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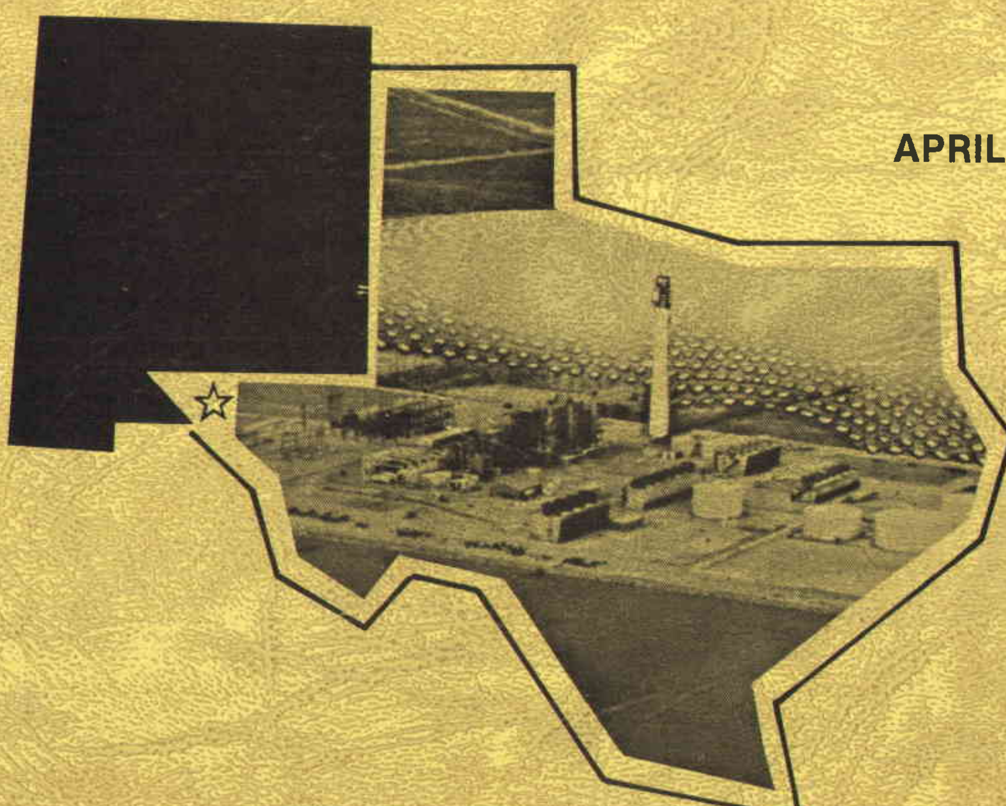
NEWMAN UNIT 1 ADVANCED SOLAR REPOWERING

FINAL REPORT

prepared for:
U.S. DEPARTMENT OF ENERGY



APRIL 1982

VOLUME 2

The Electric Company

EL PASO ELECTRIC COMPANY

FINAL REPORT

EL PASO ELECTRIC COMPANY
NEWMAN UNIT 1 SOLAR REPOWERING
ADVANCED CONCEPTUAL DESIGN

MAY 1982

VOLUME 2

Prepared for
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APPENDIX A

APPENDIX A

SELECTION OF PREFERRED SYSTEM

This section of the report summarizes the selection process resulting in the most practical system configuration for solar repowering Newman Unit 1. Section A.1 presents the characteristics of the alternative system configurations evaluated along with the rationale for selecting water/steam central receiver technology for this application. Section A.2 summarizes the results of the subsystem trade studies leading to the selection of specific solar components and the heliostat field geometry/tower location. The system trade study results are presented in Section A.3 including the rationale for selecting the preferred system configuration and the solar repowering percentage. Section A.4 summarizes the characteristics of this preferred system.

