAS
EL PASO ELECTRIC COMPANY
STONE & WEBSTER ENGINEERING CORPORATION BOSTON, MASS.
14380-EP-660A-SR-1


LOT PLAN
UNIT NO. 1 - NEWMAN POWER STATION - EL PASO, TEXAS
EL PASO ELECTRIC COMPANY
STONE & WEBSTER ENGINEERING CORPORATION
DRAWING NUMBER 14380-FY-3A-SR-8
NOT TO BE USED FOR CONSTRUCTION
ISSUED FOR STUDY PURPOSES ONLY
BLOWDOWN BASIN
INJECTION WELL CHARGING POND
EXCLUSION AREA 382' R.
FUTURE TRANSMISSION LINE R.O.W. 350' WIDE
GAS METERING STATION
WELL WATER LINES
HELIOSTAT MAINT. BLDG
TOWER FOUNDATION 85'-0" DIA.
WATER TREATING AREA
ACID STORAGE TANKS
FUTURE COOLING TOWER
OIL TANK AREA
(UNITS 4 & 5 AND RELATED CHANGES NOT SHOWN)
FDN. DETAIL WELL WATER TANK UNIT NO. 2
NOTES: FOR PLOT PLAN SEE DWG. 9666-FY-1A. FOR YARD PAVING SEE DWG. 9666-FY-3A.
SCALE 1" = 60'
14380-FY-3A-SR-8



NOTES:

1. SCALE: 3/64" = 1' - 0" (UOS).
2. FLOOR PLANS, PLATFORMS & DETAILS: 14380-EC-601B-SR
3. TOWER PIPING: 14380-EP-659A-SR & 659B-SR
4. ALL SECTIONS CALLED FOR ON THIS SHEET ARE DETAILED ON THIS SHEET.

THIS DRAWING CREATED ELECTRONICALLY

NOT TO BE USED FOR CONSTRUCTION

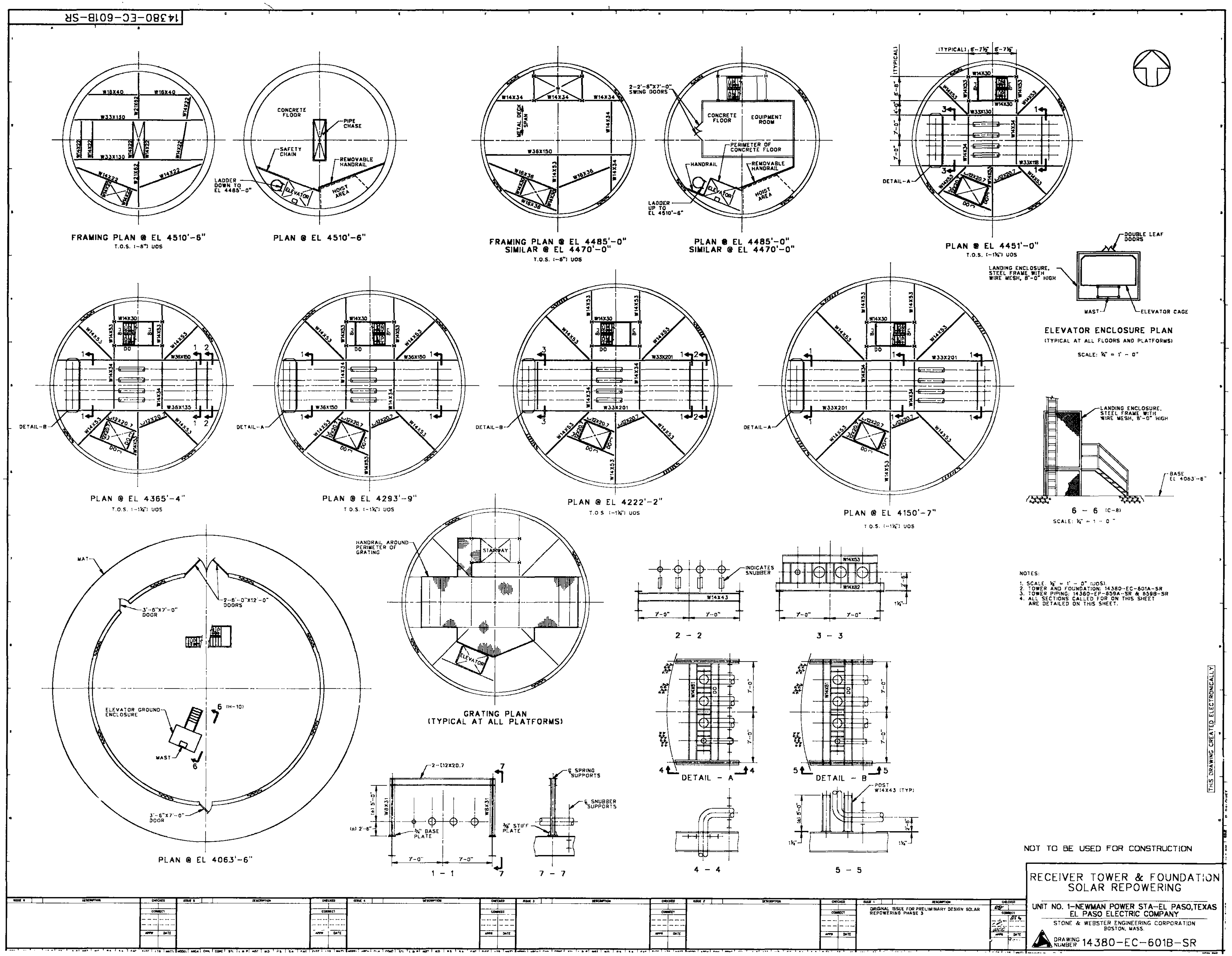
ORIGINAL ISSUE FOR PRELIMINARY DESIGN SOLAR REPOWERING PHASE 5

RECEIVER TOWER & FOUNDATION
SOLAR REPOWERING

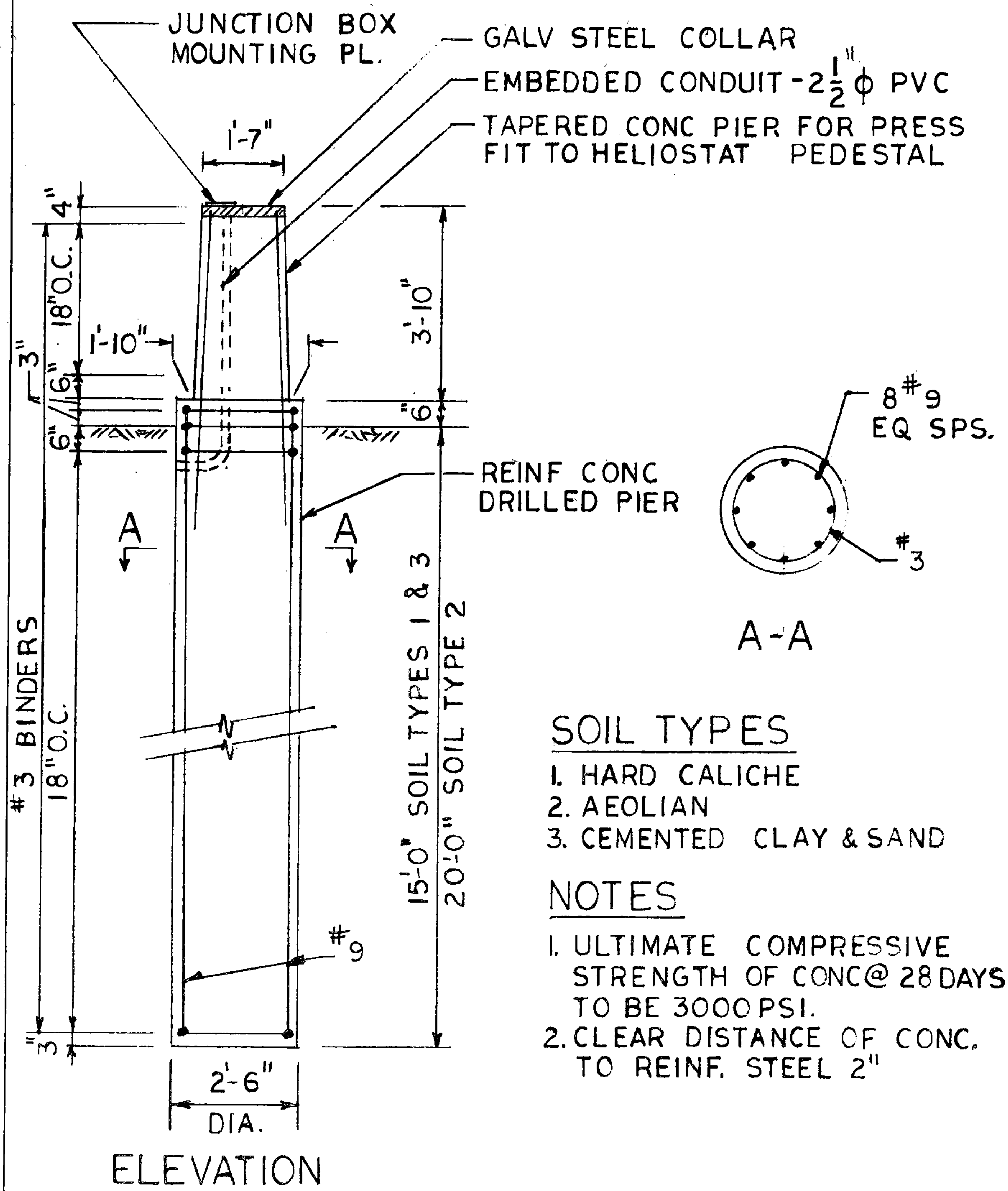
UNIT NO. 1-NEWMAN POWER STA-EL PASO, TEXAS
EL PASO ELECTRIC COMPANY

STONE & WEBSTER ENGINEERING CORPORATION
BOSTON, MASS.

DRAWING NUMBER 14380-EC-601A-SR



14380-EC-601B-SR
FRAMING PLAN @ EL 4510'-6"
T.O.S. (-8") UOS
PLAN @ EL 4510'-6"
CONCRETE FLOOR
PIPE CHASE
SAFETY CHAIN
REMOVABLE HANDRAIL
LADDER DOWN TO EL 4485'-0"
ELEVATOR
HOIST AREA
FRAMING PLAN @ EL 4485'-0"
SIMILAR @ EL 4470'-0"
T.O.S. (-8") UOS
2-2'-6"X7'-0" SWING DOORS
CONCRETE FLOOR
EQUIPMENT ROOM
PERIMETER OF CONCRETE FLOOR
HANDRAIL
LADDER UP TO EL 4510'-6"
PLAN @ EL 4485'-0"
SIMILAR @ EL 4470'-0"
PLAN @ EL 4451'-0"
T.O.S. (-1½") UOS
DOUBLE LEAF DOORS
LANDING ENCLOSURE, STEEL FRAME WITH WIRE MESH, 8'-0" HIGH
MAST
ELEVATOR CAGE
ELEVATOR ENCLOSURE PLAN
(TYPICAL AT ALL FLOORS AND PLATFORMS)
PLAN @ EL 4365'-4"
T.O.S. (-1½") UOS
PLAN @ EL 4293'-9"
T.O.S. (-1½") UOS
PLAN @ EL 4222'-2"
T.O.S. (-1½") UOS
PLAN @ EL 4150'-7"
T.O.S. (-1½") UOS
6 - 6
BASE EL 4063'-6"
MAT
3'-6"X7'-0" DOOR
2-8'-0"X12'-0" DOORS
ELEVATOR GROUND ENCLOSURE
PLAN @ EL 4063'-6"
HANDRAIL AROUND PERIMETER OF GRATING
STAIRWAY
GRATING PLAN
(TYPICAL AT ALL PLATFORMS)
INDICATES SNUBBER
2 - 2
3 - 3
DETAIL - A
DETAIL - B
1 - 1
7 - 7
4 - 4
5 - 5
SPRING SUPPORTS
SNUBBER SUPPORTS
NOTES:
1. SCALE: ⅛" = 1' - 0" (UOS).
2. TOWER AND FOUNDATION: 14380-EC-601A-SR
3. TOWER PIPING: 14380-EP-859A-SR & 859B-SR
4. ALL SECTIONS CALLED FOR ON THIS SHEET ARE DETAILED ON THIS SHEET.
NOT TO BE USED FOR CONSTRUCTION
THIS DRAWING CREATED ELECTRONICALLY
ORIGINAL ISSUE FOR PRELIMINARY DESIGN SOLAR REPOWERING PHASE 3
RECEIVER TOWER & FOUNDATION
SOLAR REPOWERING
UNIT NO. 1-NEWMAN POWER STA-EL PASO,TEXAS
EL PASO ELECTRIC COMPANY
STONE & WEBSTER ENGINEERING CORPORATION
BOSTON, MASS.
DRAWING NUMBER 14380-EC-601B-SR



SOIL TYPES

1. HARD CALICHE
2. AEOLIAN
3. CEMENTED CLAY & SAND

NOTES

1. ULTIMATE COMPRESSIVE STRENGTH OF CONC @ 28 DAYS TO BE 3000 PSI.
2. CLEAR DISTANCE OF CONC. TO REINF. STEEL 2"

POWER INDUSTRY GROUP	TITLE HELIOSTAT FOUNDATION SOLAR REPOWERING NEWMAN STATION UNIT 1 EL PASO ELECTRIC COMPANY	SCALE: 3/8" = 1'-0"
CHECKED		DATE: 9-26-83
CORRECT		
APPROVED		SKETCH NUMBER 14380-SSK-1A
REVISIONS ② ③ ④ ⑤		

APPENDIX M

APPENDIX M

COLLECTOR FIELD STUDIES

PERFORMED BY WESTINGHOUSE
ELECTRIC CORPORATION

M.1 COLLECTOR FIELD OPTIMIZATION

Optimization of the heliostat field was performed using the MIRVAL heliostat performance code and the associated field layout preprocessor program, both developed by Sandia National Laboratory. As a design basis, the optimized heliostat field must produce a total receiver incident power that allows 50% solar repowering of the 82 MW_e Newman Unit 1 Electric Plant at noon winter solstice with an assumed 1000 W/m^2 direct normal insolation. The optimization included examination of the effects of the total number of heliostats, tower height, heliostat spacing, aiming strategy, and field shape.

Heliostat Field Constraints

Constraints on the shape of the field at the Newman Station site exist. These constraints set limits on the available range of optimization. For instance, a north field was chosen since the receiver will be located near Unit 1, the unit designated for repowering. Existing station facilities will be located south of the receiver. Also, the area available to the field is limited to the west by a transmission line right-of-way. Furthermore, exclusion areas exist for gas line right-of-ways, wells, meters, pipes, and small roads. Table M.1-1 lists equations that represent the boundaries of the excluded areas.

Receiver Heat Flux Limit

Optimization of the heliostat field shape and the aiming strategy also considered the receiver heat flux distribution specified by the receiver designer. The specified heat flux vertical profile is shown in Figure M.1-1. Any heat flux spillage beyond the absorber surface is limited to no more than 25 kW/m^2.

Operational Considerations

In addition to the physical constraints on the field layout and the receiver heat flux distribution sought by the receiver designer, operational considerations influenced the allocation of heliostats to the east and west sides of the field. Based on discussions with a heliostat vendor, it was

TABLE M.1-1
EXCLUDED AREAS

Exclusion	Excluded Area Boundary Equations
1. Gas pipeline right-of-way	$y > -0.798x + 853.4$ $y < -0.798x + 923.5$
2. Transmission lines	$y < 0.0174x + 148.8$ $x < 0.0126y - 73.6$
3. Gas lines	$y < 0.0026x + 203.3$ $y > 0.0026x + 191.1$
4. East-West	$-770.0 > x > 770.0$
5. Road	$y < 0.0175x + 54.3$
6. Gas meter	$154.2 < y < 181.7$ $9.6 < x < 40.1$
7. Well	$521.9 < x < 537.2$ $142.4 < y < 157.6$
8. Small pipes or roads	a) $y < 154.2$ $23.3 < x < 26.4$ b) $y < 191.3$ $67.7 < x < 72.2$ c) $148.4 < y < 192.5$ $531.3 < x < 533.2$

where

x = positive in east direction, meters
y = positive in north direction, meters

Receiver is located at (0.,0.) and directions are based on true North.

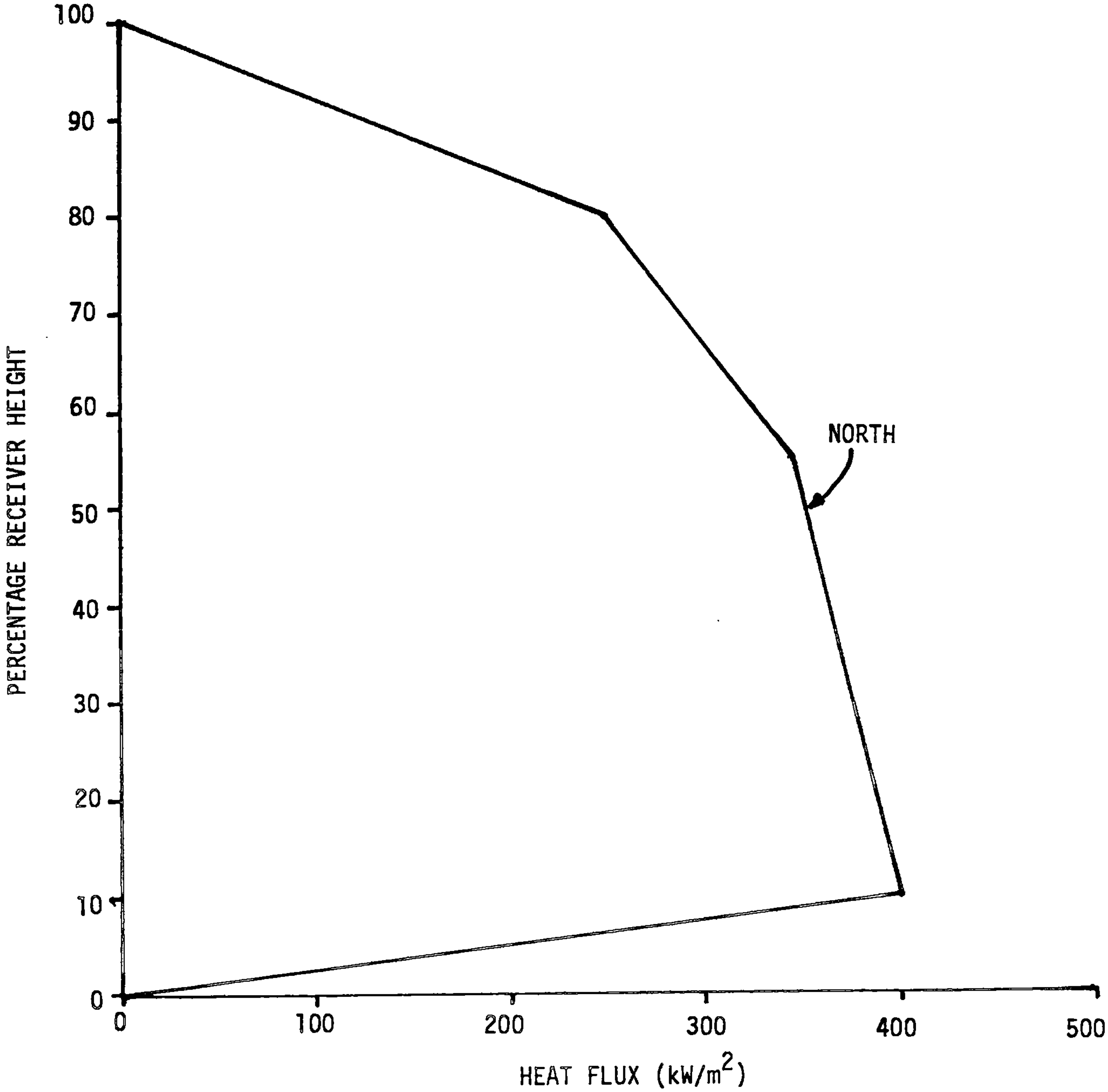


Figure M.1-1. Vertical Heat Flux Profile Specified By Receiver Designer concluded that efficient startup and morning and evening operation in general depend on some significant amount of heliostats on the east and west edges of the field. Consequently, heliostats were placed at the sides of the fields that may have been indicated as most effective at the north end of the field based on a design point optimization alone.

Field Optimization Assumptions

During the course of field optimization studies, field parametric analyses were performed with several underlying assumptions. The heliostat reflectivity was assumed to be 90% for clean reflective surface and 86% on an annual average basis. For every 100 heliostats in the field, only 98 were assumed operational at any one time. The heliostats were assumed to have the following characteristics:

Height	8.79 meters (28.83 feet)
Width	11.06 meters (36.29 feet)
Height to Centerline	4.70 meters (15.42 feet)
Percentage Area That Is Reflective	97.60
Number of Facets On Vertical Axis	2
Number of Facets On Horizontal Axis	8
Standard Deviation of Angle of Rotation of Moveable Axis	0.00075 radians
Standard Deviation of Angle of Rotation of Fixed Axis	0.00075 radians
Standard Deviation of Mirror Normal	0.001 radians

The receiver was assumed to be an external type receiver. Because of the parallel nature of the heliostat field design and receiver design, the dimensions of the receiver were somewhat different for different stages of field optimization.

Total Number of Heliostats

The total number of heliostats, 1875, was based on economic model calculations and the total solar power required to produce 41 MW_e under design conditions at the Newman Unit 1 electric plant.

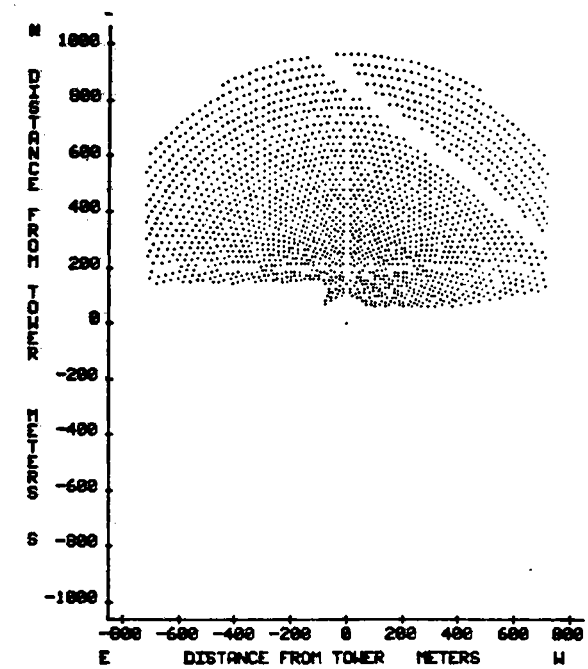
Tower Height

Field layouts assuming a range of receiver centerline elevations, 2000 heliostats, and the above constraints and assumptions are shown in Figure M.1-2. As the tower height decreases the required land area increases to minimize shading and blocking. At some point, however, the space between rows of heliostats can not be decreased because of physical interference of adjacent heliostats. Design point and annual average performance calculations were performed for each combination of tower height and field layout shown in Figure M.1-2. Design point and annual average efficiency plots for the different receiver centerline elevations are shown in Figures M.1-3 and M.1-4. Preliminary field preparation costs and the tower construction costs were also calculated. These preliminary field preparation and tower costs for the different receiver centerline elevations are shown in Figure M.1-5.

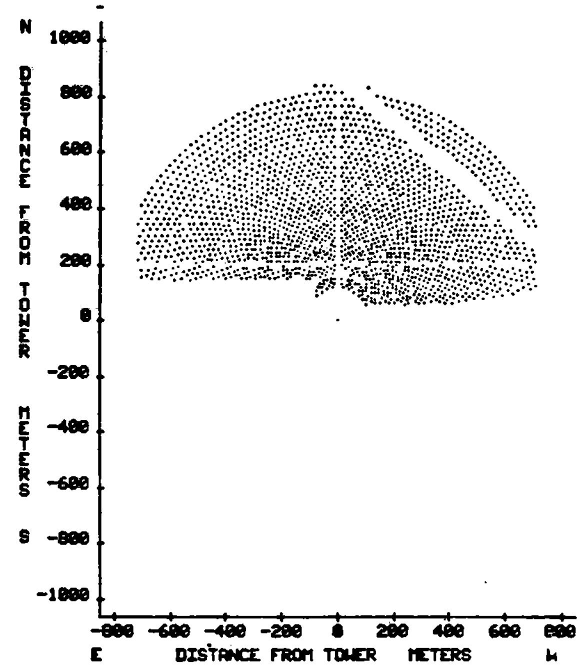
The final receiver centerline elevation of 155 meters was the result of economic trade-off calculations using data from the performance and cost studies.

Heliostat Spacing

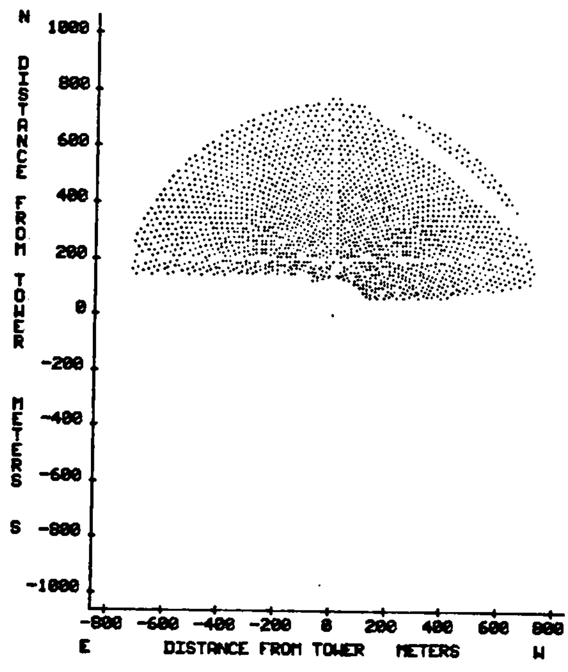
Field spacing was optimized by iterative application of the MIRVAL field layout preprocessor, which follows a radial stagger strategy, and MIRVAL itself, to assess performance implications of each layout. The circumferential space between heliostats in the first ring of heliostats (the variable input to the preprocessor) was varied over a range of values assuming a 155 meter receiver centerline elevation and 2000 heliostats. Resulting field layouts are shown in Figure M.1-6. Increased spacing increases land area and field preparation costs. At some point, decreasing the space between heliostats causes a noticeable increase in blocking and shading. Furthermore, physical interference occurs when the spacing becomes too small. Annual average and design point performance calculations were performed for each field layout, and the results are shown in Figures M.1-7 and M.1-8. The final circumferential space between adjacent heliostat pedestals in the first ring of heliostats was chosen to be 20.46 meters (67.13 feet) which represents a value for x of 0.85 in Figures M.1-7 and M.1-8 and assumes a heliostat length of 11.06 meters (36.29 feet).



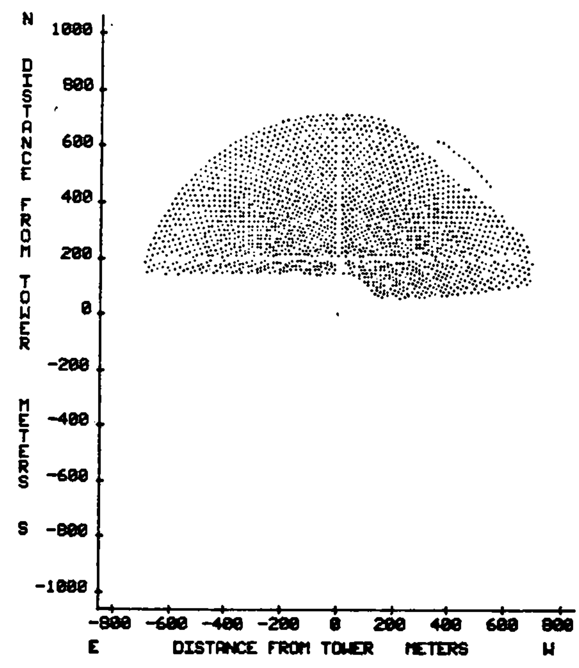
a) 131 Meter Receiver
Centerline Elevation



a) 155 Meter Receiver
Centerline Elevation



c) 178 Meter Receiver
Centerline Elevation



d) 200 Meter Receiver
Centerline Elevation

Figure M.1-2. Field Layouts for Range of Receiver
Centerline Elevations

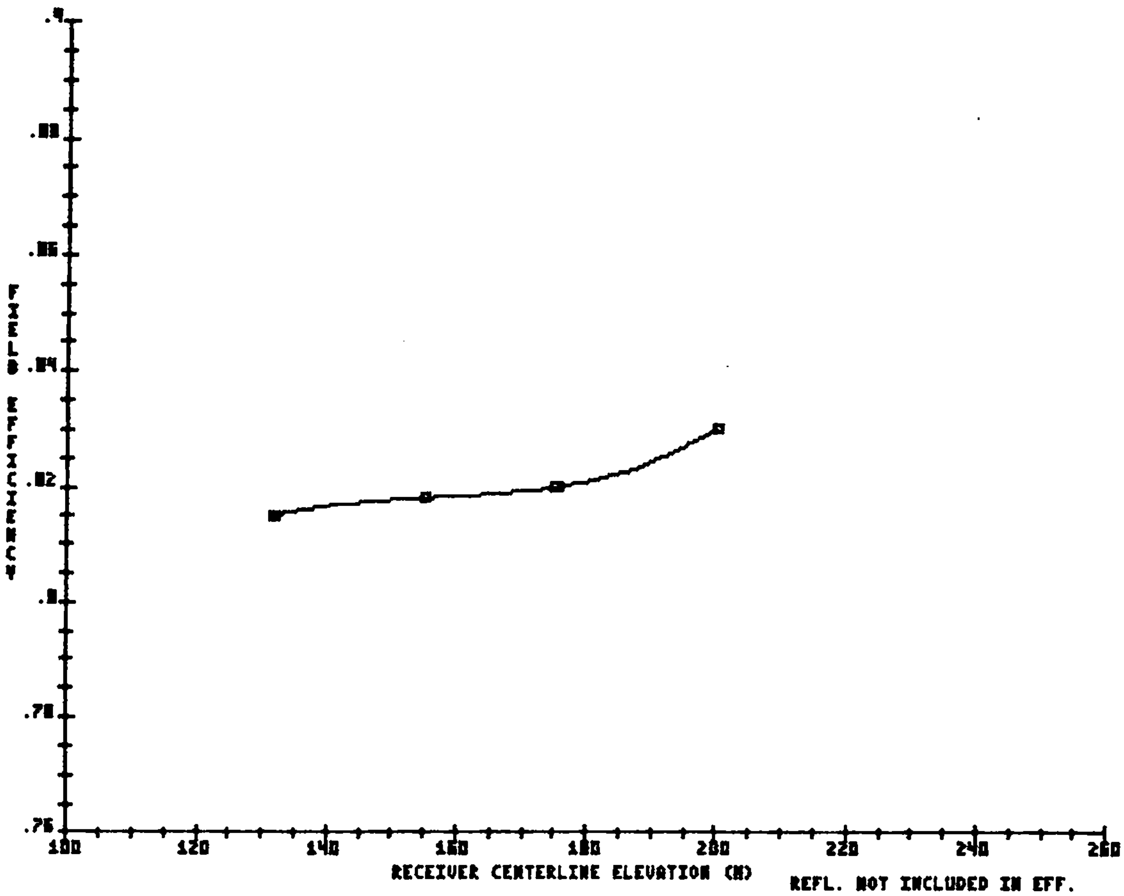


Figure M.1-3. Field Efficiency Versus Receiver Centerline Elevation At Design Point

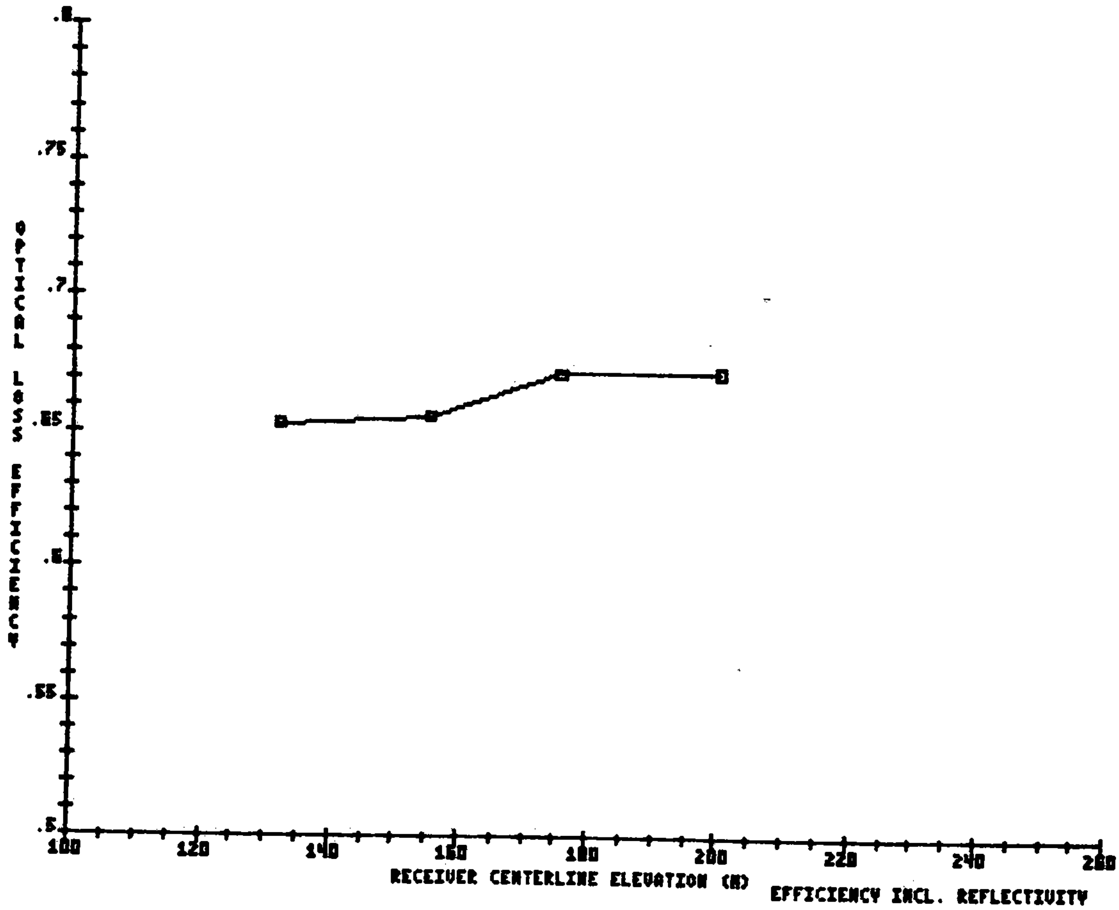


Figure M.1-4. Optical Loss Efficiency Versus Receiver Centerline Elevation - Annual Average

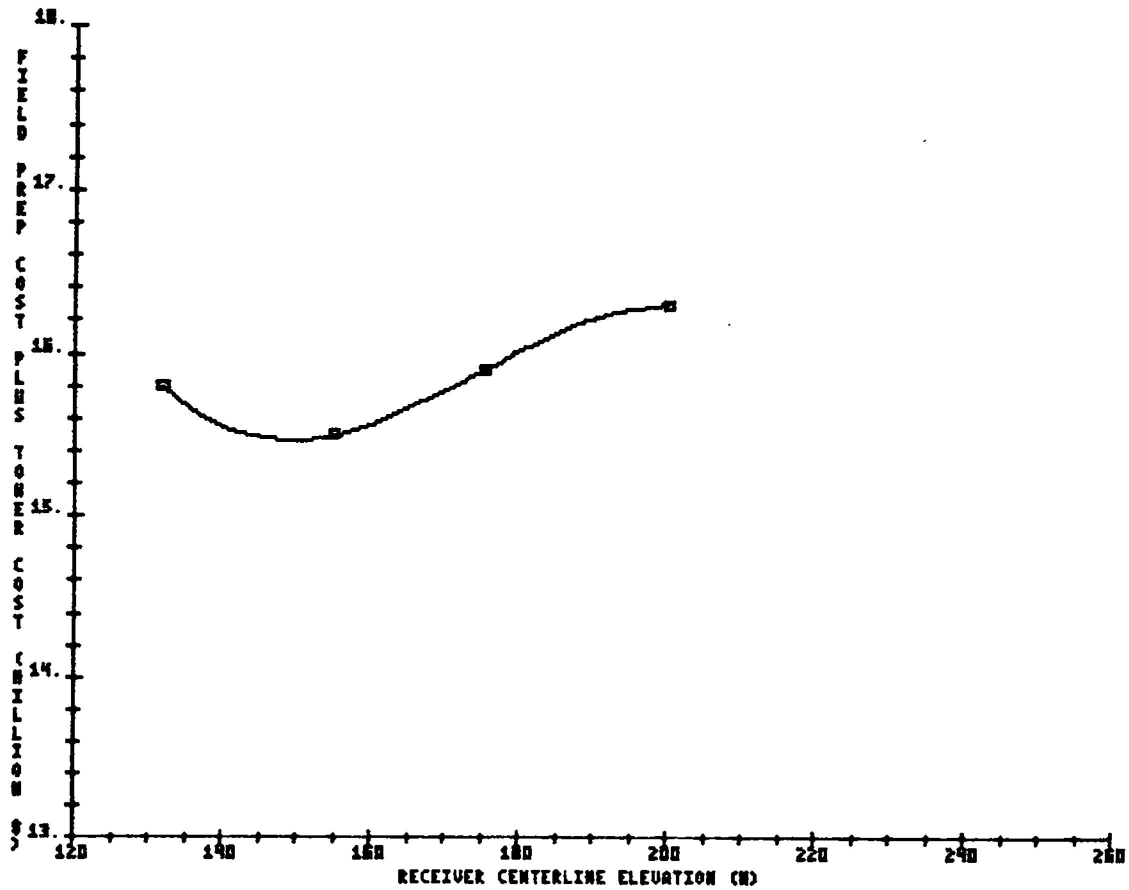
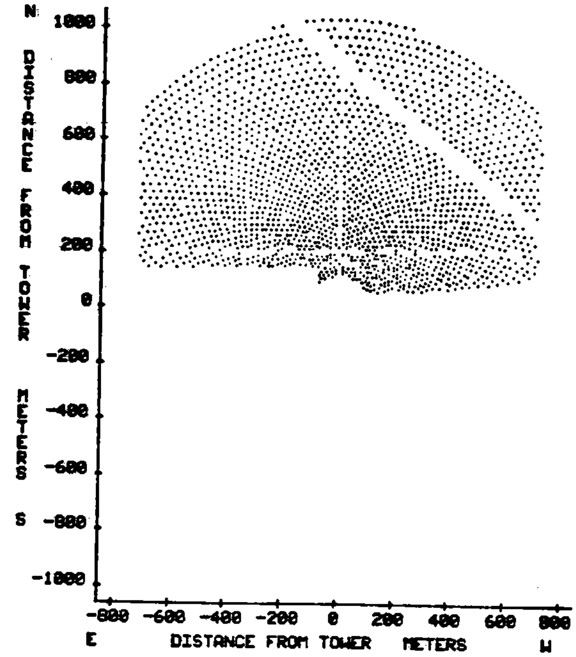
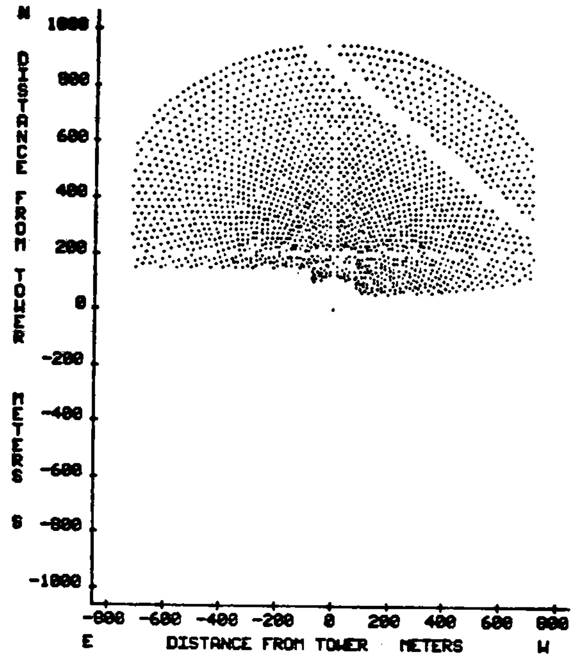


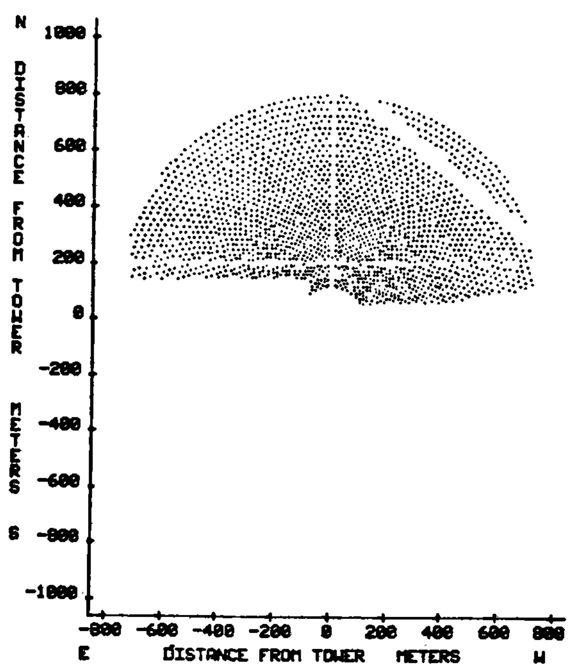
Figure M.1-5. Field Preparation Cost Plus Tower Cost Versus Receiver Centerline Elevation



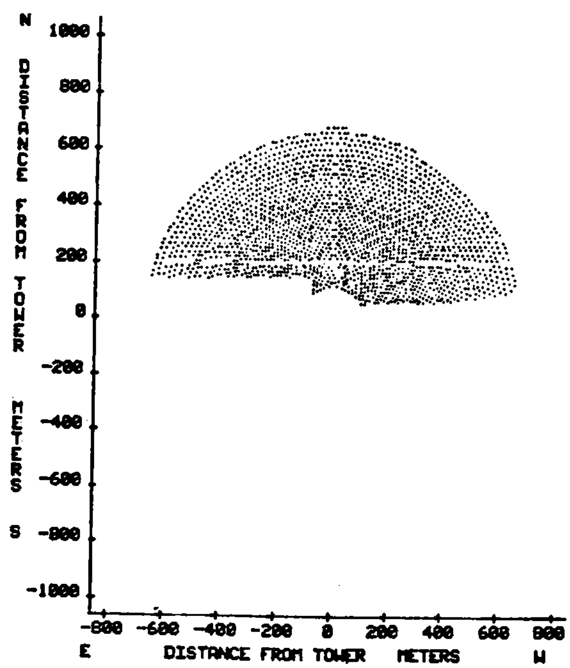
a) 25.2 Meter Circumferential Space



b) 23.5 Meter Circumferential Space



c) 19.7 Meter Circumferential Space



d) 15.2 Meter Circumferential Space

Figure M.1-6. Field Layouts For Different Heliostat Spacing In First Heliostat Ring

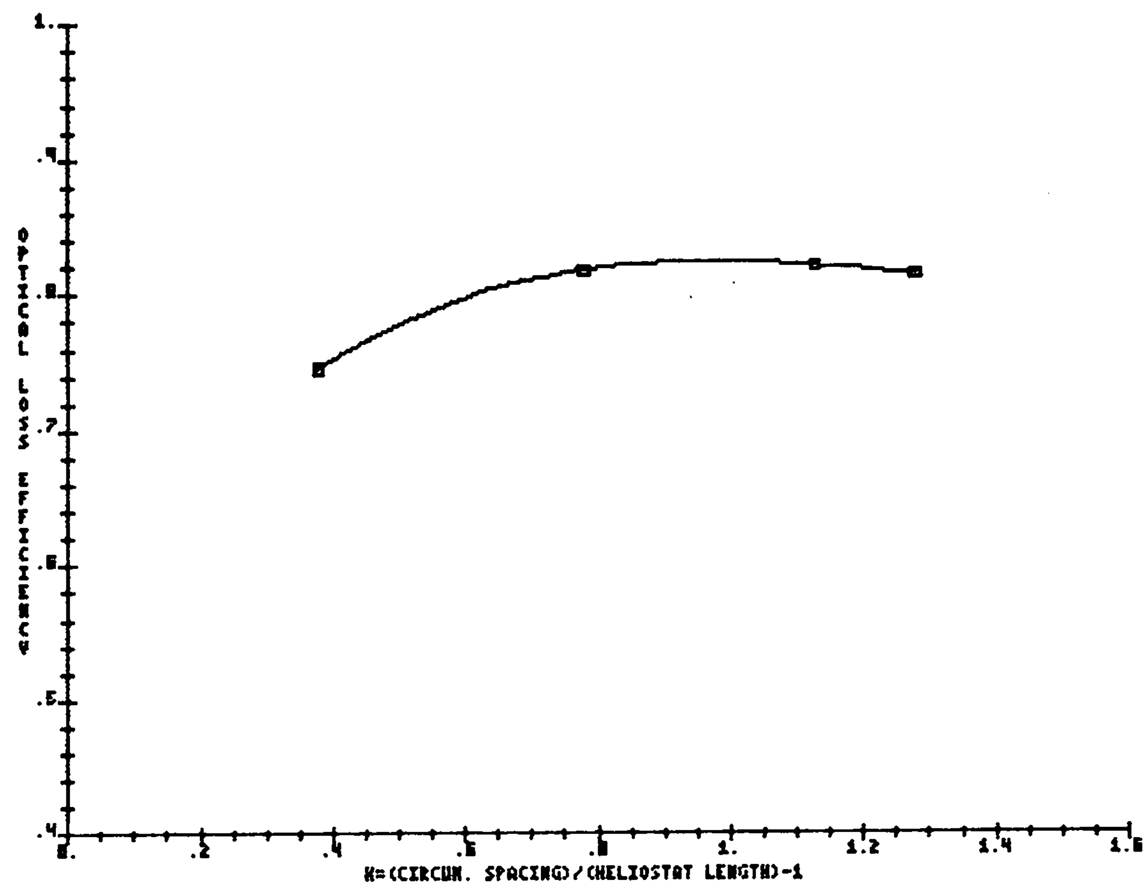


Figure M.1-7. Optical Loss Efficiency Versus Circumferential Space In First Ring - Design Point

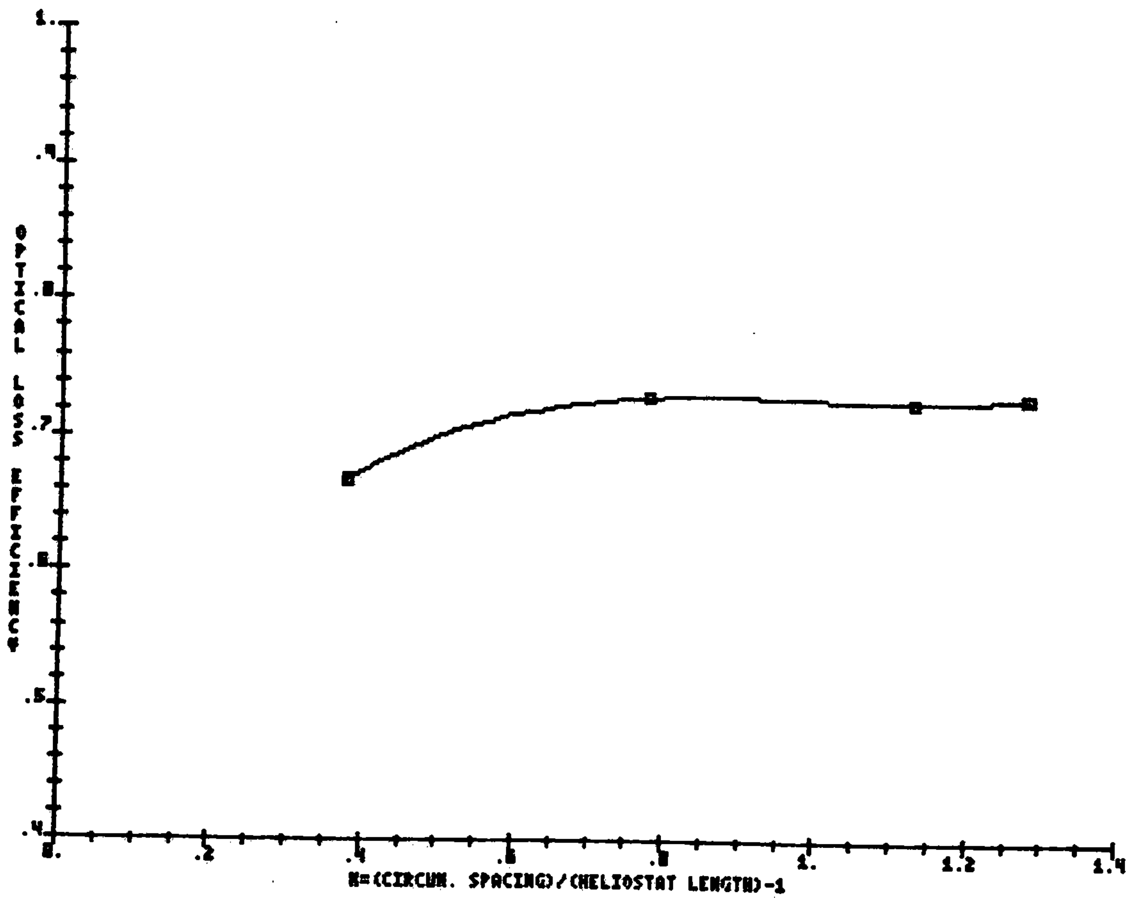


Figure M.1-8. Optical Loss Efficiency Versus Circumferential Space In First Ring - Annual Average

Aiming Strategy

The aiming strategy is designed to keep the redirected solar power that misses the receiver, spillage, to a low level and to result in a receiver heat flux distribution which is acceptable to the receiver designer. Spillage depends on the heliostat aiming errors and the choice of the receiver aimpoint locations. The flux distribution depends on aimpoint locations and on the relationship between the aimpoint location and the position of the heliostat in the field. The aiming strategy is based on a desired heat flux profile and considers the heliostat's direction from the receiver and the heliostat's slant range. An important additional element of the aiming strategy is to distribute aimpoints among the heliostats in such a way that local shadowing of the field or a small cluster of inoperative heliostats will not cause a major local discontinuity in the overall heat flux distribution on the receiver.