A.1 DESCRIPTION OF SYSTEM ALTERNATIVES

The EPE system has a total generating capacity of 1,033 MWe. Sufficient land is available to apply solar repowering to all EPE gas and oil-fired units, which represent 922 MWe or 89 percent of the total system. EPE selected Newman Unit 1 for the solar repowering demonstration program for the following reasons: (1) widespread market potential exists for solar repowering of reheat steam turbines similar to Newman Unit 1; (2) more than 14.2 km² (3,500 acres) of unencumbered, flat land is available adjacent to the Newman Station; (3) the remaining economic life of Newman Unit 1 favors dispatch of the solar repowered unit relative to the balance of the EPE system; (4) no apparent major institutional or environmental constraints exist; and (5) the operating history of the Newman Unit 1 turbine generator has demonstrated the capability to sustain cyclic operating conditions that could result from solar application.

Newman Unit 1 is an 82 MWe (net) tandem-compound, double-flow, reheat steam turbine built in 1960 for baseload duty using natural gas as the primary fuel (oil as a limited alternate fuel source). The Baseline Configuration for solar repowering Newman Unit 1 utilizes water/steam central receiver technology to provide main steam to the high pressure stage 10.1 MPa/538°C and reheat steam to the intermediate stage 2.9 MPa/538°C of the turbine generator. Fossil energy is used to supplement solar generated steam for intermittent cloudy day operation and for economic dispatch when solar energy is not available. This configuration was selected during the proposal preparation phase on the basis of providing an economically attractive system (estimated cost/value ratio of 0.75 - see Section A.3) with minimum technology risk for operation in 1985 with hardware procurement beginning approximately 4 years earlier.

The rationale for EPE's choice of water/steam as the working fluid in its solar repowering conceptual design is that water/steam systems are the simplest, lowest technology solution to solar repowering existing generating units and will, therefore, minimize technical risk.

Some of the advantages of water/steam usage as a working fluid are:

Water/steam is a technology familiar to the utility industry.

No special considerations are required in the boiler loop of a water/steam system.

Water/steam systems use proven materials in proven applications; the behavior and lifetimes of the materials are known under all expected operating conditions.

The question of technical risk will be an important one in early solar repowering demonstrations. The goal of a solar repowering demonstration will be to verify the technical viability of solar repowering concepts and developed hardware and it will serve as a necessary stepping stone to later large-scale stand-alone solar facilities. EPE believes that the solar repowering design developed for Newman Unit 1 minimizes technical risk since it incorporates proven, standard water/steam technology. This minimization of technical risk is important to the conservative electric utility industry.

Expanding on the technical risk issue, an unfavorable solar repowering demonstration may imply that solar is not an acceptable generation alternative for the 1990's. In EPE's opinion, the system chosen for an initial demonstration must have a high probability to successfully prove that it may be suitably constructed and operated, widely integrated into electric utility systems, and that it satisfies the national interest aspect of the overall solar research program.

Table A.1-1 has summarized the characteristics of the Baseline Configuration. The heliostat field was sized to provide a repowering fraction of 75 percent at an insolation level of 950 W/m² at 2 p.m. winter solstice. The heliostat field consisted of 4,735 heliostats (81.8 m² mirror area each) and provided 225 MWt to receivers mounted on a tower at an elevation of 170 m.

The principal solar/fossil interface between the existing Newman Unit 1 and the solar subsystem for the Baseline Configuration consists of (1) steam supply piping interface from the solar (both primary and reheat receivers) and the fossil steam generators, (2) feedwater piping interface supply to the solar and fossil steam generators, (3) control interface between the fossil and solar subsystems, and (4) power supply interface to the heliostat field, primary and reheat receivers, valves, and pumps.

Steam generated by the solar subsystem is mixed with the steam provided by the existing fossil steam generator prior to admission to the high pressure and intermediate stages of the turbine. Attemperation of the solar generated steam is the primary means of ensuring that temperatures are maintained within turbine design limits. However, if required, heat flux control may be accommodated within the heliostat field controls. Solar generated steam is used whenever available, with fossil steam generation replacing any steam flow reduction due to intermittent cloud cover and for economic dispatch.

The feedwater supplied to each steam generator matches the steam flow and pressure requirements of each unit by means of a coordinated control system. The control system of the existing unit will be modified and interfaced with the solar system by means of a master control system.

The heliostats employed in the collector field for design analyses are the Westinghouse Second Generation Heliostats, which have a glass reflective surface area of 81.8 m^2 (880 ft^2), an aspect ratio of 1.5:1, a weight of 3,725 kg (8,200 pounds). This heliostat concept was selected as representative of the class of configurations that will be available in 1985 for solar repowering applications.

The external central receiver concepts (primary and reheat) employed for the Baseline Configuration are based on the advanced water/steam pumped recirculation central receiver technology being developed by DOE. This boiler technology is well known throughout the utility industry. Primary receiver length is 27.8 m and the diameter is 18.4 m. Length of the reheat receiver is 5.0 m with a diameter of 18.4 m. This technology was selected over the once-through boiler technology (see Section A.2.2) on the basis of utilizing commercial/utility boiler design approaches, utilizing conventional boiler materials with known properties and demonstrated lifetimes, having the greatest potential to satisfy intermittent cloudy day operating requirements, minimizing maintenance, being available for a 1985 demonstration, and being more compatible with existing water treatment facilities and flow requirements of the existing recirculating boiler.

Table A.1-2 summarizes the cost estimate for the Baseline Configuration for the demonstration unit and for the Nth commercial unit. These cost estimates evolved during the performance of the subsystem trade studies and were continuously updated during the performance of the system configuration evaluations.

The data presented in Table A.1-2 were used for the EPE system network analysis (Section A.3) to select the overall site-specific system configuration (but not necessarily the geometries for specific subsystems such as the heliostat field) and are based on utilizing a separate heliostat/receiver/tower subsystem located adjacent to the turbine building for supplying the reheat steam conditions, as opposed to the field location established for the Baseline Configuration as indicated in Table A.1-1. It should be further noted that the Preferred Configuration selected from the trade studies provides a heliostat north field geometry with a single tower, located adjacent to the turbine building, supporting both the primary and reheat receivers. The selected configuration does not influence the relative comparisons of the system alternatives since each alternative can utilize the north field geometry; rather, the primary effect is a reduction in the magnitude of the cost/value ratios which will be presented in Section A.3.

Four alternate configurations (Table A.1-1) were developed to assess the performance, economic attractiveness, ease of operation and maintenance, and environmental and safety impact of the Baseline Configuration. The alternate configurations were: (1) a configuration incorporating thermal energy buffer storage subsystems (15 to 30 minute capacity) in the primary and reheat steam flow paths, (2) a configuration incorporating thermal energy buffer storage in only the primary steam flow path with an auxiliary fossil fueled boiler used to supplement the solar generated reheat steam, and (3) a configuration using solar energy (with the option of buffer storage, the fourth configuration) to provide primary steam to the high pressure stage and using fossil energy, through incorporation of an auxiliary boiler, to provide reheat steam conditions. Alternate 2 was eliminated from further consideration during the initial performance of the trade studies on the basis of being less cost effective than the other system configurations while not offering any benefit in terms of improved operations, reduced maintenance, or enhanced reliability. The cost estimates for the alternate configurations are presented in Section A.3.