The field is divided into three zones of equal land area as shown in Figure M.1-9. Each heliostat according to its position in the field is assigned to one of the three zones. Each zone is related to its own receiver vertical heat flux profile. By dividing the field into 3 zones and relating those zones to individual vertical heat flux profiles, a better vertical flux distribution is obtained on the east and west sides of the receiver.

In this study, the availability of a heliostat is assumed to be 98 percent. A heliostat is made unavailable in the MIRVAL model by aiming it an arbitrary 100 receiver heights above the receiver. The unavailable heliostats are chosen by a random number generator.

The relative shape of the desired vertical heat flux profiles on the east, north, and west sides of the receiver are shown in Figure M.1-10 as a plot of fraction of receiver height versus relative heat flux. The absolute values of the heat flux are not important because the normalized values are used. The normalized heat flux curves are integrated by steps of 1 percent receiver height and totaled. The total integrated value is equated to the number of

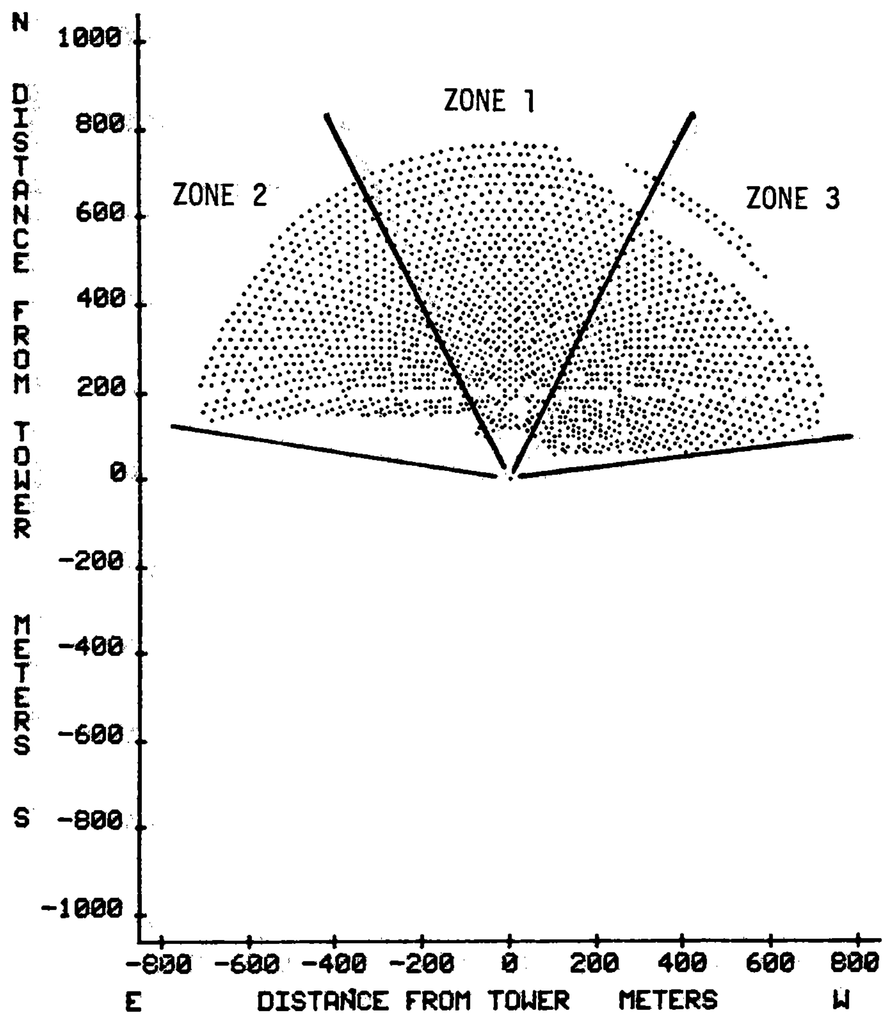


Figure M.1-9. Equal Land Area Zones

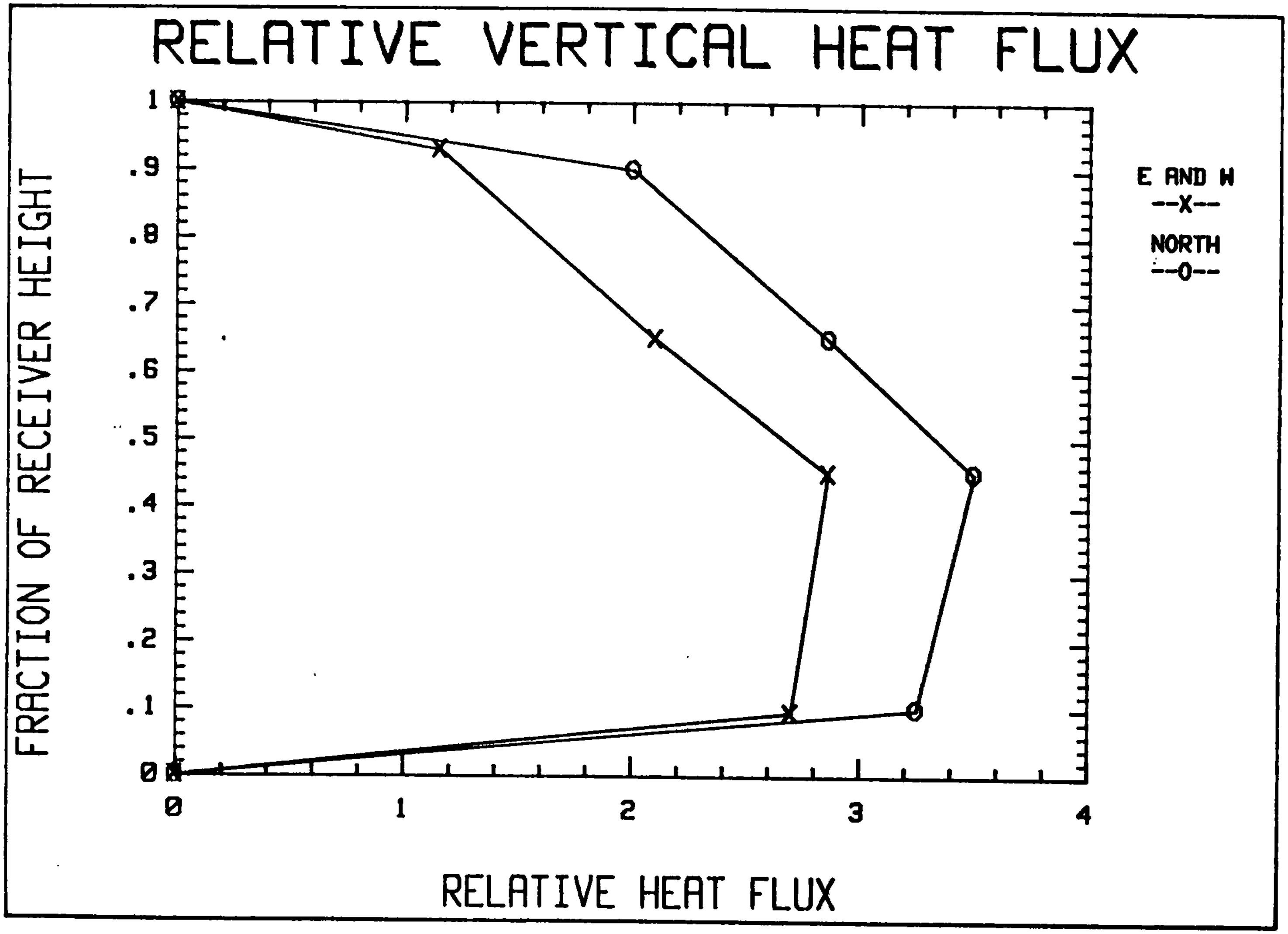


Figure M.1-10. Relative Shape of Receiver Vertical Heat Flux Profiles active heliostats in a given zone, and the total number of heliostats needed to be aimed at each 1 percent of receiver height is calculated.

In MIRVAL, an external receiver is modeled as a truncated right circular cylinder. The aimpoint for a heliostat is a point on the surface of the cylinder which is a given distance above the receiver bottom. This distance above the receiver bottom divided by the total receiver height is referred to as the fraction of receiver height. It is this fraction of receiver height that is specified for each heliostat on a computer tape. MIRVAL reads aimpoint fraction of receiver height values for each heliostat from the computer tape. MIRVAL multiplies the fraction of receiver height by the total height of the receiver to get the aimpoint's distance above the receiver bottom. MIRVAL then calculates the location of the aimpoint on the receiver surface as a point which is in a vertical plane with the heliostat center and the receiver centerline and is the above mentioned distance above the receiver bottom.

A relative shape of 4 aimpoint sets is assumed. Figure M.1-11 shows the relative aimpoint set shape as a plot of fraction of receiver height versus 20 radial heliostat field sections. All heliostats have the same aiming errors, but the effect of the errors is greater for heliostats that are farther away from the receiver. For this reason, a slant range dependent aiming strategy, where the farthest heliostats are aimed more near the center of the receiver, is beneficial. For a given number of heliostats, the radial heliostat field sections are transformed into a slant range dependent aiming strategy. When the field is divided into three zones as described previously, each zone has the same relative aimpoint set shape, but the slant range dependency is different.

The four aimpoint sets shown in Figure M.1-11 do not have an equal number of heliostats assigned to them. The number of heliostats in each aimpoint is calculated by comparing the location of the aimpoints on the receiver to the number of heliostats needed at that location, which is based on the desired heat flux profile shown in Figure M.1-10. Where two aimpoint sets affect the same section of receiver, the number of heliostats needed at that section are

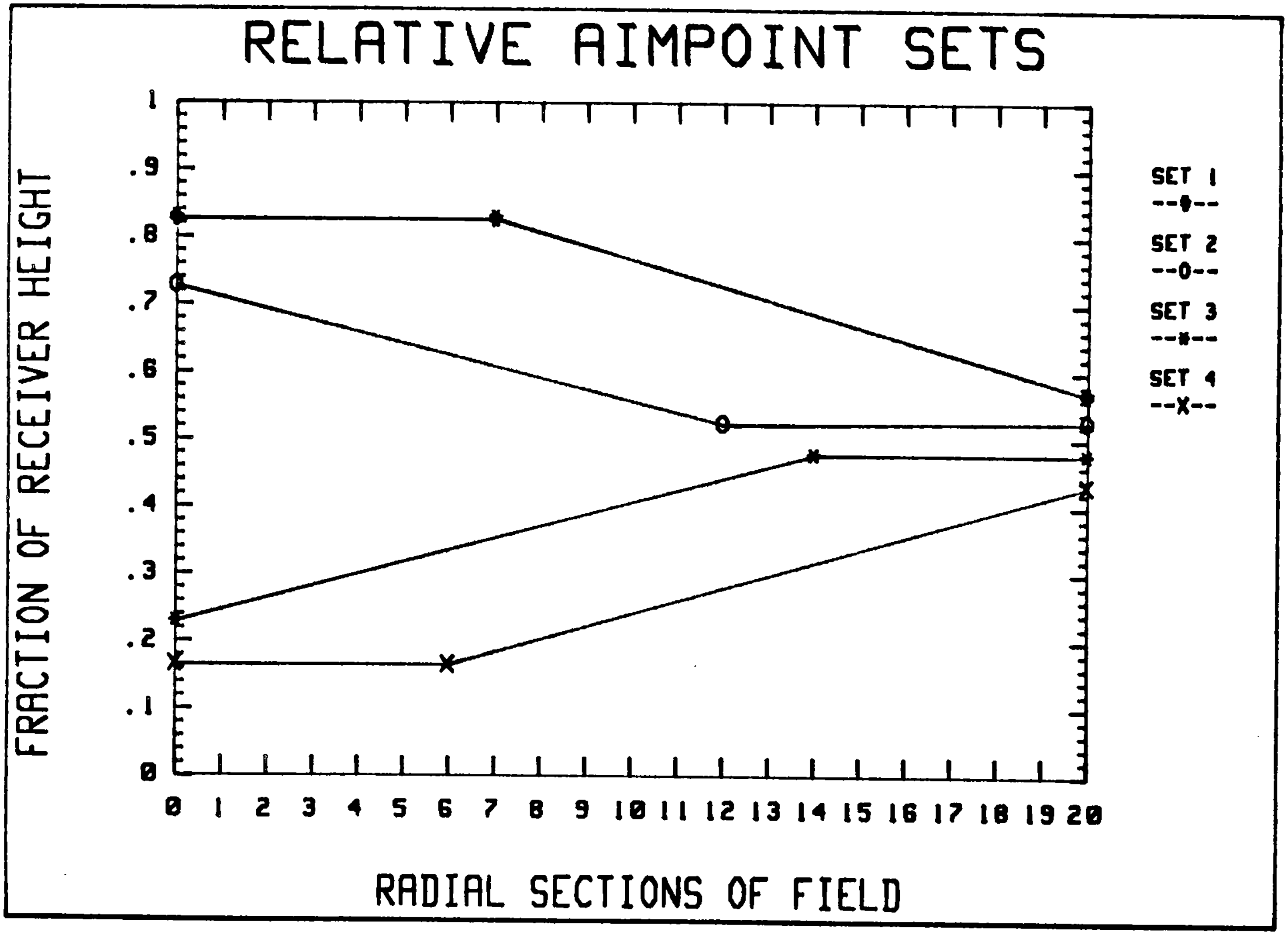


Figure M.1-11. Relative Aimpoint Set Shape divided evenly into both aimpoint sets. The number of heliostats in a given radial section is calculated, and a probability of a heliostat being aimed at a certain aimpoint in that radial section is determined. Using the aimpoint probability and a random number generator, the aimpoint towards which a heliostat is aimed is determined.

This relatively complex process of selecting aimpoints has as one objective to distribute aimpoints among the heliostats in such a way as to prevent local shadowing of the field or a small cluster of inoperative heliostats from causing a major local perturbation in the overall heat flux distribution on the receiver. Also, this type of aimpoint selection results in a uniformly distributed receiver heat flux.

The final aiming strategy for all three field zones is shown in Figure M.1-12 as a plot of aimpoint fraction of receiver height versus slant range.

Canting Strategy

To examine the effect of canting strategy on receiver heat flux and power distribution, three canting strategies were assumed:

a) One cant for all heliostats based on the slant range of the heliostat farthest from the receiver.

b) Two cants. One cant for one-third of the heliostats closest to the receiver based on the slant range of the heliostat farthest from the receiver in that group. One cant for all other heliostats based on the slant range of the heliostat farthest from the receiver in that group.

c) All heliostats are canted according to their position in the field.

MIRVAL was used to calculate performance for the three canting strategies assuming all parameters except the canting strategy were held constant. All performance calculations were for noon winter solstice. Figures M.1-13, M.1-14, and M.1-15 show receiver heat flux contours for each case. Case (a) has the lowest peak heat flux, and the 0.350 MW/m^2 contour line is the smallest. Increasing the number of cant angles slightly increases the

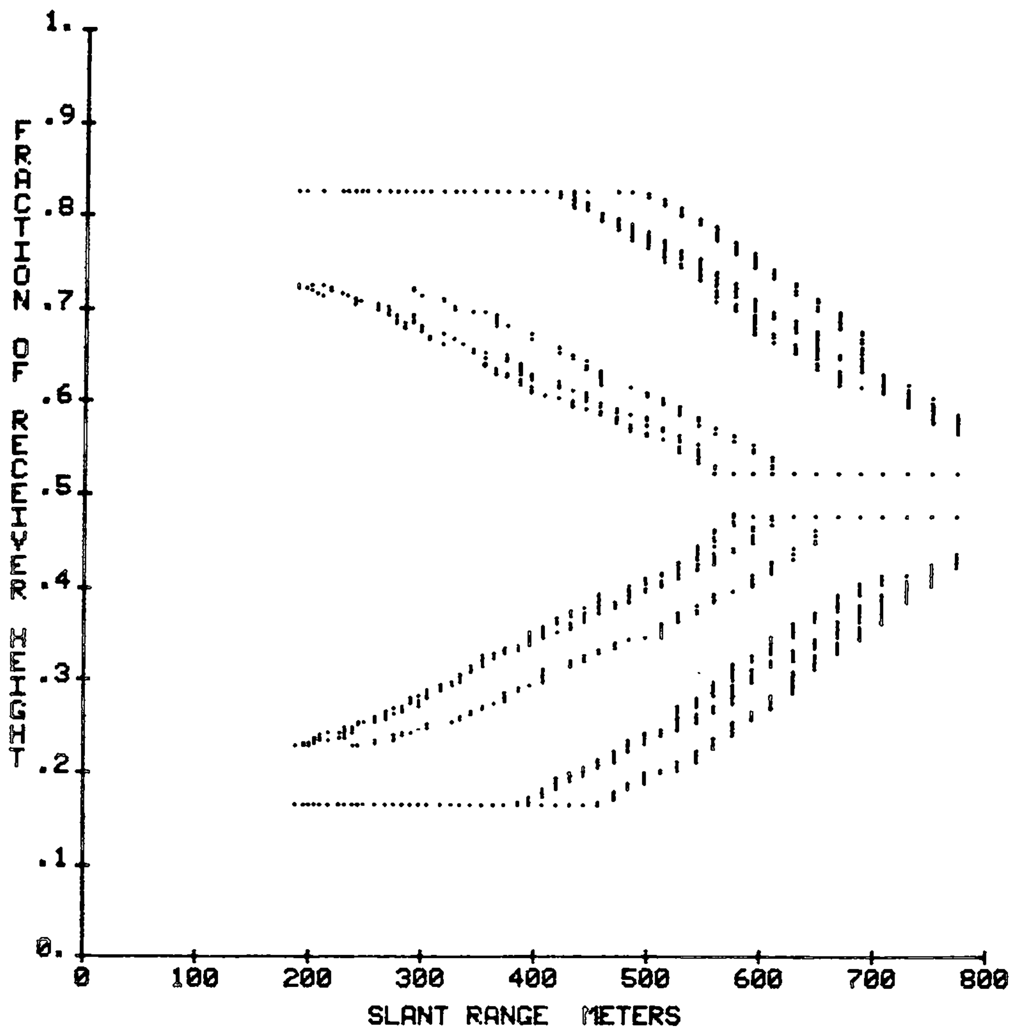


Figure M.1-12. Aiming Strategy For All Three Zones Of Final Field

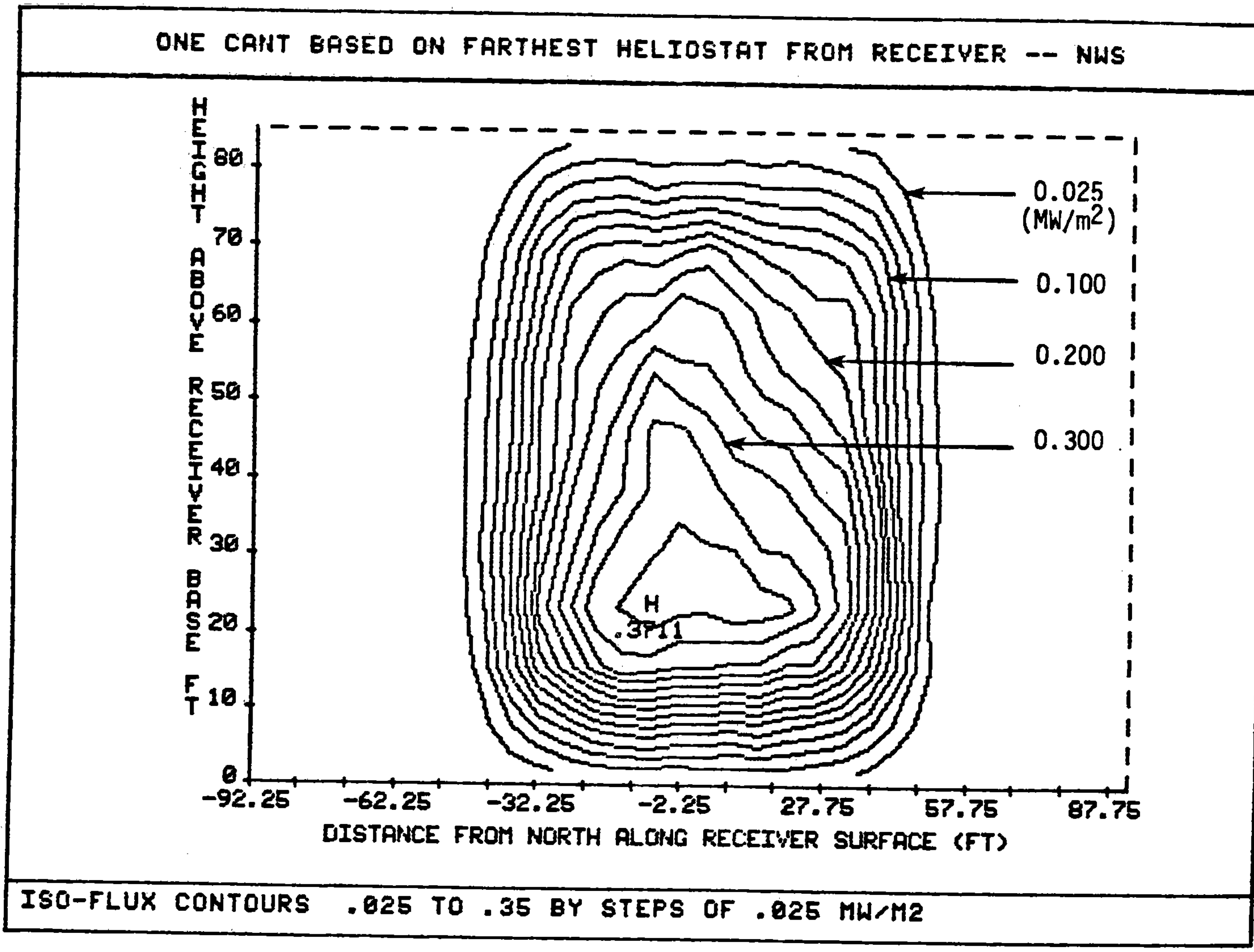
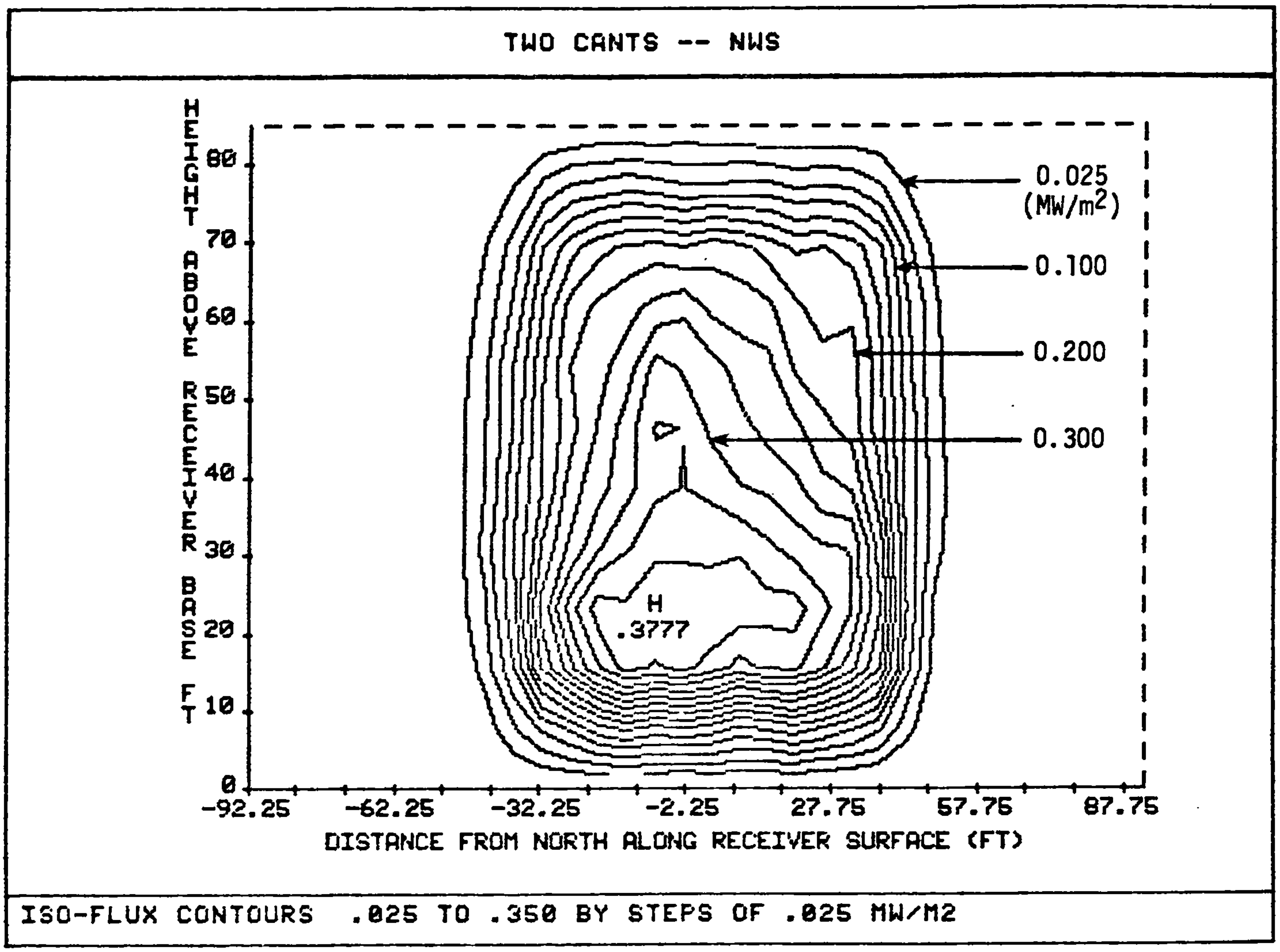


Figure M.1-13. Iso-Flux Contours For One Cant Based On Farthest Heliostat From Receiver



M.1-14. Iso-Flux Contours For Two Cants

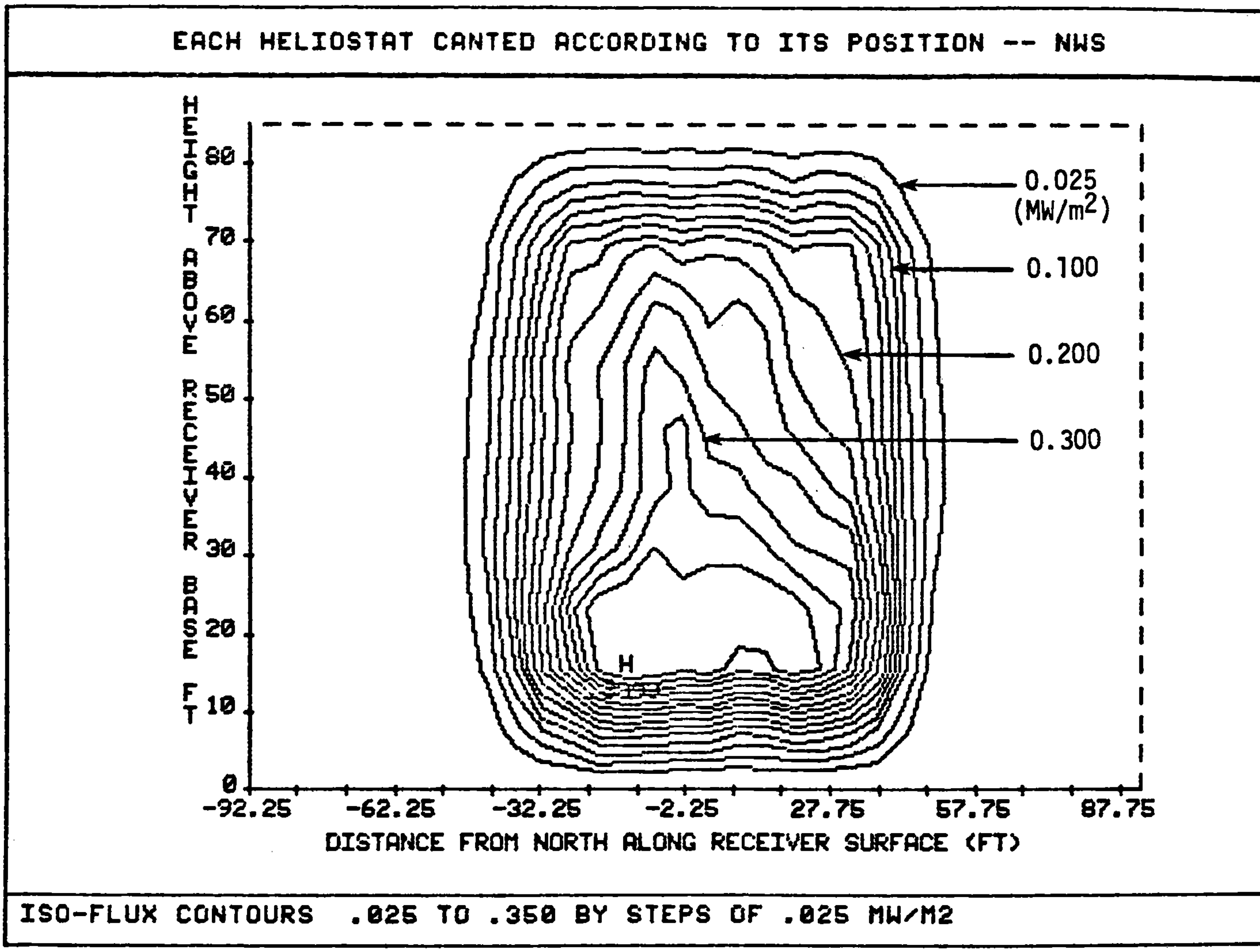


Figure M.1-15. Iso-Flux Contours For Each Heliostat Canted According To Its Position spread of the heat flux around the receiver and slightly increases the total power on the receiver. Figures M.1-16 to M.1-18 show the circumferential power distribution for each case and Figure M.1-19 shows the circumferential power distribution for all cases together.

Figures M.1-20 to M.1-22 show a comparison of the calculated vertical heat flux profile and the north heat flux profile limit specified by the receiver designer.

Increasing the number of cant angles in the heliostat field results in a slight circumferential spreading of heat flux and a very slight increase in total power incident on the receiver. Canting strategy has very little effect on the circumferential power distribution. Because heliostat installation and construction costs would be lower and because canting strategy does not have a large effect on performance, the final field has one cant for all heliostats based on the slant range of the heliostat farthest from the receiver.

Optimization Results

The optimization of the collector field considered excluded land areas, a vertical receiver heat flux profile, startup, morning and evening operation, tower height, heliostat spacing, aiming strategy, and canting strategy. The final field layout with 1875 heliostats is shown in Figure M.1-23. The assumed heliostat characteristics were described above. The heliostat locations for the final field were calculated using the field layout preprocessor associated with MIRVAL assuming a receiver centerline height from the ground of 155 meters (508.5 feet), 20.46 meters (67.12 feet) circumferential space between adjacent heliostats in the first ring of heliostats, a slant range, field position dependent aiming strategy, one cant for all heliostats based on the slant range of the heliostat farthest from the receiver, and 1875 heliostats. Figure M.1-24 shows a comparison of the specified receiver heat flux profile and the MIRVAL calculated heat fluxes for a 25.91 meter (85 foot) high, 8.95 meter (29.36 foot) radius external receiver.

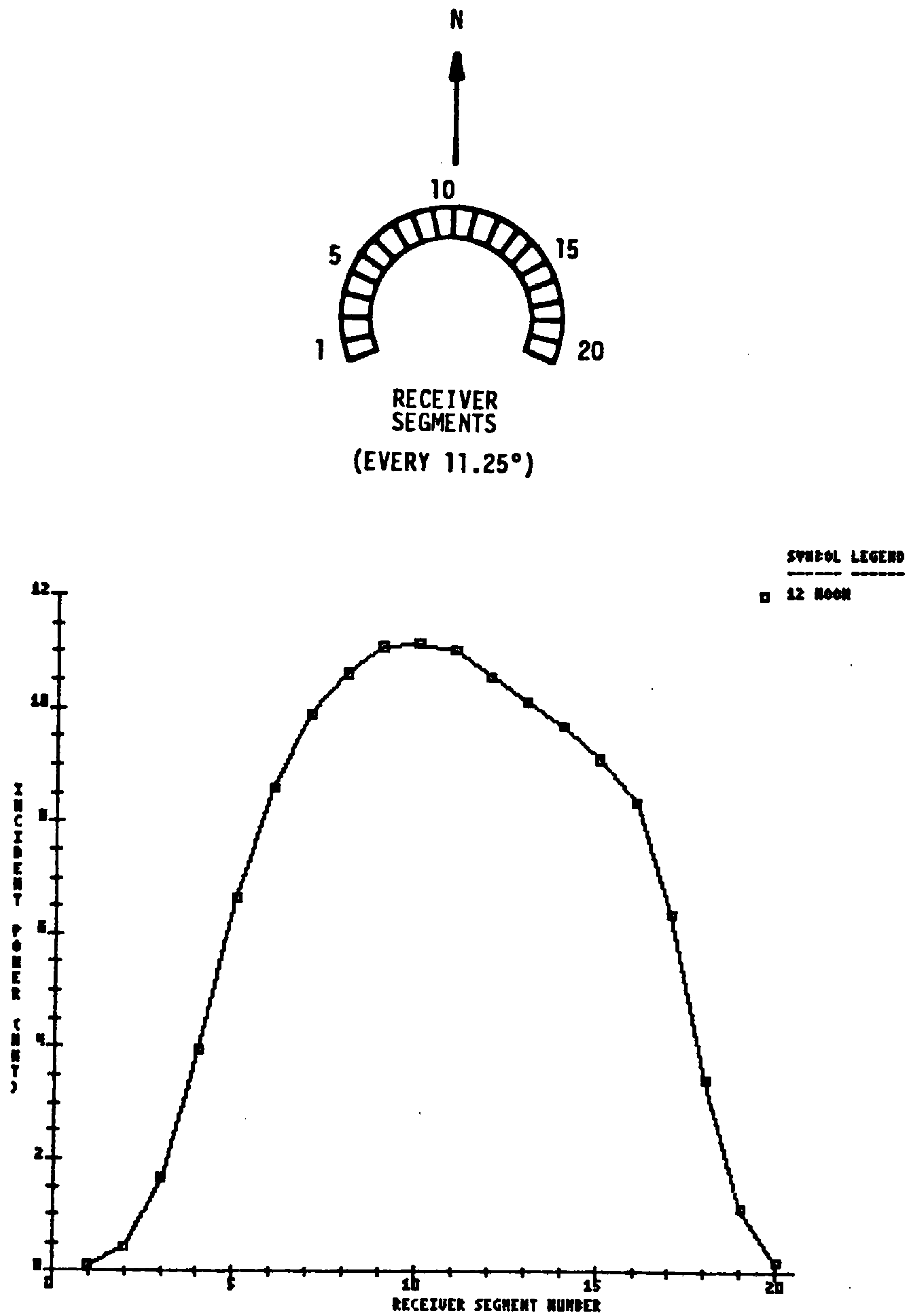


Figure M.1-16. Design Point Circumferential Power Distribution - One Cant Based On Farthest Heliostat

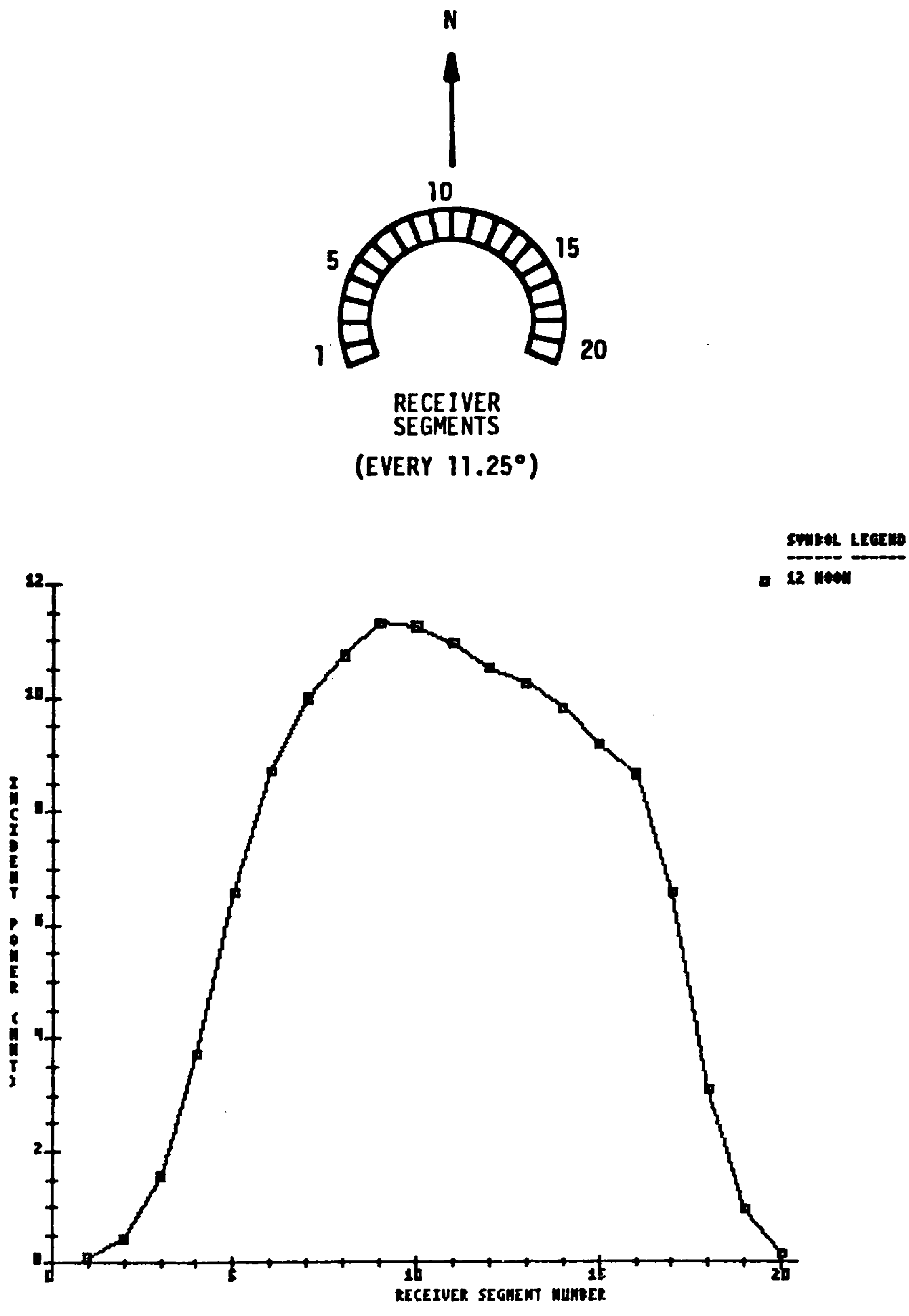


Figure M.1-17. Design Point Circumferential Power Distribution - Two Cants

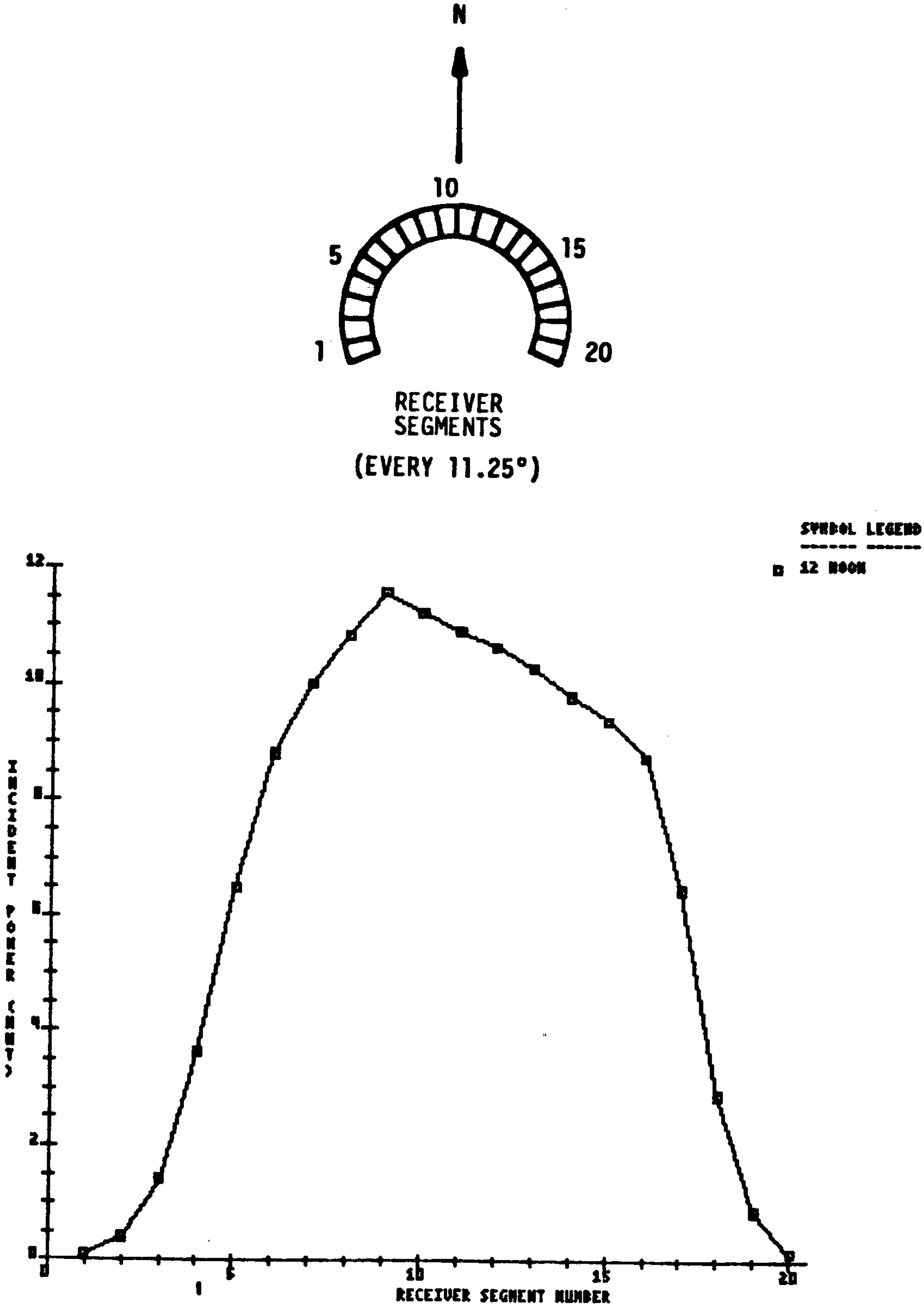


Figure M.1-18. Design Point Circumferential Power Distribution - Each Heliostat Canted According To Its Position

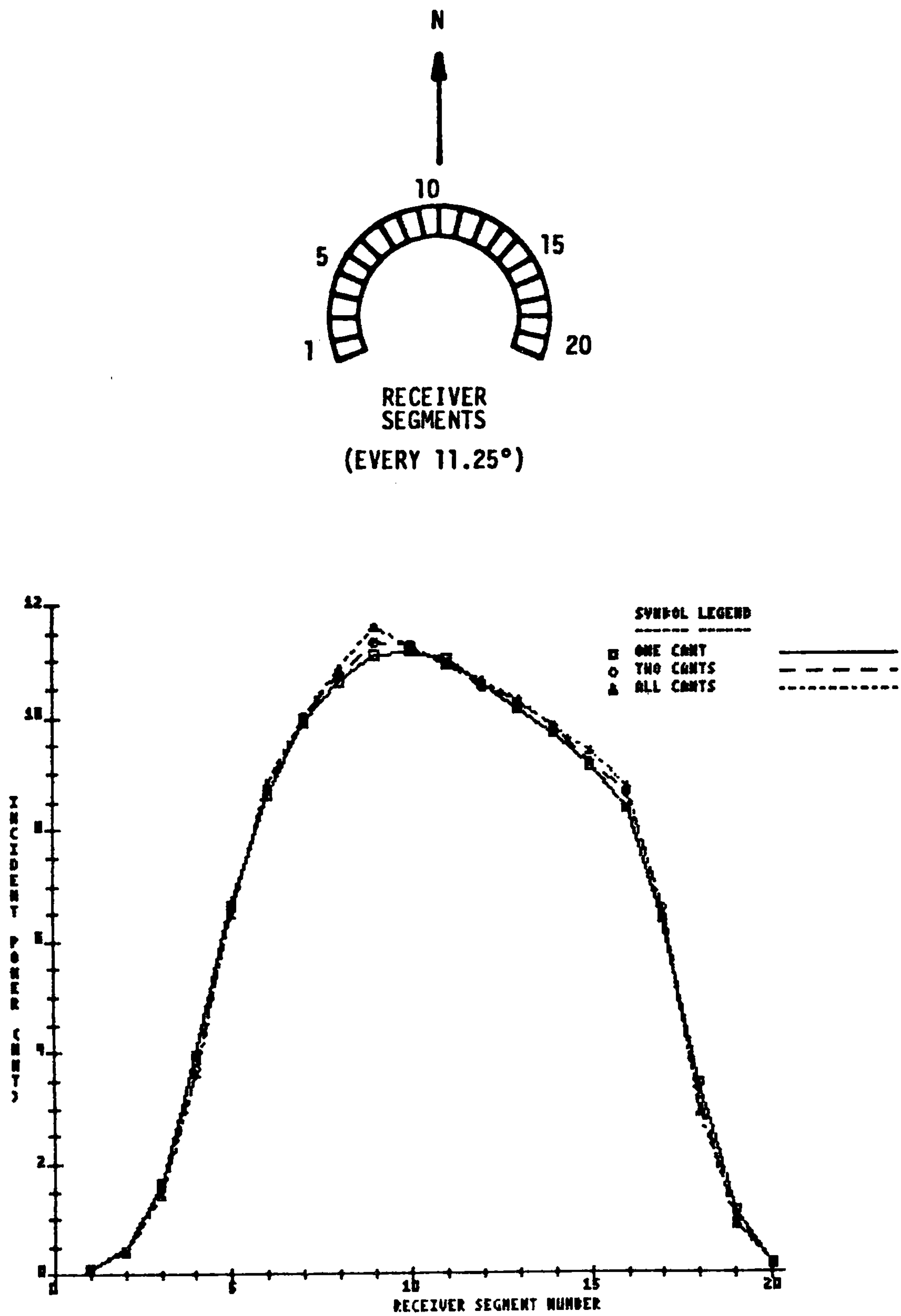


Figure M.1-19. Design Point Circumferential Power Distribution — One Cant, Two Cants, and All Cants - 12 Noon

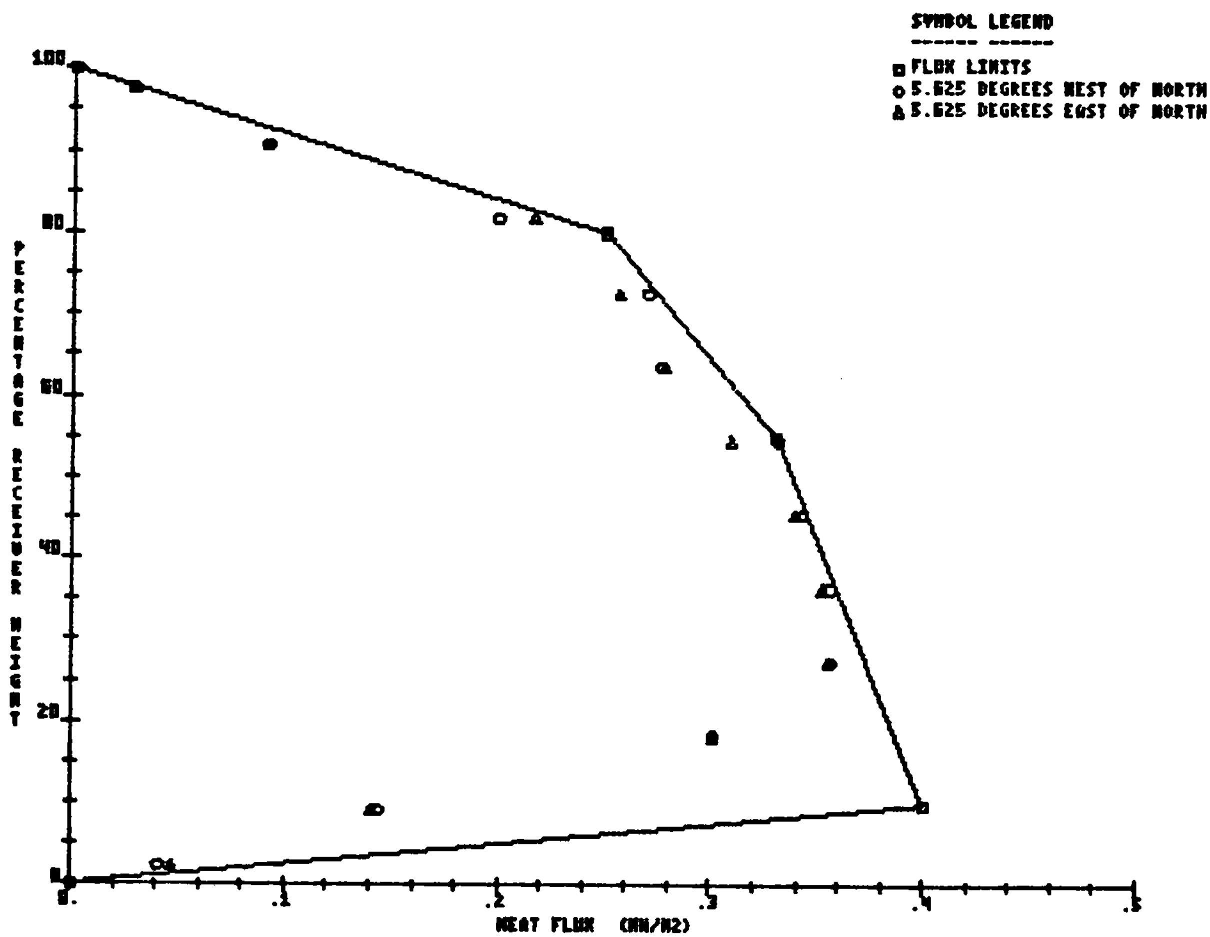


Figure M.1-20. Design Point Vertical Heat Flux For One Cant Based On Farthest Heliostat