TABLE A.1-1

SOLAR REPOWERED NEWMAN UNIT 1 CHARACTERISTICS
OF ALTERNATE SYSTEM CONFIGURATIONS

	Baseline Configuration	Alternate 1	Alternate 2	Alternate 3	Alternate 4
1. CONFIGURATION DESCRIPTION					
(a) Primary Steam	Solar	Solar	Solar	Solar	Solar
(b) Reheat Steam	Solar	Solar	Solar	Auxiliary Heater	Auxiliary Heater
(c) Buffer Storage	----	Primary/ Reheat	Primary	----	Primary
(d) Intermittent Cloudy Day	Fossil Boiler	Buffer Storage	Buffer Storage/ Auxiliary Heater	Fossil Boiler	Buffer Storage/ Auxiliary Heater
(e) Economic Dispatch	Fossil Boiler	Fossil Boiler	Fossil Boiler	Fossil Boiler	Fossil Boiler
2. REPOWERED UNIT CHARACTERISTICS					
(a) Unit Type	Reheat Steam Turbine	Reheat Steam Turbine	Reheat Steam Turbine	Reheat Steam Turbine	Reheat Steam Turbine
(b) Unit Rating	79.6 MWe	79.6 MWe	79.6 MWe	79.6 MWe	79.6 MWe
(c) Repowering Percentage	75%	75%	75%	64%	64%
(d) Collector Subsystem					
- Field Configuration	360	360	360	360	360
- Field Area	1.7 km	1.7 km	1.7 km	1.7 km	1.7 km
- Heliostat Area	387,100 m	387,100 m	387,100 m	329,000 m	329,000 m
- Number of Heliostats	4,735	4,735	4,735	4,025	4,025
(e) Primary Receiver					
- Type	External	External	External	External	External
- Size	18.4 m dia by 27.8 m long	18.4 m dia by 27.8 m long	18.4 m dia by 27.8 m long	18.4 m dia by 27.8 m long	18.4 m dia by 27.8 m long
- Heat Loss	25 MWht	25 MWht	25 MWht	25 MWht	25 MWht

TABLE A.1-1 (Cont)

	Baseline Configuration	Alternate 1	Alternate 2	Alternate 3	Alternate 4
(f) Reheat Receiver					
- Type	External	External	External	----	----
- Size	18.4 m dia by 5.0 m long	18.4 m dia by 5.0 m long	18.4 m dia by 5.0 m long	----	----
- Heat Loss	5 MWht	5 MWht	5 MWht	----	----
(g) Tower					
- Number	1	1	1	1	1
- Height	170 m	170 m	170 m	155 m	155 m
(h) EPGS					
- Gross Unit Efficiency	41.3	41.3	41.3	41.3	41.3
- Net Unit Efficiency (Solar/Fossil)	37.5/39.5	37.5/39.5	37.5/39.5	37.5/39.5	37.5/39.5
- Turbine	10.1 MPa/538°C/ 538°C	10.1 MPa/538°C/ 538°C	10.1 MPa/538°C/ 538°C	10.1 MPa/538°C/ 538°C	10.1 MPa/538°C/ 538°C
- Port Load	EPE Correction Curve	EPE Correction Curve	EPE Correction Curve	EPE Correction Curve	EPE Correction Curve
- Minimum Output	8 MWe	8 MWe	8 MWe	8 MWe	8 MWe
- Heat Rejection	Wet Cooling Tower	Wet Cooling Tower	Wet Cooling Tower	Wet Cooling Tower	Wet Cooling Tower
(i) Fossil Boiler					
- Type	Gas/Oil	Gas/Oil	Gas/Oil	Gas/Oil	Gas/Oil
- Rated Load Efficiency	84.4%	84.4%	84.4%	84.4%	84.4%
- Part Load	84.4%	84.4%	84.4%	84.4%	84.4%
- Startup Energy	106x10 kJ (100 MBtu)	106x10 kJ (100 MBtu)	106x10 kJ 100 MBtu)	106x10 kJ (100 MBtu)	106x10 kJ (100 MBtu)
- Bank Energy	15.8x10 kJ/startup (15 MBtu/startup)	----	----	15.8x10 kJ/Startup (15MBtu/startup)	----

TABLE A.1-1 (Cont)

	Baseline Configuration	Alternate 1	Alternate 2	Alternate 3	Alternate 4
- Minimum Standby	36%	----	----	36%	----
(j) Auxiliary Heater					
- Startup Energy/ Bank Energy	----	----	37.1x10 kJ (35 MBtu)/ 8x10 kJ (7.5 MBtu)	37.1x10 kJ (35 MBtu)/ 8x10 kJ (7.5 MBtu)	37.1x10 kJ (35 MBtu)/ 8x10 kJ (7.5 MBtu)
- Efficiency	----	----	85%	85%	85%
(k) Buffer Storage					
- Size	----	15 Min	15 Min	----	15 Min
- Efficiency	----	100%	100%	----	100%
- Turbine	----	482°C/482°C	----	----	482°C