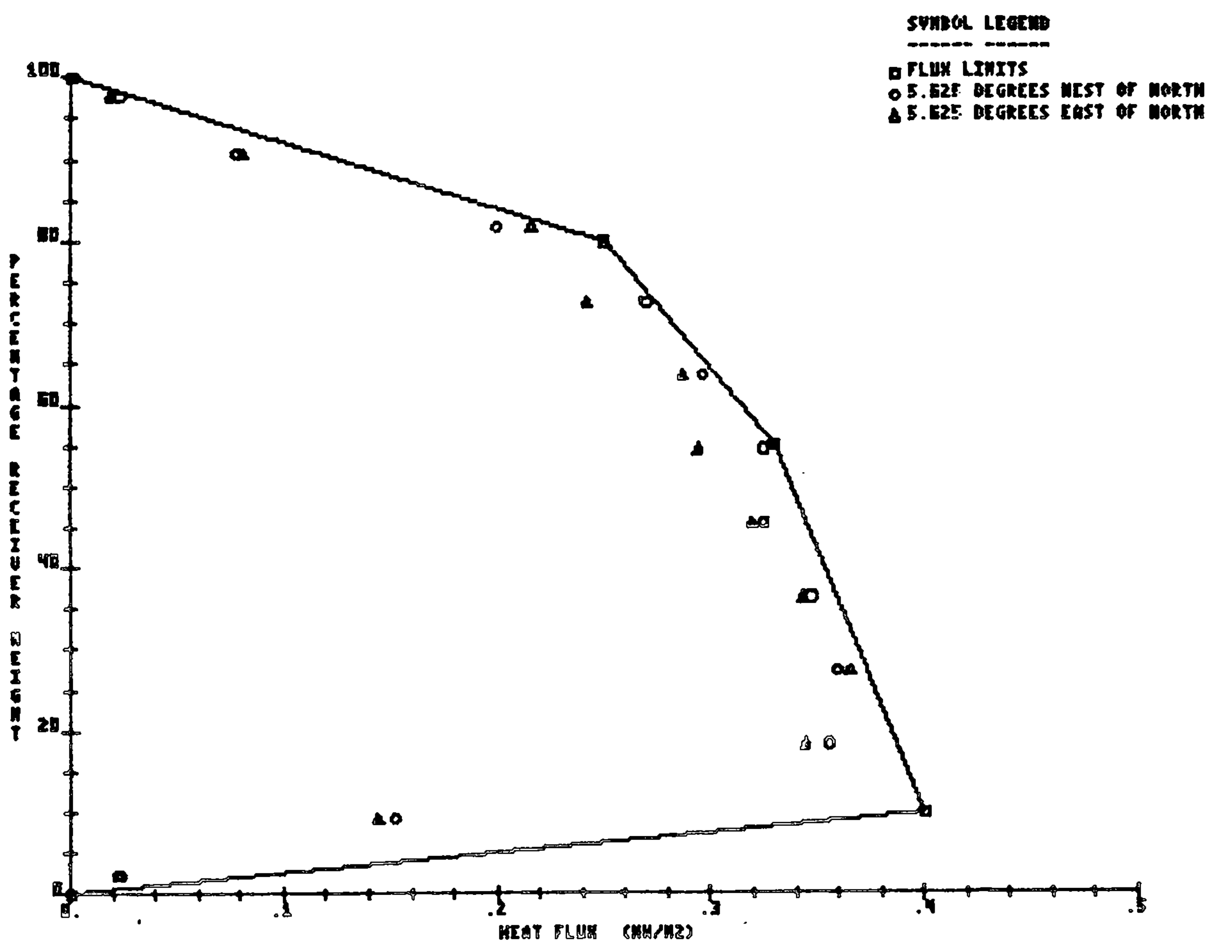


Figure M.1-21. Design Point Vertical Heat Flux For Two Cants

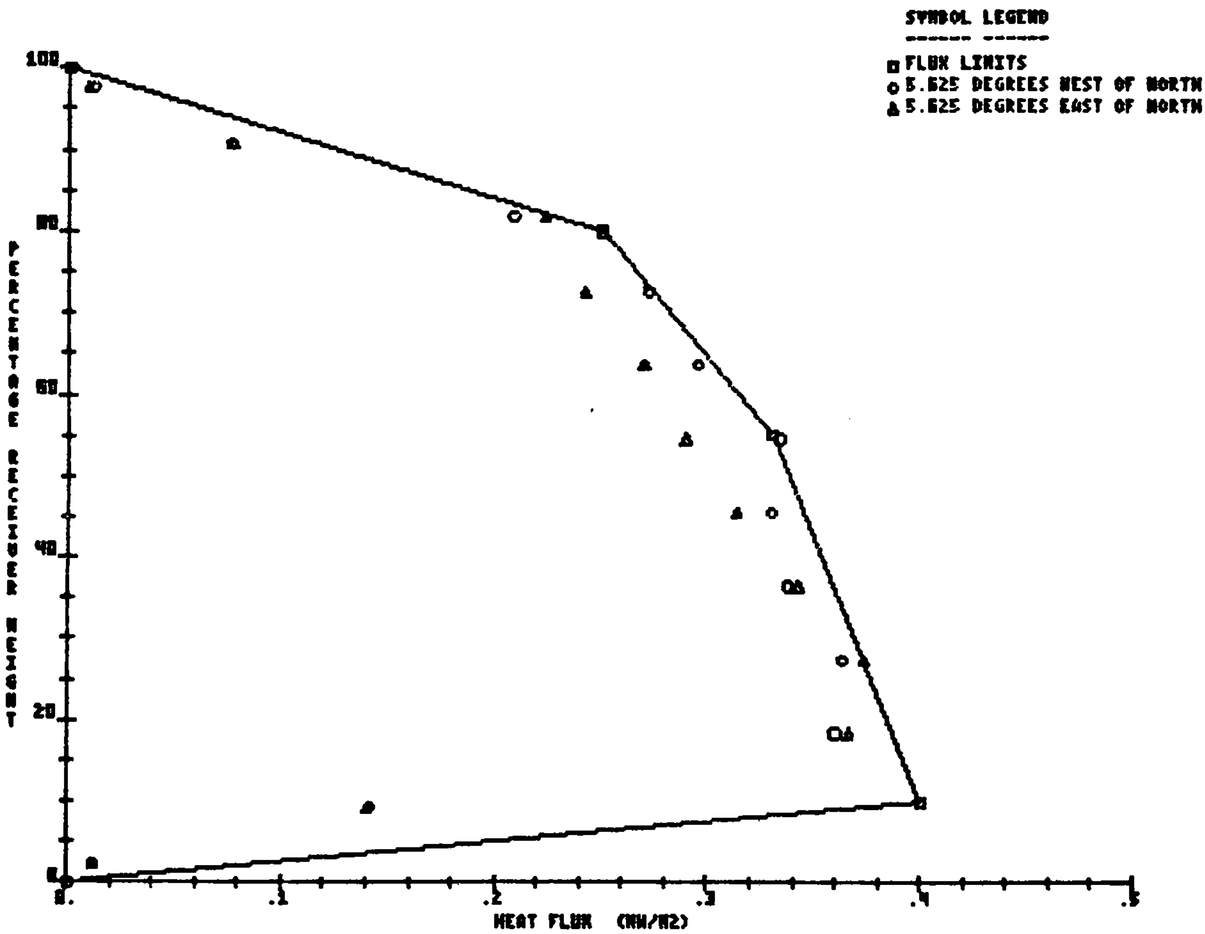


Figure M.1-22. Design Point Vertical Heat Flux For Each Heliostat Canted According to Its Position

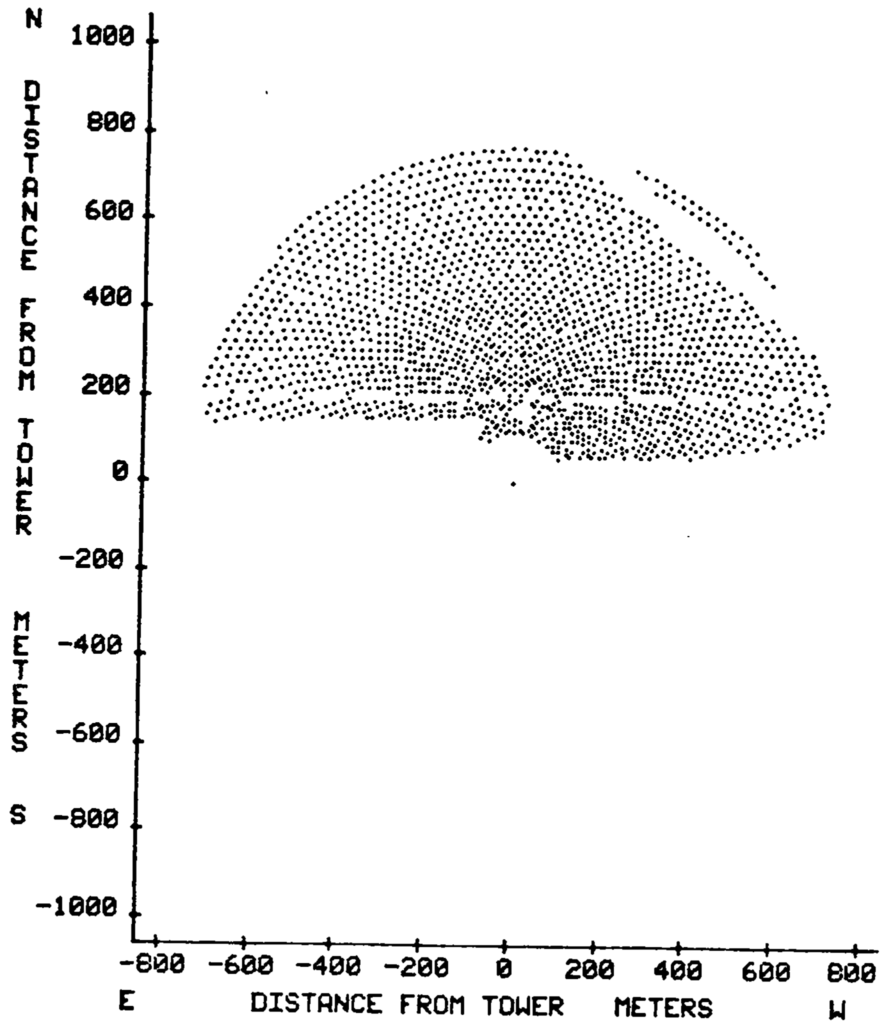


Figure M.1-23. Optimized Heliostat Field - 1875 Heliostats

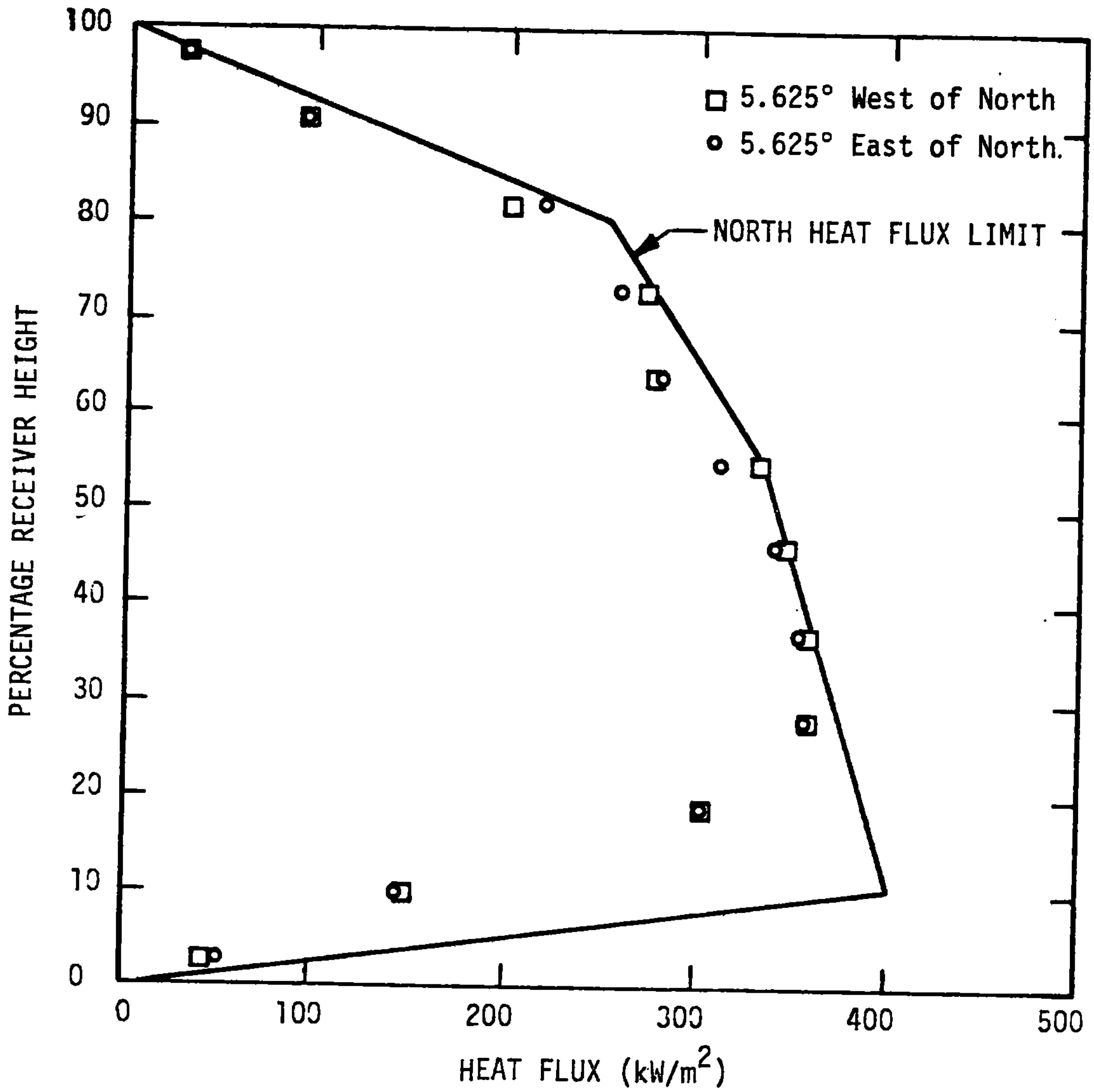


Figure M.1-24. Design Point Vertical Heat Flux Profile

M.2 HELIOSTAT FIELD PERFORMANCE

MIRVAL, a program developed by Sandia Laboratories, is used to calculate the performance of the north heliostat field described as the final optimized field in Section M.1.

Field performance, including total receiver incident power and receiver heat flux distribution, is calculated at noon winter solstice (design point), 8 a.m. winter solstice, 9 a.m. winter solstice, 10 a.m. winter solstice, 8 a.m. summer solstice, 10 a.m. summer solstice, noon summer solstice, and annual average.

Heliostat characteristics assumed in the performance calculations are identical to those described in Section M.1. On-axis canting is assumed with the cant determined by the farthest heliostat from the receiver. The mirror panels are curved in both the length and width directions, and the focal length is the slant range of the farthest heliostat from the receiver.

The Babcock and Wilcox receiver is an external receiver. In MIRVAL, an external receiver is named a McDonnell Douglas receiver and is represented by a truncated right circular cylinder. The following dimensions are assumed for the receiver:

Height	25.91 meters (85.0 feet)
Diameter	17.90 meters (58.7 feet)
Vertical Distance From Ground to Centerline	155.0 meters (508.5 feet)
Arc Angle	202.5 degrees

A preprocessor for the MIRVAL computer code defines the heliostat positions in an x-y plane relative to the receiver centerline position. Several field shapes, heliostat spacings, and total number of heliostats were examined in Section M.1. The final field with 1875 heliostats is shown in Figure M.1-23.

The aiming strategy is field position and slant range dependent. The intent of a field position and slant range dependent aiming strategy is to keep the redirected solar power that misses the receiver, the spillage, to a low level and to result in a receiver heat flux distribution which meets the design specifications. More detail of how the aiming strategy is developed can be found in Section M.1.

Sandia laboratories developed a computer program, MIRVAL, which is used to evaluate the performance of competing heliostat designs and for computation of the solar thermal input to a receiver from a field of heliostats. In this study, MIRVAL is used to determine the total power incident on the receiver and to define the resulting receiver heat flux maps. Several heliostat and receiver models are available in MIRVAL, but the previously described McDonnell Douglas types are used.

Power density calculations were performed with MIRVAL. A power density run calculates the heat flux on an assigned number of receiver sub-areas. In this case, the receiver was divided up into 32 azimuthal sub-areas and 12 axial sub-areas. Each flux map sub-area is referred to as a flux bin. Each azimuthal flux bin represents an angle of 11.25 degrees. For an 8.95 meter radius receiver, each azimuthal flux bin has a 1.76 meter arc length. The top and bottom axial flux bins have a height of 4 feet (1.22 meters) and all others have a height of 7.7 feet (2.35 meters). Figure M.2-1 shows a representation of the flux bins.

Along with receiver heat flux maps, MIRVAL prints a summary of the heliostat field performance including total solar power incident on the receiver, total power blocked, total power absorbed by the heliostats, etc.

The accuracy and convergence of the flux maps depends on the number of Monte Carlo trials. An acceptable flux map with a 32 by 12 grid is created by using 1 million or more Monte Carlo trials, whereas an acceptable total incident power is calculated using around 100,000 trials.

The design point for the heliostat field and receiver is noon winter solstice. At 12:00 noon winter solstice, 1875 heliostats produce 134 MW_t incident power on a 25.92 meter (85 foot) receiver assuming 1000 W/m^2 direct normal

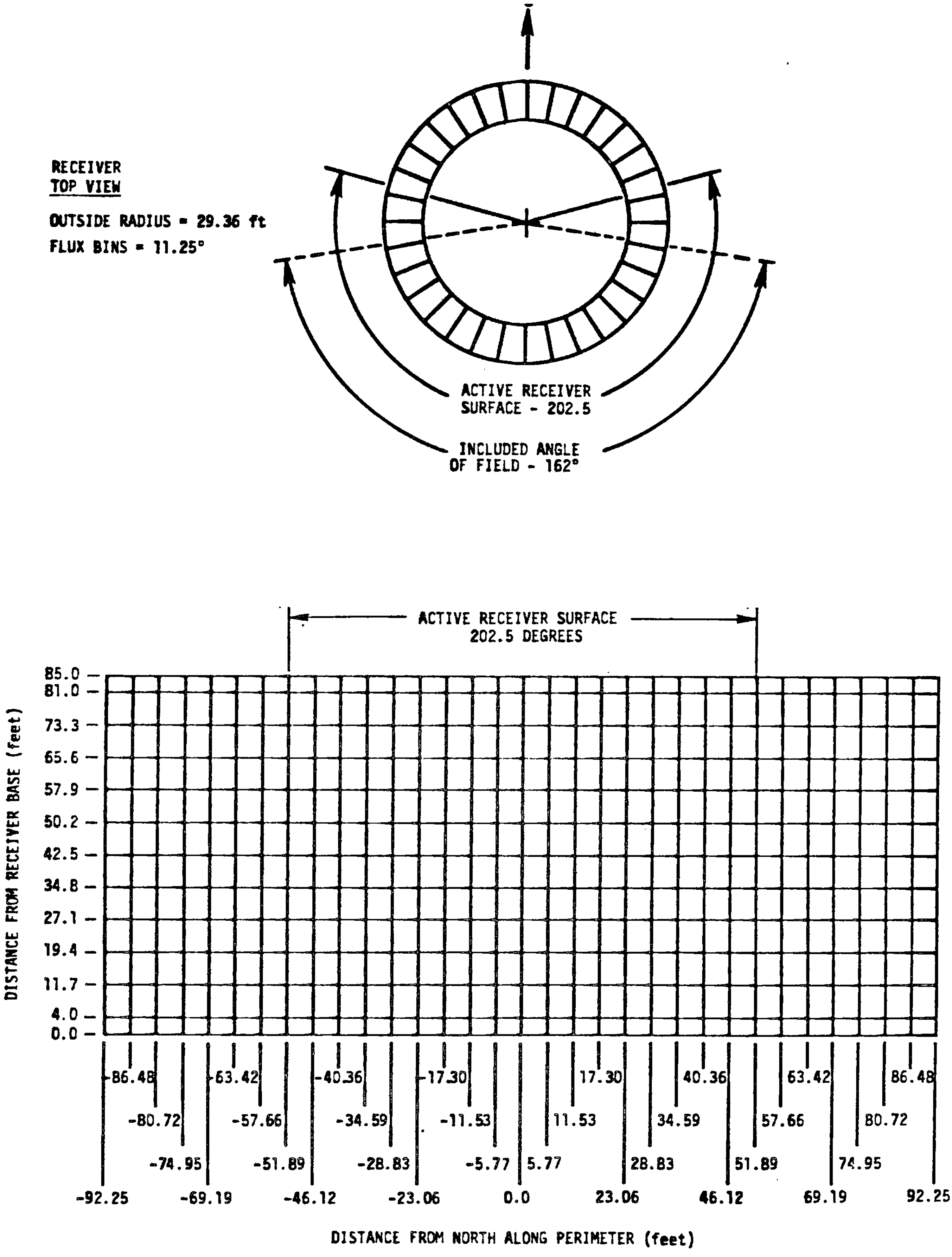


Figure M.2-1. Flux Bins

insolation. A receiver heat flux map for noon winter solstice is shown in Table M.2-1. The peak heat flux is 371 kW/m^2. Figure M.2-2 shows the design point vertical heat flux profile as calculated by MIRVAL compared to the receiver designer heat flux specifications. At design point, the spilled flux which is beyond the absorber surface is never greater than 25 kW/m^2. Figures M.2-3 and M.2-4 show the flux profiles for every 11.25 degrees of receiver up to 225 degrees. An iso-flux contour map of the receiver at noon winter solstice is shown in Figure M.2-5. Note how the slant range, field position dependent aiming strategy has resulted in a very uniform flux distribution. Table M.2-2 and Figure M.2-6 show the collector field performance as power efficiencies for several optical events. Receiver flux profiles and receiver circumferential power distributions at several times of day on winter solstice are shown in Figures M.2-7 and M.2-8.

At times on winter solstice other than noon, the insolation is less because light rays from the sun have longer path lengths through the atmosphere. At times other than noon on winter solstice and at other times of the year, the cosine loss increases. Therefore, the total incident power at times other than solar noon on winter solstice is less than at noon winter solstice. These effects are shown in Table M.2-3 for 8 a.m. winter solstice, 9 a.m. winter solstice, 10 a.m. winter solstice, 8 a.m. summer solstice, 10 a.m. summer solstice, and 12 noon summer solstice. Also in Table M.2-3, the collector field performance for each case is shown as power efficiencies for several optical events. Heat flux maps for each case are given in Table M.2-4 to M.2-9.

Using the clear day insolation model in MIRVAL, the annual average performance of the collector field was calculated. An annual average heliostat reflectivity of 86% was assumed. The annual average collector field performance is given in Table M.2-10.

TABLE M.2-1

RECEIVER HEAT FLUX MAP
12:00 NOON WINTER SOLSTICE

The following table is a flux map summary of 225 degrees of the receiver. Only 202.5 degrees of the receiver are actually active. The top and bottom flux bins are 4 feet (1.219 meters) high. All other bins are 7.7 feet (2.347 meters) high. Flux is in MW/m^2.

									N										
0.000	0.000	.001	.008	.016	.027	.032	.032	.030	.028	.028	.032	.028	.036	.028	.025	.023	.010	.003	0.000
.000	.002	.011	.031	.062	.085	.090	.094	.078	.091	.090	.089	.082	.081	.082	.070	.056	.028	.006	.000
.001	.006	.029	.069	.124	.168	.190	.192	.190	.199	.216	.188	.170	.159	.154	.141	.116	.064	.018	.003
.002	.010	.038	.088	.152	.204	.220	.238	.239	.270	.256	.241	.216	.202	.181	.186	.150	.088	.030	.007
.003	.014	.047	.107	.173	.220	.245	.258	.299	.276	.278	.260	.236	.221	.212	.197	.158	.084	.034	.006
.005	.016	.052	.106	.182	.219	.260	.295	.331	.331	.309	.287	.270	.266	.240	.219	.162	.095	.034	.009
.006	.018	.052	.120	.182	.246	.279	.301	.330	.343	.339	.314	.313	.298	.274	.264	.197	.098	.041	.006
.003	.016	.063	.130	.213	.267	.309	.339	.346	.356	.352	.350	.325	.322	.313	.286	.221	.108	.036	.007
.002	.015	.052	.132	.236	.293	.345	.351	.371	.357	.355	.366	.364	.358	.332	.295	.218	.121	.029	.004
.001	.006	.039	.112	.189	.241	.289	.317	.312	.301	.301	.294	.296	.270	.269	.226	.170	.095	.032	.003
0.000	.003	.017	.051	.082	.109	.137	.149	.156	.144	.141	.137	.144	.129	.121	.108	.077	.042	.013	.001
0.000	.001	.002	.008	.019	.031	.039	.044	.047	.041	.047	.043	.047	.046	.036	.032	.022	.007	.002	.000

SUM OF POWER IN EACH COLUMN, MW (FROM LEFT TO RIGHT)

1	.0969	11	11.0350
2	.4471	12	10.5747
3	1.6544	13	10.1260
4	3.9444	14	9.6834
5	6.6466	15	9.1225
6	8.5813	16	8.3348
7	9.8987	17	6.3724
8	10.6222	18	3.4277
9	11.1034	19	1.1323
10	11.1486	20	.1912

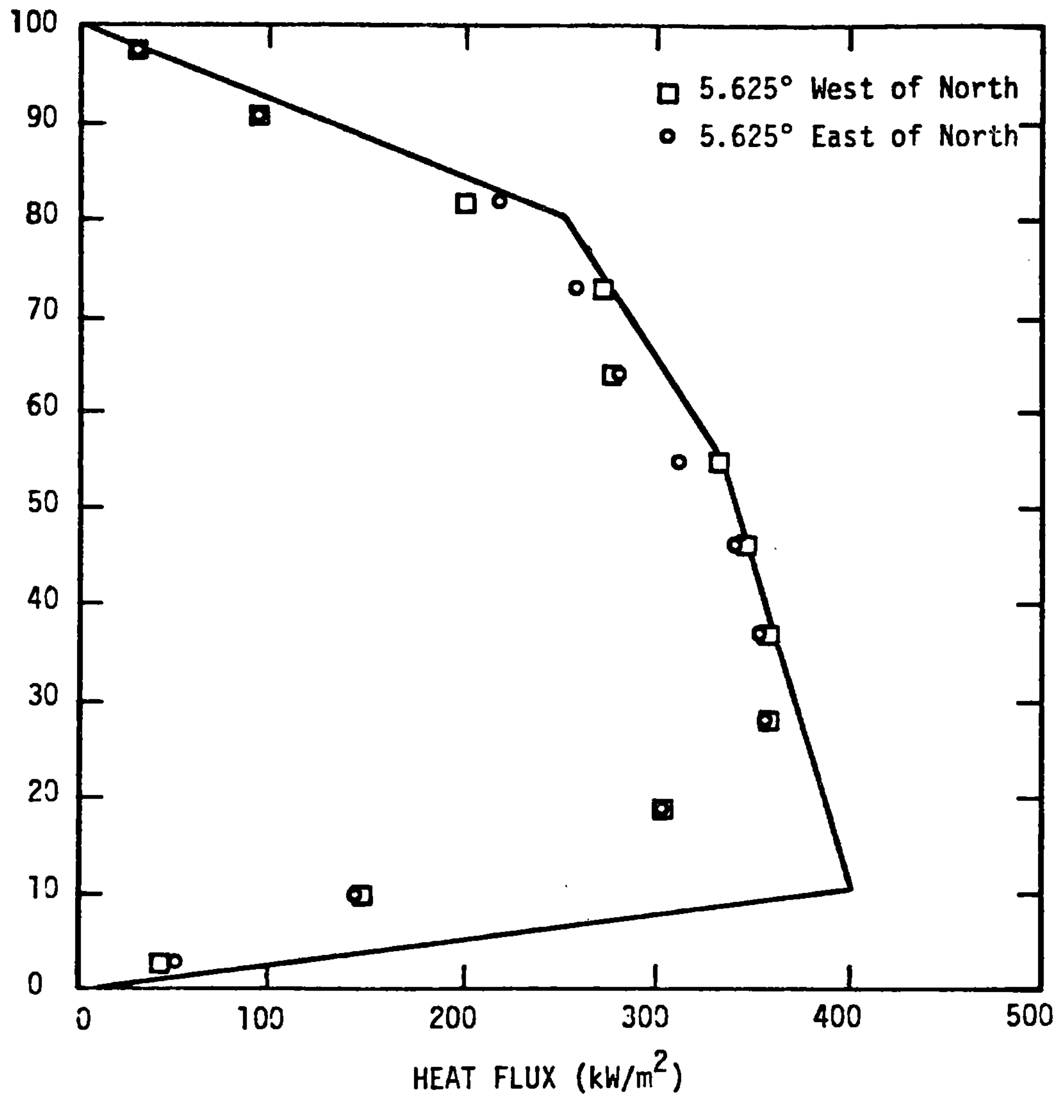
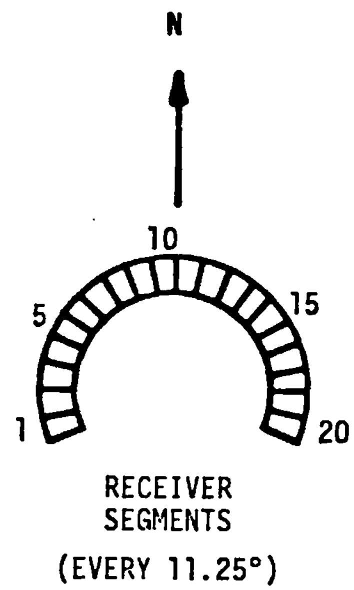


Figure M.2-2. Design Point Vertical Heat Flux Profile



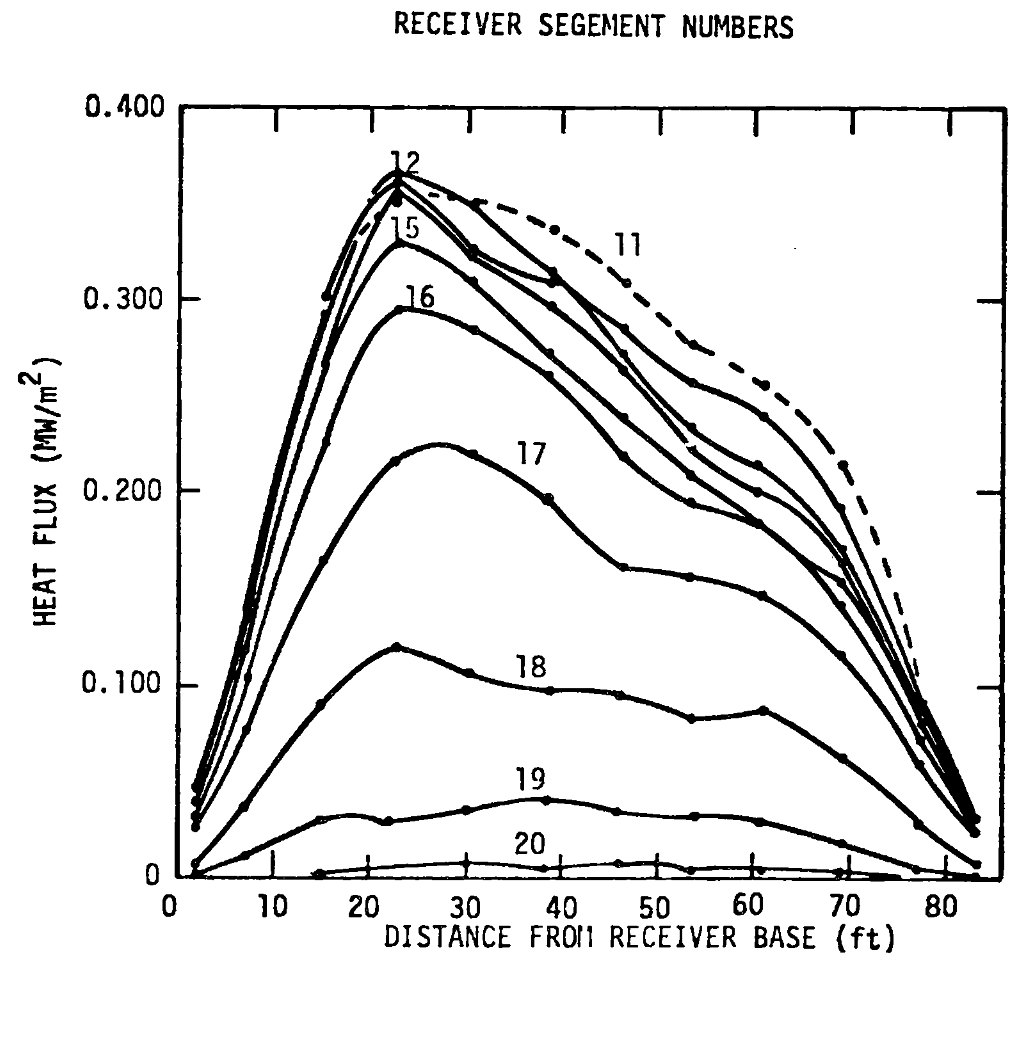


Figure M.2-3. Heat Flux On East Side of Receiver (Noon Winter Solstice)

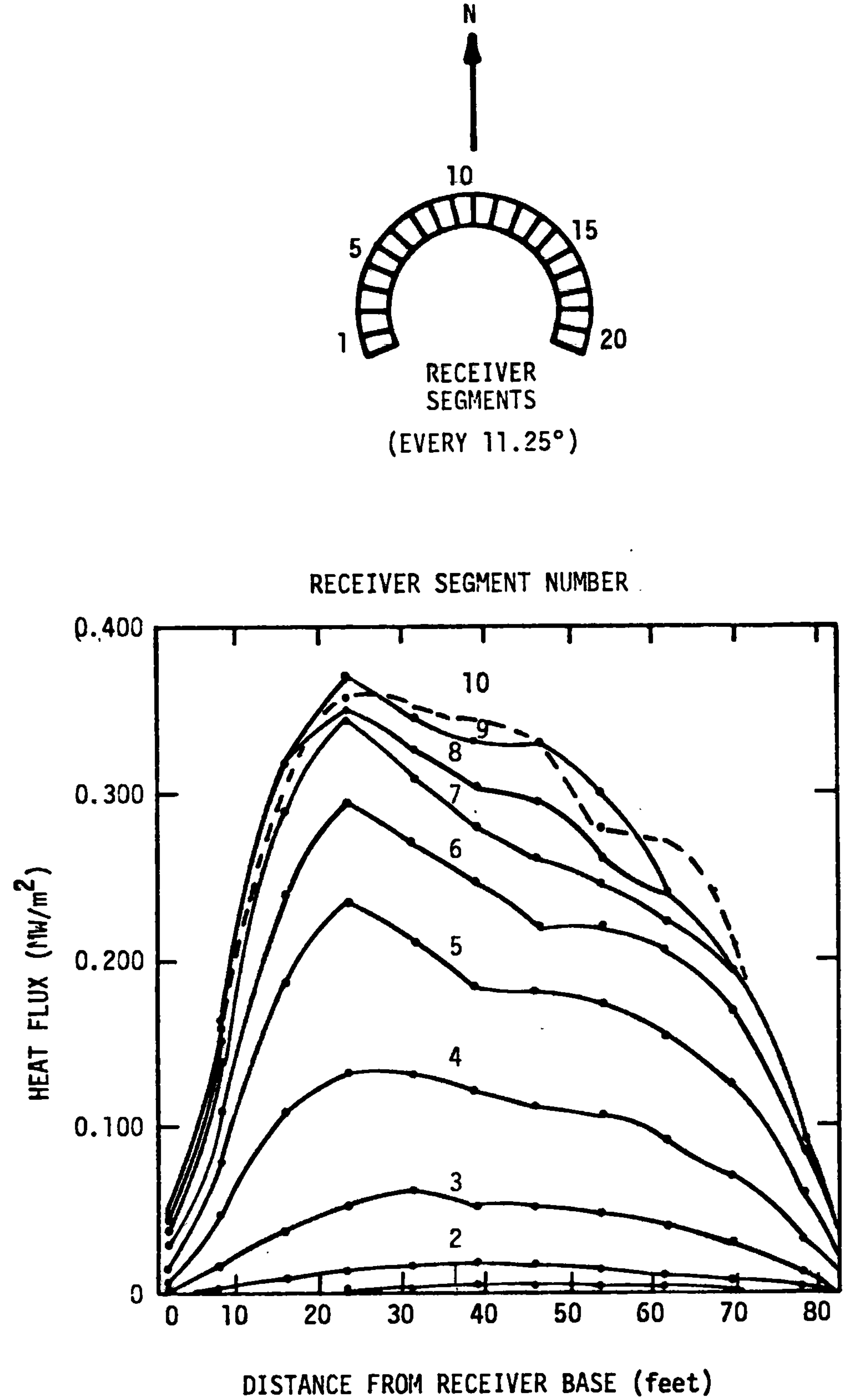


Figure M.2-4. Heat Flux On West Side of Receiver
(Noon Winter Solstice)

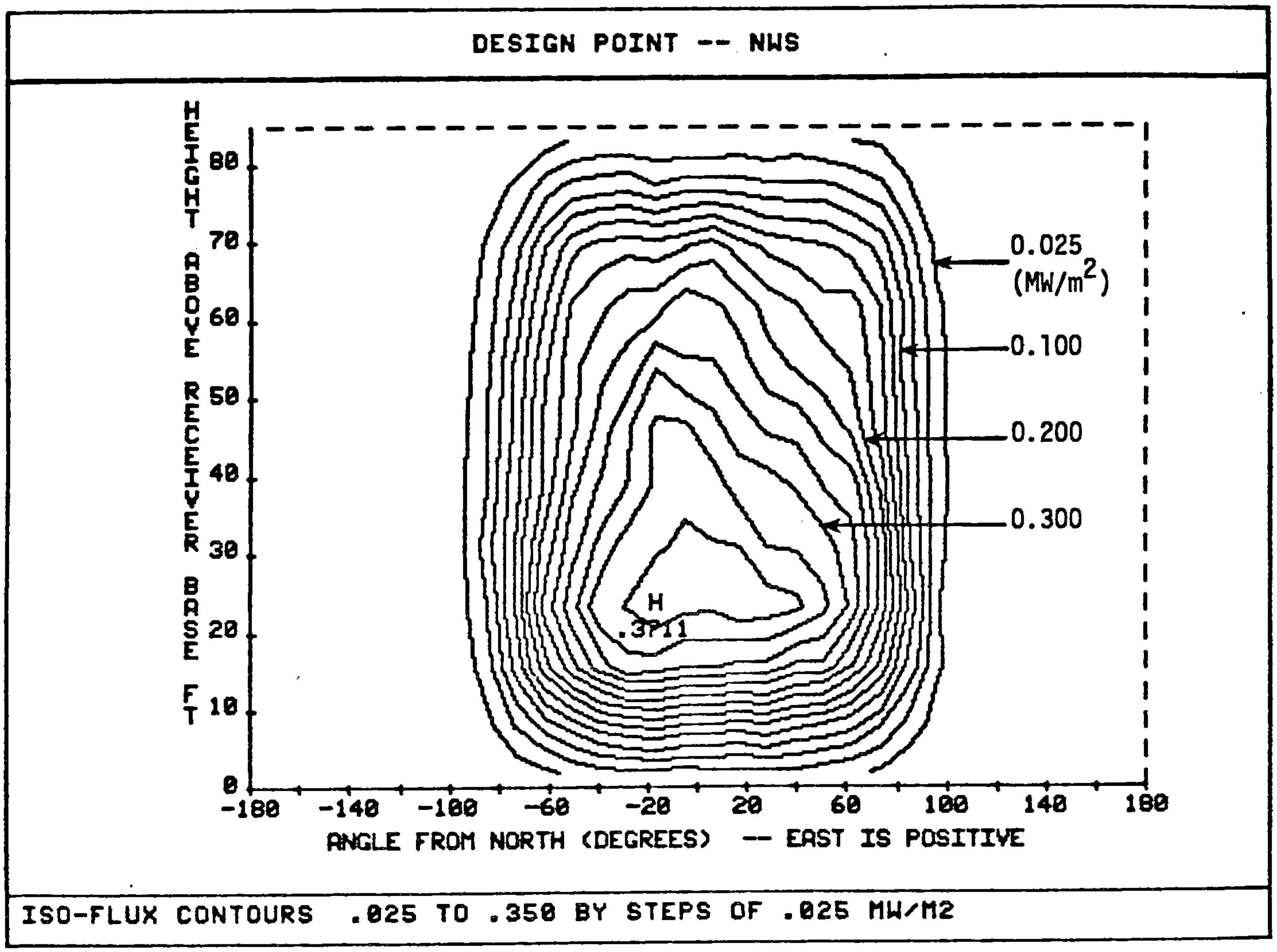


Figure M.2-5. Receiver Iso-Flux Contours At Design Point

TABLE M.2-2

DESIGN POINT COLLECTOR PERFORMANCE
NOON WINTER SOLSTICE

Total Power Incident On Receiver (percent)	134.2
Heliostat Availability (percent)	98.0
Not Lost to Cosine and Shadowing (percent)	92.6
Reflectivity (percent)	90.0
Not Lost to Blocking (percent)	98.5
Not Lost to Attenuation (percent)	94.0
Not Lost to Spillage (percent)	99.7
Insolation (W/m^2)	1000.0

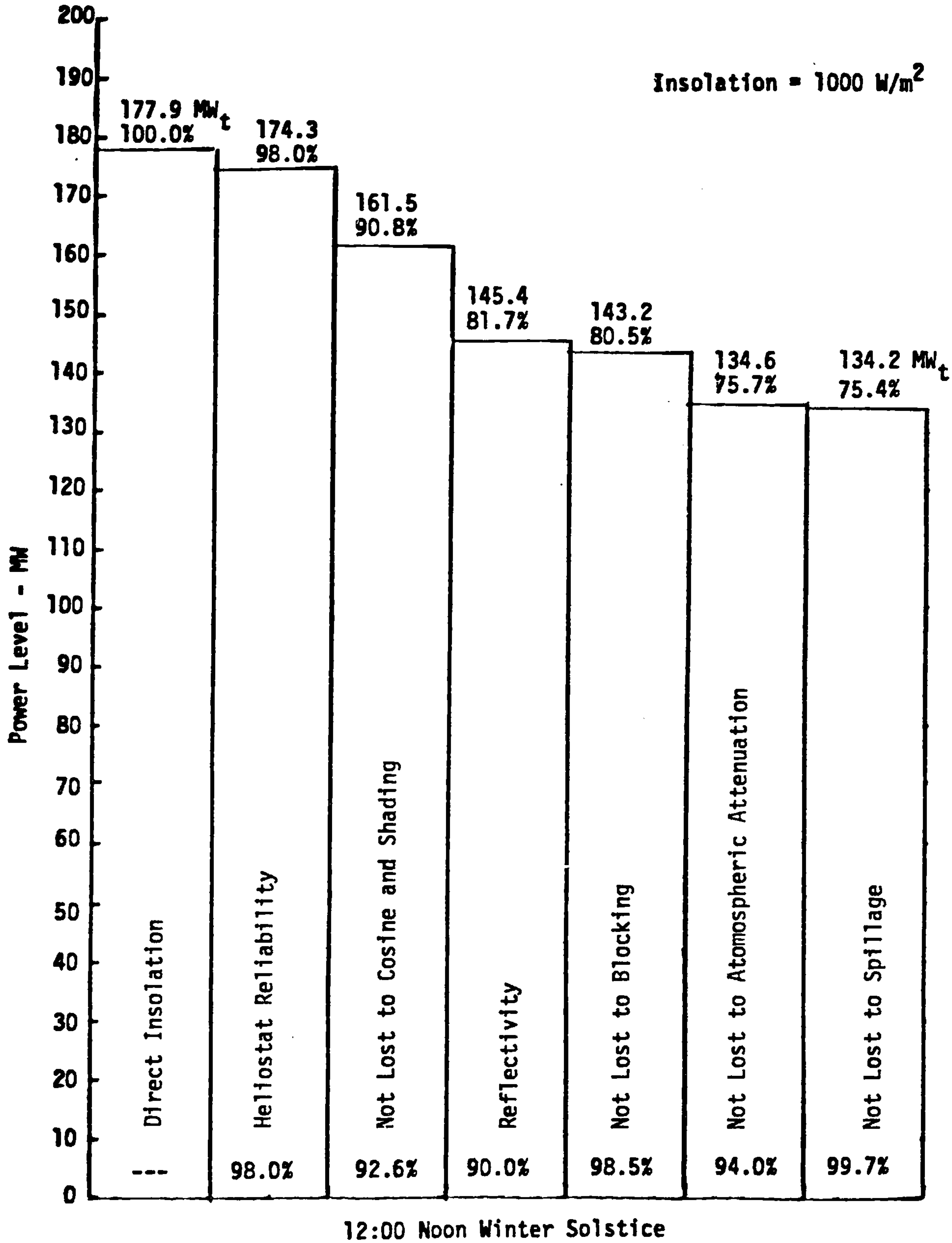


Figure M.2-6. Efficiency Chart

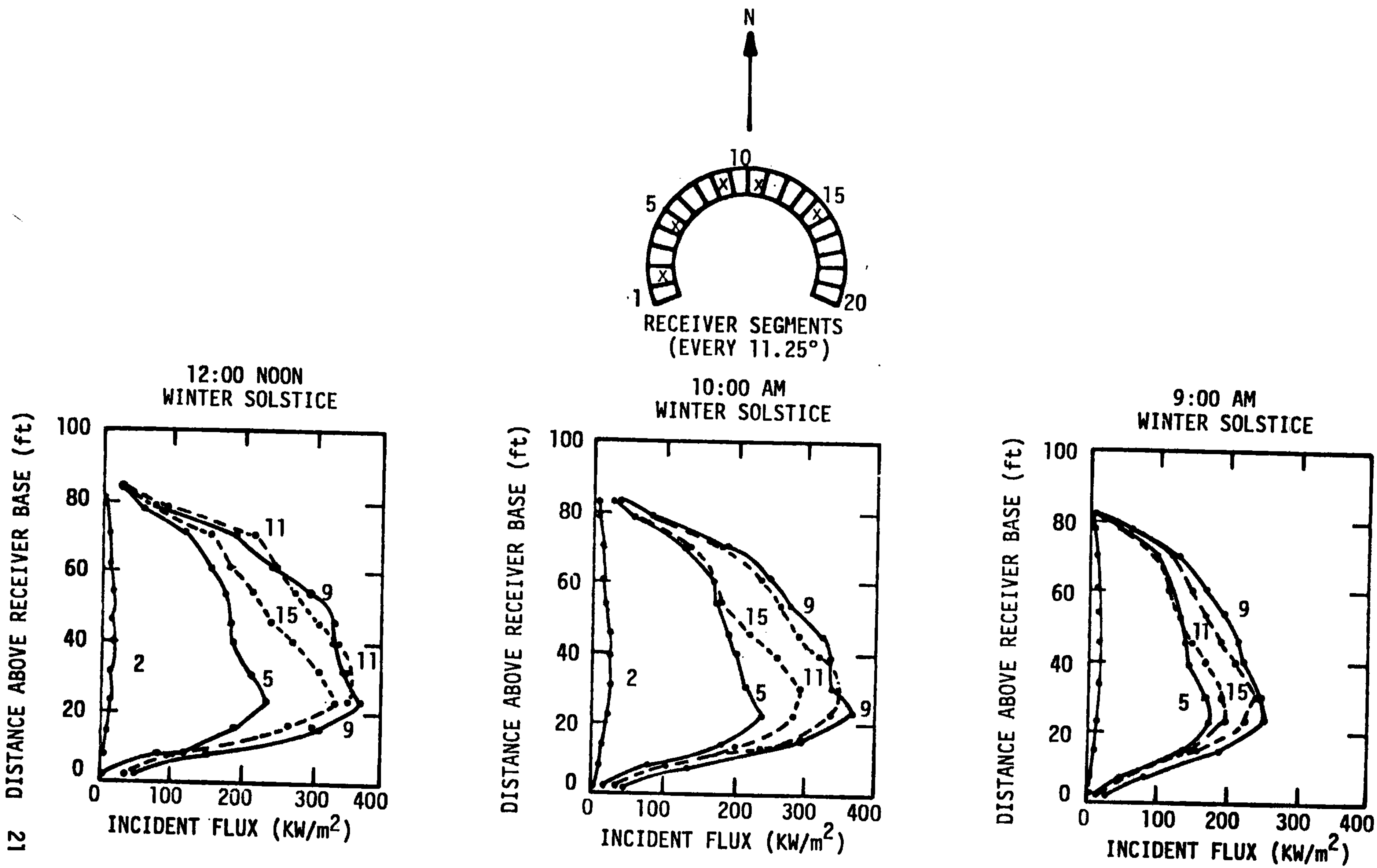


Figure M.2-7. Receiver Heat Flux Profiles - Winter Solstice

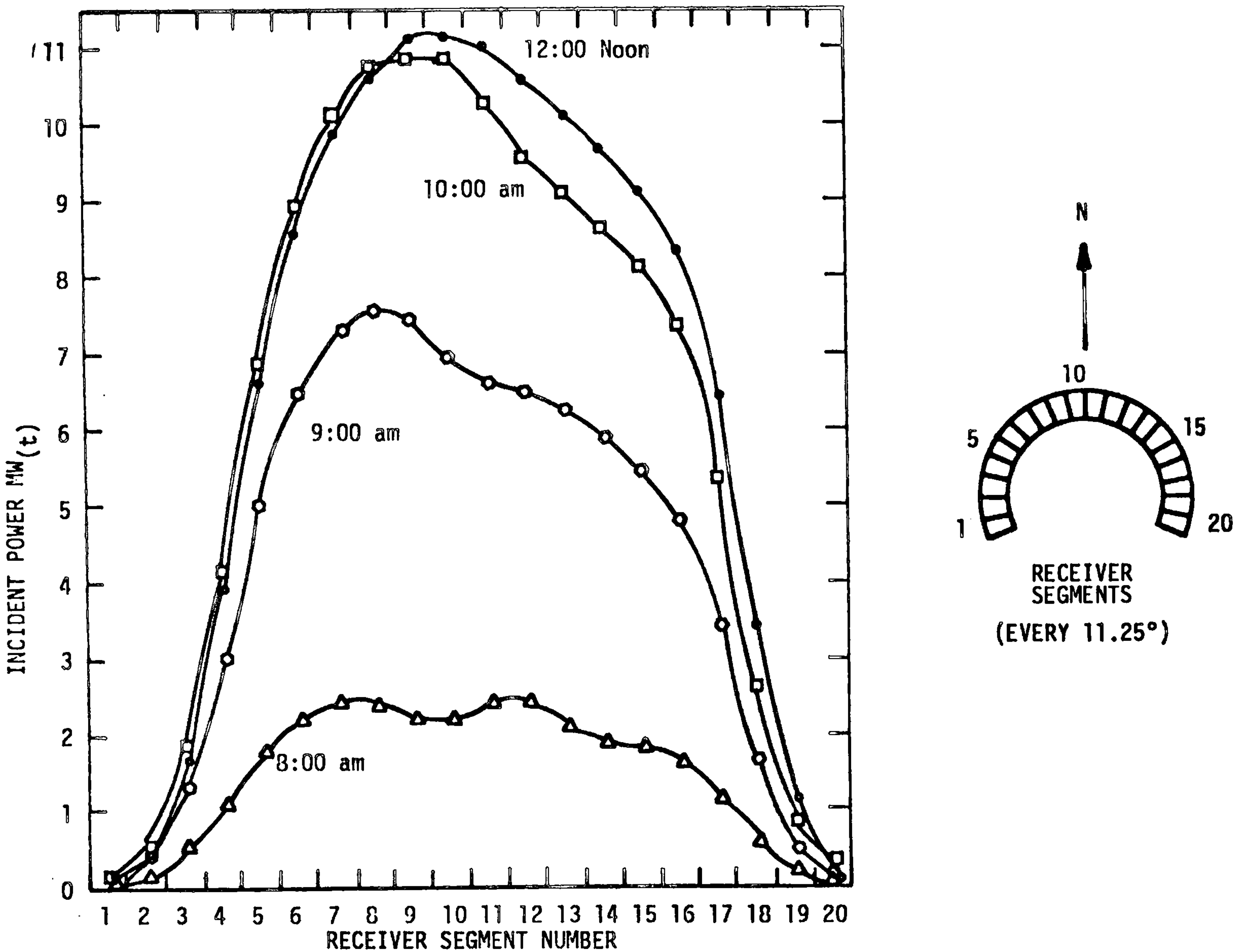


Figure M.2-8. Winter Solstice Receiver Circumferential Power Distribution

TABLE M.2-3

MORNING WINTER SOLSTICE AND SUMMER SOLSTICE COLLECTOR FIELD PERFORMANCE

	8 a.m.* Winter Solstice	9 a.m. Winter Solstice	10 a.m. Winter Solstice	8 a.m. Summer Solstice	10 a.m. Summer Solstice	Noon Summer Solstice
Total Power Incident on Receiver (MW_t)	29.3	86.9	114.8	87.2	112.9	123.5
Heliostat Availability (percent)	98.0	98.0	98.0	98.0	98.0	98.0
Not Lost to Cosine and Shadowing (percent)	56.6	78.4	82.4	72.3	81.0	85.0
Reflectivity (percent)	90.0	90.0	90.0	90.0	90.0	90.0
Not Lost to Blocking (percent)	99.1	98.8	98.6	99.0	98.6	98.6
Not Lost to Attenuation (percent)	93.7	93.8	94.0	94.0	94.0	94.1
Not Lost to Spillage (percent)	99.7	99.7	99.7	99.7	99.8	99.8
Insolation (W/m^2)	357	765	905	829	960	1000

*Sun elevation angle is not above the normal operating limit of 15°.