TABLE A.1-2

SOLAR REPOWERED NEWMAN UNIT 1 BASELINE CONFIGURATION -
75% REPOWERING FRACTION (SOLAR REHEAT-SEPARATE TOWER)
REVISED COST ESTIMATES (1980 MILLIONS OF DOLLARS)

	Category	Demonstration Unit	Nth Unit
5100	Site Improvements	5.6	5.6
5200	Administrative Areas	1.0	1.0
5300	Collector Subsystem	86.0	22.2
5400	Receiver Subsystem	22.2	19.5
	Primary Receiver	(10.5)	(8.4)
	Reheat Receiver	(2.8)	(2.2)
	Primary Tower	(2.4)	(2.4)
	Reheat Tower	(1.0)	(1.0)
	Primary Piping	(4.5)	(4.5)
	Reheat Piping	(1.0)	(1.0)
5500	Master Control Subsystem	4.6	1.1
5600	Nonsolar Energy Subsystem	0.5	0.5
5700	Energy Storage Subsystem	0	0
5800	Electric Power Generating Subsystem	3.4	2.2
	Total Direct Cost	123.3	52.1
	Contingency and Spares (15 Percent)	18.5	7.8
	Indirect Costs (15 Percent)	18.5	7.8
	Total Capital Investment	160.3	67.7
	AFUDC (20 Percent)	32.0	13.5
	Total Capitalization	192.3	81.2
	Annual O&M (3 Percent)	5.8	2.4

A.2 SUBSYSTEM ANALYSIS RESULTS

This section presents the trade-off study results for the collector, receiver, and thermal energy buffer storage subsystems.

A.2.1 Collector Field Studies

The Baseline Configuration utilizes a 360° field of heliostats located north of Newman Unit 1. The primary and reheat receivers are located at the top of a single tower that is approximately 0.762 km (2,500 feet) from the turbine building. Trade studies were performed for the collector subsystem to assess the merits of (1) alternate field locations, (2) north field with the tower adjacent to the turbine building (requiring the relocation of Farm Road 2529) versus the 360° field of heliostats for both the primary and reheat receivers, (3) a separate heliostat field and tower for both the primary and reheat receivers, and (4) locating the reheat receiver at a station below the top of the primary tower. The results of these trade studies are summarized in Table A.2-1. The most cost effective configuration utilizes a north field of heliostats with a single tower housing both the primary and reheat receivers located near the turbine building. The centerline of the reheat receiver for this configuration is located at a station approximately 60 m below the centerline of the primary receiver.

This configuration results in an effective cost savings of approximately 12 million dollars when compared to the Baseline Configuration (including provision for relocating Farm to Market Road 2529 to the north). This cost saving is primarily realized from a reduction in the number of heliostats resulting from the north field and from savings in primary and reheat piping resulting from locating the tower near the turbine building.

A.2.2 Water/Steam Receiver Concepts

The Baseline Configuration defined in the proposal for solar repowering Newman Unit 1 uses first generation water/steam central receiver technology (once-through boiler) to provide main steam to the high pressure stage (10.1 MPa/538°C) and reheat steam to the intermediate stage (2.9 MPa/538°C) of the turbine generator. A trade study was performed to assess the merits of the application of improved water/steam receiver concepts (recirculation boilers) to repowering Newman Unit 1.

Four water/steam receiver concepts were reviewed for this application as follows:

Receiver Configuration	Primary Vendor Contacted
External/Once-Through Boiler	Rockwell International
External/Forced Recirculation Boiler/Screened Tube Concept	Babcock and Wilcox
External/Forced Recirculation Boiler	Combustion Engineering
Cavity/Natural Recirculation Boiler	Martin-Marietta/ Foster Wheeler

The first concept is currently being developed by DOE for the 10 MWe Central Receiver Pilot Plant under construction at Barstow, California. Full scale, single panel tests of this concept have been completed at the Central Receiver Test Facility in Albuquerque, New Mexico. DOE as part of the Advanced Water/Steam Receiver Program is studying the latter three concepts. The Phase 1 conceptual design studies were completed for each concept in early 1980. A series of meetings was held with each of the vendors and data packages were provided for use in the performance of the EPE Program. Note that the vendors indicated a willingness to respond to a future receiver procurement specification to be issued as part of the design phase of the demonstration program even though the configuration may differ from their recommended designs. This trade study is therefore concerned only with selecting a receiver concept. A vendor will be competitively selected in a subsequent program phase.

Table A.2-2 presents a summary of key design, performance, and cost characteristics for each of these concepts. These data were developed on the basis of providing a primary receiver thermal power output of 141 MW which is equivalent to a 75 percent repowering fraction.

The alternate concepts were compared on the basis of the following criteria: performance, costs, development risk, operating and maintenance, reliability, safety, and new technology demonstration. The characteristics of each of the receiver concepts relative to these criteria are also summarized in Table A.2-2. The water/steam recirculation boiler technology was selected for this repowering application over the once-through boiler technology on the basis of utilizing proven commercial/utility boiler design approaches, utilizing conventional boiler materials with known properties and demonstrated lifetimes, having the greatest potential to satisfy intermittent cloudy day operating requirements, minimizing maintenance, more closely matching existing water treatment facilities capabilities, and being available for a 1985 demonstration. The external, pumped recirculation receiver was preferred to the cavity, natural recirculation receiver on the basis of lowest capital cost, comparable performance and reliability, a delivery schedule more compatible with a 1985 demonstration, less susceptibility to flow stagnation and burnout in low heat flux regions, and ease of replacement, if necessary, of the superheater tubes. The comparison was close enough, however, that EPE would not object to substitution of an internal cavity receiver if it was desirable to demonstrate this concept.

A.2.3 Thermal Energy Buffer Storage (TES) Concepts

Four thermal energy buffer storage (TES) concepts were evaluated to determine if the inclusion of buffer storage as part of the solar repowering subsystem is cost effective for this application. A buffer storage system is not technically required to permit unit operation during intermittent cloudy days since the existing fossil boiler can be fired at a rate (10-20 percent steam flow/minute) sufficient to offset most of the anticipated insolation transients. Three of the TES concepts utilize low vapor pressure storage media (HITEC).

In the first concept, the charging steam from the receiver is first desuperheated, condensed, and subcooled, which in turn heats the storage media liquid. In this single-set sensible heat storage system, the maximum achievable storage temperature is less than 371°C (700°F), therefore, the maximum steam temperature that can be generated by this TES system is less than 343°C (650°F).

The second TES concept uses a two-set sensible heat storage system. In this concept, the superheated charging steam supplies energy to a high temperature sensible heat storage set, while the latent heat and subcooling of the charging steam are utilized in heating a low temperature sensible heat storage set. The high temperature storage set has a top storage temperature of 510°C (950°F), sufficient to produce superheat steam 482°C at a pressure level compatible with the intermediate pressure (IP) turbine.

The third TES concept stores only the energy from the superheat of the charging steam, while the saturated steam is then directed to the feedwater heaters. This concept can provide primary and reheat steam at a temperature of 482°C (900°F).

The first concept was discarded on the basis of not having the temperature capability to buffer the high pressure stage transients. Due to the increased number of heat exchangers and storage vessels, the second concept was judged to be more costly than the third approach. The third concept was developed in further detail to establish a capital cost estimate.

Figure A.2-1 shows a flow schematic for this low vapor pressure storage media (HITEC) concept. The achievable heat rate is about 9,411 kJ/kWh (8,920 Btu/kWh) with a net electrical output of 73

MWe; the reduced output resulting from the reduction in steam temperature to 482°C. This concept also has a very limited (slow) charging rate. For example, if only the first point feedwater heater is supplied by the saturated steam from the charging circuit, it would require 4 hours to fully charge the TES (15 minutes to discharge). The capital cost estimate for this concept is approximately 6 million dollars (as indicated on Figure 3.2-1).