TABLE M.2-4

RECEIVER HEAT FLUX MAP
8:00 A.M. WINTER SOLSTICE

The following table is a flux map summary of 225 degrees of the receiver. Only 202.5 degrees of the receiver are actually active. The top and bottom flux bins are 4 feet (1.219 meters) high. All other bins are 7.7 feet (2.347 meters) high. Flux is in MW/m^2.

N

0.000	.000	.001	.003	.006	.007	.009	.008	.010	.010	.008	.009	.010	.009	.008	.006	.002	.001	.000	0.000
.000	.001	.004	.010	.017	.024	.025	.025	.022	.022	.024	.025	.023	.020	.020	.016	.009	.003	.001	.000
.001	.003	.009	.019	.035	.044	.047	.044	.036	.039	.045	.047	.039	.033	.031	.028	.020	.010	.003	.001
.001	.003	.013	.026	.040	.051	.054	.053	.048	.048	.053	.053	.045	.038	.038	.034	.026	.016	.005	.001
.001	.005	.014	.028	.044	.054	.057	.057	.057	.056	.060	.056	.050	.043	.040	.039	.029	.017	.007	.002
.002	.006	.017	.033	.049	.060	.064	.068	.069	.073	.072	.071	.061	.053	.049	.044	.033	.018	.007	.003
.002	.007	.019	.036	.056	.068	.072	.075	.078	.087	.090	.084	.074	.066	.060	.055	.037	.018	.007	.002
.002	.007	.020	.042	.064	.078	.082	.082	.079	.083	.091	.089	.079	.070	.066	.059	.037	.016	.006	.001
.001	.005	.018	.040	.063	.080	.088	.088	.077	.072	.082	.083	.073	.070	.066	.056	.035	.016	.004	.001
.001	.003	.013	.030	.047	.058	.068	.061	.048	.041	.048	.054	.051	.044	.047	.038	.024	.012	.003	.000
.000	.001	.004	.011	.017	.021	.024	.022	.013	.009	.012	.017	.015	.013	.017	.017	.013	.007	.002	.000
0.000	0.000	.001	.002	.004	.005	.005	.006	.004	.002	.002	.004	.003	.003	.004	.006	.005	.002	.001	.000

SUM OF POWER IN EACH COLUMN, MW (FROM LEFT TO RIGHT)

1	.0363	11	2.4041
2	.1664	12	2.4143
3	.5417	13	2.1265
4	1.1455	14	1.8782
5	1.7999	15	1.8188
6	2.2392	16	1.6132
7	2.4259	17	1.1002
8	2.4038	18	.5492
9	2.2006	19	.1865
10	2.2098	20	.0460

TABLE M.2-5

RECEIVER HEAT FLUX MAP
9:00 A.M. WINTER SOLSTICE

The following table is a flux map summary of 225 degrees of the receiver. Only 202.5 degrees of the receiver are actually active. The top and bottom flux bins are 4 feet (1.219 meters) high. All other bins are 7.7 feet (2.347 meters) high. Flux is in MW/m^2.

									N										
.000	.001	.004	.007	.014	.021	.021	.026	.024	.024	.024	.023	.023	.023	.018	.017	.009	.002	.000	.000
.000	.002	.009	.025	.046	.059	.069	.068	.066	.062	.060	.062	.057	.053	.052	.047	.027	.010	.002	.000
.001	.006	.021	.056	.096	.132	.136	.140	.132	.124	.120	.121	.108	.101	.092	.083	.060	.033	.007	.001
.002	.008	.030	.071	.116	.151	.168	.170	.166	.152	.147	.146	.135	.115	.111	.104	.077	.043	.014	.003
.003	.013	.034	.082	.134	.164	.176	.190	.193	.176	.170	.153	.149	.129	.123	.114	.084	.046	.016	.005
.004	.016	.042	.087	.137	.177	.203	.210	.219	.209	.192	.188	.175	.161	.147	.122	.094	.050	.019	.005
.004	.018	.047	.096	.141	.184	.216	.225	.228	.235	.225	.221	.204	.191	.171	.150	.102	.050	.020	.004
.004	.017	.049	.103	.166	.205	.231	.246	.248	.251	.240	.234	.226	.200	.192	.164	.110	.052	.015	.003
.003	.014	.046	.104	.176	.216	.259	.262	.256	.237	.224	.227	.228	.212	.194	.174	.114	.048	.013	.002
.001	.007	.033	.081	.137	.181	.200	.205	.194	.166	.153	.160	.164	.165	.154	.125	.091	.044	.010	.001
.000	.002	.012	.030	.054	.078	.091	.090	.083	.059	.050	.053	.058	.070	.068	.063	.051	.022	.005	.000
0.000	.000	.001	.005	.011	.020	.020	.023	.027	.013	.010	.011	.014	.022	.018	.017	.016	.006	.001	.000

SUM OF POWER IN EACH COLUMN, MW (FROM LEFT TO RIGHT)

1	.0883	11	6.5912
2	.4210	12	6.5295
3	1.3419	13	6.2736
4	3.0454	14	5.8623
5	5.0090	15	5.4530
6	6.4652	16	4.7951
7	7.3004	17	3.3987
8	7.5507	18	1.6636
9	7.4694	19	.4971
10	6.9694	20	.1035

TABLE M.2-6

RECEIVER HEAT FLUX MAP
10:00 A.M. WINTER SOLSTICE

The following table is a flux map summary of 225 degrees of the receiver. Only 202.5 degrees of the receiver are actually active. The top and bottom flux bins are 4 feet (1.219 meters) high. All other bins are 7.7 feet (2.347 meters) high. Flux is in MW/m^2.

									N										
0.000	.001	.002	.010	.019	.020	.032	.026	.025	.029	.030	.027	.027	.028	.026	.019	.014	.004	.001	0.000
.000	.003	.013	.031	.056	.072	.083	.080	.076	.083	.088	.076	.073	.066	.067	.056	.039	.014	.004	.000
.002	.007	.029	.071	.116	.157	.174	.173	.166	.171	.166	.159	.141	.131	.122	.111	.088	.043	.011	.002
.003	.009	.037	.086	.147	.191	.209	.222	.218	.222	.212	.193	.177	.167	.151	.144	.116	.063	.022	.004
.004	.016	.045	.097	.156	.205	.221	.247	.250	.250	.235	.214	.195	.174	.161	.155	.117	.058	.024	.005
.005	.019	.050	.102	.171	.210	.245	.268	.288	.292	.258	.236	.227	.211	.196	.173	.127	.071	.028	.009
.004	.021	.056	.112	.183	.224	.259	.282	.306	.302	.293	.276	.268	.242	.232	.211	.141	.071	.026	.007
.005	.019	.056	.130	.204	.242	.290	.300	.307	.322	.317	.297	.275	.263	.262	.228	.166	.074	.022	.004
.003	.017	.057	.132	.217	.281	.317	.341	.333	.322	.305	.293	.294	.286	.258	.239	.163	.073	.018	.002
.001	.008	.037	.101	.171	.247	.270	.277	.268	.259	.249	.228	.218	.218	.206	.184	.131	.060	.016	.002
.000	.003	.016	.043	.067	.104	.127	.131	.138	.124	.106	.091	.099	.099	.093	.083	.062	.032	.008	.001
0.000	.001	.004	.008	.011	.024	.031	.035	.040	.034	.027	.020	.026	.029	.031	.028	.016	.006	.001	0.000

SUM OF POWER IN EACH COLUMN, MW (FROM LEFT TO RIGHT)

1	.1138	11	9.3178
2	.5093	12	8.6121
3	1.6518	13	8.2292
4	3.7760	14	7.7745
5	6.2022	15	7.3286
6	8.0745	16	6.6354
7	9.1885	17	4.8103
8	9.7021	18	2.3256
9	9.8397	19	.7467
10	9.8270	20	.1500

TABLE M.2-7

RECEIVER HEAT FLUX MAP
8:00 A.M. SUMMER SOLSTICE

The following table is a flux map summary of 225 degrees of the receiver. Only 202.5 degrees of the receiver are actually active. The top and bottom flux bins are 4 feet (1.219 meters) high. All other bins are 7.7 feet (2.347 meters) high. Flux is in MW/m^2.

									N										
0.000	.001	.003	.010	.014	.017	.027	.027	.026	.020	.021	.018	.013	.009	.007	.003	.002	.000	.000	.000
.000	.003	.011	.027	.053	.066	.073	.070	.067	.060	.058	.059	.047	.041	.030	.023	.017	.010	.004	.001
.003	.007	.025	.059	.103	.132	.150	.143	.142	.135	.130	.114	.107	.096	.093	.079	.058	.033	.013	.005
.003	.011	.034	.064	.137	.165	.176	.177	.177	.168	.163	.158	.134	.114	.111	.090	.068	.037	.015	.004
.003	.013	.042	.084	.149	.176	.187	.192	.198	.189	.174	.155	.138	.124	.107	.096	.069	.043	.017	.004
.004	.014	.048	.100	.148	.183	.209	.216	.219	.207	.182	.164	.156	.131	.109	.091	.069	.039	.015	.005
.004	.019	.052	.104	.157	.199	.206	.220	.236	.224	.211	.180	.166	.138	.115	.103	.072	.039	.019	.007
.003	.019	.053	.109	.177	.218	.246	.245	.242	.255	.227	.205	.178	.166	.139	.127	.091	.053	.023	.005
.004	.017	.057	.125	.194	.250	.277	.273	.265	.252	.228	.222	.193	.184	.170	.132	.094	.055	.023	.007
.001	.009	.038	.092	.163	.203	.230	.233	.219	.210	.192	.180	.171	.164	.164	.141	.096	.058	.020	.006
.000	.002	.013	.034	.066	.089	.106	.118	.112	.095	.093	.080	.076	.074	.078	.065	.044	.019	.008	.001
0.000	.000	.005	.009	.015	.022	.034	.030	.031	.029	.025	.020	.018	.012	.019	.015	.006	.001	.000	0.000

SUM OF POWER IN EACH COLUMN, MW . (FROM LEFT TO RIGHT)

1	.1039	11	6.9331
2	.4748	12	6.3421
3	1.5551	13	5.6948
4	3.4105	14	5.1276
5	5.6213	15	4.6614
6	7.0231	16	3.9425
7	7.8068	17	2.8147
8	7.9001	18	1.5949
9	7.8603	19	.6439
10	7.5143	20	.1889

TABLE M.2-8

RECEIVER HEAT FLUX MAP
10:00 A.M. SUMMER SOLSTICE

The following table is a flux map summary of 225 degrees of the receiver. Only 202.5 degrees of the receiver are actually active. The top and bottom flux bins are 4 feet (1.219 meters) high. All other bins are 7.7 feet (2.347 meters) high. Flux is in MW/m^2.

									N										
0.000	.001	.002	.007	.014	.023	.029	.030	.023	.025	.025	.020	.015	.021	.010	.012	.005	.005	.002	0.000
.000	.003	.013	.036	.056	.068	.080	.077	.080	.076	.076	.068	.068	.065	.060	.049	.028	.019	.006	.002
.002	.007	.031	.076	.122	.161	.177	.180	.175	.168	.178	.155	.143	.138	.137	.118	.087	.053	.020	.007
.002	.013	.036	.094	.147	.201	.206	.221	.218	.217	.202	.200	.175	.161	.157	.138	.109	.070	.027	.009
.002	.018	.044	.093	.163	.198	.220	.240	.252	.245	.227	.199	.196	.171	.162	.148	.109	.070	.027	.006
.005	.020	.057	.110	.163	.212	.236	.246	.256	.253	.244	.213	.209	.190	.166	.154	.110	.066	.029	.007
.005	.021	.053	.110	.174	.220	.239	.256	.260	.278	.264	.243	.230	.218	.183	.163	.126	.067	.024	.008
.005	.020	.055	.132	.201	.255	.288	.282	.294	.308	.290	.278	.248	.244	.238	.207	.155	.095	.037	.008
.002	.020	.064	.145	.211	.299	.305	.325	.316	.296	.292	.310	.294	.271	.264	.221	.155	.100	.039	.008
.002	.010	.044	.110	.179	.235	.277	.301	.281	.273	.253	.255	.251	.248	.224	.193	.148	.086	.038	.009
.000	.002	.015	.043	.072	.116	.129	.137	.127	.130	.112	.111	.104	.107	.107	.090	.061	.030	.016	.003
0.000	0.000	.001	.005	.013	.029	.035	.042	.039	.027	.032	.020	.023	.028	.018	.015	.005	.003	.001	0.000

SUM OF POWER IN EACH COLUMN, MW (FROM LEFT TO RIGHT)

1	.0894	11	8.9336
2	.5515	12	8.4656
3	1.7043	13	7.9893
4	3.9453	14	7.5815
5	6.1945	15	7.0625
6	8.2098	16	6.1666
7	9.0295	17	4.5055
8	9.4933	18	2.7192
9	9.4424	19	1.0979
10	9.3700	20	.2726

TABLE M.2-9

RECEIVER HEAT FLUX MAP
12:00 A.M. SUMMER SOLSTICE

The following table is a flux map summary of 225 degrees of the receiver. Only 202.5 degrees of the receiver are actually active. The top and bottom flux bins are 4 feet (1.219 meters) high. All other bins are 7.7 feet (2.347 meters) high. Flux is in MW/m^2.

N

0.000	0.000	.002	.006	.014	.014	.023	.023	.021	.022	.028	.020	.021	.021	.014	.012	.012	.007	.001	0.000
.001	.003	.016	.035	.053	.073	.077	.085	.073	.089	.095	.076	.079	.076	.067	.067	.052	.022	.009	.002
.001	.008	.027	.070	.124	.160	.173	.190	.183	.177	.190	.179	.162	.153	.164	.141	.107	.066	.028	.006
.002	.009	.040	.086	.152	.195	.211	.219	.229	.247	.221	.233	.197	.180	.186	.171	.139	.086	.034	.010
.004	.012	.045	.092	.155	.204	.213	.236	.258	.258	.246	.229	.216	.207	.186	.192	.151	.083	.036	.006
.003	.015	.047	.102	.160	.199	.238	.246	.274	.272	.273	.254	.228	.225	.219	.192	.146	.099	.029	.008
.003	.016	.049	.107	.159	.195	.240	.261	.285	.286	.294	.274	.261	.250	.259	.213	.180	.093	.042	.008
.003	.014	.054	.119	.191	.232	.277	.285	.315	.317	.315	.298	.291	.304	.279	.258	.199	.107	.042	.010
.003	.017	.063	.143	.213	.272	.306	.339	.351	.336	.335	.343	.328	.310	.307	.281	.206	.127	.055	.005
.001	.013	.051	.111	.182	.246	.279	.314	.308	.294	.301	.288	.276	.275	.289	.229	.168	.107	.041	.007
.000	.003	.015	.051	.075	.098	.110	.134	.149	.142	.127	.121	.120	.141	.126	.108	.080	.037	.011	.002
0.000	.001	.004	.008	.007	.016	.030	.035	.032	.034	.028	.027	.027	.038	.028	.021	.020	.008	.001	.001

SUM OF POWER IN EACH COLUMN, MW (FROM LEFT TO RIGHT)

1	.0821	11	9.9954
2	.4531	12	9.5659
3	1.6856	13	9.0026
4	3.8042	14	8.8632
5	6.0777	15	8.6699
6	7.7912	16	7.7099
7	8.8725	17	5.9547
8	9.6381	18	3.4406
9	10.1171	19	1.3559
10	10.0898	20	.2621

TABLE M.2-10
ANNUAL AVERAGE COLLECTOR PERFORMANCE

Heliostat Availability (percent)	98.0
Not Lost to Cosine and Shadowing (percent)	82.7
Reflectivity (percent)	86.0
Not Lost to Blocking (percent)	98.6
Not Lost to Attenuation (percent)	93.9
Not Lost to Spillage (percent)	99.7

M.3 CLOUD TRANSIENT MODEL

A cloud transient model was developed to calculate the power incident on ten sections of the receiver when a shadow covers part of the heliostat field. The sections are adjacent vertical strips which cover the receiver surface. The output of the model provides input to a detailed model of the solar receiver system.

This subsection of the report describes how the cloud transient model works, the assumptions that are used, the basic equations in the model, the inputs that the user must provide, and the application of the model to two cloud transients.

Before using the model, the user must divide the heliostat field into equal-area zones such as those shown in Figure M.3-1. The model, which is designed for an electronic spreadsheet on a personal computer, then goes through the following steps in sequence:

1. It calculates the contribution of each zone to the solar power incident on the receiver. The user has specified the fraction of each zone that is illuminated.

2. It sums the contributions from all the zones to obtain the total power incident on the receiver.

3. It calculates the contribution of each zone to the solar energy flux at ten points which are located at the centers of the ten vertical sections of the receiver. Figure M.3-2 shows the locations of the points and the corresponding receiver sections for the El Paso receiver.

4. It sums the contributions from all zones that are visible from each point to obtain the total solar energy flux at the points.

5. Using the solar energy flux values at the ten points plus the angular widths of the sections, the model distributes the total power incident on the receiver among the ten receiver sections.

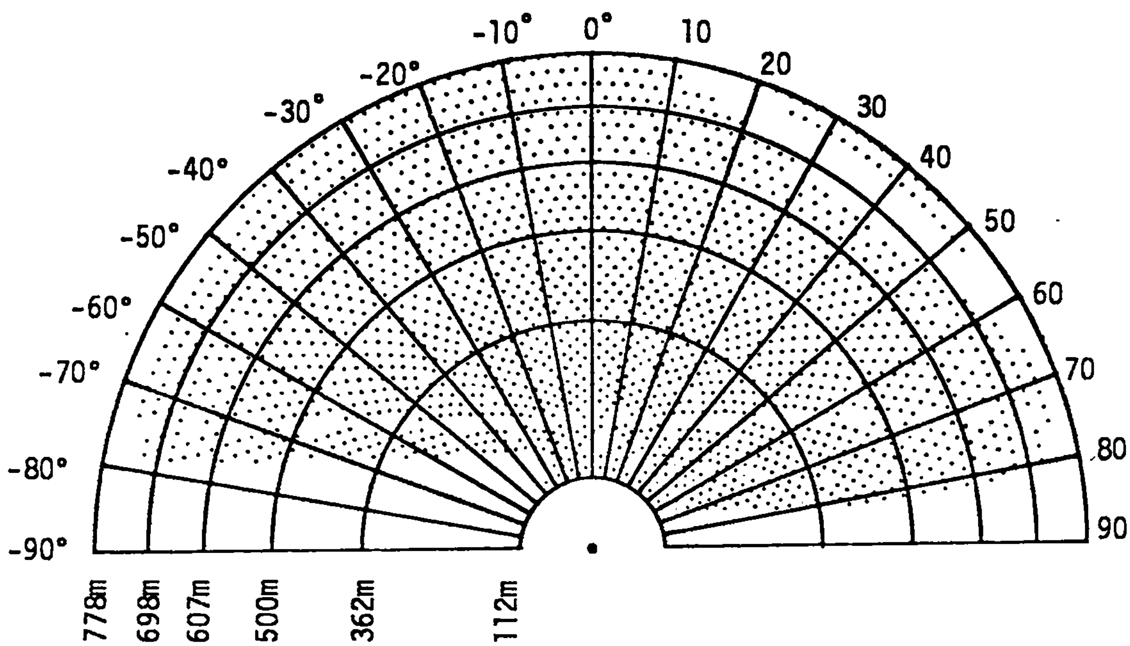


Figure M.3-1. Ninety Equal Area Zones for the Heliostat Field

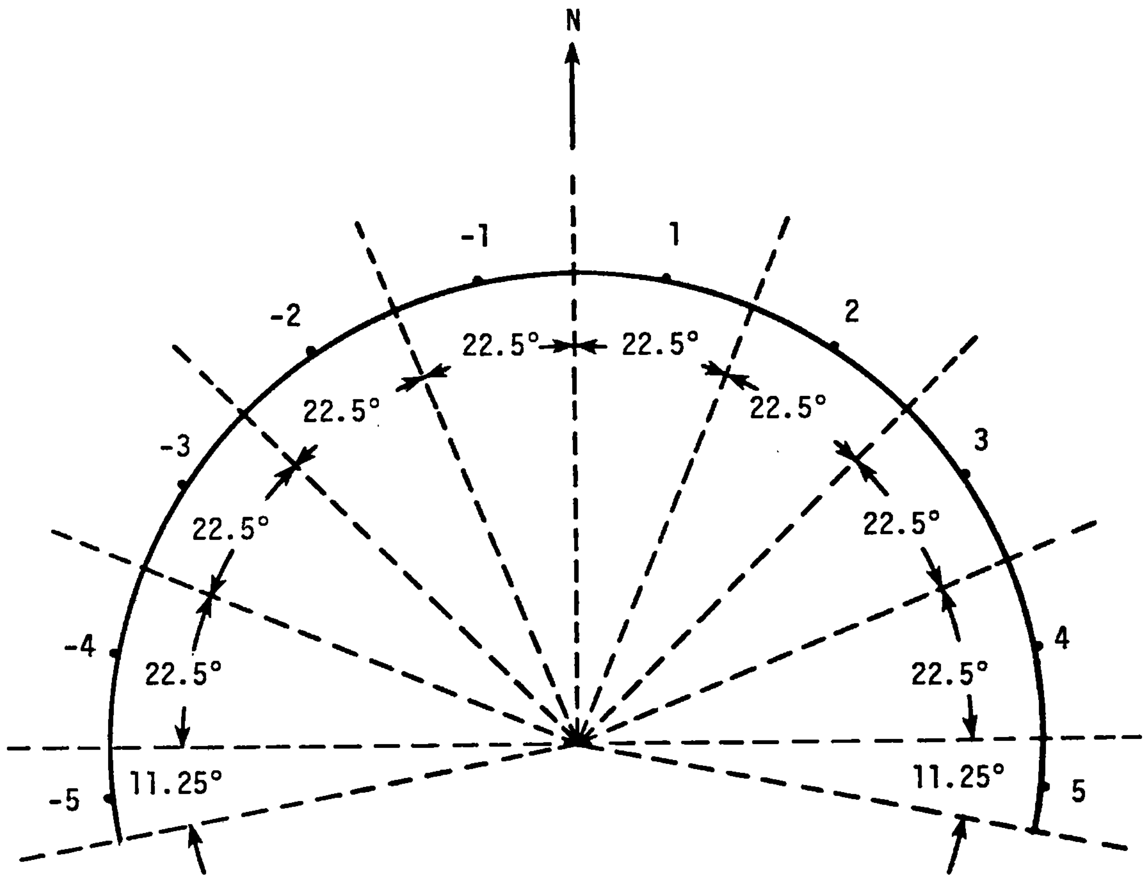


Figure M.3-2. Horizontal Cross Section through Receiver Showing Ten Receiver Sections and Points at the Center of Each Section

Steps 1 through 5 are repeated for sequential positions of a shadow that moves across the heliostat field. The results obtained are solar powers incident on the ten receiver sections as a function of the progress of the shadow.

Five assumptions are used in the model. First, it is assumed that the sunlight reflected from each zone comes from a single heliostat located at the effective center of the zone. Second, it is assumed that the beam of sunlight reflected from each zone has a circular cross section at the receiver. Third, it is assumed that the energy flux distribution in the beam peaks on the axis of the beam and falls linearly to zero at the edge of the beam. Fourth, it is assumed that the receiver surface may be approximated by a cylindrical surface. Finally, it assumed that there is no spillage of solar energy around the receiver.

The equations used in the model are as follows:

The solar power incident on the receiver from zone (j,k) is given by PWRjk where

$$PWRjk = I * (Ajk * PPFCTRjk * Rgj * COSijk) * Rm * Taj * ILFCTRjk \quad (1)$$

where

j is an index identifying radial zones
k is an index identifying azimuthal zones
I is the solar insolation
Ajk is the land area in zone (j,k)
PPFCTRjk is the fraction of zone (j,k) that is populated with heliostats
Rgj is the ratio of mirror area to land area in zone (j,k)
COSijk is the cosine of the angle of incidence of the sun's rays on a heliostat at the effective center of zone (j,k)
Rm is the reflectivity of the mirrors
Taj is the atmospheric transmission from zone (j,k) to the receiver
ILFCTRjk is the fraction of zone (j,k) that is illuminated by the sun.

The total power on the receiver, PWR, is the sum of the contributions from each of the zones

$$PWR = \Sigma\ PWRjk \quad (2)$$

The solar energy flux incident at the n^{th} point on the receiver from zone (j, k) is given by PHIjkn where

$$PHIjkn = PWRjk * (3/(\pi * (BEAMRADj)^2)) *$$

$$(1 - ((RCVRRAD * SIN(ABS(RCVANGLn - ANGLjk)))/BEAMRADj)) \quad (3)$$

where

BEAMRADj is the radius of the beam from zone (j,k)
RCVRRAD is the radius of the receiver
RCVANGLn is the angular position of the n^{th} point on the receiver measured clockwise from north
ANGLjk is the angular position of the effective center of zone (j,k) measured clockwise from north

Equation (3) is made up of three major factors. The first factor, PWRjk, is given by Equation (1). The product of the first two factors gives the peak flux on the axis of the beam; the peak flux is three times the average flux. The third factor accounts for the linear fall-off of the flux from the axis to the edge of the beam. Figure M.3-3 should be helpful in understanding the third factor.

The total solar energy flux at the n^{th} point, PHIn, is given by

$$PHIn = \Sigma\ PHIjkn \quad (4)$$

where the summation is over all the zones that are visible from the n^{th} point.

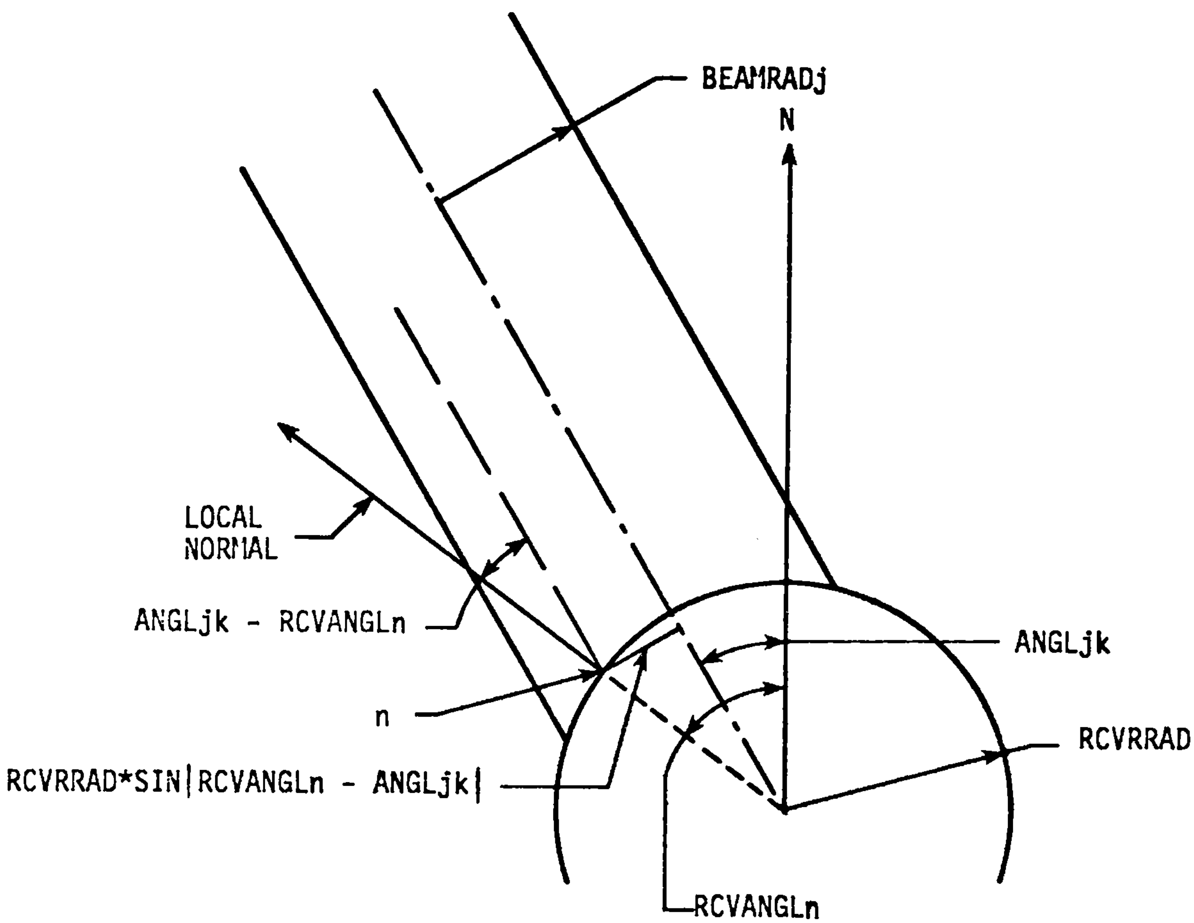


Figure M.3-3. Geometry Used for Calculating the Solar Energy Flux Incident at Point n on the Receiver from a Zone Located at ANGLjk

The solar power incident on the n^{th} section of the receiver is given by PWRn where

$$PWRn = PWR * ((PHIn * ARCn)/(\Sigma(PHIn * ARCn))) \quad (5)$$

Equations (1) through (5) are the basic equations that are built into the cloud transient model.

The model requires that the user provide the following information:

- o the radius of the receiver;
- o the angular widths of the ten receiver sections;
- o the angular position of the ten points which are at the centers of the receiver sections;
- o the elevation angle of the sun above the horizon;
- o the azimuthal angle of the sun, clockwise from north;
- o the insolation value;
- o The height of the center of the receiver above the plane that contains the centers of the heliostats;
- o the area of one of the equal-area zones;
- o the reflectivity of the mirrors;
- o the distance from the axis of the receiver tower to the most remote heliostat;
- o the ratio of mirror area to land area in the radial zones;
- o the atmospheric transmission factors for the radial zones;
- o the polar coordinates of the effective centers of each of the zones;
- o the radius of the reflected beams at the receiver for each radial zone;
- o the fraction of each zone that is populated with heliostats;
- o the fraction of each zone that is sunlit.

The application of the model to two cloud transients is presented here. The first application is to a cloud that produces a semi-infinite shadow. The shadow moves across the heliostat field from west to east at solar noon on the winter solstice. The second application is to a small cloud that casts a circular shadow. The shadow moves from north to south across the western half of the field at 9 a.m. on the winter solstice.

The inputs used for the applications were as follows:

- The radius of the receiver was 8.95 meters, the same as that of the design receiver.
- The angular widths of the receiver sections were those shown in Figure M.3-2.
- the angular positions of the ten points on the receiver were consistent with Figure M.3-2.
- The elevation and azimuth angles of the sun were values calculated for solar noon and 9 a.m. on the winter solstice.
- The insolation values used were 1000 W/m^2 at solar noon and 885 W/m^2 at 9 a.m.
- The height of the receiver above the plane of the centers of the heliostats was 150 meters, which is consistent with the plant design.
- The area of each of the ninety equal-area zones shown in Figure M.3-1 was 10,344 m^2.
- The reflectivity of the mirrors was 0.9.
- The distance from the tower to the most remote heliostat was 766 meters.
- For the radial zones, the radius of the effective centers of the zones (RADjk), the ratio of mirror area to land area (Rgj), the atmospheric transmission (Taj), and the radius of the beam at the receiver (BEAMRADj) were as follows:

j	RADjk (m)	Rgj	Taj	BEAMRADj (m)
1	268	.37	.96	5.8
2	436	.29	.95	5.9
3	556	.23	.94	6.0
4	654	.20	.93	6.1
5	739	.17	.92	6.1

The beam radii were calculated based on the assumption that all heliostats had the same focal length which equaled the slant range to the most remote heliostat. The width of the heliostat was assumed to be 11.1 meters.

- The fraction of each zone that was populated by heliostats was estimated by inspecting Figure M.3-1.
- The fraction of each zone that was sunlit was estimated by eye with a model of the shadow placed at the proper location on Figure M.3-1.

For the semi-infinite shadow, the front of the shadow was advanced across the heliostat field in 240 meter steps as shown in Figure M.3-4.

The power incident on the 10 sections of the receiver identified in Figure M.3-2 was calculated for the shadow positions shown in Figure M.3-4. The results are shown in Figure M.3-5.

For the small circular shadow, the center of the shadow was advanced across the field in steps of about 169 meters as shown in Figure M.3-6. The radius of the shadow was 194 meters, one-fourth the field radius. The power incident on the 10 sections of the receiver was calculated for these shadow positions. The results are shown in Figure M.3-7.

It should be noted that the use of distance as the measure of shadow movement in the analysis permits any assumed value of cloud speed to be used when the results are used in system response studies.

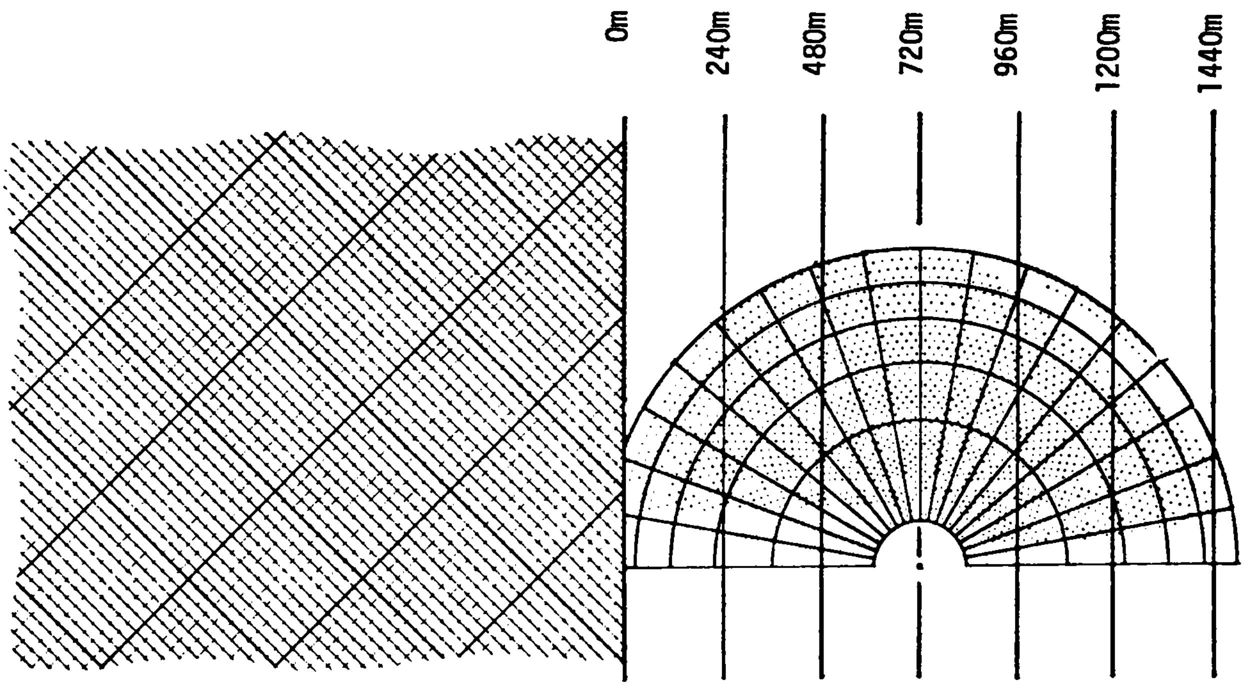


Figure M.3-4. Positions of Front of Semi-Infinite Shadow as it Advances Across the Heliostat Field from West to East

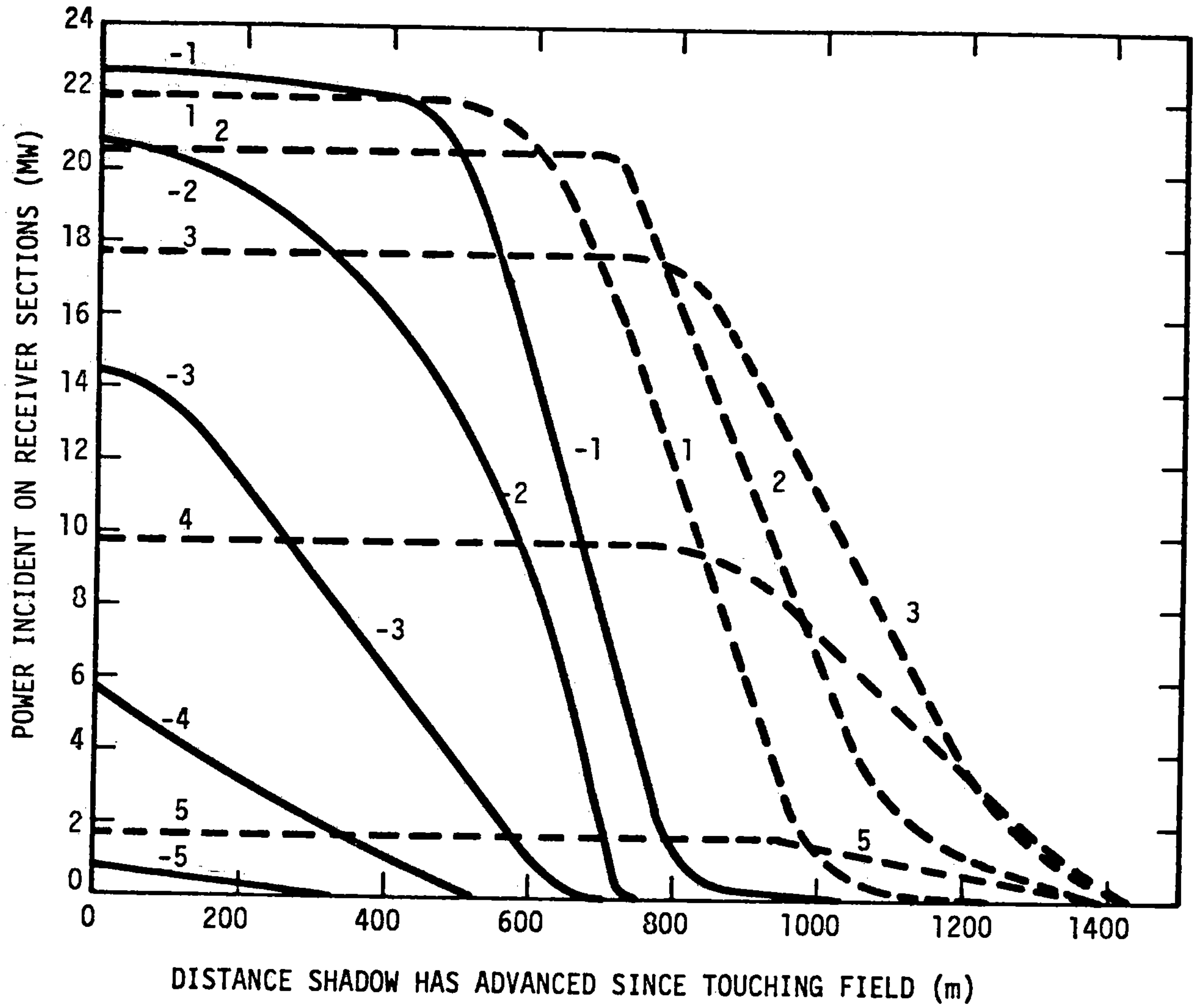


Figure M.3-5. Power Incident on the Ten Sections of the Receiver Shown in Figure 2 When a Semi-Infinite Shadow Moves Across the Heliostat Field from West to East at Noon on the Winter Solstice

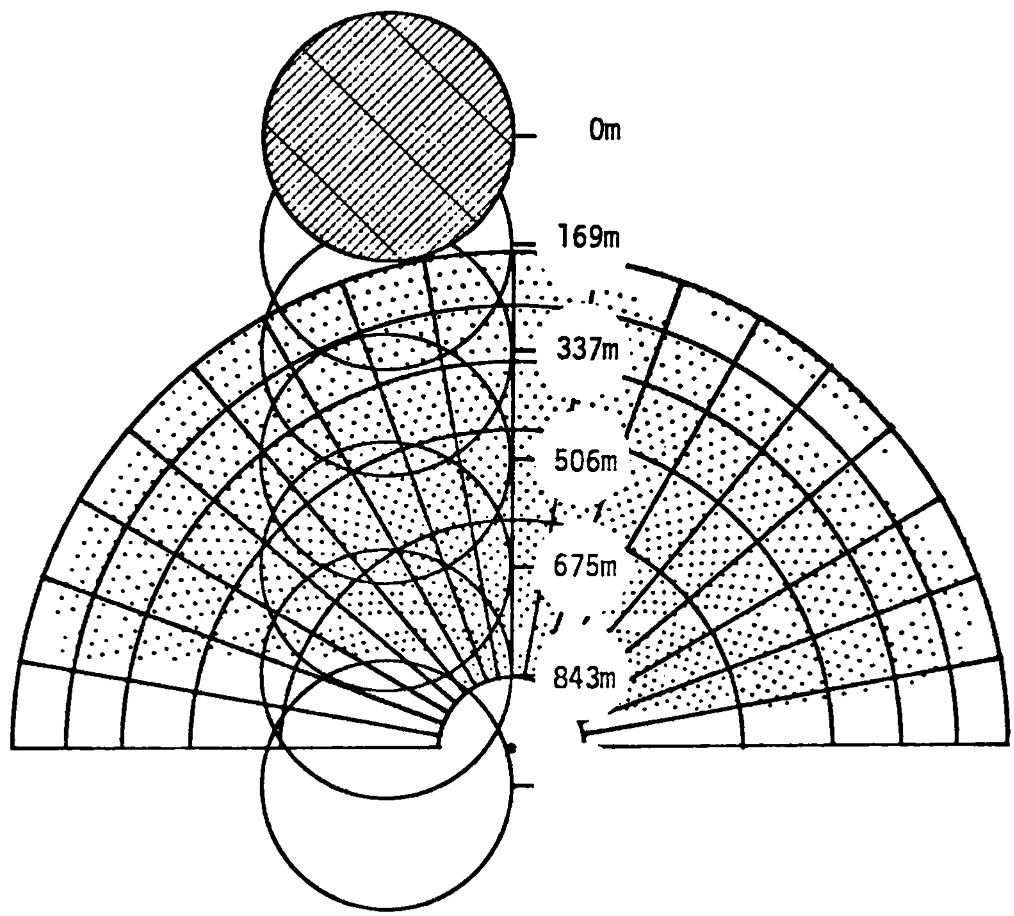


Figure M.3-6. Positions of Center of a 194 Meter Radius Shadow as it Crosses Western Half of Field from North to South

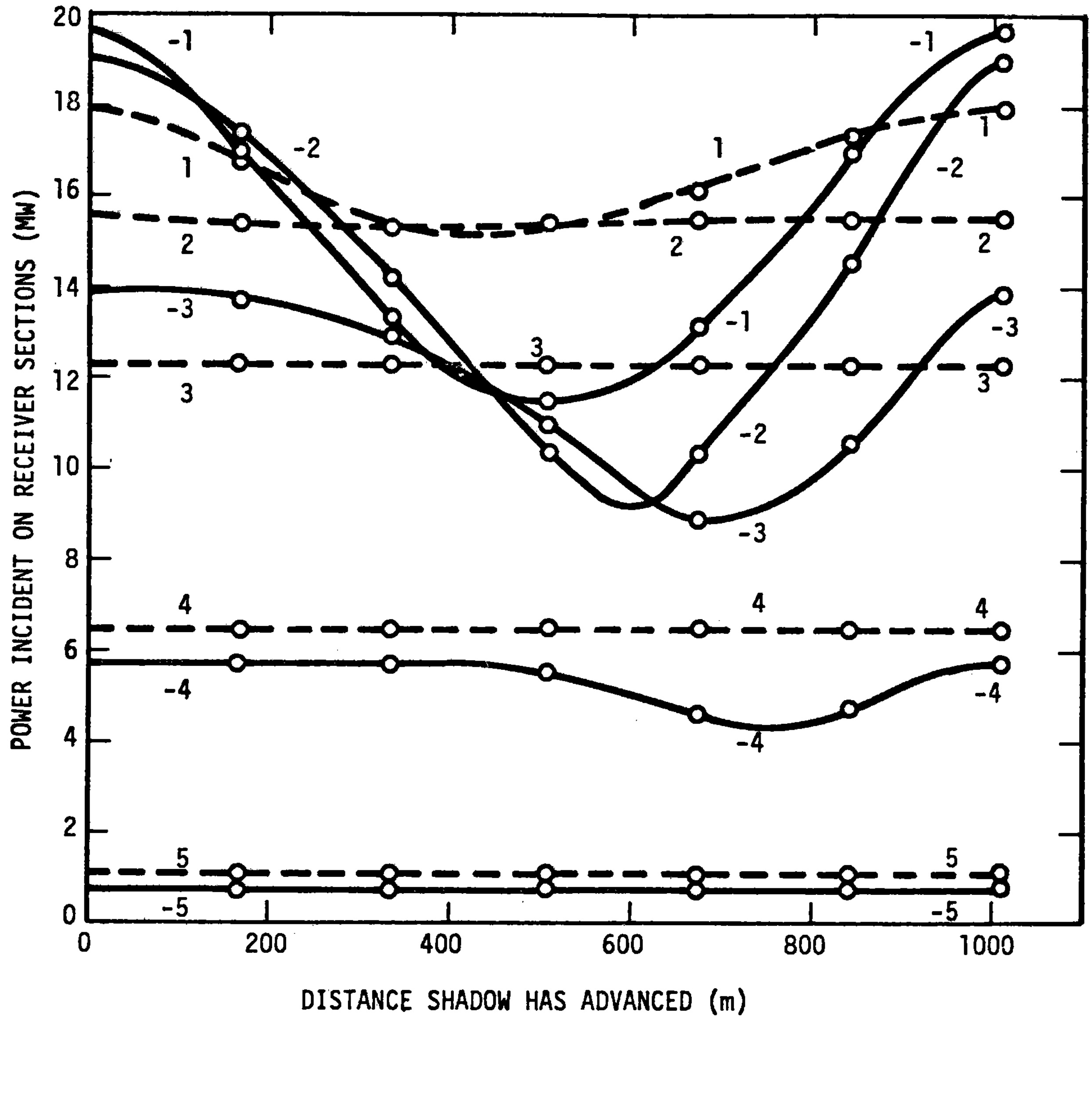


Figure M.3-7. Power Incident on the Ten Sections of the Receiver Shown in Figure 2 When a 194 Meter Radius Shadow Crosses the Western Half of the Heliostat Field from North to South at 9 a.m. on the Winter Solstice

M.4 Angular Distribution Study

A study was done to determine the angular distribution of solar energy arriving at three points on the receiver. Looking out from a point on the side of the receiver, a person would see more heliostats toward the north than toward the south. This means that the angular distribution of solar energy incident at the point will be skewed toward the north. The purpose of this analysis was to find out how badly the distribution is skewed at three points on the side of the receiver. The receiver designer was interested in this kind of analysis because of its applicability to evaluating the performance of single tubes in the receiver. A case in point was the evaluation of the "screen tube" receiver design developed during the conceptual design phase.

This subsection of the report describes how the angular distribution study was done, the assumptions that were used, the inputs that were used, and the results that were obtained.

At the start of the analysis, the heliostat field was split into ninety equal area zones similar to the zones shown in Figure M.3-1 of the subsection describing the cloud transient model. The zones were each ten degrees wide. Then, the following sequential procedure was followed:

1. The solar power, PWRjk, incident on the receiver from each zone in the heliostat field was calculated using Equation (1) from the cloud transient model.

2. The solar energy flux, PHIjkn, incident at the n^{th} point from each zone that is visible from the point was calculated using Equation (3) from the cloud transient model.

3. The energy flux contributions at the n^{th} point from all zones that are at the same azimuthal angle in the field, were summed. The sum is the total solar energy flux, PHInk, at the point from a ten degree segment of the heliostat field. This solar energy flux is incident at the point at an angle (ANGLjk - RCVANGLn) with respect to the local normal to the cylindrical receiver surface; the pertinent angles are shown in Figure M.3-3 of the subsection on the cloud transient model.

4. The values of PHInk were normalized so that the sum of the energy flux values PHInk from all the ten degree increments of the field was unity.

5. The normalized values of PHInk were plotted to obtain the angular distribution at the n^{th} point.

6. The normalized values of PHInk were plotted in integral form.

7. From the integral curve, the skew angle was determined. The skew angle is defined as the angle from the local normal at which one-half of the flux comes from angles less than this angle and one-half comes from angles greater than this angle.

Five assumptions were used; the first four were also used in the cloud transient model. First, it was assumed that the sunlight reflected from each zone comes from a single heliostat located at the effective center of the zone. Second, it was assumed that the beam of sunlight reflected from each zone has a circular cross section at the receiver. Third, it was assumed that the energy flux distribution peaks on the axis of the beam and falls linearly to zero at the edge of the beam. Fourth, it was assumed that the receiver surface was cylindrical. Finally, it was assumed that either of two focussing strategies was used: either the heliostats were all focussed the same with the focal length, f, equal to the slant range to the most remote heliostat (f = SLRmax); or each heliostat was focussed to a focal length equal to its slant range f = SLRj.

The following inputs were used in the calculations:

- The radius of the receiver was 9.06 meters.
- The angular positions, RCVANGLn, of the three points on the receiver were -30°, -52.5°, and -78.75°.
- The elevation and azimuth angles of the sun were values calculated for solar noon on the winter solstice.
- The insolation was 1000 W/m^2.

- The height of the receiver above the plane containing the centers of the heliostats was 151 meters.
- The area of each of the ninety equal-area zones was 11,456 m^2.
- The reflectivity of the mirrors was 0.9.
- The distance from the tower to the most remote heliostat was 819 meters.
- For the radial zones, identified by the index j, the radius of the effective centers of the zones (RADjk), the ratio of mirror area to land area (Rgj), the atmospheric transmission (Taj), and the radius of the beam at the receiver (BEAMRADj) were as follows:

j	RADjk (m)	Rgj	Taj	f=SLRmax BEAMRADj (m)	f=SLRj BEAMRADj (m)
1	282	.35	.96	5.9	2.5
2	459	.23	.95	6.1	3.8
3	585	.19	.94	6.3	4.7
4	687	.16	.93	6.4	5.5
5	777	.14	.92	6.5	6.2

Angular distributions calculated for three cases are shown in Figure M.4-1. Two of the distributions (RCVANGLn = -78.75°) are for the point furthest around the side of the receiver. These distributions are the ones which are least symmetric about the local normal to the receiver surface; i.e., they are skewed the most. The third distribution is for the point 52.5° west of north on the receiver. It can be seen from the figure that the latter distribution is much more symmetric about the local normal than the former two distributions are.

Integral curve representations of the angular distribution in Figure M.4-1 are shown in Figure M.4-2. The skew angles for each distribution are derived from these curves. One-half of the incident solar energy flux comes from angles less than the skew angle; one-half comes from angles greater than the skew angle.

The skew angles obtained from all the calculations are shown in Figure M.4-3. The figure shows how much the angular distribution is skewed toward the north from the local normal at each of the three points. The lower part of Figure M.4-3 shows the skew angles when all the heliostats have a focal length equal to the maximum slant range. This focal length gives the largest skew angles. The upper half of Figure M.4-3 shows the skew angles when each heliostat has a focal length equal to its slant range.

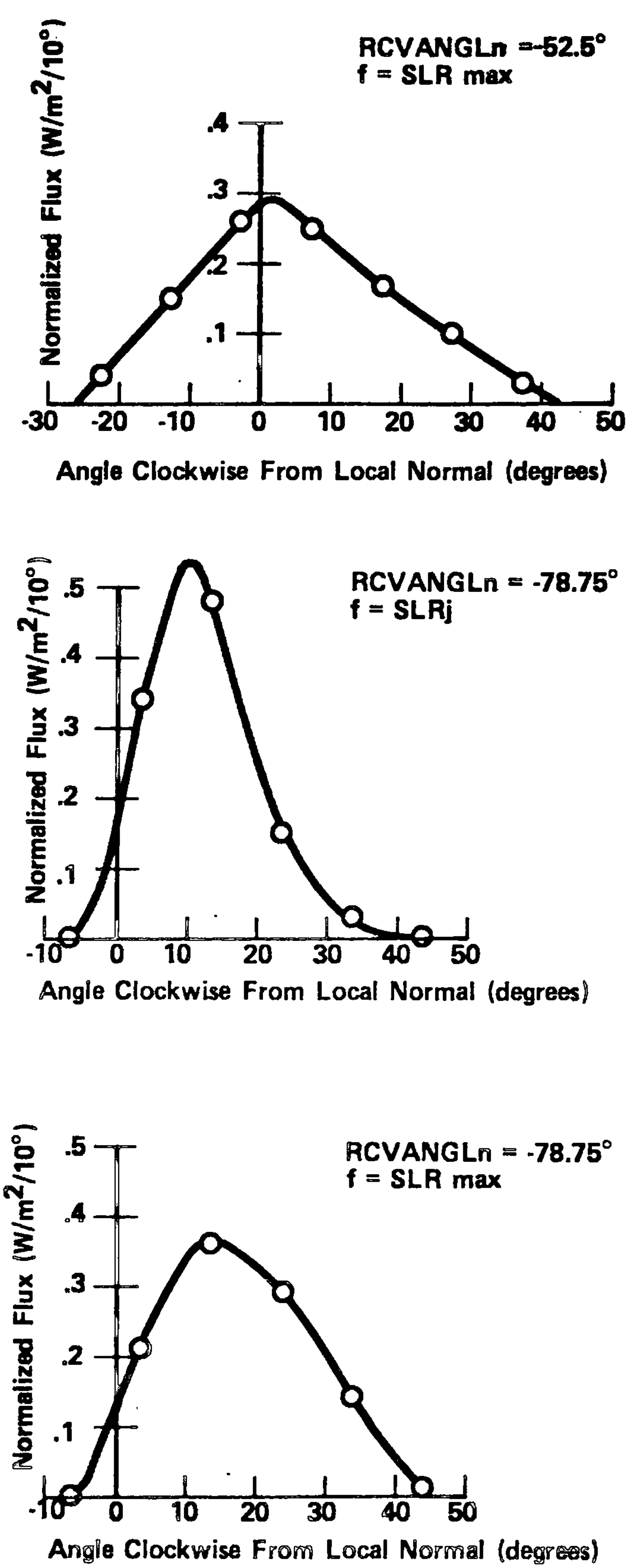


Figure M.4-1. Angular Distribution of Energy Incident At Two Points On Receiver

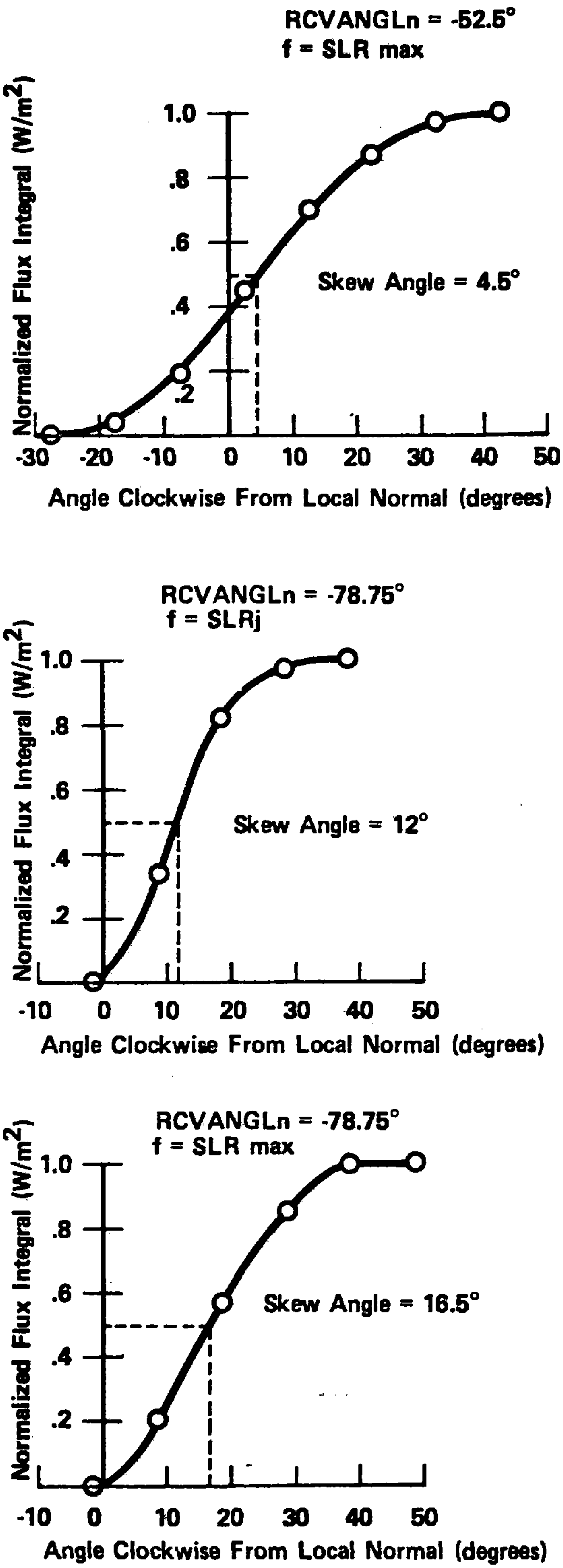
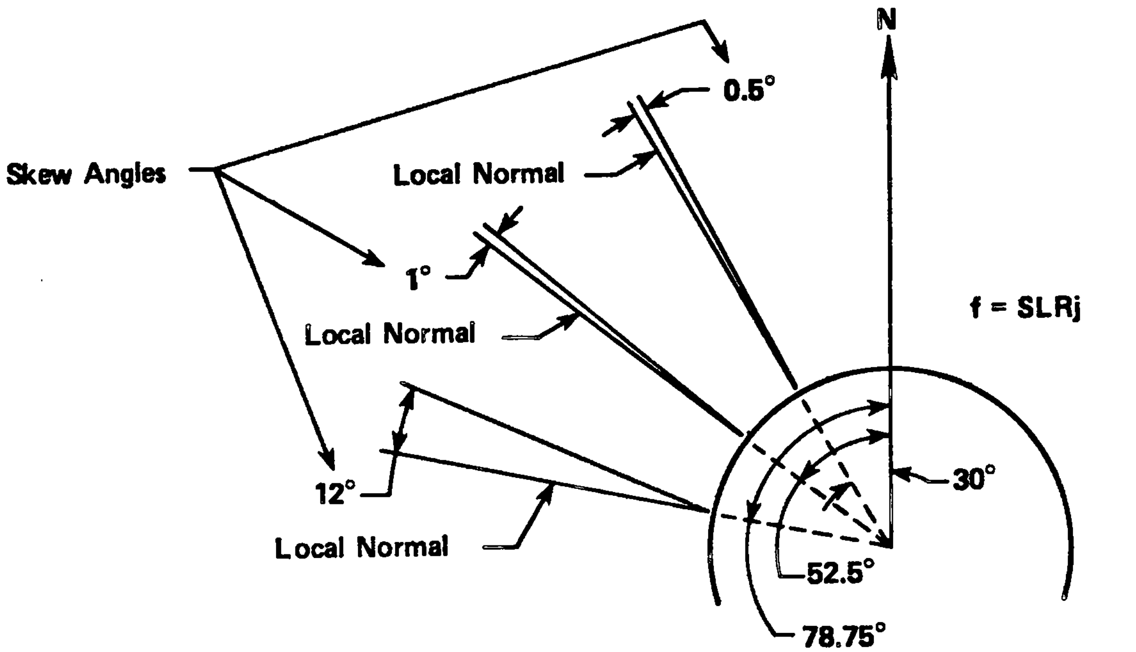


Figure M.4-2. Flux Integral Curves For Two Points On Receiver



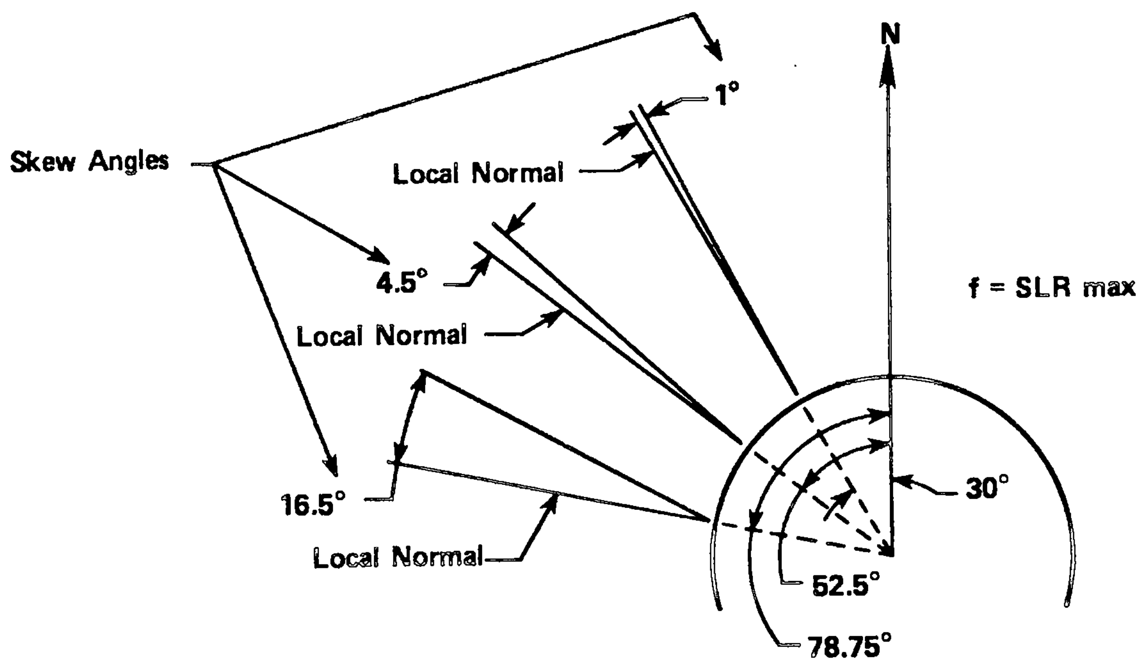


Figure M.4-3. Skew Angles for Angular Distribution of Solar Energy at Three Points on Receiver

M.5 HELIOSTAT POWER FAILURE STUDY

The effect of an electrical power loss to the heliostat controllers on the receiver and structures above, below, and behind the receiver was examined. With total power loss to the heliostat field, the heliostats are not able to track the sun and the operator can not defocus any heliostats. The receiver and structures around the receiver would be exposed to uncontrolled heat flux from the disabled heliostats. Points of interest include how long high levels of heat flux would remain on the receiver and nearby structures and what level of heat flux would be expected. A modified version of MIRVAL computer code is used to calculate two-dimensional receiver heat flux distributions at noon winter solstice and 8:00 a.m. summer solstice assuming a total power loss to the heliostat field described in Section M.2.

For all MIRVAL calculations, the heliostat dimensions, heliostat locations, aiming strategy, and tower height described in Section M.2 were held constant. The only parameters varied for certain MIRVAL runs were the height and radius of the receiver so that different structures near the receiver absorber surface could be modeled.

By using an UPDATE procedure, the original version of the MIRVAL computer code was modified to allow performance calculations for a case of power loss to the heliostat field. MIRVAL is a Monte-Carlo code which traces rays from the sun to the heliostat and then up to the receiver. Tallies are kept to quantify optical losses such as a ray hitting the ground, a ray absorbed in the mirror, a ray blocked by the back of another heliostat, etc. An equation of time is used to determine the position of the sun. Then, two rays are defined from the sun in subroutine RAYGEN: one from the center of the sun (VC) and one from some random position on the sun's disc (VR). The ray from the center of the sun along with a heliostat aimpoint is used to determine the angle and position of a heliostat. The random ray is the ray that could potentially strike a heliostat and be redirected towards the receiver if it does not become subject to some optical loss event. The modification to MIRVAL simply calls subroutine RAYGEN twice. The first time RAYGEN is called at a reference time (TREF) and returns with a ray from the center of the sun (VC) and a random ray (VRFAKE) at the reference time. This first random ray is ignored and RAYGEN is called again at some time increment (TADD) after the reference time and a new random ray is returned (VR) with an ignored ray from the center of the sun (VCFAKE). Thus, the heliostat position can be frozen at a certain time (TREF) and the performance calculation can be performed at some later time of day (TREF2=TREF+TADD).

Heliostat power loss calculations were performed at noon winter solstice and 8:00 a.m. summer solstice. At noon winter solstice, the sun's azimuth angle is changing relatively quickly, and its elevation angle is relatively constant. If power loss occurs at noon winter solstice, the receiver heat flux is expected to drift towards the east. The present Babcock and Wilcox receiver design has an active receiver angle of 202.5 degrees around north. Beyond 202.5 degrees, there are metal support structures with an outside radius of about 24 feet (7.32 meters). Figure M.5-1 shows a top view schematic of the receiver. Since one of the objectives of the MIRVAL calculations is to determine the effect of heliostat power loss on structures south of the active receiver surface, calculations at noon winter solstice were performed assuming a receiver radius of 24 feet (7.32 meters) instead of the actual receiver radius of 29.4 feet (8.95 meters). The distance from the ground to the center of the receiver was always kept at 508.5 feet (155 meters). At 8:00 a.m. summer solstice, the sun's elevation angle increases relatively quickly, and its azimuth angle changes relatively slowly. Thus, the receiver heat flux is expected to drift downwards and slightly to the east in the case of heliostat power loss. Several cases were examined at 8:00 a.m. summer solstice assuming the actual receiver radius, 29.4 feet (8.95 meters). Because the structure directly below the receiver base only has a 20 foot (6.10 meter) radius, a case was repeated with a 20 foot radius for comparison. To determine the flux above and below the receiver, the receiver height was assumed to be 125 feet (38.10 meters) instead of 85 feet (25.91 meters). A summary of the cases examined is given in Table M.5-1.

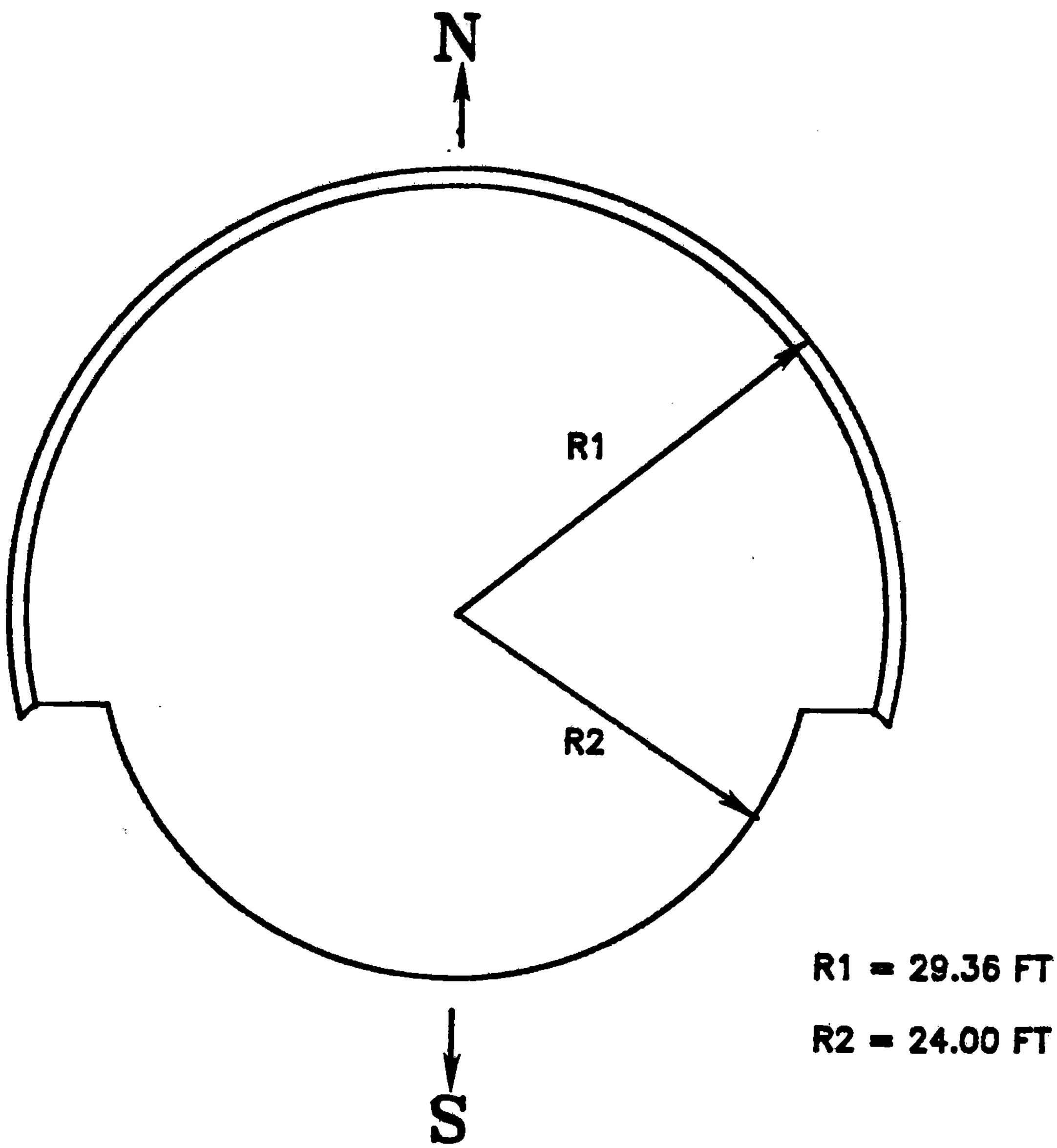


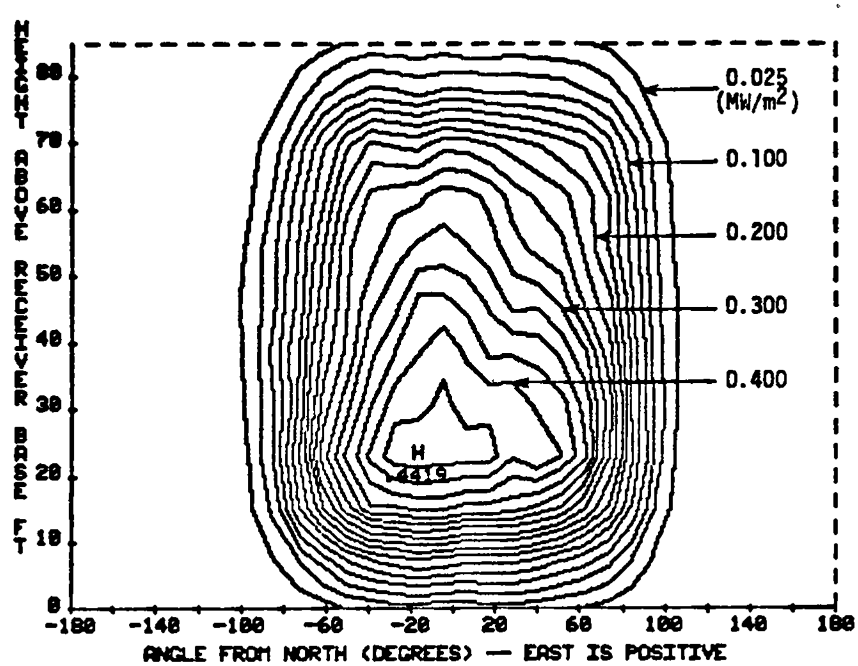
Figure M.5-1. Receiver Top View Schematic

TABLE M.5-1
SUMMARY OF MIRVAL HELIOSTAT POWER LOSS CASES

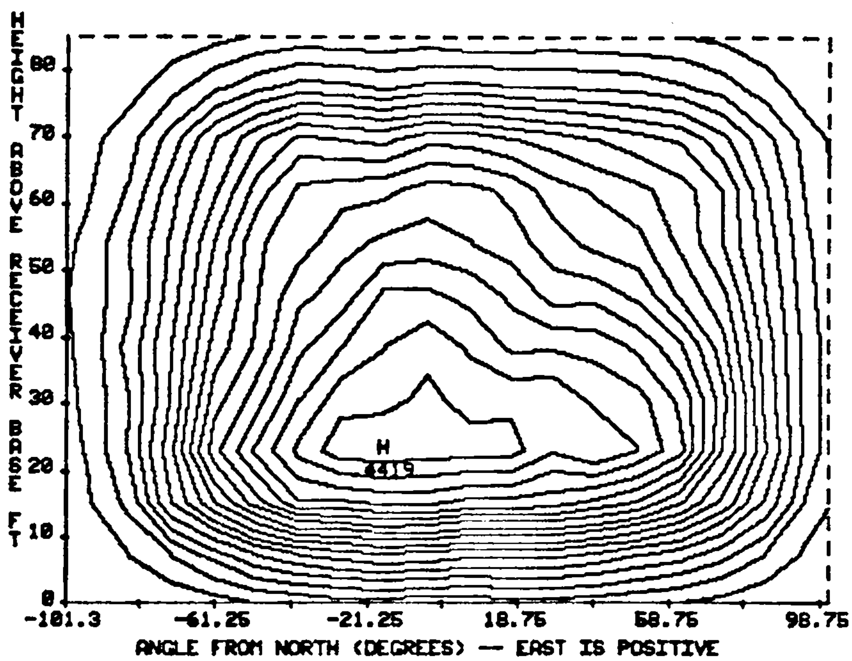
Case	Month	Day	Time	Insolation W/m^2	Time Increment TADD (sec)	Receiver Height (ft)	Receiver Radius (ft)
1	12	21	12	1000	0	85	24.0
2	12	21	12	1000	120	85	24.0
3	12	21	12	1000	240	85	24.0
4	12	21	12	1000	360	85	24.0
5	12	21	12	1000	600	85	24.0
6	6	21	8	829	0	85	29.36
7	6	21	8	829	120	125	29.36
8	6	21	8	829	240	125	29.36
9	6	21	8	829	360	125	29.36
10	6	21	8	829	600	125	29.36
11	6	21	8	829	240	125	20.0

Figures M.5-2 to M.5-6 show the receiver flux distribution in the form of iso-flux contours for the cases run at noon winter solstice assuming a receiver radius of 24 feet (7.32 meters). For these cases, the heat flux shown between +101.25 degrees and -101.25 degrees from north has no direct meaning for the present receiver design. The reason the heat flux has no direct meaning is because the receiver actually has a 29.36 foot (8.95 meter) radius in that 202.5 included angle rather than 24 feet (7.32 meter) as modeled. The heat flux of interest is the flux outside of ±101.25 degrees from north where the receiver support structures actually do have a radius of 24 feet (7.32 meter). Figure A.2.-1-30 shows the heat flux distribution at noon winter solstice assuming a 24 foot (7.32 meter) radius and a powered heliostat field. The flux distribution is given for 360 degrees of the receiver and for just the angle of the absorber surface, 202.5 degrees. Figures M.5-3 to M.5-6 show receiver iso-flux contours for two, four, six, and ten minutes of power loss starting at noon winter solstice. After two minutes of power loss, the heat flux off the east side of the active absorber surface is about 200 kW/m^2. After four, six, and ten minutes of power loss, the flux on the east side of the absorber surface is about 210 kW/m^2, 100 KW/m^{2}m, and 60 kW/m^2, respectively.

Figure M.5-7 to M.5-11 show the receiver flux distribution for the cases at 8:00 a.m. summer solstice assuming a 29.36 foot (8.95 meter) receiver radius. Figure M.5-7 shows the flux distribution for a powered field. The peak flux is 277 kW/m^2, and the flux at the base of the receiver is about 25 kW/m^2. Figures M.5-8 to M.5-11 show the receiver iso-flux contours for the cases of two, four, six, and ten minutes of power loss starting at 8:00 a.m. summer solstice. These figures show the flux distribution for 360 degrees with a height that extends 20 feet (6.10 meter) above and below the absorber surface and the flux distribution for just the area of the absorber surface, 202.5 degrees and 85 feet (25.91 meter) high. After two minutes of power loss, the heat flux at the base of the receiver is about 90 kW/m^2 and the peak heat flux on the receiver is about 237 k/Wm^2. After four, six, and ten minutes of power loss, the heat flux at the base of the receiver is about 170 kW/m^2, 130 kW/m^2, and 20 kW/m^2 and the peak heat flux is about 240 kW/m^2,

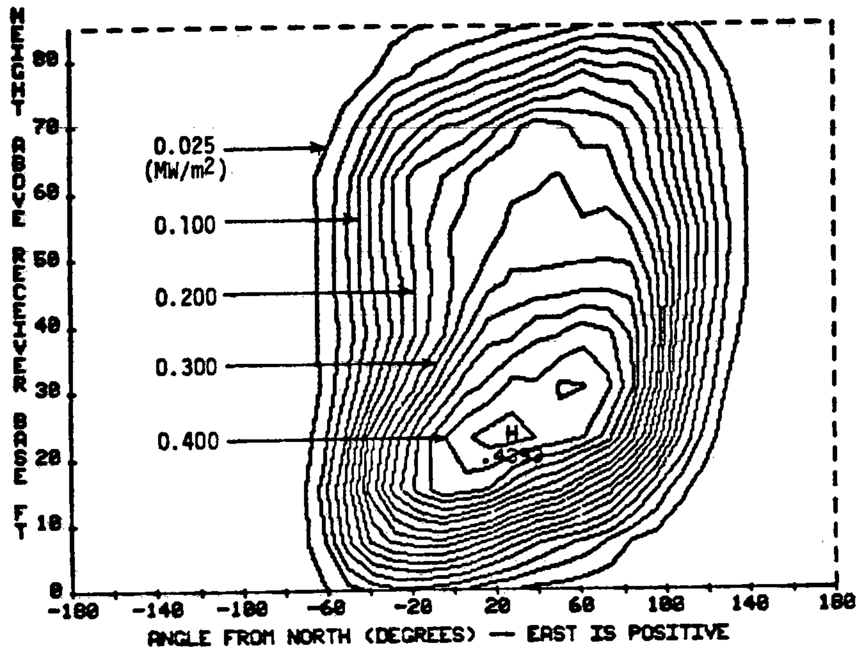


a) 360 Degrees

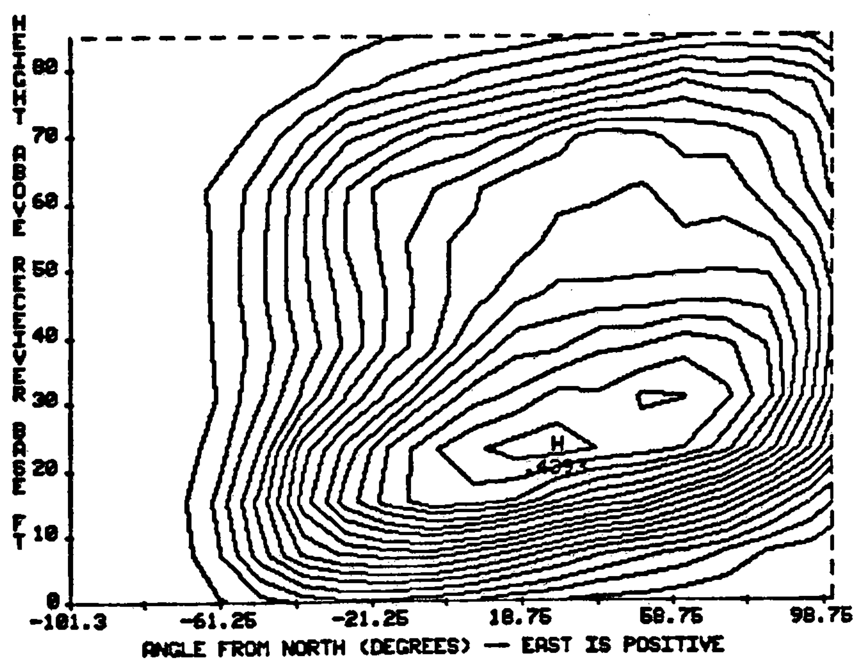


b) 202.5 Degrees - Angle of Active Absorber Surface

Figure M.5-2. Iso-Flux Contours At Noon Winter Solstice With 24 Foot (7.32 Meter) Receiver Radius

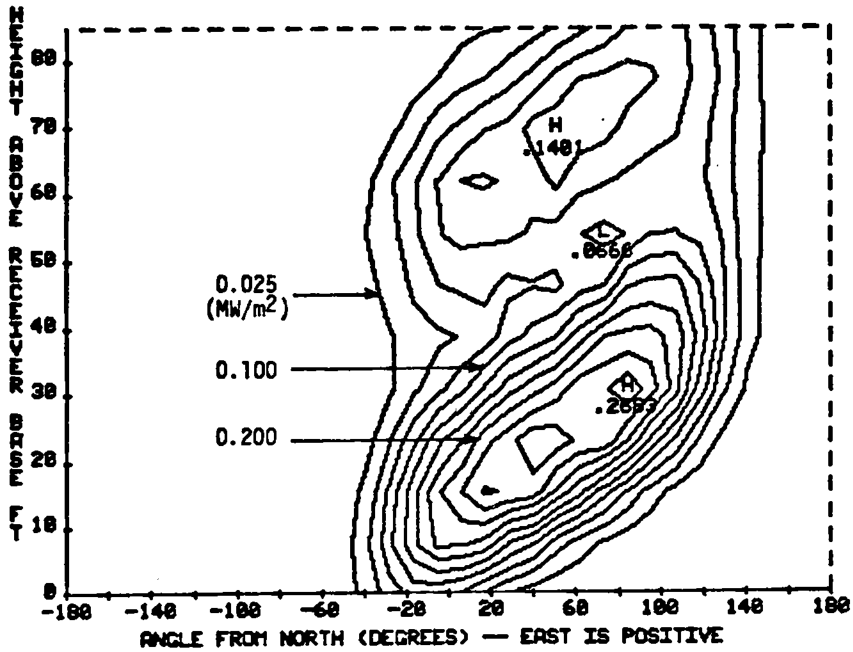


a) 360 Degrees

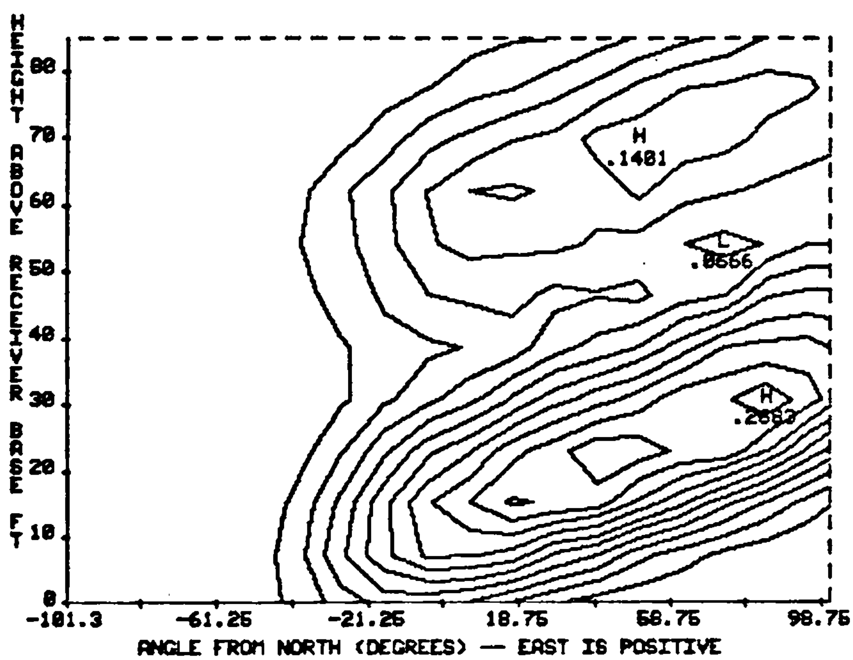


b) 202.5 Degrees - Angle of Active Absorber Surface

Figure M.5-3. Iso-Flux Contours With 24 Foot (7.32 Meter) Receiver Radius After Two Minutes of Power Loss Starting At Noon Winter Solstice

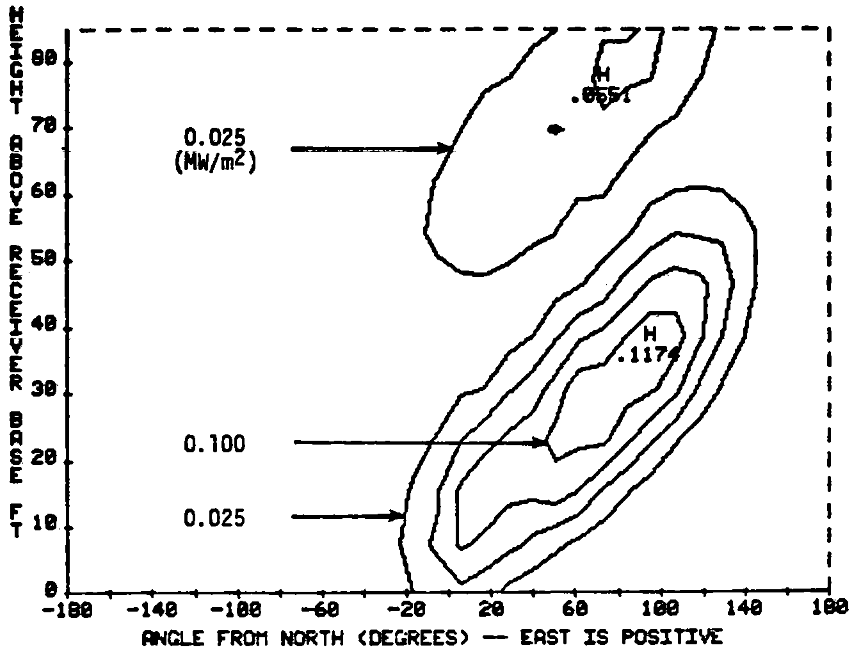


a) 360 Degrees

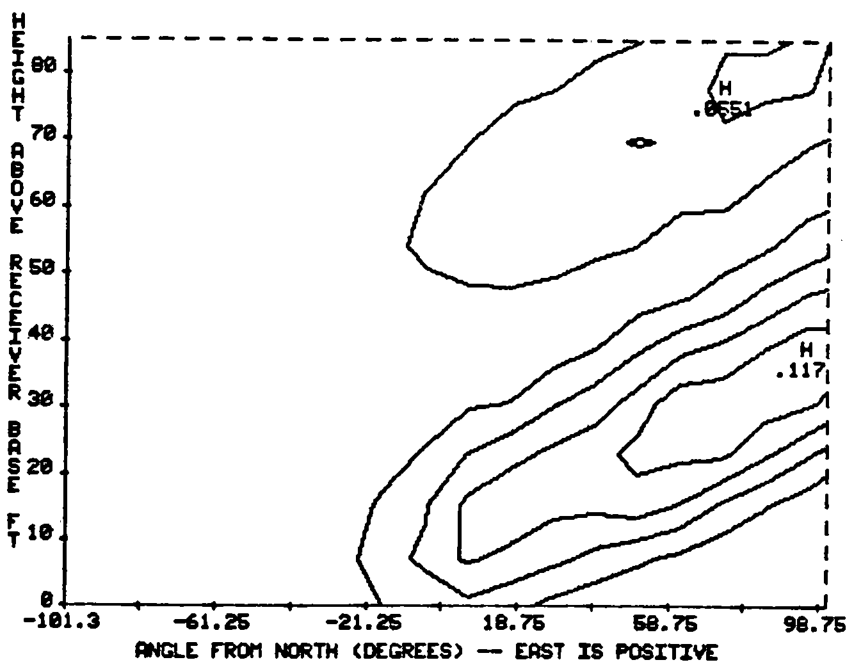


b) 202.5 Degrees - Angle of Active Absorber Surface

Figure M.5-4. Iso-Flux Contours With 24 Foot (7.32 Meter) Receiver Radius After Four Minutes of Power Loss Starting At Noon Winter Solstice

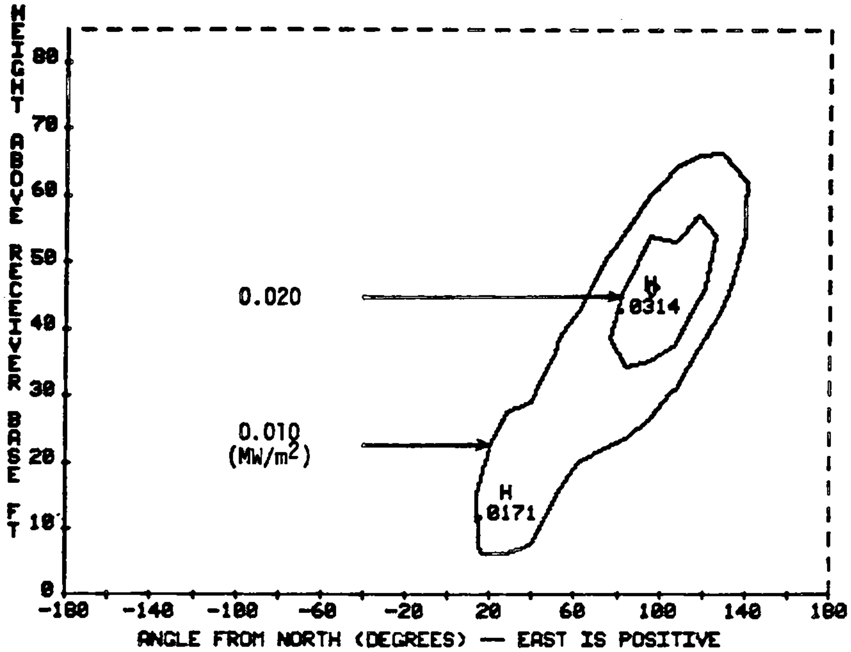


a) 360 Degrees

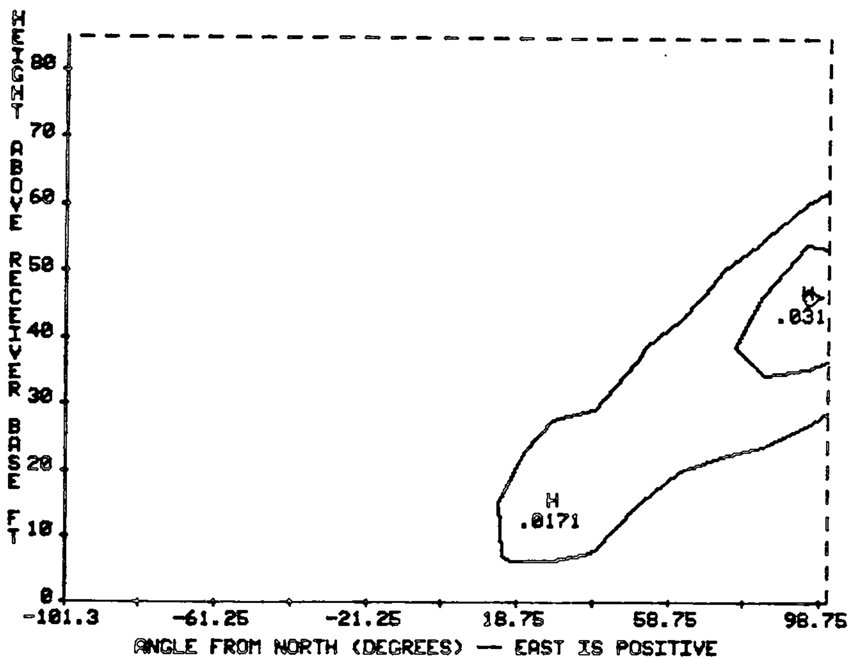


b) 202.5 Degrees - Angle of Active Absorber Surface

Figure M.5-5. Iso-Flux Contours With 24 Foot (7.32 Meter) Receiver Radius After Six Minutes of Power Loss Starting At Noon Winter Solstice

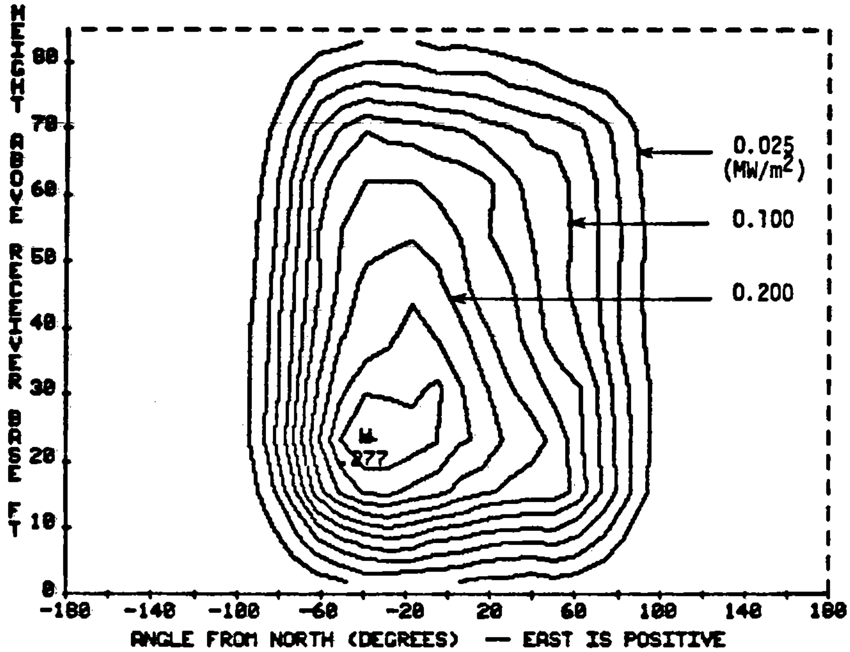


a) 360 Degrees

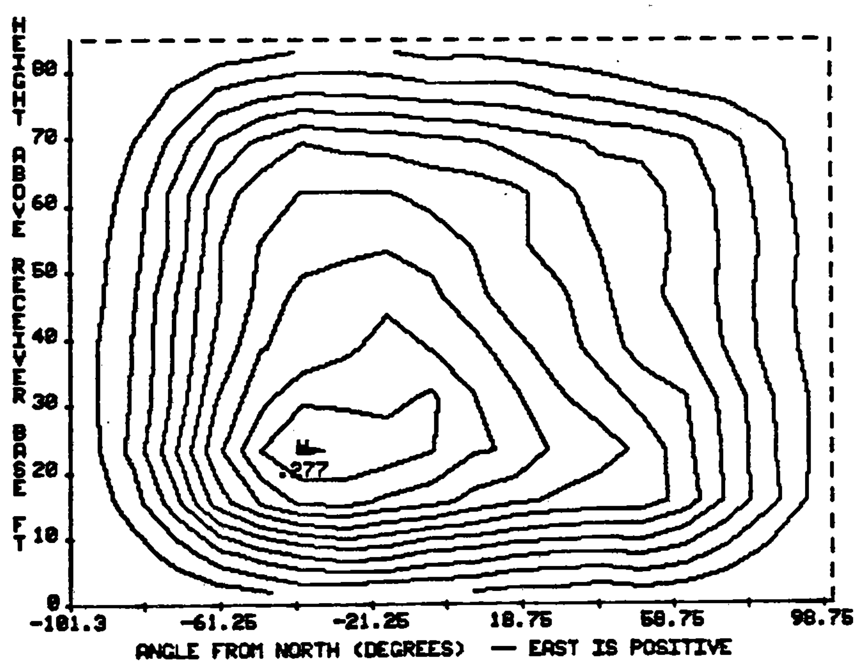


b) 202.5 Degrees - Angle of Active Absorber Surface

Figure M.5-6. Iso-Flux Contours With 24 Foot (7.32 Meter) Receiver Radius After Ten Minutes of Power Loss Starting At Noon Winter Solstice