In the low vapor pressure storage media concept, the cost of the heat exchangers comprises the greater part of the total TES cost. Therefore, the fourth concept studied minimizes heat exchanger components in an effort to reduce cost. A variable pressure accumulator (VPA) is utilized to minimize the heat transfer surface area. The flow schematic of the TES system is shown in Figure A.2-2. In charging this system, the superheat of the charging steam is transferred to the high temperature sensible heat set, and the latent heat is transferred to hot water. Assuming the VPA fully-charged pressure is 10.3 MPa (1,500 psia) and the fully-discharged pressure is 3.4 MPa (500 psia), then when fully discharged, 90 percent of the accumulator volume is filled with saturated high temperature water at 313°C (596°F), with a cushion of saturated steam (at the same temperature and pressure) above it. In the discharge mode, steam is drawn from the top as the pressure in the steam cushion decreases; some of the water in the vessel flashes to steam. The steam from the accumulator is superheated to 482°C (900°F) in the single heat exchanger and directed to the IP turbine. As flashing to steam is continued, the water decreases in temperature, the saturation pressure decreases, and the water level is lowered by the amount of water converted to steam. In the discharged state, the accumulator water volume is 60 percent. In this concept, all evaporation and steam generation are internal to the VPA. The heat rate is about 11,078 kJ/kWh (10,500 Btu/kWh) and produced a net electrical power of 54 MWe. The capital cost estimate for this concept is approximately 5 million dollars as shown in Figure A-2; the major cost item is the accumulator.

The value of thermal energy buffer storage for this solar repowering application was established by dispatching the Baseline Configuration and Alternate 1 (Table A.1-1) on the EPE system (see Section A.3). This analysis indicated that the capital cost of the thermal energy buffer storage subsystem for providing primary and reheat steam must be less than $1.5 to $2.5 million to be cost effective for solar repowering Newman Unit 1; otherwise, it is more cost effective to utilize the existing fossil boiler to supplement the solar generated steam for operation of the unit during cloudy days, provided the boiler can accommodate such supplemental operation. Since none of the concepts evaluated have projected capital costs close to this range and since the boiler itself does not present any unreasonable operational constraints, the inclusion of a thermal

TABLE A.2-1

COLLECTOR SUBSYSTEM - TRADE STUDY RESULTS

	Baseline Configuration	Separate 360° Reheat Field	Separate N-Reheat Field	North Field
1. Configuration Description				
Solar Repowering Fraction (%)	75	75	75	75
Primary/Reheat Field	360°/360°	360°/360°	360°/North	160° N/160° N
No. of Towers	1	2	2	1
Primary/Reheat C/L Height (m)	170/155	159/66	159/132	190/132
Outermost Heliostat Radius (m)	820	770	770	1100
2. Primary Receiver				
Type	External	External	External	External
Size (m)	16.5 dia x 24.5 long	15.0 dia x 27.0 long	15.0 dia x 27.0 long	15.0 dia x 20.0 long
3. Reheat Receiver				
Type	External	External	External	External
Size (m)	16.5 dia x 5.0 long	9.9 dia x 11.5 long	16.5 dia x 16.5 long	15.0 dia x 20.0 long
4. No. of Heliostats				
Primary	4023	4048	4048	3790
Reheat	712	702	605	615
5. Thermal Power (2 PM Winter Solstice)				
Primary (MWt)	191	193	193	192
Reheat (MWt)	34	34	33	33
6. Demonstration Unit Cost (1980 M$)				
Collector Subsystem	86.0	86.3	84.5	80.0
Receiver Subsystem				
Primary Receiver	10.5	10.5	10.5	10.5
Primary Tower	2.9	2.6	2.6	3.1
Primary Piping	3.7	3.7	3.7	1.3
Reheat Receiver	2.8	2.8	2.8	2.8
Reheat Tower	---	1.0	2.2	---
Reheat Piping	4.0	2.5	1.0	1.8
TOTAL	109.9	109.4	107.3	99.5