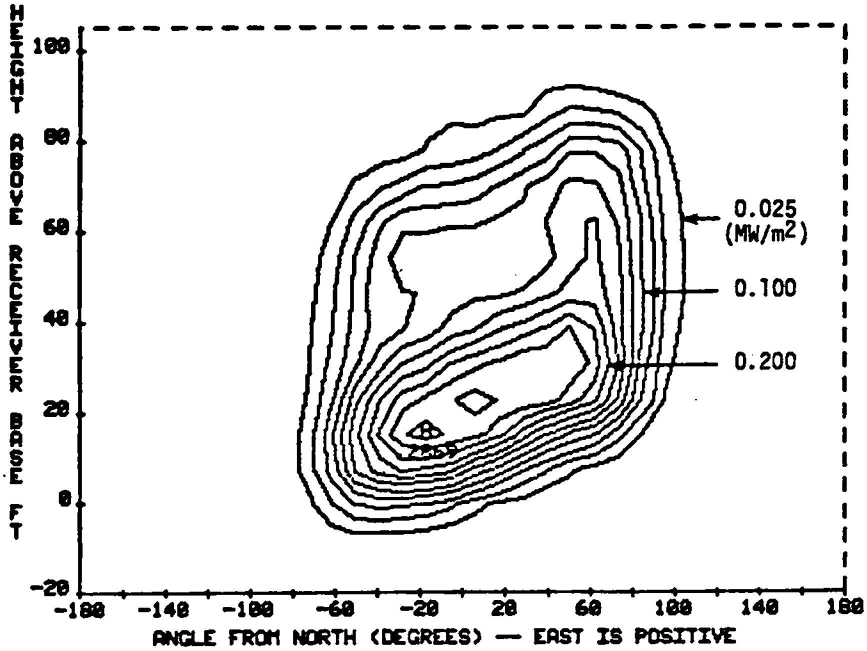


a) 360 Degrees

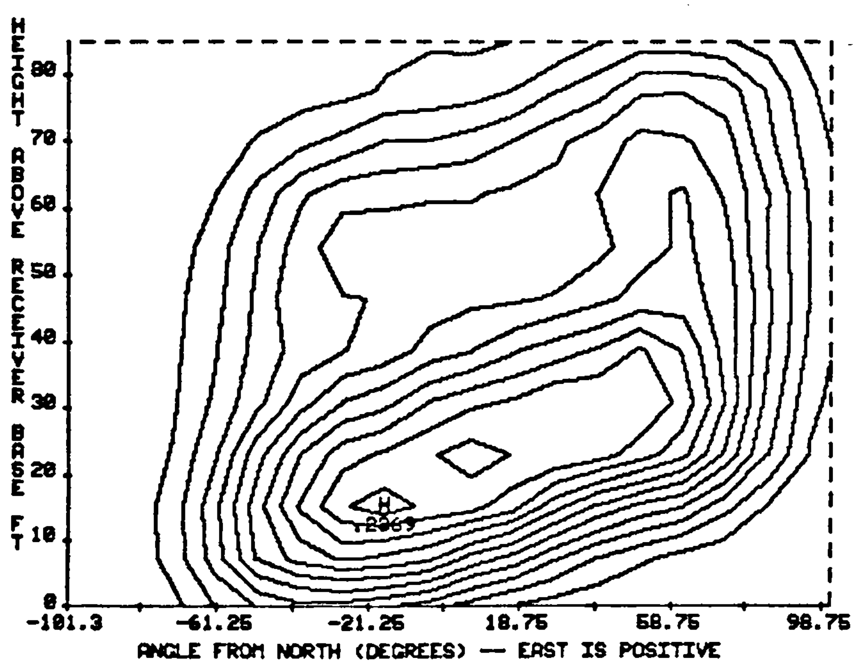


b) 202.5 Degrees - Angle of Active Absorber Surface

Figure M.5-7. Iso-Flux Contours at 8:00 A.M. Summer Solstice With 29.36 Foot (8.95 Meter) Receiver Radius

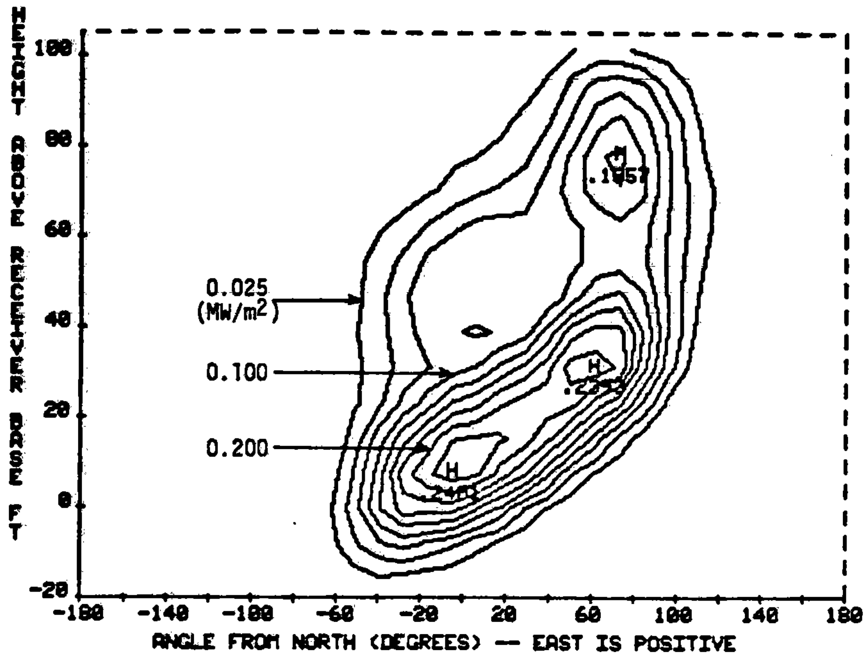


a) 360 Degrees, ± 20 Feet (6.10 Meters)

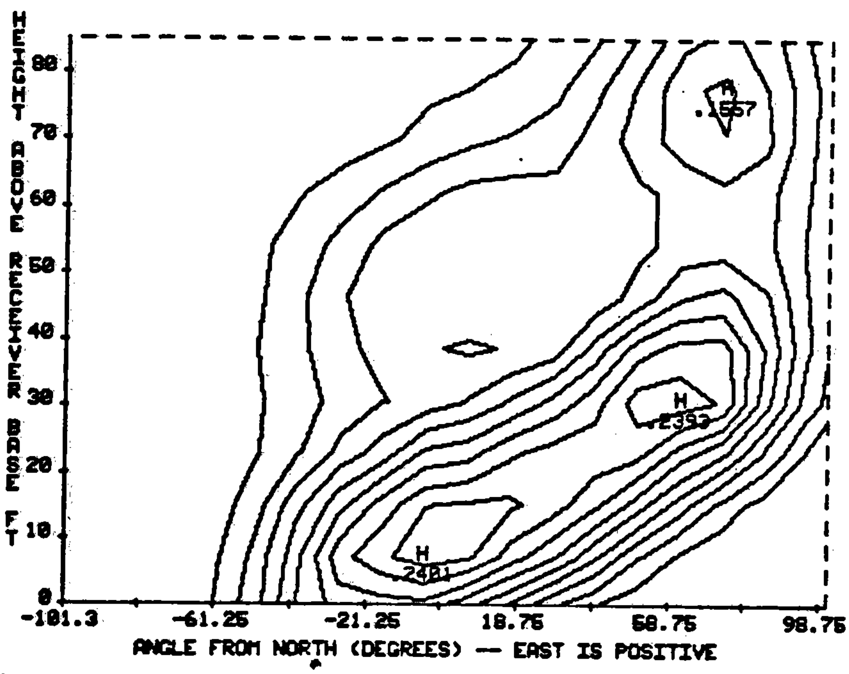


b) 202.5 Degrees, 85 Feet (25.91 Meters) - Area of Active Absorber Surface

Figure M.5-8. Iso Flux Contours With 29.36 Foot (8.95 Meter) Receiver Radius After Two Minutes of Power Loss Starting At 8:00 a.m. Summer Solstice

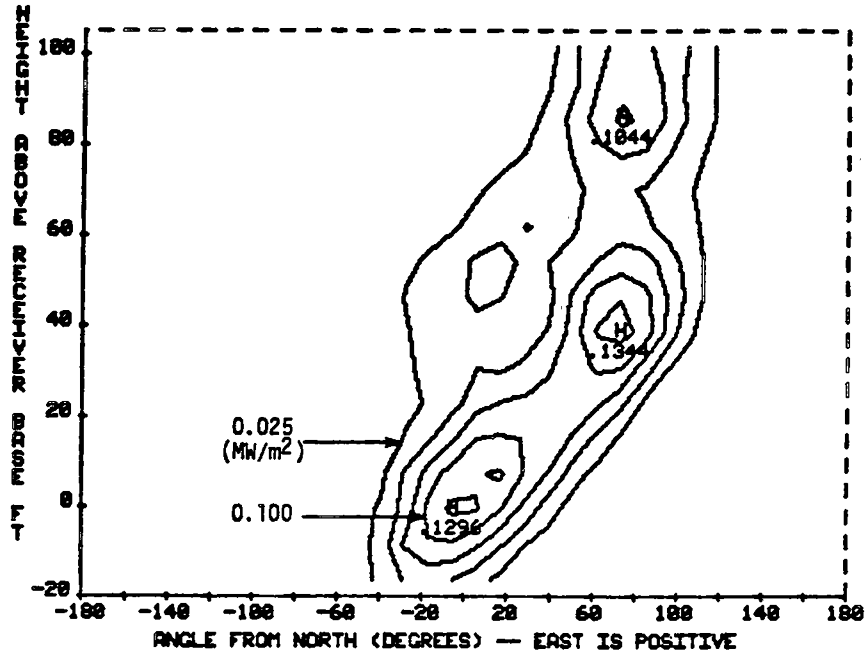


a) 360 Degrees, ± 20 Feet (6.10 Meters)

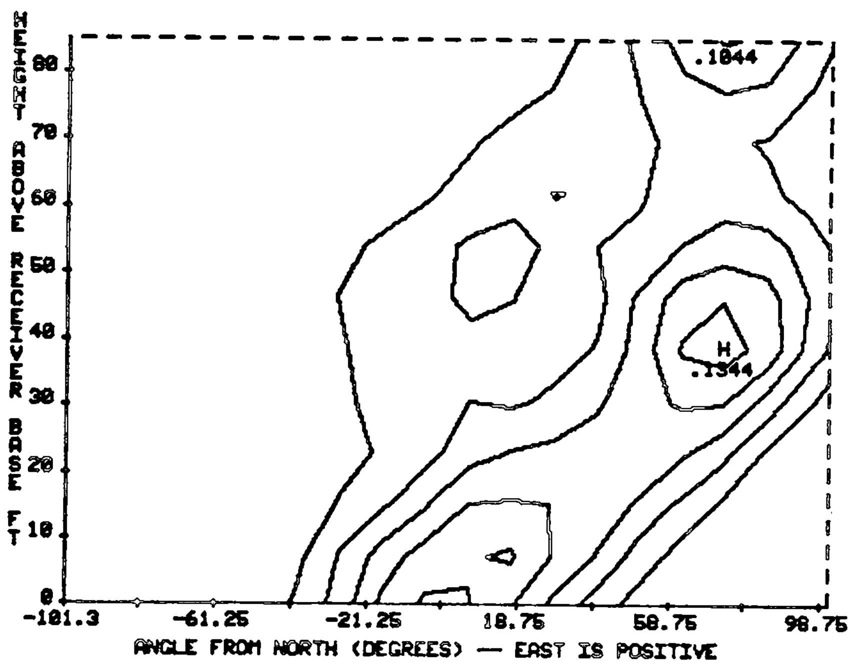


b) 202.5 Degrees, 85 Feet (25.91 Meters) - Area of Active Absorber Surface

Figure M.5-9. Iso-Flux Contours With 29.36 Foot (8.95 Meter) Receiver Radius After Four Minutes of Power Loss Starting at 8:00 a.m. Summer Solstice

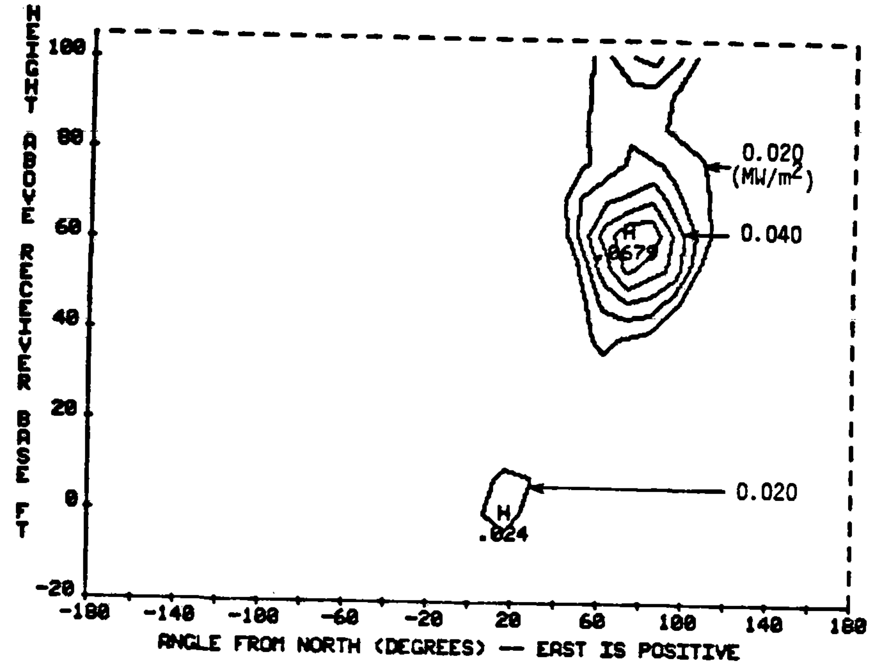


a) 360 Degrees, ± 20 Feet (6.10 Meters)

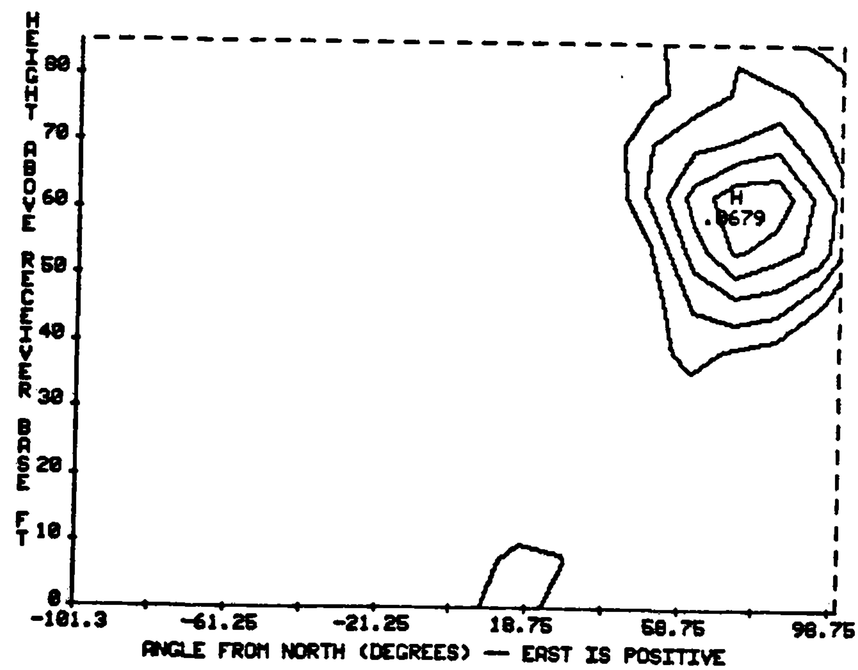


b) 202.5 Degrees, 85 Feet (25.91 Meters) - Area of Active Absorber Surface

Figure M.5-10. Iso Flux Contours With 29.36 Foot (8.95 Meter) Receiver Radius After Six Minutes of Power Loss Starting At 8:00 a.m. Summer Solstice



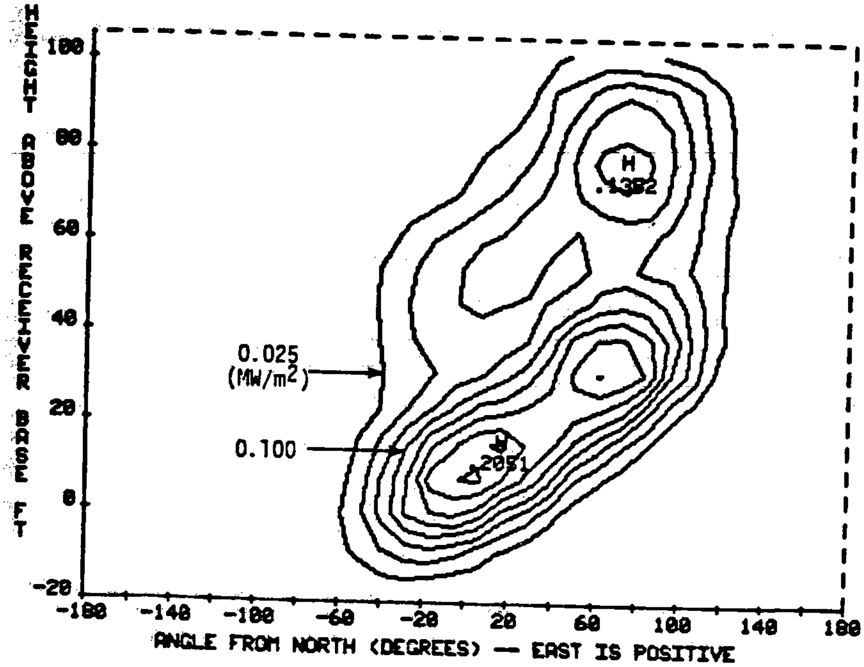
a) 360 Degrees, ± 20 Feet (6.10 Meters)



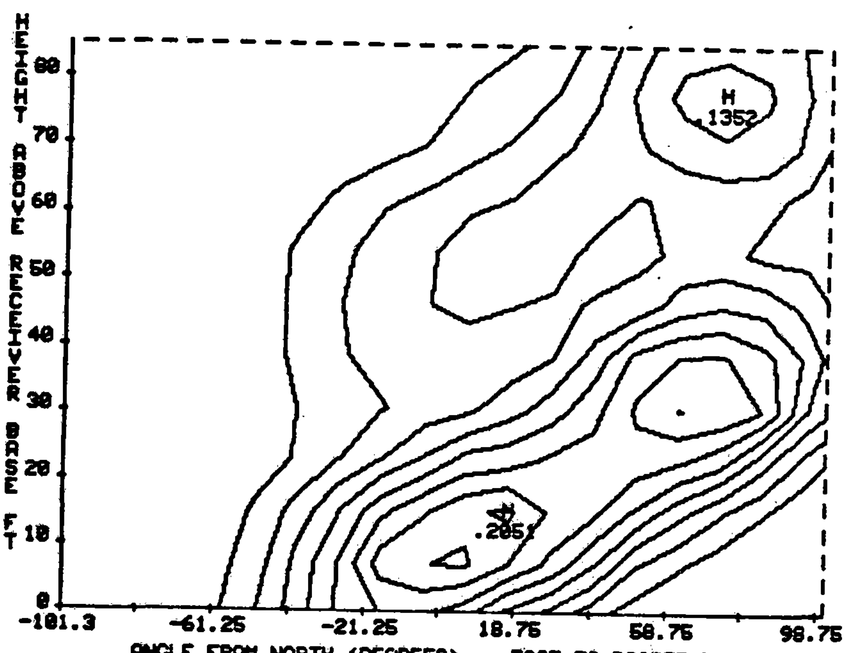
b) 202.5 Degrees, 85 Feet (25.91 Meters) - Area of Active Absorber Surface

Figure M.5-11. Iso-Flux Contours With 29.36 Foot (8.95 Meter) Receiver Radius After Ten Minutes of Power Loss Starting AT 8:00 a.m. Summer Solstice

134 kW/m^2, and 68 kW/m^2, respectively. Because the structures below the receiver actually have a radius of only 20 feet (6.10 meter), the 4 minute power loss case starting at 8:00 a.m. summer solstice was repeated assuming a 20 foot radius. The results are shown in Figure M.5-12. Figure M.5-13 shows the flux distribution with a 29.36 foot (8.95 meter) radius above the receiver base and a 20 foot (6.10 meter) radius below the receiver.



a) 360 Degrees, ± 20 Feet (6.10 Meters)



b) 202.5 Degrees, 85 Feet (25.91 Meters) - Area of Active Absorber Surface

Figure M.5-12. Iso-Flux Contours With 20 Foot (6.10 Meter) Receiver Radius AFter Four Minutes of Power Loss Starting At 8:00 a.m. Summer Solstice

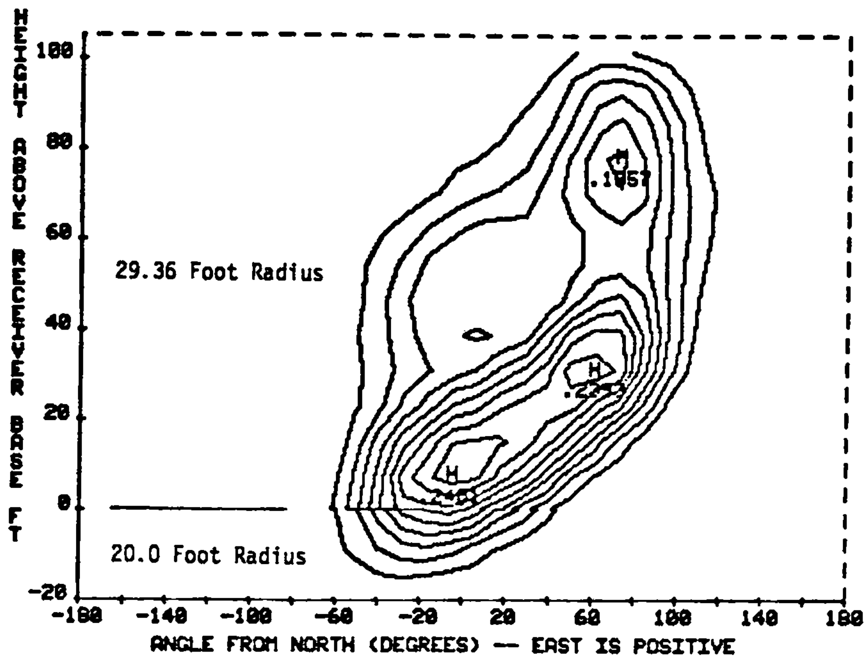


Figure M.5-13. Iso-Flux Contours After Four Minutes of Power Loss Starting At 8:00 a.m. Summer Solstice - 29.36 Foot (8.95 Meter) Radius Above Receiver Base, 20.00 Foot (6.10 Meter) Radius Below Receiver

M.6 RECEIVER FLUX DISTRIBUTIONS WITH CLOUD COVER

The effect of a semi-infinite cloud when it approaches from the west, north, south, and northwest directions and shades partial sections of the heliostat field was examined using MIRVAL. In particular, the resulting receiver heat flux distribution of a partially shaded field was calculated assuming the heliostats, receiver, and field parameters described in Section M.2 for seven different cases at noon winter solstice:

a) A semi-infinite cloud approaching from the south which shades 1/2 of the heliostats in the field.

b) A semi-infinite cloud approaching from the south which shades 1/3 of the heliostats in the field.

c) A semi-infinite cloud approaching from the north which shades 1/2 of the heliostats in the field.

d) A semi-infinite cloud approaching from the north which shades 1/3 of the heliostats in the field.

e) A semi-infinite cloud approaching from the northwest which shades 1/2 of the heliostats in the field.

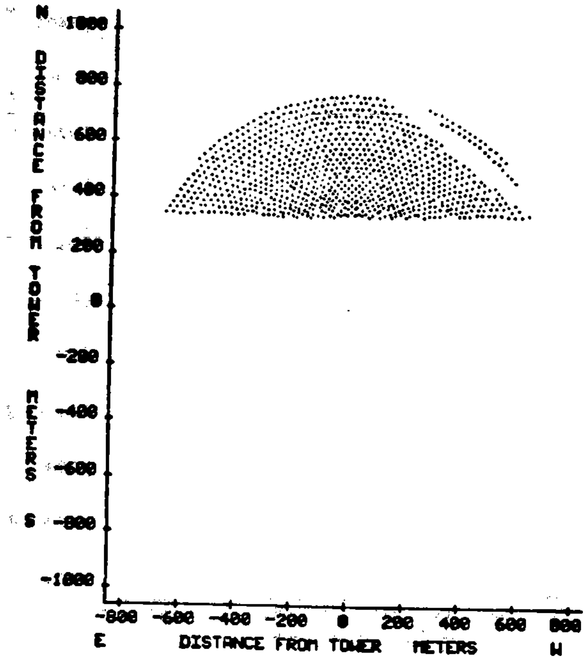
f) A semi-infinite cloud approaching from the northwest which shades 1/3 of the heliostats in the field.

g) A semi-infinite cloud approaching from the west which shades 1/3 of the heliostats in the field.

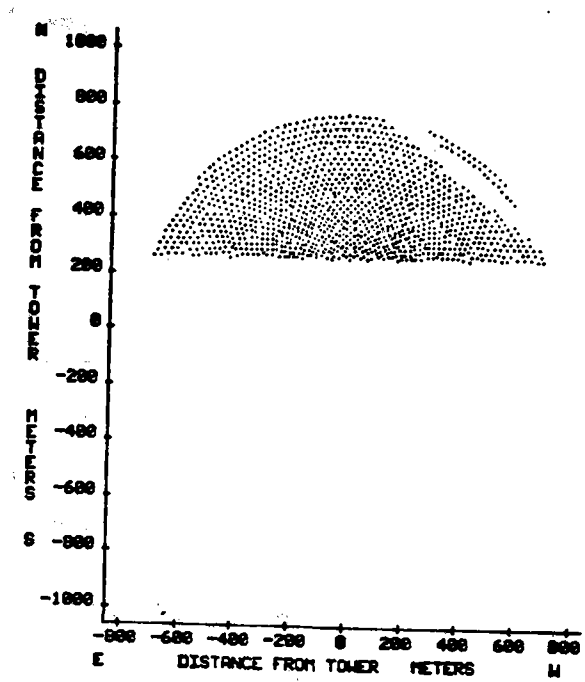
Computer tapes, which included the location and aimpoint for each of the 1875 heliostats in the original field, were made as input for MIRVAL. To model a given cloud shadow, a short FORTRAN program was developed which sorted through the original field computer tapes and determined which heliostats had locations under the shadow and which were left unshaded. Then, a new computer tape with the unshaded heliostats, their location and their aimpoints was made. This new tape, with less than the original 1875 heliostats, was then used as input to MIRVAL. If the cloud shaded 1/2 of the field, then the new tape would include only 938 heliostats. If the cloud shaded 1/3 of the field, then the new tape would include only 1250 heliostats. MIRVAL computer code performance calculations were then performed at noon winter solstice using identical input values as used for the original field.

Figure M.6-1 shows the layout of heliostat fields shaded on the south and north sides by a semi-infinite cloud. Flux map tables are given for each case in Tables M.6-1 through M.6-4. Receiver iso-flux contour maps are shown for the south and north shaded field in Figures M.6-2 to M.6-5.

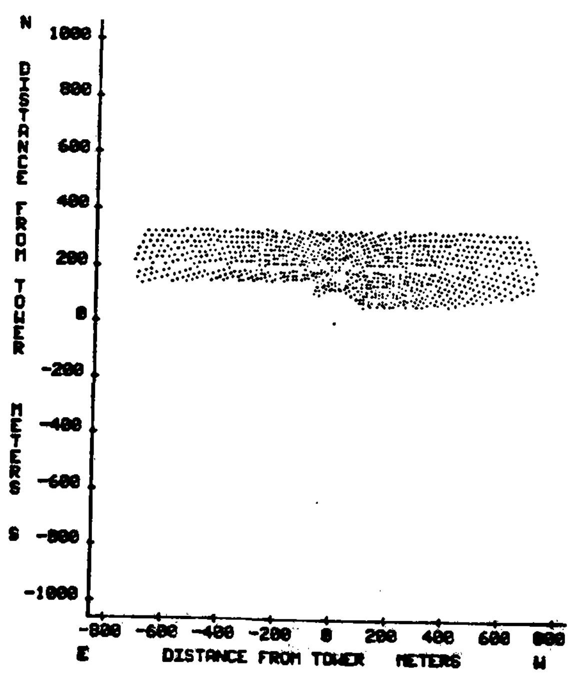
The iso-flux contour plots assume a receiver with a 17.90 meter (58.7 foot) diameter which results in a 56.23 meter (184.5 foot) perimeter. Therefore, the iso-flux contour plots show 360 degrees of the receiver from a -28.11 meter (-92.25 foot) to a 28.11 meter (92.25 foot) from north along the receiver surface. Figure M.6-6 shows the field layouts of the north-west and west shaded fields. Tables M.6-5 to M.6-7 are the flux maps and Figures M.6-7 to M.6-9 show the iso-flux contour plots for the north-west and west shaded fields.



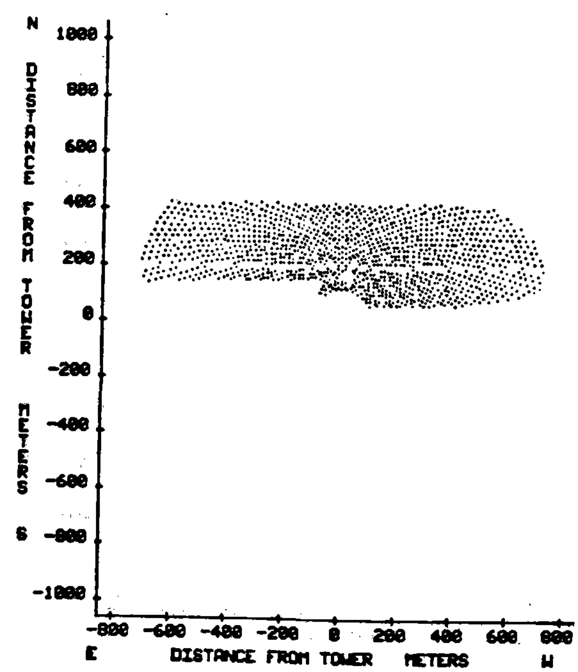
a) 1/2 Shaded On South Side



b) 1/3 Shaded On South Side



c) 1/2 Shaded On North Side



d) 1/3 Shaded On North Side

Figure M.6-1. South and North Shaded Heliostat Fields

TABLE M.6-1

RECEIVER HEAT FLUX MAP FOR FIELD
WITH 1/2 SHADED ON SOUTH SIDE

The following table is a flux map summary of 225 degrees of the receiver. Only 202.5 degrees of the receiver are actually active. The top and bottom flux bins are 4 feet (1.219 meters) high. All other bins are 7.7 feet (2.347 meters) high. Flux is in MW/m^2.

									N										
.000	0.000	0.000	.001	.003	.006	.009	.011	.014	.014	.012	.014	.007	.005	.003	.000	.000	0.000	0.000	0.000
0.000	0.000	.000	.002	.013	.024	.037	.041	.042	.049	.055	.043	.036	.021	.008	.002	.001	.000	0.000	0.000
.000	.001	.003	.011	.031	.066	.093	.108	.118	.135	.142	.133	.092	.054	.029	.009	.002	.000	.000	0.000
.000	.001	.004	.019	.048	.086	.124	.154	.182	.198	.191	.167	.133	.090	.052	.021	.008	.001	.000	0.000
.000	.001	.008	.028	.064	.112	.169	.207	.234	.247	.224	.206	.175	.133	.091	.045	.018	.004	.001	.000
.001	.003	.012	.036	.089	.159	.215	.262	.294	.308	.295	.267	.227	.207	.141	.075	.030	.007	.002	.000
.000	.003	.012	.039	.096	.169	.241	.283	.305	.325	.315	.302	.273	.232	.158	.089	.031	.009	.002	.000
.000	.002	.009	.030	.083	.146	.216	.263	.281	.292	.287	.265	.239	.204	.129	.065	.022	.006	.002	.000
0.000	.001	.004	.016	.047	.110	.178	.216	.238	.235	.239	.217	.199	.146	.085	.038	.010	.003	.000	0.000
0.000	.000	.001	.006	.025	.069	.117	.151	.162	.170	.161	.147	.118	.079	.044	.015	.002	.000	.000	0.000
0.000	0.000	.000	.001	.006	.024	.044	.059	.063	.062	.062	.048	.034	.021	.010	.003	.000	.000	0.000	0.000
0.000	0.000	0.000	.000	.002	.004	.008	.013	.012	.014	.011	.009	.004	.002	.001	.000	0.000	0.000	0.000	0.000

SUM OF POWER IN EACH COLUMN, MW (FROM LEFT TO RIGHT)

1	.0070	11	8.1795
2	.0437	12	7.4563
3	.2194	13	6.3120
4	.7806	14	4.9131
5	2.0778	15	3.0874
6	3.9972	16	1.4962
7	5.9502	17	.5166
8	7.2384	18	.1303
9	7.9677	19	.0260
10	8.3910	20	.0033

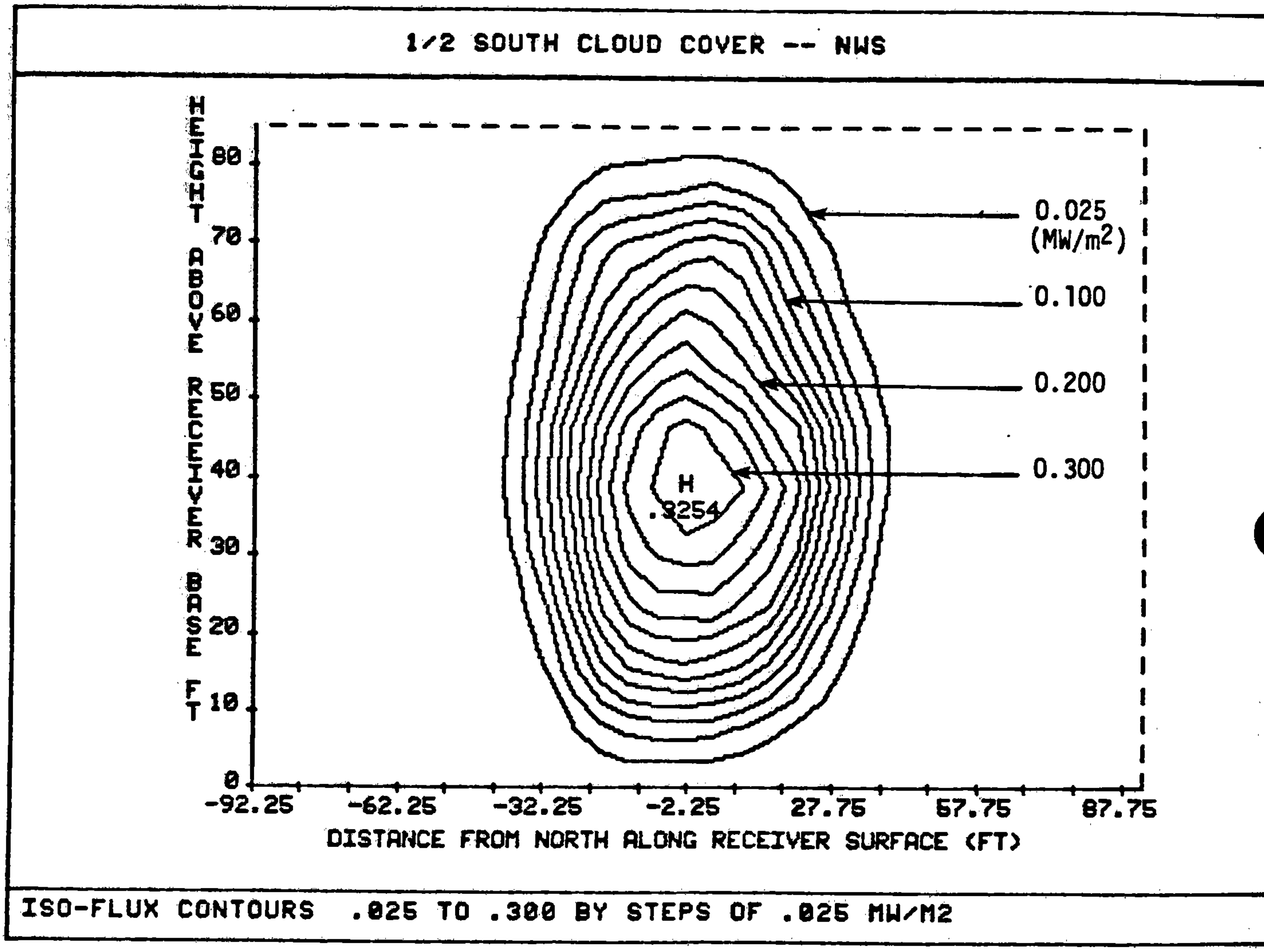


Figure M.6-2. Receiver Iso-Flux Contour Map For Field With 1/2 Shaded On South Side - 360 Degrees

TABLE M.6-2

RECEIVER HEAT FLUX MAP FOR FIELD
WITH 1/3 SHADED ON SOUTH SIDE

The following table is a flux map summary of 225 degrees of the receiver. Only 202.5 degrees of the receiver are actually active. The top and bottom flux bins are 4 feet (1.219 meters) high. All other bins are 7.7 feet (2.347 meters) high. Flux is in MW/m^2.

									N										
0.000	0.000	.000	.001	.006	.014	.017	.022	.018	.021	.017	.017	.019	.011	.008	.003	.001	0.000	0.000	0.000
0.000	.000	.002	.009	.023	.043	.065	.066	.060	.063	.063	.065	.055	.040	.023	.013	.003	.000	0.000	0.000
.000	.001	.008	.027	.065	.112	.134	.144	.152	.161	.163	.159	.128	.103	.069	.040	.016	.002	.001	.000
.000	.004	.015	.036	.090	.141	.166	.200	.208	.221	.214	.203	.175	.135	.099	.062	.029	.008	.002	.000
.001	.006	.019	.053	.109	.163	.204	.231	.253	.252	.246	.221	.196	.174	.126	.092	.041	.015	.004	.001
.001	.007	.026	.071	.132	.198	.246	.287	.300	.312	.288	.276	.257	.240	.190	.128	.058	.026	.007	.001
.001	.006	.030	.070	.140	.211	.253	.297	.333	.334	.326	.316	.295	.274	.217	.154	.073	.027	.006	.001
.001	.004	.021	.058	.129	.205	.249	.292	.317	.323	.322	.311	.296	.250	.199	.124	.059	.021	.004	.000
0.000	.002	.010	.039	.092	.172	.247	.283	.300	.313	.319	.296	.265	.217	.161	.088	.036	.009	.001	.000
0.000	.000	.004	.020	.063	.128	.202	.237	.238	.252	.240	.215	.191	.160	.105	.051	.014	.004	.000	0.000
0.000	0.000	.001	.007	.026	.059	.092	.104	.114	.107	.103	.091	.071	.063	.039	.017	.003	.001	0.000	0.000
0.000	0.000	.000	.002	.005	.016	.019	.021	.027	.029	.026	.021	.012	.010	.007	.002	.000	0.000	0.000	0.000

SUM OF POWER IN EACH COLUMN, MW (FROM LEFT TO RIGHT)

1	.0206	11	9.5141
2	.1258	12	8.9550
3	.5490	13	8.0213
4	1.6115	14	6.8775
5	3.6052	15	5.0998
6	5.9665	16	3.1807
7	7.7334	17	1.3715
8	8.9131	18	.4628
9	9.4777	19	.0990
10	9.7464	20	.0157

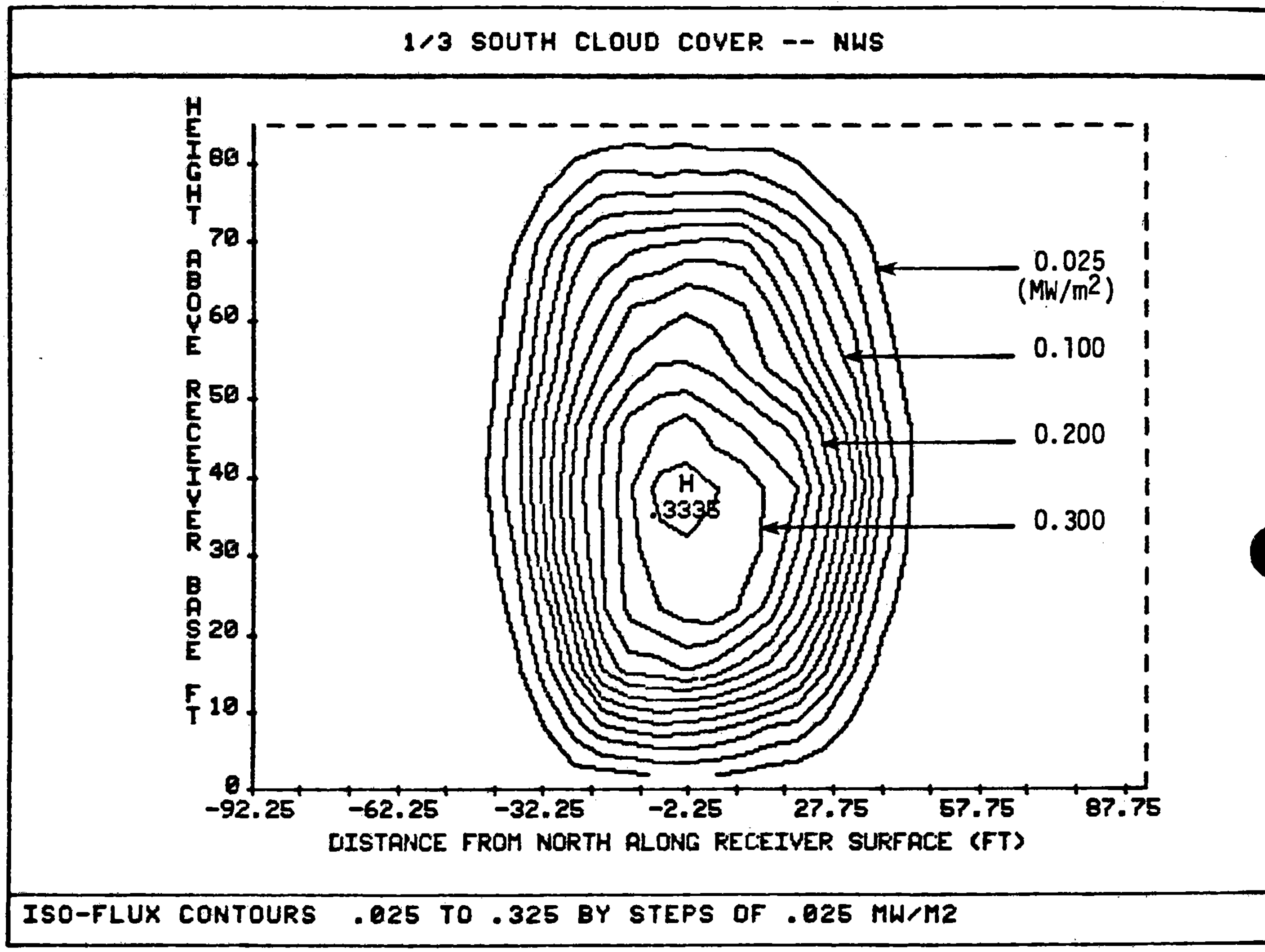


Figure M.6-3. Receiver Iso-Flux Contour Map For Field With 1/3 Shaded On South Side - 360 Degrees

TABLE M.6-3

RECEIVER HEAT FLUX MAP FOR FIELD WITH 1/2 SHADED ON NORTH SIDE

The following table is a flux map summary of 225 degrees of the receiver. Only 202.5 degrees of the receiver are actually active. The top and bottom flux bins are 4 feet (1.219 meters) high. All other bins are 7.7 feet (2.347 meters) high. Flux is in MW/m^2.

									N										
0.000	.001	.001	.007	.014	.019	.021	.020	.020	.018	.018	.016	.020	.024	.026	.031	.020	.009	.002	0.000
.000	.002	.009	.024	.047	.055	.056	.054	.042	.040	.042	.041	.054	.064	.071	.066	.054	.024	.006	.001
.001	.007	.022	.059	.098	.101	.095	.084	.069	.063	.060	.070	.083	.099	.128	.140	.118	.063	.020	.003
.003	.010	.033	.076	.107	.112	.101	.085	.077	.067	.062	.073	.077	.108	.143	.164	.143	.085	.028	.005
.003	.014	.036	.077	.108	.097	.077	.053	.053	.044	.043	.047	.060	.084	.123	.151	.138	.080	.032	.007
.003	.016	.038	.072	.087	.072	.041	.023	.021	.019	.019	.024	.032	.056	.105	.141	.141	.088	.033	.008
.003	.015	.042	.077	.085	.068	.042	.021	.015	.016	.018	.023	.035	.070	.125	.170	.161	.101	.034	.007
.004	.015	.048	.093	.136	.125	.101	.074	.064	.071	.073	.084	.093	.130	.196	.228	.193	.104	.032	.004
.002	.014	.049	.119	.176	.197	.168	.147	.132	.127	.130	.143	.161	.204	.243	.261	.211	.111	.032	.005
.001	.008	.041	.101	.162	.190	.177	.153	.146	.130	.133	.148	.165	.197	.229	.223	.168	.092	.026	.004
.000	.003	.016	.046	.076	.090	.094	.093	.090	.084	.082	.083	.095	.113	.110	.106	.076	.040	.013	.002
.000	.000	.003	.010	.017	.022	.026	.032	.029	.027	.033	.030	.033	.037	.034	.029	.020	.007	.003	.000

SUM OF POWER IN EACH COLUMN, MW (FROM LEFT TO RIGHT)

1	.0778	11	2.8366
2	.4249	12	3.1343
3	1.3861	13	3.6387
4	3.0921	14	4.7743
5	4.5278	15	6.2025
6	4.6466	16	6.9309
7	4.0249	17	5.8745
8	3.3508	18	3.2804
9	3.0217	19	1.0597
10	2.8245	20	.1869

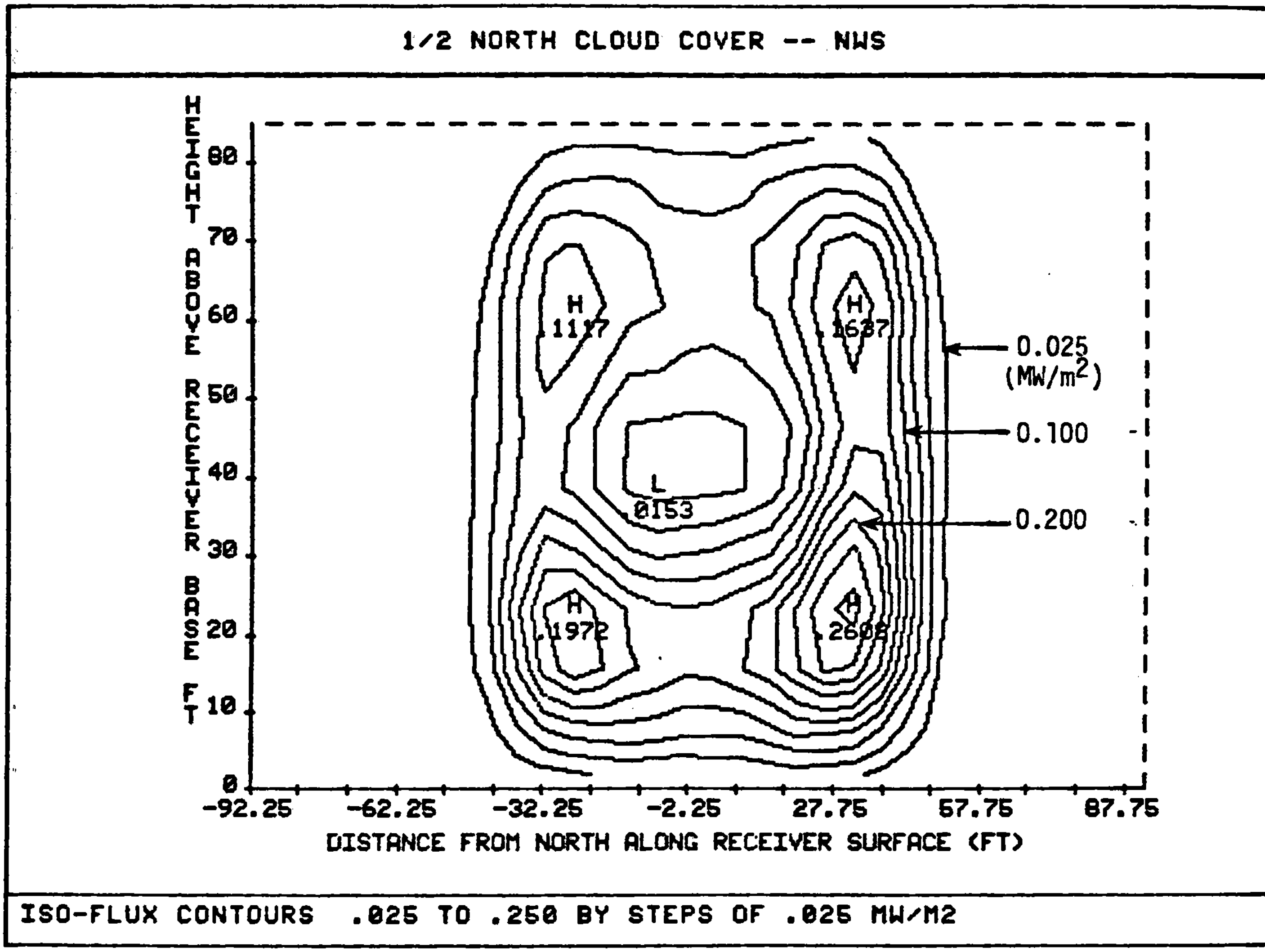


Figure M.6-4. Receiver Iso-Flux Contour Map For Field With 1/2 Shaded On North Side - 360 Degrees

TABLE M.6-4

RECEIVER HEAT FLUX MAP FOR FIELD
WITH 1/3 SHADED ON NORTH SIDE

The following table is a flux map summary of 225 degrees of the receiver. Only 202.5 degrees of the receiver are actually active. The top and bottom flux bins are 4 feet (1.219 meters) high. All other bins are 7.7 feet (2.347 meters) high. Flux is in MW/m^2.

N

0.000	.001	.002	.009	.013	.025	.028	.026	.022	.021	.025	.024	.029	.028	.024	.025	.018	.008	.001	0.000
.000	.001	.010	.029	.056	.072	.083	.075	.066	.061	.063	.065	.069	.079	.075	.073	.054	.025	.007	.001
.001	.006	.026	.069	.116	.140	.151	.135	.111	.103	.103	.112	.121	.131	.151	.146	.119	.062	.018	.003
.002	.011	.038	.084	.142	.166	.155	.135	.110	.102	.104	.107	.122	.141	.158	.178	.144	.086	.030	.004
.003	.015	.042	.086	.138	.139	.117	.096	.085	.083	.084	.095	.110	.128	.160	.177	.143	.087	.033	.007
.004	.017	.047	.091	.123	.116	.083	.055	.051	.050	.050	.061	.080	.120	.165	.184	.157	.089	.034	.008
.004	.016	.051	.099	.131	.124	.091	.055	.044	.046	.047	.060	.091	.150	.205	.215	.184	.104	.038	.008
.003	.017	.055	.116	.170	.191	.153	.128	.120	.116	.126	.136	.169	.214	.258	.270	.218	.108	.033	.005
.002	.014	.050	.125	.203	.254	.247	.232	.209	.197	.198	.213	.249	.273	.298	.284	.211	.115	.033	.004
.001	.007	.041	.106	.179	.234	.256	.256	.238	.223	.224	.220	.230	.249	.261	.228	.168	.090	.025	.002
.000	.003	.016	.047	.079	.107	.134	.134	.132	.127	.123	.117	.125	.119	.120	.109	.077	.038	.011	.002
0.000	0.000	.003	.009	.017	.026	.031	.037	.042	.041	.038	.039	.037	.041	.034	.028	.022	.008	.002	0.000

SUM OF POWER IN EACH COLUMN, MW (FROM LEFT TO RIGHT)

1	.0866	11	4.7677
2	.4455	12	5.0228
3	1.5580	13	5.7673
4	3.5562	14	6.7593
5	5.5755	15	7.7589
6	6.4754	16	7.7966
7	6.1862	17	6.1661
8	5.4977	18	3.3520
9	4.9410	19	1.0847
10	4.7023	20	.1819

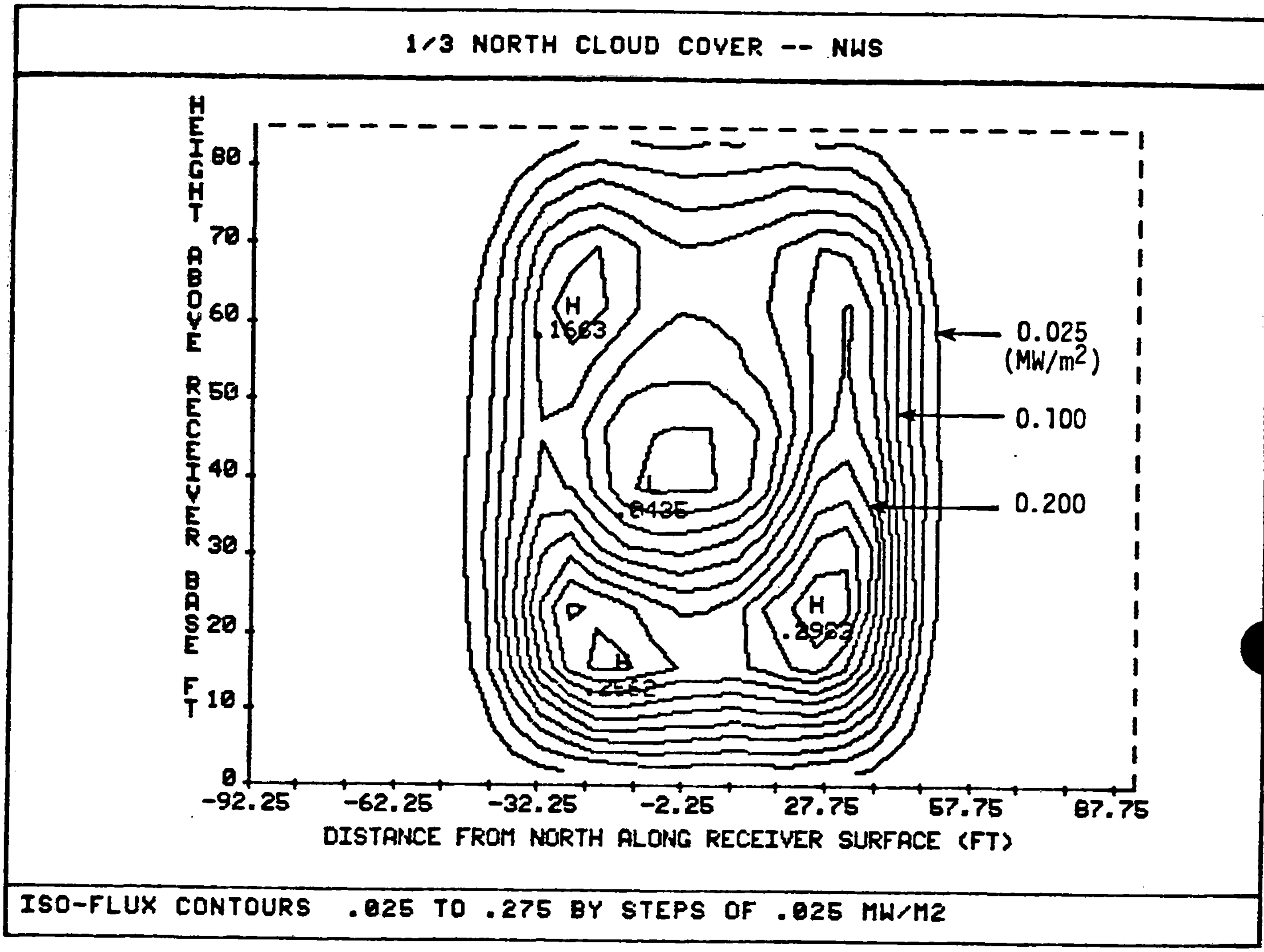
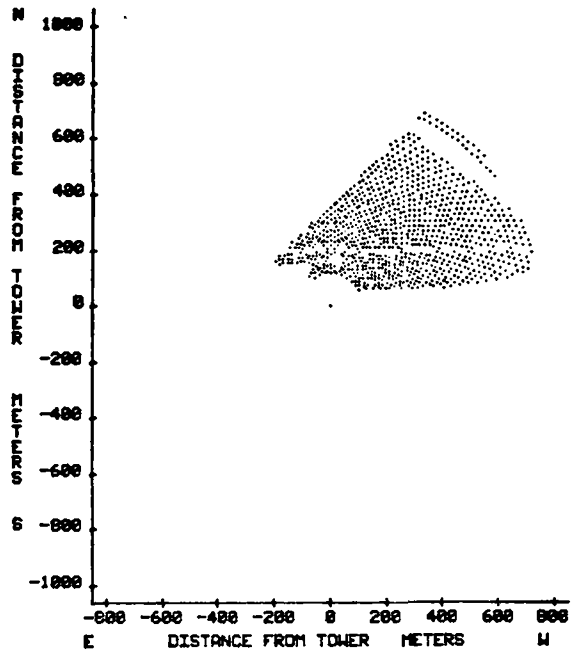
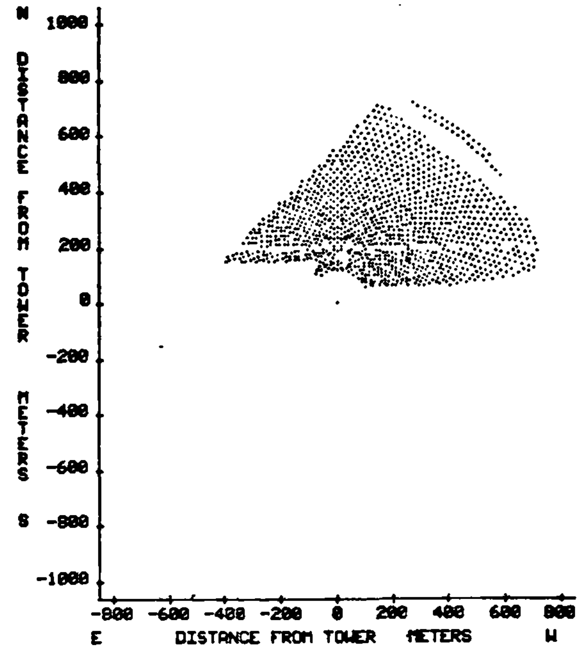


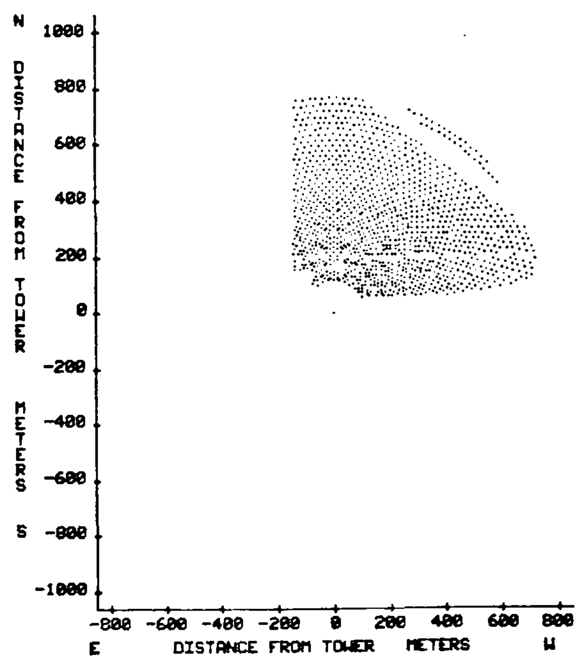
Figure M.6-5. Receiver Iso-Flux Contour Map For Field With 1/3 Shaded On North Side - 360 Degrees



a) 1/2 Shaded On Northwest Side



b) 1/3 Shaded On Northwest Side



c) 1/3 Shaded On West Side

Figure M.6-6. Northwest and West Shaded Heliostat Fields

TABLE M.6-5

RECEIVER HEAT FLUX MAP FOR FIELD WITH 1/2 SHADED ON NORTHWEST SIDE

The following table is a flux map summary of 225 degrees of the receiver. Only 202.5 degrees of the receiver are actually active. The top and bottom flux bins are 4 feet (1.219 meters) high. All other bins are 7.7 feet (2.347 meters) high. Flux is in MW/m^2.

N

0.000	0.000	0.000	.000	.002	.006	.007	.013	.015	.021	.025	.026	.030	.031	.029	.028	.020	.008	.002	0.000
0.000	0.000	0.000	.001	.003	.009	.015	.025	.029	.043	.055	.070	.078	.079	.081	.070	.057	.024	.005	.000
0.000	0.000	.000	.001	.005	.012	.026	.037	.045	.059	.097	.134	.147	.159	.152	.152	.118	.067	.016	.003
0.000	0.000	.000	.001	.004	.011	.021	.036	.050	.070	.115	.147	.179	.189	.185	.180	.153	.081	.029	.006
0.000	0.000	.000	.001	.002	.004	.012	.025	.037	.056	.093	.148	.187	.200	.213	.190	.154	.087	.031	.007
0.000	0.000	0.000	.000	.000	.001	.005	.009	.019	.037	.075	.144	.196	.239	.231	.223	.167	.096	.033	.010
0.000	0.000	0.000	.000	.001	.003	.007	.010	.016	.035	.076	.158	.222	.277	.273	.255	.192	.102	.039	.009
0.000	0.000	.000	.001	.005	.015	.026	.038	.051	.089	.133	.216	.268	.306	.313	.287	.216	.113	.033	.007
0.000	0.000	.000	.003	.012	.026	.046	.069	.098	.140	.202	.262	.313	.331	.336	.291	.216	.122	.036	.005
0.000	0.000	.000	.003	.013	.025	.042	.073	.099	.140	.184	.229	.262	.271	.270	.229	.171	.089	.025	.004
0.000	0.000	.000	.001	.005	.013	.025	.045	.059	.081	.108	.117	.134	.125	.129	.105	.076	.040	.012	.002
0.000	0.000	0.000	.000	.001	.005	.011	.014	.024	.030	.035	.036	.045	.044	.039	.033	.021	.007	.002	0.000

SUM OF POWER IN EACH COLUMN, MW (FROM LEFT TO RIGHT)

1	0.0000	11	4.8270
2	0.0000	12	6.8341
3	.0037	13	8.3559
4	.0493	14	9.1341
5	.2095	15	9.1457
6	.5094	16	8.3093
7	.9664	17	6.3569
8	1.5665	18	3.4187
9	2.1544	19	1.0765
10	3.2056	20	.2161

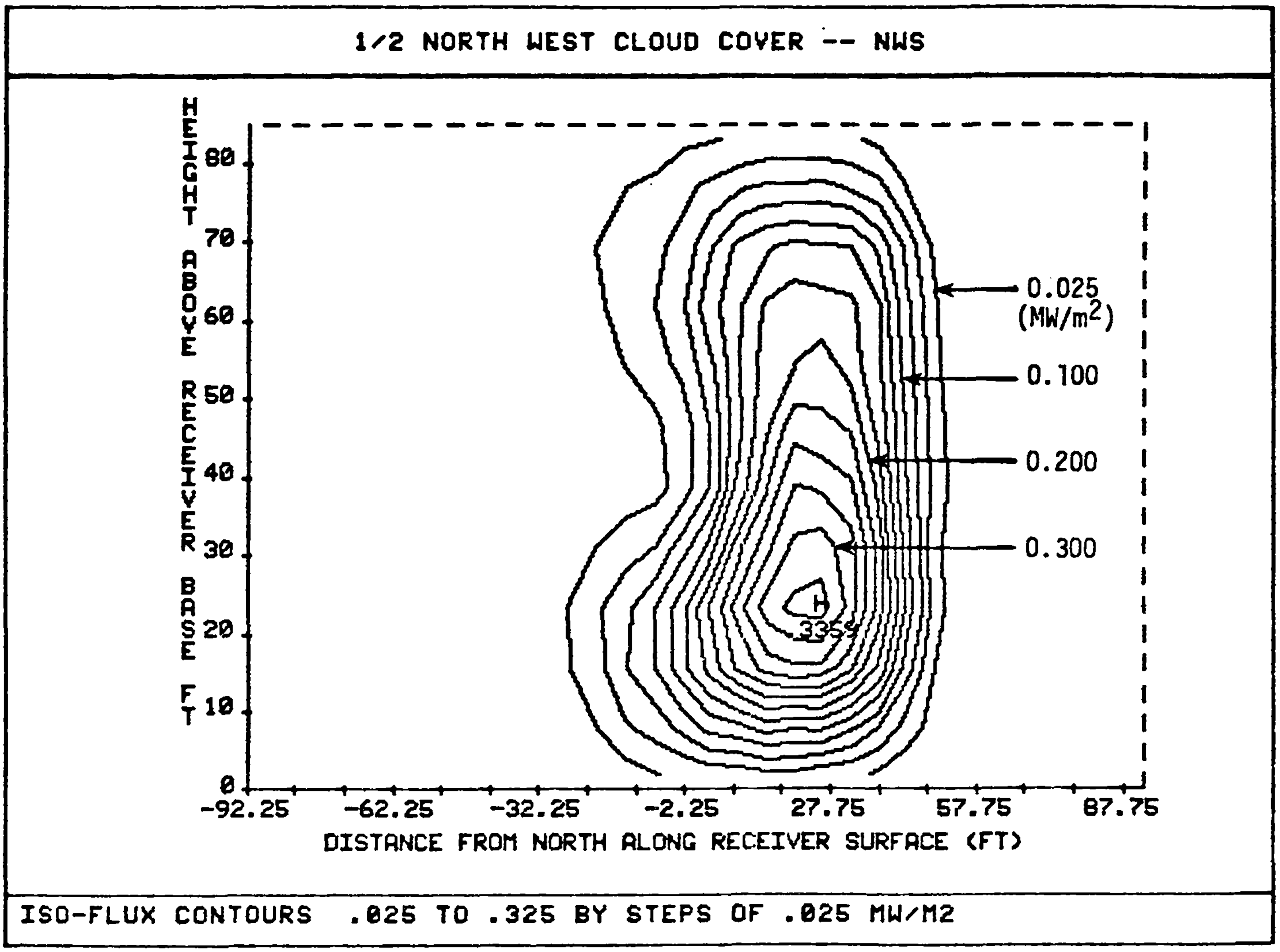


Figure M.6-7. Receiver Iso-Flux Contour Map For Field With 1/2 Shaded On Northwest Side - 360 Degrees

TABLE M.6-6

RECEIVER HEAT FLUX MAP FOR FIELD WITH 1/3 SHADED ON NORTHWEST SIDE

The following table is a flux map summary of 225 degrees of the receiver. Only 202.5 degrees of the receiver are actually active. The top and bottom flux bins are 4 feet (1.219 meters) high. All other bins are 7.7 feet (2.347 meters) high. Flux is in MW/m^2.

									N										
0.000	0.000	.001	.004	.011	.014	.023	.022	.023	.024	.031	.031	.031	.028	.025	.022	.020	.008	.002	0.000
0.000	.000	.003	.012	.026	.040	.056	.061	.068	.075	.082	.092	.085	.084	.082	.073	.054	.024	.006	.000
0.000	.001	.007	.020	.042	.066	.088	.100	.118	.151	.165	.176	.166	.159	.150	.144	.120	.063	.018	.004
0.000	.001	.005	.020	.038	.062	.077	.104	.124	.158	.205	.225	.217	.194	.196	.187	.147	.086	.031	.006
0.000	0.000	.002	.010	.022	.037	.046	.065	.100	.134	.178	.200	.218	.216	.205	.189	.161	.095	.031	.006
0.000	.000	.001	.003	.008	.010	.015	.036	.067	.111	.172	.215	.244	.257	.240	.221	.174	.096	.036	.008
0.000	0.000	.001	.003	.008	.011	.021	.038	.068	.123	.188	.240	.274	.292	.290	.259	.195	.105	.034	.008
0.000	.000	.003	.013	.037	.055	.079	.103	.130	.183	.249	.288	.318	.316	.324	.283	.224	.120	.035	.007
.000	.001	.007	.030	.069	.108	.143	.179	.226	.272	.300	.333	.347	.345	.317	.295	.217	.116	.034	.005
0.000	.001	.009	.032	.072	.120	.161	.200	.221	.263	.269	.263	.273	.274	.271	.228	.164	.093	.029	.004
.000	.001	.004	.018	.041	.062	.085	.107	.131	.141	.147	.132	.129	.133	.121	.106	.077	.041	.013	.001
0.000	0.000	.001	.004	.012	.017	.023	.037	.039	.043	.038	.042	.040	.041	.035	.032	.020	.007	.003	.000

SUM OF POWER IN EACH COLUMN, MW (FROM LEFT TO RIGHT)

1	.0008	11	8.2079
2	.0210	12	9.0741
3	.1762	13	9.5171
4	.6832	14	9.5108
5	1.5409	15	9.1873
6	2.4235	16	8.2965
7	3.2716	17	6.4127
8	4.2215	18	3.4906
9	5.2943	19	1.1127
10	6.7840	20	.1972

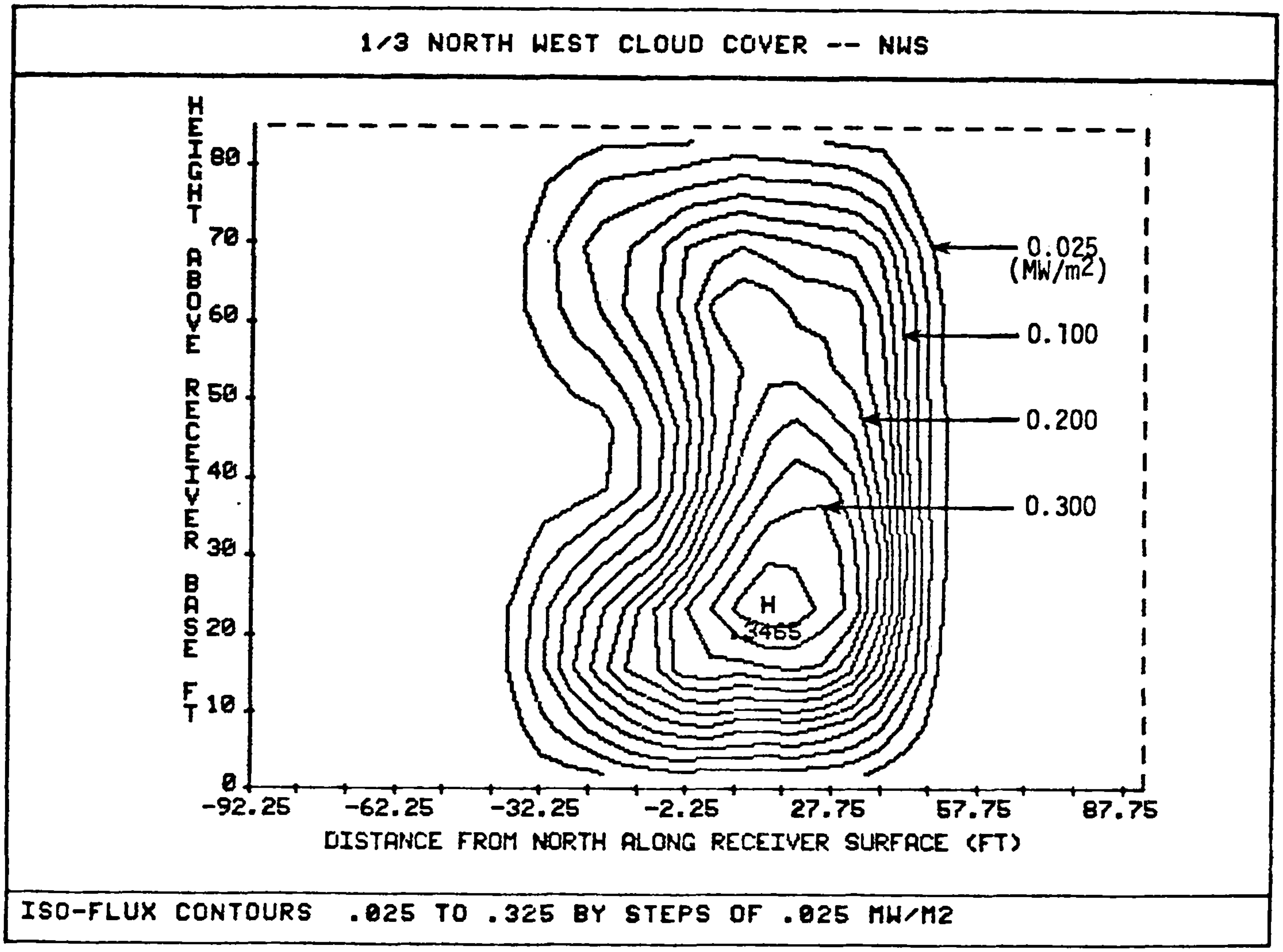


Figure M.6-8. Receiver Iso-Flux Contour Map For Field With 1/3 Shaded On Northwest Side - 360 Degrees

TABLE M.6-7

RECEIVER HEAT FLUX MAP FOR FIELD WITH 1/3 SHADED ON WEST SIDE

The following table is a flux map summary of 225 degrees of the receiver. Only 202.5 degrees of the receiver are actually active. The top and bottom flux bins are 4 feet (1.219 meters) high. All other bins are 7.7 feet (2.347 meters) high. Flux is in MW/m^2.

									N										
0.000	0.000	0.000	0.000	.000	.004	.011	.020	.023	.027	.033	.032	.033	.030	.025	.029	.021	.009	.002	.000
0.000	0.000	0.000	.000	.001	.009	.027	.042	.066	.082	.093	.089	.089	.081	.078	.067	.051	.025	.007	.001
0.000	0.000	0.000	0.000	.001	.011	.034	.075	.126	.165	.207	.194	.178	.164	.157	.149	.115	.065	.017	.003
0.000	0.000	0.000	0.000	.001	.008	.036	.087	.152	.209	.249	.234	.216	.199	.192	.183	.147	.086	.032	.005
0.000	0.000	0.000	.000	.000	.004	.025	.080	.147	.230	.257	.242	.242	.221	.215	.196	.157	.087	.031	.007
0.000	0.000	0.000	.000	.000	.004	.017	.068	.145	.233	.271	.282	.267	.257	.241	.216	.172	.094	.038	.010
0.000	0.000	0.000	.000	.001	.005	.023	.069	.151	.248	.296	.311	.310	.284	.289	.262	.200	.103	.040	.011
0.000	0.000	0.000	.000	.003	.014	.044	.106	.185	.276	.330	.352	.337	.326	.316	.290	.217	.112	.035	.006
0.000	0.000	0.000	.001	.005	.023	.057	.130	.227	.310	.346	.363	.352	.345	.321	.290	.218	.114	.034	.005
0.000	0.000	0.000	.001	.005	.021	.060	.120	.211	.273	.278	.281	.278	.276	.271	.229	.174	.094	.026	.004
0.000	0.000	0.000	.000	.002	.009	.033	.071	.104	.131	.140	.131	.135	.129	.129	.106	.081	.041	.012	.002
0.000	0.000	0.000	0.000	.001	.003	.008	.027	.034	.042	.039	.042	.044	.043	.038	.030	.018	.008	.003	.000

SUM OF POWER IN EACH COLUMN, MW (FROM LEFT TO RIGHT)

1	0.0000	11	10.3231
2	0.0000	12	10.3815
3	0.0000	13	10.0763
4	.0078	14	9.5718
5	.0807	15	9.2430
6	.4573	16	8.3253
7	1.4972	17	6.4064
8	3.5965	18	3.4213
9	6.3636	19	1.1274
10	9.0400	20	.2178

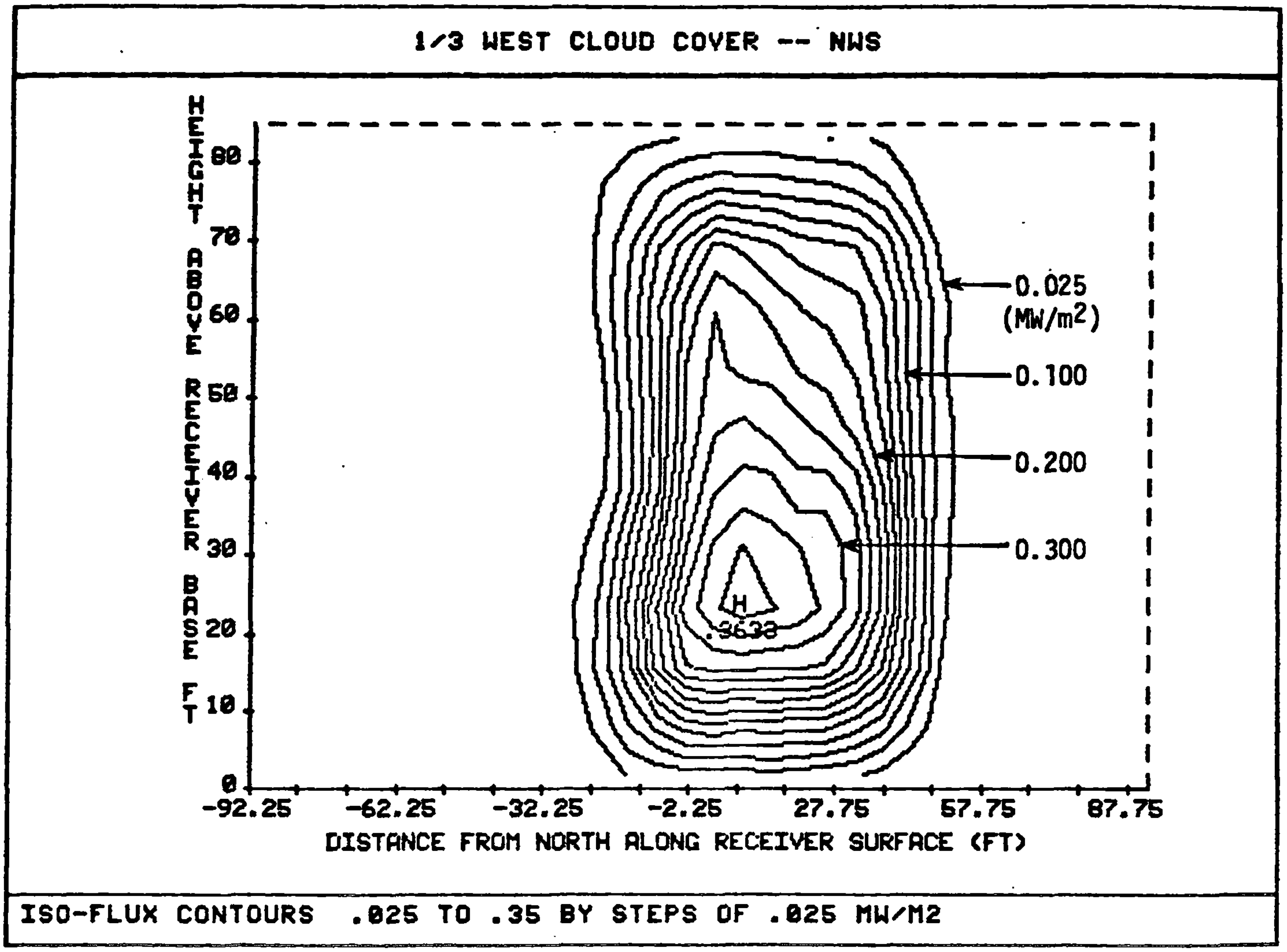


Figure M.6-9. Receiver Iso-Flux Contour Map For Field With 1/3 Shaded On West Side - 360 Degrees

APPENDIX N

APPENDIX N

PRELIMINARY FOUNDATION REPORT

STONE & WEBSTER ENGINEERING CORPORATION

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF ATTACHMENTS

SECTION 1
INTRODUCTION

This report presents the results of soil investigations and preliminary foundation engineering studies for the Solar Repowering of Unit 1 at the Newman Station of El Paso Electric Company. The purpose is to develop typical preliminary foundation designs for the heliostats and the central receiver tower, for use in the estimation of the cost of repowering. Section 2 of this report describes the physical characteristics of the site including topography, subsurface soil conditions, groundwater and seismicity. Section 3 discusses the foundation analyses and designs. Section 4 presents the conclusions and recommendations.

The Test Boriong Logs and the Laboratory Test Results are included in Attachments A and B, respectively.

Attachment C includes review comments from two heliostat vendors, ARCO Solar, Inc. and McDonnell Douglas Astronautics Company. A third vendor, Martin Marietta Aerospace, and Sandia Laboratories (Livermore, California) had no review comments. A response to the comments is also included in the Attachment.

SECTION 2
SITE DESCRIPTION

The site is located about 24 km (15 miles) north of El Paso, Texas, about 1.61 km (1 mile) south of the New Mexico border, as shown in Figure 2.0-1.

The proposed central receiver tower is located just north of the existing Unit 1 at Newman Station. The heliostat field, which lies north of the tower, as shown in Figure 2.0-2, is nearly semicircular in shape with a radius of approximately 0.8 km (0.5 mile). Natural gas and petroleum pipelines are buried in an easement which transects the northeast portion of the field. These pipelines will not be relocated and no heliostats will be installed in this area. However, existing electric transmission lines currently running north through the proposed field will be relocated.

2.1 SITE TOPOGRAPHY

The site is open land with an average slope of approximately one percent from west to east. The maximum slope is nearly three percent at the western extreme, gradually decreasing to less than one half percent in the eastern portion of the heliostat field. Several arroyos lead into the site area from the west.

The existing site topography derived from the USGS Quadrangle Map for North Franklin Mountain, Texas, is shown in Figure 2.0-2. Ground surface elevations obtained at each test boring location are in reasonable agreement with these contour lines.

2.2 SUBSURFACE PROFILE

The site lies in the Tularosa Basin which is a large graben, bounded by fault block mountains to the east and west. Approximately 300 to 600 m (1,000 to 2,000 ft) of sediments overlie bedrock in the site area. During December 1982, a total of twelve widely spaced test borings were drilled to a maximum depth of 15.3 m (50 ft) in the area of the heliostat field and receiver tower. These borings were drilled by Raba-Kistner Consultants, Inc. of El Paso, Texas, and supervised by Stone & Webster Engineering Corporation (SWEC).

The locations of the borings are shown in Figure 2.0-2. The logs of the borings are included in Attachment A. All borings were drilled using hollow stem auger techniques. Samples were generally obtained at 1.53 m (5 ft) intervals using a 5.1 cm (2 in.) OD split barrel sampler, driven by a 63.6 kg (140 lb) hammer falling 76 cm (30 in.). In selected borings, additional samples were obtained using a 8.3 cm (3 1/4 in.) OD sampler with a brass liner.

Laboratory soil tests consisted of confined triaxial shear tests and index testing of seven 6.3 cm (2.5 in.) dia tube samples obtained by use of the 8.3 cm (3 1/4 in.) OD sampler. These tests were performed by SWEC to determine the soil strength and modulus, and for soil identification. The results of the laboratory testing are included in Attachment B.

The subsurface conditions encountered in the borings are represented by five strata which are described in the following sections of this report. These strata are depicted on the subsurface profiles, Figures 2.2-1 thru 2.2-3. Soil descriptions of individual samples are included on the boring logs which are found in Attachment A of this report.

For additional information regarding subsurface conditions in the area, refer to the Report on Subsurface Investigation, Newman Power Station - Unit 4 prepared by SWEC and issued July 12, 1974.

2.2.1 Slightly Cemented Clays, Silts and Sands

This stratum includes a surficial layer, generally about 0.61 m (2 ft) thick, which typically is moist and of low density. It consists of a variety of soils ranging from silt "topsoil" to coarse to fine sand. Six of the borings (R-2, R-7, R-8, R-10, R-11 and R-12) encountered the low density soils to a depth of up to 3.81 m (12.5 ft.) These lower soils are typically damp fine sand, clays, silty fine sands and fine sandy silts of probable aeolian origin (deposited by wind), since they are of low density, are somewhat cemented and exhibit root holes similar to a loess. However, it is possible that these soils are slopewash, carried into the area from the arroyos to the west. In any event, these soils are only slightly cemented by clay and/or calcium carbonate.

The properties of these soils are greatly affected by water content, the soil plasticity (as defined by Atterberg limit testing), percentage of fines, the degree of calcium carbonate cementation and the density. Except at the surface, the natural water content is about one half the plastic limit value for the samples tested. Therefore, in the natural state, the water content is not considered to be a major factor in the evaluation of soil properties, provided the water content is not increased. No reliable correlations with density are possible because of the overriding effects of cementation and plasticity. These two properties (at low natural water content) have the greatest effect upon the strength and modulus of the soil. The higher the plasticity and cementation, the higher the strength and modulus. To a degree, the standard penetration test, performed during sampling in the field, reflected this increase in strength and modulus.

The boring logs and laboratory test data were evaluated particularly with respect to the plasticity and cementation. This evaluation yielded the typical properties for this layer which are discussed in more detail in Section 3 of this report.

The soils within this stratum are susceptible to large reductions in strength and modulus if wetted. Therefore, the properties discussed above apply only to materials in the relatively dry state.

Test boring R-3 was drilled on the grounds of the existing power station. It is believed that the upper few feet of soil are fill which is not representative of the soils typically found within this stratum.

2.2.2 Cemented Clays and Sands

This stratum was encountered beneath the slightly cemented clays, sands and silts over the eastern two-thirds of the site. Generally, it is moderately plastic sandy clay and slightly to moderately plastic clayey sand. The sand content typically varies between 30 to 60 percent. It is usually moderately cemented by calcium carbonate and relatively porous. However, the degree of cementation and porosity varies as indicated by the erratic standard penetration test results. These soils are susceptible to reductions in strength and modulus upon wetting, particularly for the less cemented layers. This is demonstrated to some degree by the relatively low standard penetration test values obtained in boring R-3 where the soils have a higher water content (probably resulting from leaking pipelines in this area).

The soil properties were developed based upon the laboratory test data and test boring information. These properties are described in Section 3 of this report.

2.2.3 Cemented Clayey Coarse to Fine Sand

This stratum is a transitional layer between the overlying cemented clays and sands stratum and the underlying gravelly sand stratum. The soils are typically slightly to moderately plastic and are slightly to moderately cemented with calcium carbonate. For the engineering purposes of this study, the properties of this stratum are considered similar to the cemented clays and sands.

2.2.4 Cemented Silty Sand and Gravel

This stratum is found below a thin mantle of surficial soils at the western end of the site. The soils are typically silty coarse to fine sands with gravel contents of between 10 and 30 percent. Fines are slightly plastic varying between 10 and 40 percent of the sample by weight; however, occasional samples are moderately plastic or nonplastic. Cementation varies as indicated by the variation in standard penetration test results. Very hard layers of caliche were encountered in the borings. Caliche is a soil deposit which has been naturally cemented by minerals (primarily calcium carbonate) into a hard mass. An extensive deposit of very hard caliche was observed at the bottom of an arroyo about 0.3 to 0.6 m (1 to 2 ft) below the adjacent ground surface. This arroyo runs approximately east-west, north of the existing road and south of boring R-6. In addition, R-6 encountered the very hard caliche layer at a depth of about 1.1 m (3.5 ft) and had not completely penetrated the layer when the boring was stopped at 2.0 m (6.5 ft.)

See Section 3 of this report for the estimated properties of this stratum.

2.2.5 Gravelly Sand

The gravelly sand stratum is the deepest layer penetrated beneath the eastern portion of the heliostat field. It is typically dense to very dense with less than five percent fines. The estimated properties of this material are presented in Section 3.

2.3 GROUNDWATER

Groundwater was not encountered during the exploratory investigation. Wells in the area, however, are currently drawing water from a depth of several hundred feet below the surface.

2.4 SEISMICITY

El Paso lies among mountain ranges which, in general are fault block in origin. The 1962 tectonic map of the United States shows a system of faults along the easterly face of the Franklin Mountains which extend north from the city into New Mexico.

Locally, El Paso has not experienced significant earthquake activity. The Earthquake History of the United States, U.S. Coast and Geodetic Survey (NOAA) No. 41-1, Revised, does not list any earthquakes of intensity V, Modified Mercalli Scale, or larger as having occurred within 161 km (100 miles) of the site. The area has, however, been subject to vibrations from earthquakes located outside this region. A total of 22 earthquakes of intensity V or more are listed within a radius of 322 km (200 miles) of the site.

Important tall structures, such as the central receiver tower, should be designed to resist the relatively small earthquakes which could occur in the El Paso area. A maximum horizontal ground line acceleration of 0.05 g is recommended as determined from a report entitled Probabilistic Estimate of Maximum Acceleration and Velocity in Rock in the Contiguous United States by ST Algermissen et al, 1982.

Since wind loading will govern for design of the heliostats, no seismic analysis is required.

SECTION 3
FOUNDATION ANALYSIS

Preliminary foundation analyses were made for the heliostats and the receiver tower. The results of these analyses are included in the following sections.

3.1 HELIOSTAT FOUNDATIONS

An evaluation of the soil conditions indicates that the soils may be grouped into three general cases, namely, the Aeolian Case, the Hard Caliche Case and the Cemented Clays and Sands Case. Strata thicknesses and soil properties vary from boring to boring in each group; however, these differences are not considered significant to the engineering analyses discussed in this report.

3.1.1 Aeolian Case

Borings R-3, R-7, R-8, R-10, R-11, and R-12 are grouped into the Aeolian Case. Approximately 60 percent of the heliostats would be designed for this condition as indicated in Figure 2.0-2. Characteristically, this case exhibits up to 3.82 m (12.5 ft) of slightly cemented clays, silts and sands of possible aeolian origin. The soil strength increases with depth as indicated by the three substrata shown in Figure 3.1-1. Below a depth of 3.82 m (12.5 ft), the cemented clays and sands stratum are encountered. The soil parameters for both strata are based on the laboratory test results with consideration given to depth, plasticity, calichefication, density and standard penetration test results from the borings.

3.1.2 Hard Caliche Case

The Hard Caliche Case is typical of the western portion of the field (about 20 percent of the heliostats) as indicated in Figure 2.0-2. Borings R-1, R-2, and R-6 fall into this grouping. The assigned soil parameters are shown in Figure 3.1-2. The parameters for the upper two layers, to a depth of 1.53 m (5 ft), were developed in a manner similar to that for the Aeolian Case discussed above. The lowest layer is a hard, partially or completely cemented, silty sand and gravel. It should be noted that R-6 is somewhat anomalous to this case in that it exhibits a very hard caliche layer close to the surface. This layer was also observed in an arroyo to the south of this boring. The implications of this layer are discussed below.

3.1.3 Cemented Clays and Sands Case

The third case, the Cemented Clays and Sands Case, is typical of about 20 percent of the heliostats located in the eastern portion of the site. The top 0.61 m (2 ft) of soil for this case are slightly cemented clays, silts and sands, similar to the other two cases. Below this depth, 2.45 m (8 ft) of cemented clays and sands are found. The properties of this stratum were derived in a manner similar to that used for the Aeolian Case. A gravelly sand exists below a depth of 3.0 m (10 ft.) The properties of this stratum were inferred from the Standard Penetration Test Values and soil descriptions contained in the borings logs. The assigned properties for all three layers are presented in Figure 3.1-3.

3.1.4 Heliostat Foundation Analyses

Three foundation types were initially considered for the heliostats, namely, spread footings, drilled piers and driven piles. During a preliminary review, the size of spread footings, required to resist the wind loads, was found to be excessively large. Therefore, further investigation of this alternate was not considered necessary.

Based upon discussions with heliostat suppliers, the drilled pier foundation appeared to be favored and therefore is investigated in detail. Driven pile foundations are analyzed in a manner similar to drilled pier and are discussed herein.

The drilled pier alternate was investigated by varying the diameter and length of pier for the four loading conditions considered and for the three cases of subsurface conditions described above.

The pier is reinforced concrete installed in a hole excavated by auger techniques. It is analyzed for deflection and tilting by use of the computer program entitled, Analysis of Stresses and Deflections for Laterally Loaded Piles Including Generation of P-Y Curves by Lymon C. Reese and W. Randall Sullivan. The loading conditions are based upon loads obtained from a heliostat supplier, McDonnell Douglas Corporation. These loads are presented in Table 3.1-1.

Based upon the results of the laboratory triaxial testing, it is concluded that the soils (with the exception of the gravelly sand) exhibit linear elastic behavior to at least 50 percent of their strength. Since the piers are relatively lightly loaded, linear elastic soil properties are used in the determination of pier movements.

The results of these analyses are presented in Table 3.1-2. A number of pier diameters and lengths were investigated for the first case studied, the Aeolian Case. It should be noted that because of the linear elastic properties of the soil (which is not typical of soils in general), the deflection is essentially independent of pier diameter for the stiffer piers (greater than approximately 91.5 cm (36 in.). The effect of pier length is significant, at least in part because of the denser soils at depth.

The acceptance criteria for all conditions of loading are presented in Table 3.1-3. For the maximum overturning condition, two criteria are selected. In order to minimize potential voids around the pier near the surface into which water may flow, a maximum of 1.0 cm (0.4 in.) is chosen as the maximum allowable deflection at the ground surface. More importantly, in order to prevent or to minimize permanent deformation, the maximum soil stress should be kept below 0.35 of the ultimate soil strength. This criteria is of utmost importance since permanent deformation will allow wobble of the foundation under subsequent loadings as well as decrease the resistance to the torsional loads discussed below.

Some permanent deformation is expected near the ground surface where the soil confinement is low. This deformation will be a maximum at the ground surface and decrease to essentially zero at a depth equal.to two pier diameters 1.53 m (5 ft).

For the operating overturning condition of load, tilting must be less than 0.0015 radians. This criterion is typical of criteria suggested by heliostat manufacturers.

For the Aeloian Case, a 76 cm (30 in.) dia, 6.1 m (20 ft) long pier meets this criterion. For the Hard Caliche Case and the Cemented Clays and Sands Case, a 76 cm (30 in.) dia, 4.6 m (15 ft) long pier meets the acceptance criteria.

The torque condition of loading is of nearly equal significance as the overturning condition, because this condition imposes about 80 percent of the maximum horizontal load and moment in combination with a high torque load. Furthermore, little research and experience exists for this case.

The rotation induced by the maximum torque load will be less than 0.0007 radians for the three cases of soil conditions studied. The rotation for the operating torque condition will be about one third of the maximum values. These computed rotations are not large but are based upon limited information which requires confirmation before final design. In order to minimize the slip between the concrete and soil and keep the soil deformations in the elastic range, the maximum torque stress is kept below 0.35 of the ultimate strength. Using this criterion in the torque stress analysis, the pier sizes selected in the maximum overturning analysis are found to be acceptable.

The reinforced concrete pier would require eight No. 6 reinforcing bars arranged in a circular formation over the entire depth of the pier.

An alternate foundation design was also investigated. This design is similar to the reinforced concrete pier studied except that a steel pipe is used for flexural strength. This pipe would be inserted into a predrilled hole and the annulus between the pipe and the soil grouted with a neat cement grout. The interior of the pipe would not be filled with concrete or grout.

Several pipe sizes were studied. A 81 cm (32 in.) dia pipe with a 0.635 cm (0.25 in.) wall thickness, installed in a 91 cm (36 in.) dia hole is considered the preferred design. The results are shown in Table 3.1-2. Pipes installed in smaller holes would require a substantial increase in steel to maintain the same stiffness of the pile which is critical in this case.

In order for the steel pipe alternate to properly function, it is necessary that the bond between the steel and grout be maintained. For the relatively low stresses anticipated for the heliostats, it is likely that this bond will be adequately maintained. Before a final design is developed for a heliostat foundation utilizing a steel pipe, this question of bond should be evaluated.

Current practice for heliostat foundations is toward the use of drilled piers rather than driven piles. For this reason, the drilled pier was emphasized in this report. However, an alternative design consisting of an 81 cm (32 in.) dia driven steel pile may be possible in the central area of the heliostat field where the Aeolian Case governs. Difficult driving conditions are expected in other areas of the site and therefore driven piles are not considered practical.

The caliche layers found within the cemented clays and sands stratum in the central portion of the site may also be difficult to penetrate, possibly requiring predrilling or an increased wall thickness to resist the high driving stresses. Such requirements would be significant to the cost effectiveness of this alternate. In addition to this potential installation problem, the adhesion between the soil and the smooth-walled pile is unknown. Load tests would be required to determine this value (which may be relatively low).

The plant estimate should be based upon the reinforced concrete pier concept, since this scheme is representative of current practice and has the least unknowns. Economic comparisons of the alternates should be made before the subsurface investigation is performed for final design, since one or both of the alternates may be found uneconomical, and therefore further technical evaluation would not be required.

3.1.5 Pier Design and Construction Considerations

The analysis is predicated upon maintaining the water content of the soil near its present water content throughout the life of the project. The slightly cemented clays, silts and sands are particularly susceptible to a significant loss of strength and decrease in modulus upon wetting. The decrease could be on the order of fivefold for these soils. The other cemented soils may also be affected. Because of layering, the loss will not be uniform within a layer. The more calichefied materials will be little affected while those cemented by dry clay particles will undergo greater changes. Therefore, it is imperative that the soils surrounding the piers be maintained watertight. This could be accomplished by mounding and nominally compacting the drill cuttings around the pier to shed rainwater.

At present, the site grading of the heliostat field has not been evaluated in determining the optimum heliostat layout. Site grading requirements could be minimized by extending the heliostat foudations further above the ground surface at certain locations. This would compensate for variations in terrain and facilitate the installation of drainage swales and ditches. This, in effect, raises the elevation of the applied wind load with a resulting increase in the bending moment on the foundation. To study this case, a pier, 76 cm (30 in.) in diameter embedded 6.1 m (20 ft) is investigated for the Aeolian soil conditions case, with an extension 0.61 m (2 ft) above the ground. As shown in Table 3.1-2, for the operating condition of loading, the acceptance criteria are slightly exceeded. However, for the maximum condition, the deflection at the ground surface and the horizontal stress in the soil exceed the acceptance criteria by approximately 20 and 40 percent, respectively. This study demonstrates the sensitivity of the analysis to relatively minor changes in loading. Should future grading studies indicate that extension of the pier is desirable in small areas of the heliostat field, consideration should be given to deepening the embedment or increasing pile stiffness to reduce the deflection.

An extremely hard caliche layer was encountered in boring R-6 and observed in an arroyo south of this boring. The areal extent and thickness of this layer is not known. Should this layer prove to be extensive, with well defined limits, it is probable that the pier diameter and depth of embedment can be reduced for foundations in this material. These reductions are expected to be sufficient to offset the added drilling costs associated with this material.

Tilting and rotation of drilled piers is not only dependent upon the characteristics of the soil and the pier itself, but is also dependent upon construction procedures. Procedures must be developed which will minimize the disturbed zone surrounding the pier. Excessive zones of loose material should be removed before placement of concrete. The concrete must be vibrated for its full depth to provide protection of the reinforcement and filling of all indentations in the excavated wall. These considerations will minimize the tilting of the pier and, more importantly, will provide the required resistance to torsion loads.

Because of the cemented nature of most of the soil, temporary casing will not be required except near the surface where a short segment of casing may be advisable for stabilization. However, the clean gravelly sands found at depth beneath the eastern portion of the site must be cased or otherwise stabilized to prevent caving. Whatever method of stabilization is used, the procedures must be consistent with the requirements stated above to ensure intimate contact of concrete with the soil, minimization of loose materials, adequate concrete vibration and protection of the cemented soils from a significant rise in water content.

3.1.6 Geotechnical Investigations for Final Design

Since little information exists on the performance of piers subjected to torsional loads, a load test program should be undertaken as part of the final subsurface investigation. This will allow the results of the testing program to be incorporated into the final design. The test piers should be constructed in the same manner as anticipated for the production installations. In order for the tests to be respresentative of actual operating conditions, the piers should first be cycled to the maximum overturning condition from several directions to strain the soil, possibly causing permanent deformations near the surface. During this cycling operation, data can be obtained for analysis of piers for tilting without torsion which would be used to confirm the design methods used for this study. The torsion test may then be performed. A minimum of two piers with different embedment lengths, installed in an area representative of the Aeolian Case, should be tested. During this testing program, the soil moisture should simulate the conditions to be expected in the heliostat field after installation.

The subsurface investigation should also include a program of test borings and driven probes to determine the limits of the various strata encountered at the site, including the very hard caliche layer encountered in boring R-6. The driven probes, when correlated with borings, are considered a more cost effective approach for determination of significant interfaces between soft and stiff soils. This is of considerable importance for determination of areas where different embedment lengths are required for the piers.

In situ pressure meter testing of the soils should be performed as one means to determine the modulus for design of the piers. Laboratory testing of undisturbed samples should also be performed to obtain strength and elastic properties.

3.2 CENTRAL RECEIVER TOWER FOUNDATION

One test boring, R-3, was made in the area of the central receiver tower. Moist cemented clays and sands, 7.0 m (23 ft) thick, exist beneath a thin surficial mantle of medium to fine sand. It is believed that the moist condition is caused by leaking pipes in this area. This moisture reduces the soil strength and increases its compressibility. Therefore, excavation of these soils to the top of the underlying gravelly sand should be performed. Compacted sand and gravel backfill should then be placed to the bottom of the tower foundation. The allowable bearing capacity of this foundation is 0.383 MPa (8 kips per sq ft) which may be increased by 1/3 when analyzing for wind and seismic loadings.

SECTION 4
CONCLUSIONS AND RECOMMENDATIONS

The following list summarizes the key findings and recommendations presented in this report:

1. Preliminary analyses indicate that reinforced concrete pier foundations installed in an augered hole is the preferred foundation for the heliostats. The plant cost estimate should be based on this foundation type.

2. Based upon the results of the preliminary subsurface investigation, piers of 76 cm (30 in.) dia and 6.1 m (20 ft) embedment length are required for approximately 60 percent of the heliostats. Piers of 76 cm (30 in.) dia and 4.6 m (15 ft) embedment length are required for the remaining 40 percent.

3. An alternate foundation design, consisting of a 81 cm (32 in.) dia pipe, with a 0.635 cm (0.25 in.) wall thickness, installed and grouted into a 91 cm (36 in.) dia drilled hole, is also considered acceptable. However, the grout to steel bond strength should be investigated prior to proceeding with final design.

4. A driven steel pile foundation is feasible over a portion of the site where pile driving conditions are acceptable. These areas must be determined and soil-pile adhesion evaluated based upon field load tests, before a final design can be made for this alternate.

5. An economic comparison of alternates should be made prior to performing the subsurface investigation for final design.

6. In addition to the criteria for maximum tilt and rotation of the heliostat foundation of 0.0015 radians, soil stresses should be maintained below 35 percent of the ultimate capacity for both the overturning and torsional cases. This additional criteria will keep soil stresses within the elastic range, resulting in little or no permanent deformation, except near the ground surface.

7. The strength and modulus of the soil is highly dependent upon maintaining the soils at approximately their existing water content. Wetting of the soils will significantly decrease the strength and modulus; therefore, design should include provisions for drainage which will minimize the potential for an increase in moisture content.

8. Construction procedures should be established which do not result in excess zones of loose material and provide for adequate concrete vibration to assure protection of the reinforcement steel and intimate contact between concrete and soil. In addition, procedures should be developed to prevent a significant increase in water content of the cemented soils.

9. The geotechnical investigation for final design should include a full scale pier test program at the site to determine the behavior of the piers, particularly under torsional load conditions. This program

should be performed early in the design phase in order to allow incorporation of the results into the final design.

10. The central tower receiver foundation should be founded upon a compacted sand and gravel fill placed after excavation of unsuitable materials.

11. The central receiver should be designed for seismic loadings consistent with a maximum acceleration of 0.05g.

TABLE 3.1-1
PIER LOADING CONDITIONS

CONDITION I - MAXIMUM OVERTURNING	
Vertical Load	45,300 Newtons (10,190 lb)
Horizontal	31,900 Newtons (7,170 lb)
Moment	191,000 Nm (141,000 ft lb)

CONDITION II - MAXIMUM TORQUE	
Vertical Load	44,600 Newtons (10,020 lb)
Horizontal Load	24,600 Newtons (5,540 lb)
Moment	150,000 Nm (111,000 ft-lb)
Torque	29,800 Nm (22,000 ft-lb)

CONDITION III - OPERATING OVERTURNING	
Vertical Load	45,300 Newtons (10,190 lb)
Horizontal Load	9,300 Newtons (2,090 lb)
Moment	75,900 Nm (56,000 ft-lb)

CONDITION IV - OPERATING TORQUE	
Vertical Load	45,100 Newtons (10,140 lb)
Horizontal Load	7,200 Newtons (1,620 lb)
Moment	63,800 Nm (47,000 ft-lb)
Torque	8,500 Nm (6,300 ft-lb)

All loads for each condition of loading act concurrently.

TABLE 3

SUMMARY OF PIER STRESSES AND DEFLECTIOI RTURNING LOADING CONDITION

PIER DIAM CM (IN)		PIER LENGTH M (FT)	DEFLECTION AT GROUND SURFACE CM (IN.)	CHANGE IN SLOPE OF TOP OF PIER RADIANS	MAXIMUM SOIL STRESS PERCENT OF ULTIMATE	MAXIMUM CONCRETE STRESS M Pa(Psi)		LOADING CONDITION
SOIL CONDITION - AEOLIAN CASE								
122	(48)	4.6 (15)	1.17 (0.46)	0.0038	31	1.52	(220)	MAXIMUM
122	(48)	6.1 (20)	0.64 (0.25)	0.0018	18	1.59	(230)	MAXIMUM
91	(36)	4.6 (15)	1.17 (0.46)	0.0043	40	3.66	(530)	MAXIMUM
91	(36)	6.1 (20)	0.74 (0.29)	0.0026	25	3.93	(570)	MAXIMUM
76	(30)	4.6 (15)	1.27 (0.50)	0.0053	50	6.90	(1,000)	MAXIMUM
76	(30)	6.1 (20)	0.91 (0.36)	0.0040	35	7.04	(1,020)	MAXIMUM
76	(30)	6.1 (20)	0.33 (0.13)	0.0015	12	2.76	(400)	OPERATING
76	(30)	6.1 (20)	1.22 (0.48)	0.0048	49	7.52	(1,090)	MAXIMUM +
76	(30)	6.1 (20)	0.43 (0.17)	0.0017	17	2.90	(420)	OPERATING +
91*	(36)	6.1 (20)	0.89 (0.35)	0.0037	29	71.1	(10,300)	MAXIMUM
91*	(36)	6.1 (20)	0.30 (0.12)	0.0014	10	29.0	(4,200)	OPERATING
SOIL CONDITION - HARD CALICHE CASE								
76	(30)	4.6 (15)	0.76 (0.30)	0.0039	28	7.04	(1,020)	MAXIMUM
76	(30)	6.1 (20)	0.61 (0.24)	0.0034	22	7.11	(1,030)	MAXIMUM
61	(24)	4.6 (15)	1.17 (0.46)	0.0075	49	14.77	(2,140)	MAXIMUM
61	(24)	6.1 (20)	1.12 (0.44)	0.0073	46	14.77	(2,140)	MAXIMUM
76	(30)	4.6 (15)	0.28 (0.11)	0.0014	10	2.76	(400)	OPERATING
61	(24)	6.1 (20)	0.41 (0.16)	0.0028	17	5.80	(840)	OPERATING
SOIL CONDITION - CEMENTED CLAYS AND SANDS CASE								
76	(30)	4.6 (15)	0.69 (0.27)	0.0036	25	7.04	(1,020)	MAXIMUM
76	(30)	6.1 (20)	0.56 (0.22)	0.0032	20	7.04	(1,020)	MAXIMUM
76	(30)	4.6 (15)	0.25 (0.10)	0.0013	9	2.76	(400)	OPERATING

+ Maximum or Operating Loads Acting on Pier Extension 0.61 m (2 Ft) Above Ground

*Steel Shell (81.3 cm) (32 In.) Dia, 5.1 cm (2 In.) Annulus Grouted, Shell Not Filled with Concrete

TABLE 3.1-3

ACCEPTANCE CRITERIA

CONDITION I - MAXIMUM OVERTURNING

Maximum Deflection at Ground Surface	1.0 cm (0.4 in.)
Maximum Horizontal Stress on Soil	0.35 Ultimate Soil Capacity

CONDITION II - MAXIMUM TORQUE

Maximum Deflection at Ground Surface	1.0 cm (0.4 in.)
Maximum Horizontal Stress on Soil	0.35 Ultimate Soil Capacity
Maximum Pier Rotation	0.0015 radians
Maximum Torque Stress	0.35 Ultimate Soil Capacity

CONDITION III - OPERATING OVERTURNING

Maximum Tilting of Top of Pier	0.0015 radians

CONDITION IV - OPERATING TORQUE

Maximum Tilting of Top of Pier	0.0015 radians
Maximum Pier Rotation	0.0015 radians

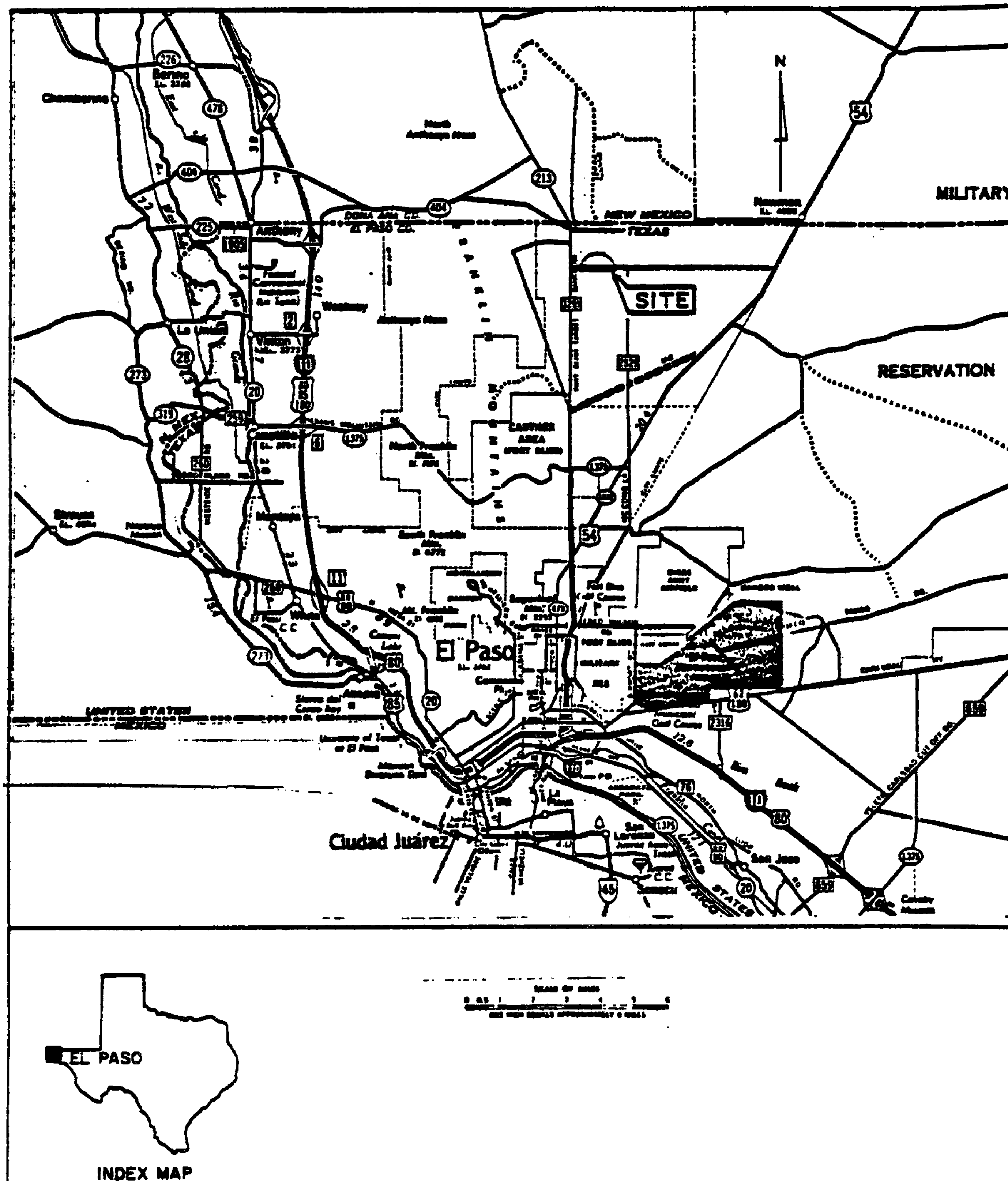
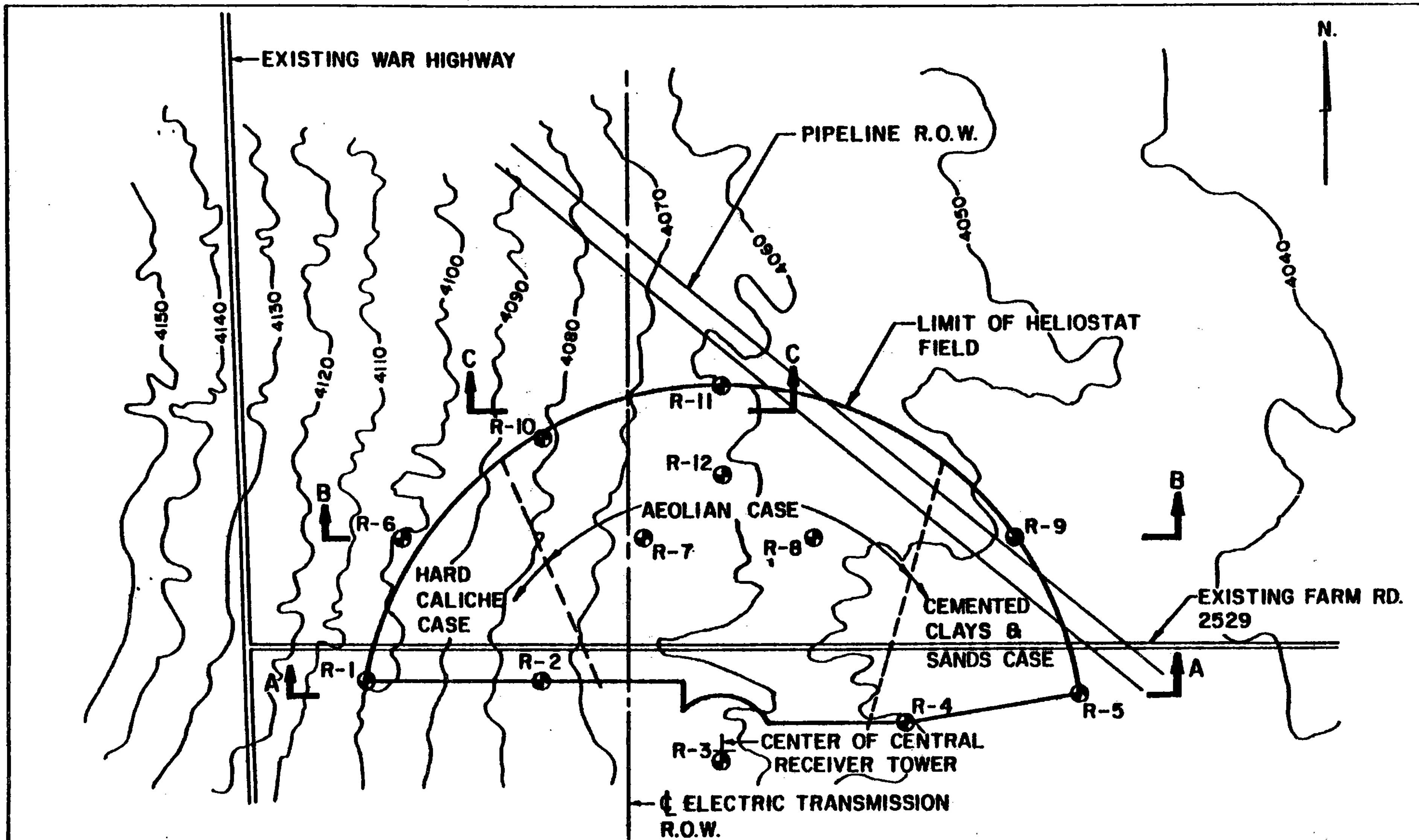


FIGURE 2.0-1
SITE LOCATION MAP
SOLAR REPOWERING
STONE & WEBSTER ENGINEERING CORP.
MARCH, 1983



0 1000 2000
SCALE-FEET

NOTES

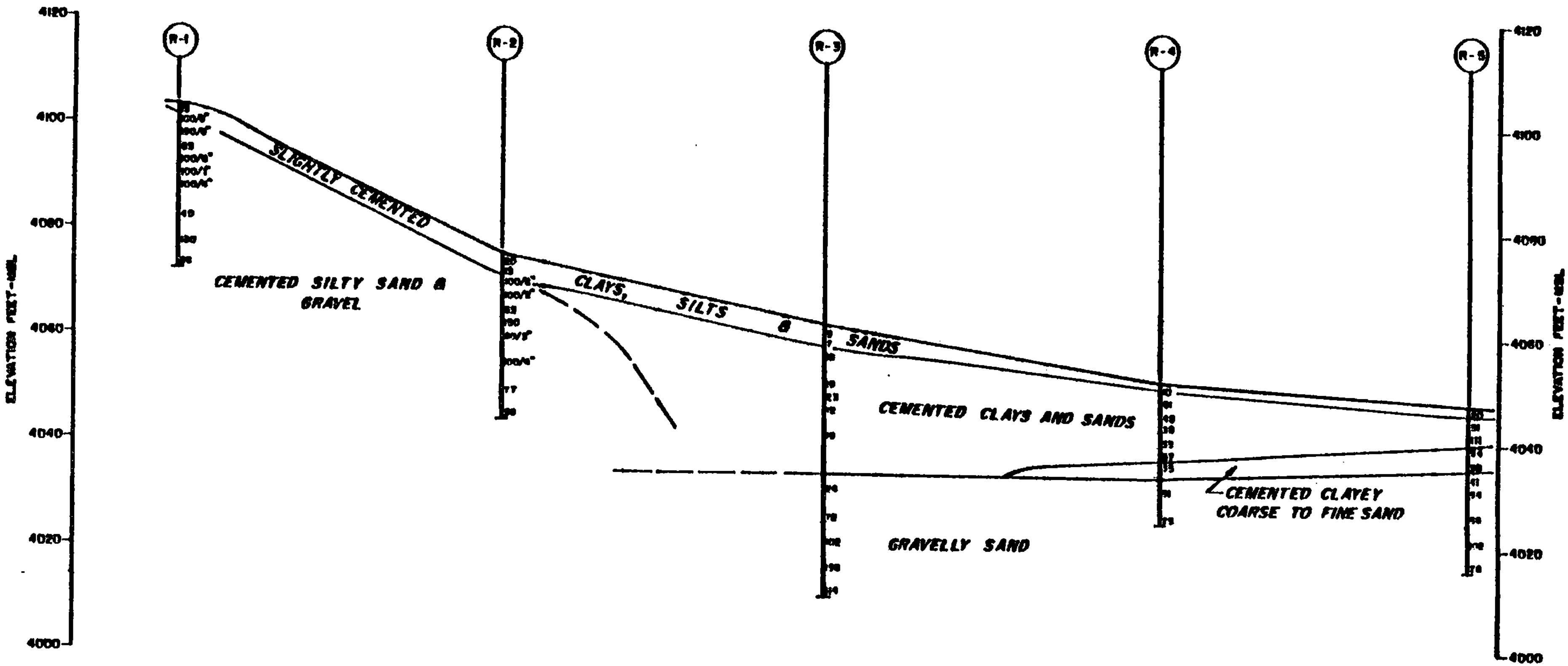
CONTOURS OBTAINED FROM USGS QUAD MAP
SEE FIGURES 2.2-1 THROUGH 2.2-3 FOR SUBSURFACE PROFILES.

LEGEND

—4050— CONTOURS OF ELEVATION ABOVE MEAN SEA LEVEL

R-2 TEST BORING

FIGURE 2.0-2
LOCATION PLAN
SOLAR REPOWERING
STONE & WEBSTER ENGINEERING CORP.
MARCH, 1983



LEGEND

(R-1) BORING SYMBOL

STANDARD PENETRATION TEST (140 LB. HAMMER DROPPING 30 IN.) BLOWS/FT.

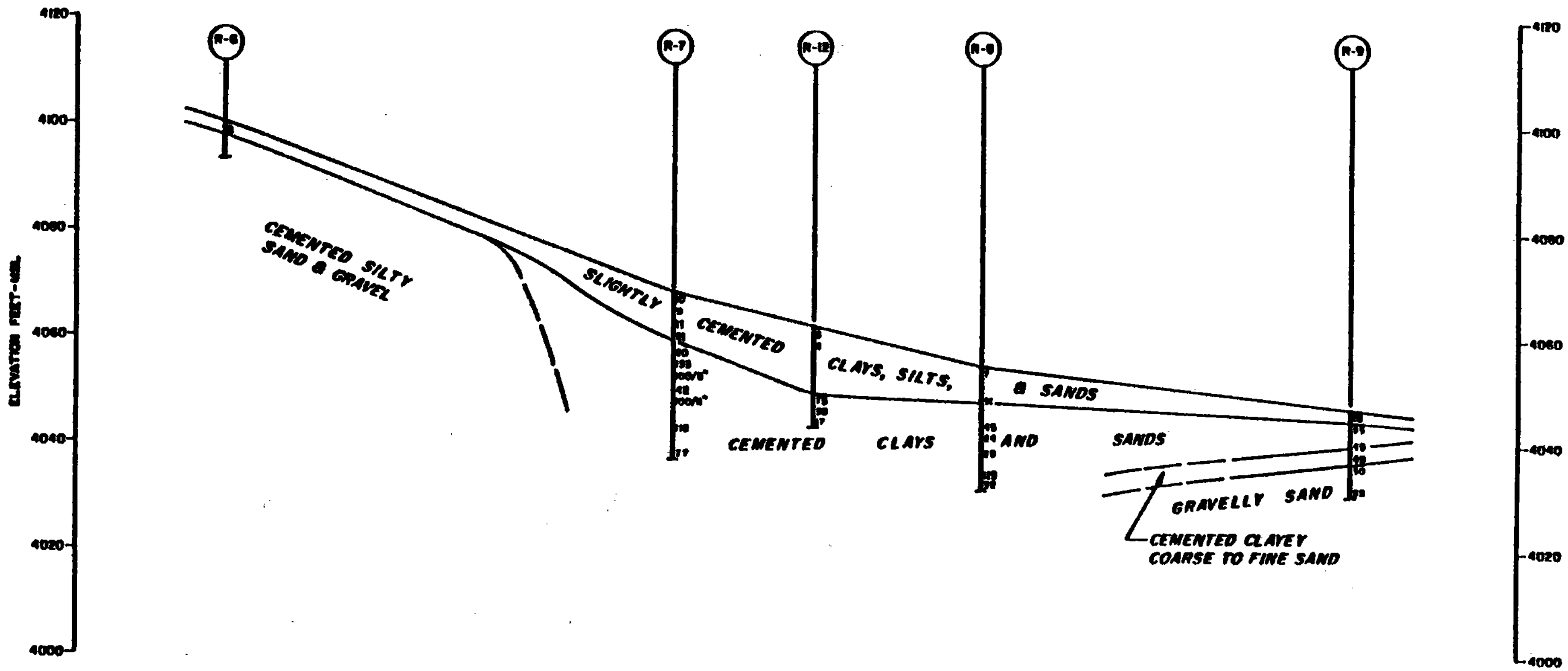
NOTES

SEE FIGURE 2.0-2 FOR LOCATION OF PROFILE

0 200 400 600 800 1000

SCALE-FEET

FIGURE 2.2-1
SUBSURFACE PROFILE A-A
SOLAR REPOWERING
STONE & WEBSTER ENGINEERING CORP.
MARCH, 1983



LEGEND

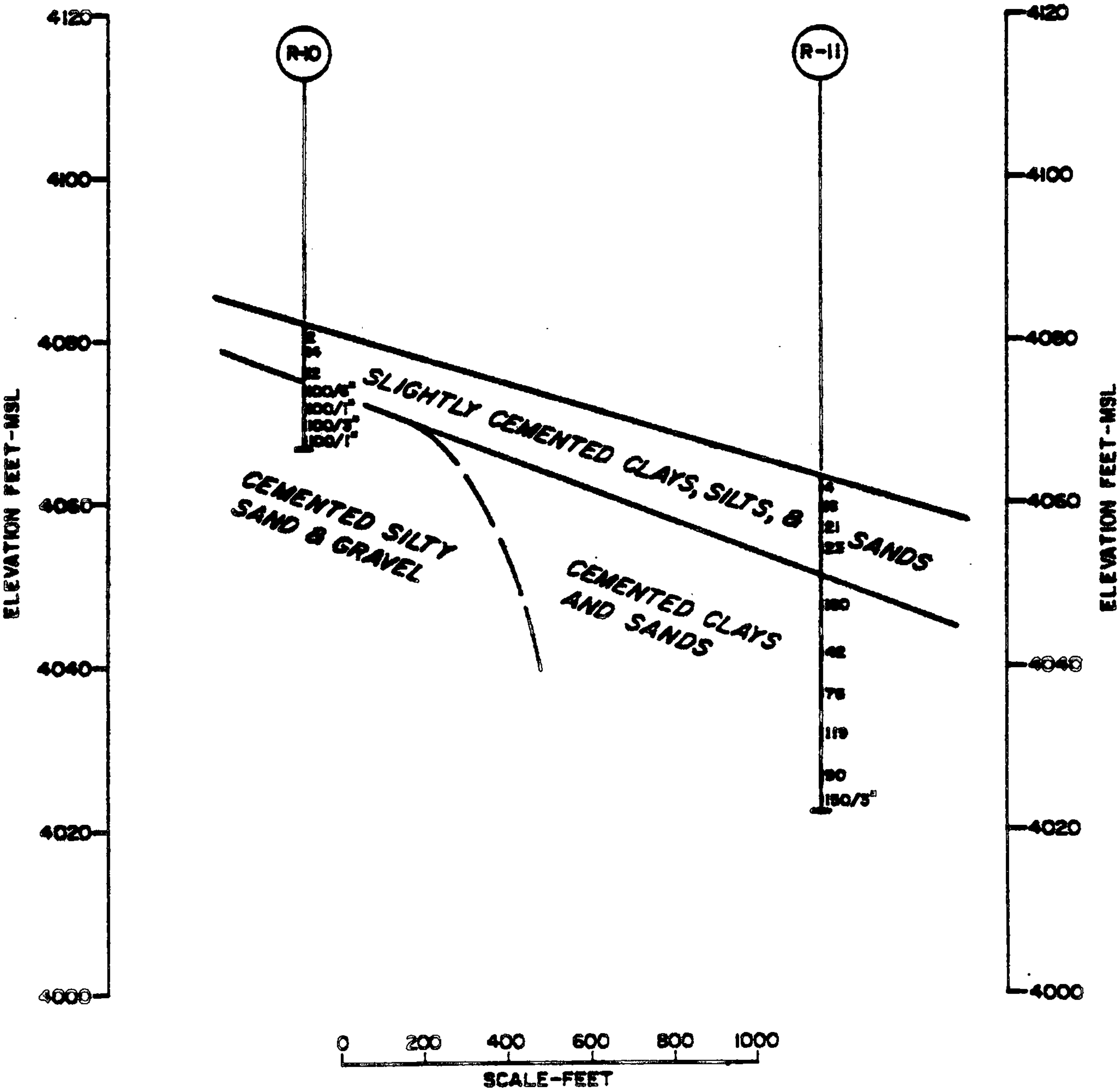
R-6 BORING SYMBOL

STANDARD PENETRATION TEST (140 LB. HAMMER DROPPING 30 IN) BLOWS/FT.

NOTES
SEE FIGURE 2.0-2 FOR LOCATION OF PROFILE

0 200 400 600 800 1000
SCALE-FEET

FIGURE 2.2-2
SUBSURFACE PROFILE B-B
SOLAR REPOWERING
STONE & WEBSTER ENGINEERING CORP.
MARCH, 1983



NOTES

SEE FIGURE 2.0-2 FOR LOCATION OF PROFILE

LEGEND

BORING SYMBOL

STANDARD PENETRATION TEST (140 LB. HAMMER DROPPING 30 IN.) BLOWS/FT.

FIGURE 2.2-3
SUBSURFACE PROFILE C-C
SOLAR REPOWERING
STONE & WEBSTER ENGINEERING CORP.
MARCH, 1983

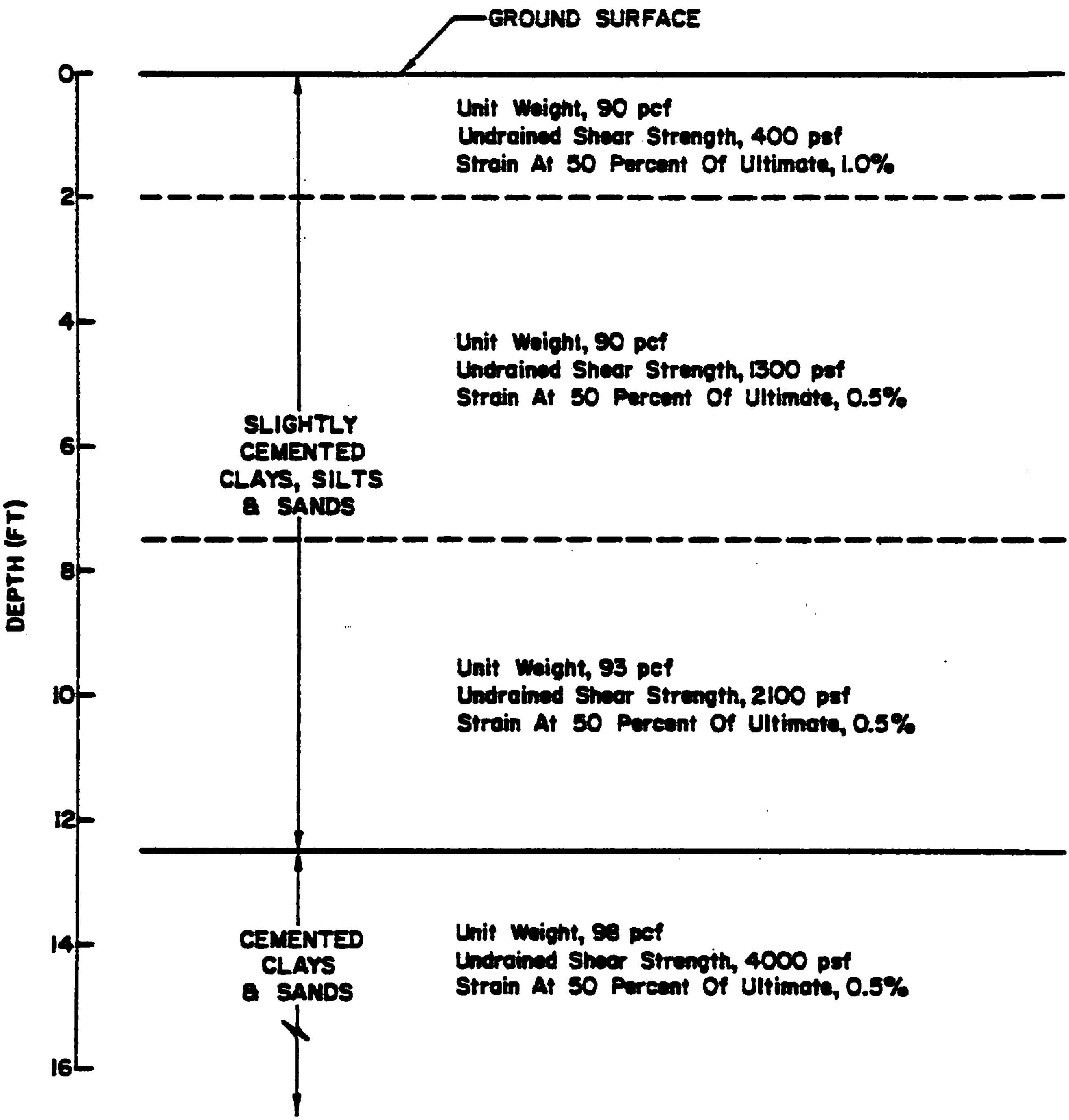


FIGURE 3.1-1
SOIL PARAMETERS
AEOLIAN CASE
SOLAR REPOWERING
STONE & WEBSTER ENGINEERING CORP.
MARCH, 1983

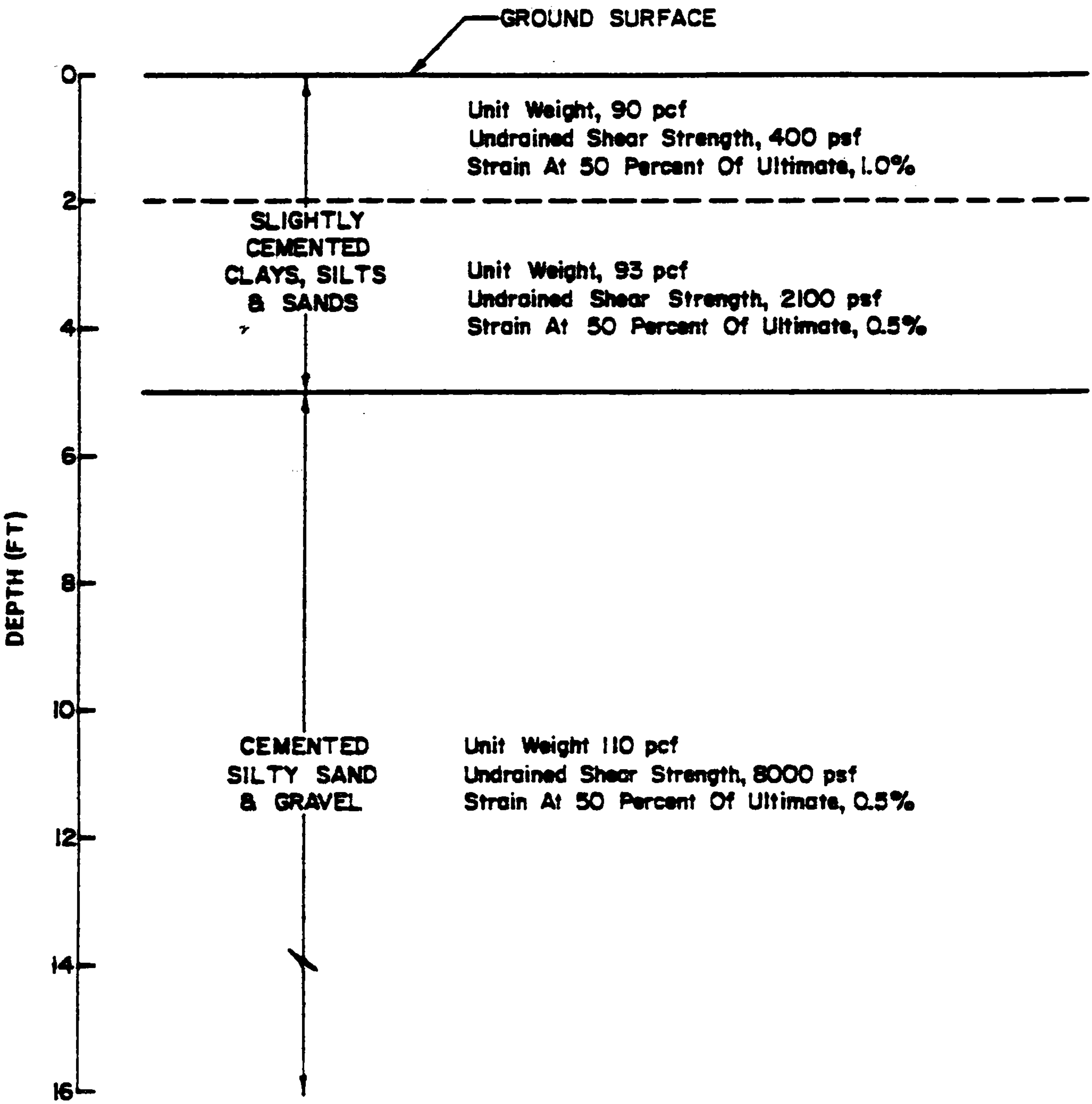


FIGURE 3.1-2
SOIL PARAMETERS
HARD CALICHE CASE
SOLAR REPOWERING
STONE & WEBSTER ENGINEERING CORP.
MARCH, 1983

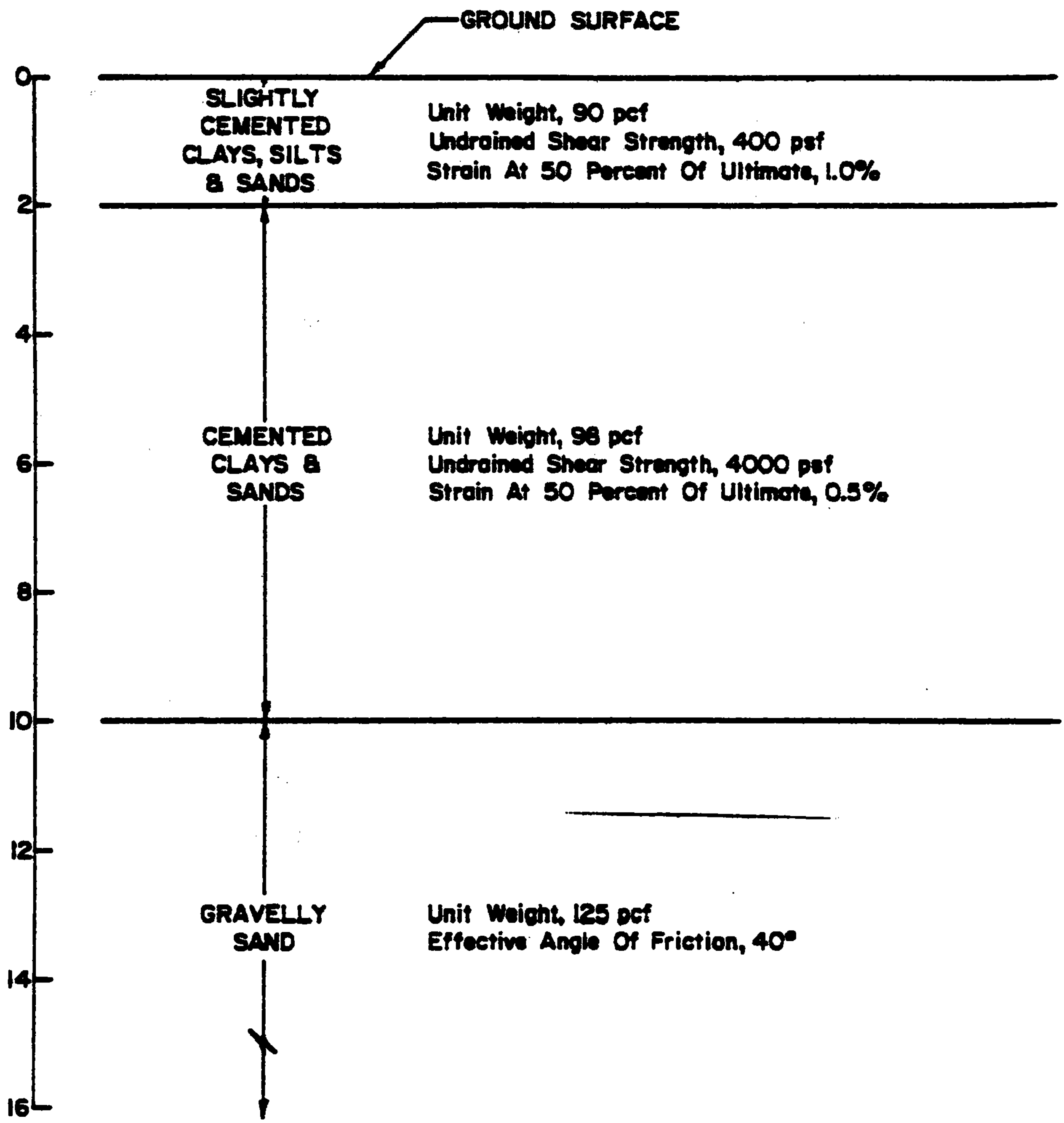


FIGURE 3.1-3
SOIL PARAMETERS CEMENTED CLAYS AND SANDS CASE
SOLAR REPOWERING
STONE & WEBSTER ENGINEERING CORP.
MARCH, 1983

REVIEW COMMENTS AND RESPONSES

ARCO Solar, Inc.
21011 Warner Center Lane
Mailing Address: Box 4400
Woodland Hills, California 91365
Telephone 213 700 7000
Telex 674838
TWX 910 494 2791

FILE COPY
SOLAR REPOWERING—
NEWMAN UNIT 1
J.O. 14380
JOB BOOK #T145 R2-5

T

NOTED APR 25 1983 R.W.KUHR

April 21, 1983

Mr. Reiner Kuhr
STONE AND WEBSTER ENGINEERING CO.
P.O. Box 2325
Boston, Mass. 02107

Dear Reiner:

I have reviewed your foundation report for the El Paso project. We are currently recommending a grouted pipe foundation where soil conditions permit because of the ease of installation and corresponding low cost. However, we have also designed a concrete pier foundation which we use for custom applications.

The cost differences per unit are not large, but need to be carefully considered for a field as large as that proposed for El Paso. We have experimented with driven pile foundations as a part of the second generation DOE contract, but have returned to drilled foundations because of the lack of torsional stiffness and the difficulty of driving foundations in some soil conditions.

In response to the question raised about the grout to steel bond, we have installed 138 units thus far with no sign of failure of the bond.

In summary, given the conclusions of the report, the soil conditions appear suitable for a steel pipe foundation, which we believe to have the lowest cost. However, if you would prefer a conrete pier, we have standard designs for that option as well.

Sincerely,

Dennis

Dennis N. Horgan

DNH:jd

cc: Floyd Blake

cc JE Brown EPE, R Gleason SEE
P Majeski 12

RESPONSE TO ARCO SOLAR, INC.

We agree with the ARCO Solar comment that the grouted pipe foundation for the heliostats may be somewhat more economical than the selected foundation. However, the details of design and construction and the strength of the grout to steel bond remain a concern to us. During final analysis and design, discussions will be held with the selected heliostat vendor to determine the preferred foundation type and requirements. At that time, a more detailed evaluation will be made.

ARCO's experience with driven pile foundations echos our attitude regarding this foundation type.

MCDONNELL DOUGLAS ASTRONAUTICS COMPANY

MCDONNELL DOUGLAS ASTRONAUTICS COMPANY
ENERGY PROGRAMS
5301 Bolsa Avenue, Huntington Beach, California 92647 (714) 896-3311 Telex: 678426

13 May 1983
A3-220-EP-JJD-83-0453

NOTED MAY 31 1983 P.Majeski

Stone & Webster Engineering Corporation
P. O. Box 2325
Boston, MA 02107

NOTED MAY 26 1983 R.W.KUHR

Attention: Mr. R. Kuhr

Dear Reiner:

Thank you for the opportunity to review the report. The report is clear, well written, and has sufficient data. However, the foundation size may be conservative.

Attached are comments offered with regard to foundation design criteria and analytical results.

I hope our comments will be of some help. Feel free to call if you have any questions.

Very truly yours,

J. J. Dietrich
J. J. Dietrich
Engineering
Solar Programs

FILE COPY
SOLAR REPOWERING
NEWMAN UNIT 1
J.O. 14330
JOB BOOK #R2-5

JJD:dmu

Attachment: As noted

cc R Baiquist / 12
P Majeski

MCDONNELL DOUGLAS CORPORATION

Attachment to:
A3-220-EP-JJD-83-0453

REVIEW OF PRELIMINARY FOUNDATION REPORT, NEWMAN UNIT 1, SOLAR REPOWRING FOR EL PASO ELECTRIC COMPANY

The following comments are offered with regard to foundation design criteria and analytical results.

1. The criteria for a maximum deflection at the ground surface of 0.4 inch and the maximum soil stress be kept below 0.35 x ultimate soil strength have not been used as criteria for previous heliostat foundation design. The effect on foundation size of using these criteria is not known. Both may be conservative and increase the size and cost of the foundation.

2. The analytical results that you obtained show significantly higher deflections than were calculated by analytical methods based on the pier testing at Barstow. For example, using the average soil properties (and the modified P-Y curves obtained from these properties) from the Barstow pier tests, an analysis was performed. For the loads of your Condition I, a pier of 30 inches in diameter and 11 foot depth gave a rotation at the top of the foundation of 1.33 mrad. This is approximately 37 percent of the 3.6 mrad rotation shown for the cemeted clays and sand case you analyzed. Your analysis was for a 20 foot pier depth and the soil properties for the cemented clays and sands case are in my opinion stiffer than Barstow soil. Perhaps the explanation lies in the analytical techniques used. It might be appropriate to try to correlate your analysis code with test results from Barstow or Albuquerque.

3. Based upon our previous experience and Solar 100 studies, we feel that the size of your heliostat foundation is conservative. A pier of 24 inches to 30 inches in diameter and a depth of 10 feet to 12 feet should be adequate for most soil conditions.

SWEC RESPONSE to McDONNELL DOUGLAS ASTRONAUTICS COMPANY

McDonnell Douglas expressed a concern that two of the acceptance criteria established for this study may be conservative and have resulted in selection of a conservative foundation design. These criteria are a limitation on the deflection at the ground surface and a restriction on the maximum allowable stress. A review of the data in the report indicates that neither of these criteria control the design. The limit on the maximum allowable deflection at the ground surface is rather arbitrary and will be re-evaluated during final design. However, maintaining a relatively low level of stress will minimize permanent deformation of the soil which is a concern. Additional testing is planned during final design to determine the stress at which permanent deflection is significant.

McDonnell Douglas checked our foundation design by utilizing the soil parameters from the Barstow load tests and the loads from our Condition I. This analysis indicated that an 11 ft pier would deflect significantly less than the 15 ft pier selected in our report. McDonnell Douglas expressed an opinion that the soils at Newman Station are stiffer than at Barstow which should result in less deflection. However, the test results to date at

Newman indicate considerably softer soils which result in deeper foundations than at Barstow. 1.27

Additional testing, including full scale testing, is planned 1.28
during the next subsurface investigation to determine the soil 1.29
parameters for final design.

APPENDIX O

APPENDIX O

CONCEPTUAL PIPE STRESS ANALYSIS REPORT

APPENDIX O

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APPENDIX O

1.0 OBJECTIVE

The overall objective of this effort was to develop an acceptable piping arrangement in the receiver tower with sufficient detail included for the project to prepare an appropriate construction estimate. Specific goals include the achievement of a minimum number of welded attachments to the piping and maximum use of standard commercial pipe support components. Additional goals were to minimize the number of attachments to the tower wall and to locate major structural steel in a fashion that would permit installation and construction of the piping within the tower in a top-to-bottom sequence.

2.0 PIPING ANALYZED

The following pipe lines were chosen for analysis within the tower.

- Main steam piping from the receiver to the existing piping interface
- Reheat supply steam piping from the receiver to the reheat heat exchanger
- Reheat return steam piping from the reheat heat exchanger to the receiver

Those lines constitute the major piping in the tower that will operate under the most severe conditions thereby requiring the greatest degree of analysis. The solar feedwater piping in the tower is smaller than the above piping and operates at much lower temperatures, therefore its analysis was deferred to the final design phase.

The following lines in the yard were reviewed for thermal flexibility and to establish support locations for pipe rack structures.

1. Cold reheat piping from the existing cold reheat piping interface to the reheat heat exchanger
2. Hot reheat piping from the reheat exchanger to the existing hot reheat piping interface

3.0 LOADING CONDITIONS ANALYZED

All systems were evaluated for pressure, thermal expansion, dead weight and hydrostatic testing weight in accordance with ANSI B31.1, Power Piping, 1980 Edition through 1981 summer addenda.

4.0 VENDOR INTERFACE

The piping evaluation included inputs from the solar receiver vendor to clarify certain concerns about the piping interface. In order to accomodate vendor imposed design requirements it was necessary to add additional constraints to receiver piping. B&W agreed to include these additional constraints and accepted the preliminary piping loads established at the receiver interface.

5.0 PIPE STRESS ANALYSIS

a. Main Steam Piping

The main steam piping was modeled from the receiver to the existing pipe interface location and includes a sufficient amount of the existing piping to establish realistic boundary condition for the pipe branch juncture. The piping beyond the tower is entirely spring hung solely to establish pipe rack structure locations in the yard. Final stress analysis may permit the use of rigid hangers in many of these locations. The model also assumes valve weights in order to establish realistic loads for pipe hangers, but does not include bypass piping or relief valves.

Additional work necessary for final design of this piping includes evaluation of all operating modes (solar-only, fossil-only, and combined solar/fossil operation), turbine trip steam hammer analysis, safety relief valve discharge analysis, wind loads on yard piping and localized detailed analysis on various piping components both existing and new.

Potential problem areas include existing pipe supports, additional pipe support requirements on existing piping, material and dimensional discontinuity stresses at the lateral branch intersection, and turbine and boiler nozzle loads. The potential of overstressed locations in the existing piping may occur due to the effects of the new valves and manifolding of the system in addition to upgrading the system analysis to the latest code requirements. It may become necessary to increase flexibility in the new piping to resolve this condition.

b. Reheat Supply and Return Steam Piping

The reheat steam piping is modeled from the receiver to the reheat heat exchanger following the same path as the main steam piping inside the tower.

Additional work necessary for final design of this piping includes determining the affects of the main steam turbine trip event on this piping, localized detailed analysis on branch components and evaluation of reheat heat exchanger nozzle loads.

Potential problem areas exist at the reheat heat exchanger nozzles since this piece of equipment has not yet been defined in detail. These problems may be averted by including piping loads requirements as part of the purchase specification.

c. Cold Reheat Piping

The cold reheat piping is modeled from the reheat heat exchanger to the existing cold reheat line interface and includes a sufficient amount of existing piping to ensure realistic interaction behavior at the branch junction. The piping model is entirely spring supported at locations common to the main steam supports in the yard assuming structural pipe racks will be in those locations. Final stress analysis may permit use of rigid hangers in many of these locations. Although the analysis is incomplete, the initial model does not appear to have any overstressed locations.

Additional work necessary for final design of this piping includes verification of the analysis done to date to confirm the piping configuration, determining the affects of the turbine trip event on this piping, wind loads on yard piping, localized detailed analysis on various piping components, both existing and new, and evaluation of all operating modes (as described for the main steam piping).

Potential problem areas are the same as those defined for the main steam system.

d. Hot Reheat Piping

The hot reheat piping is modeled in the same fashion as the cold reheat piping. This analysis is also incomplete. Contrary to the cold reheat results this work shows numerous points of overstress in both the new and existing piping. This indicates the need for additional piping to gain thermal flexibility (predominantly in the East/West direction).

This entire line must be designed to meet code requirements.

6.0 PIPE SUPPORTS

All new pipe supports have been located so that commercial pipe clamps and other standard components may be utilized eliminating the need for weldments to the piping and reducing special designs. Also, with the exception of those constraints where the piping exits the tower, all new pipe supports will be attached to structural steel members to be provided eliminating the majority of attachments to the concrete tower wall. There is no indication for the need of any special components except for pipe clamps for 13.5 in. OD pipe or for high temperature service thereby maximizing the use of automated pipe support design by the SWEPS computer program (formerly CADEPS).

7.0 GENERAL COMMENTS

The initial task of developing the receiver tower piping to an acceptable arrangement including all the objectives stated has been completed.

The effort was continued to the extent permitted to include the major yard piping. Although the analysis is incomplete, it was found that the hot reheat piping is overstressed in numerous locations and requires some additional rerouting.