TABLE A.2-2

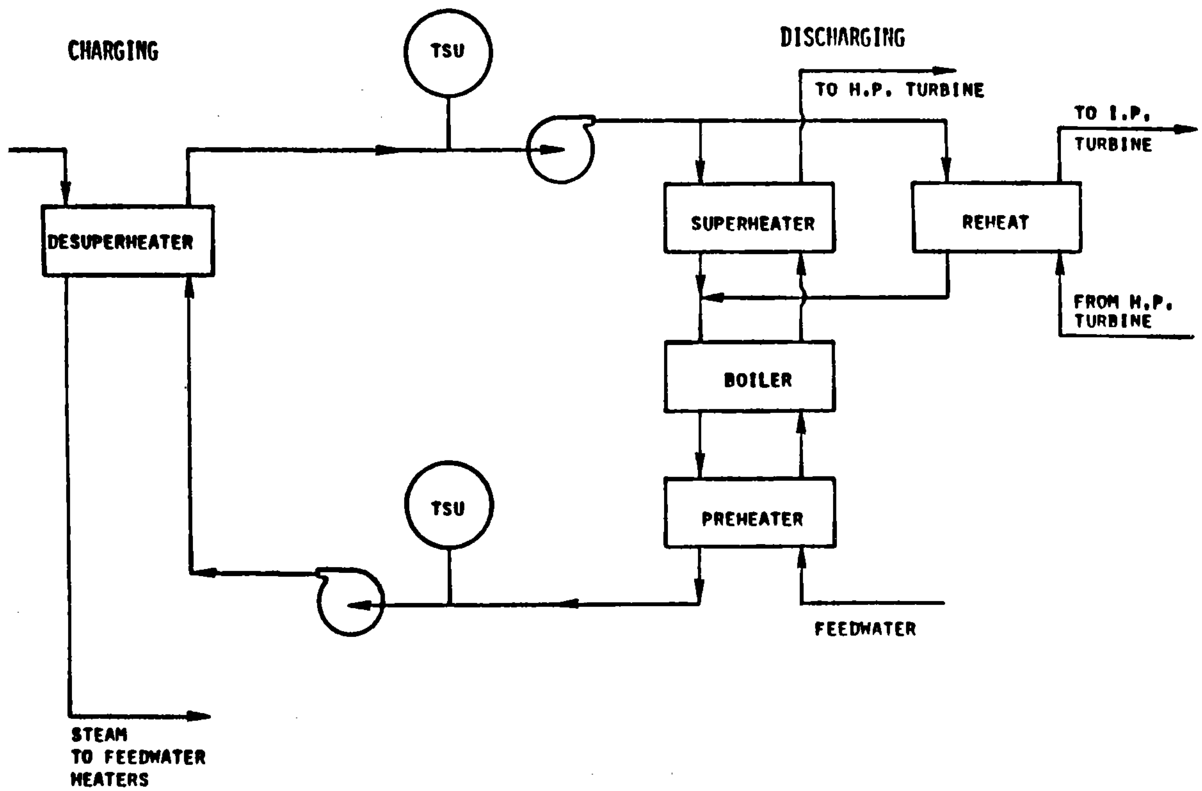
CHARACTERISTICS OF ALTERNATE RECEIVER CONCEPTS

Criteria	Receiver Alternatives: Cavity Configuration Natural Recirculation Boiler	External Configuration Forced Recirculation Boiler Screened Tube Concept	External Configuration One Pass Once-Through Steam Generator	External Configuration Forced Recirculation Boiler High Temperature Concept
Performance				
Outlet Temperature	516°C (Scalable to 555°C)	516°C (Scalable to 555°C)	516°C (Scalable to 555°C)	555°C (Scalable to 594°C)
Outlet Power	141 MW	141 MW	141 MW	141 MW
Efficiency	96 - 89%	85 - 87%	84 - 86%	85 - 87%
Capital Costs	11.5M $	10.5M $	13.4M $	7.9M $
Development Risk				
Time Frame (from Contract Date through Checkout)	5 Years	3.5 Years	3.5 Years	4 Years
Risk	Low risk design with well established boiler technology, conservative design approach, and less risk associated with coating degradation.	Low risk design with well established boiler technology, conservative design approach, and small risk associated with coating degradation due to screened tubes.	High risk design with boiler technology that requires verificaion to handle dynamic variations. Design less conservative in terms of tube size and control systems.	Intermediate risk with well established boiler technology; however, less conservative design approach and greater risk associated with coating degradation.
Operating Maintenance	Conventional boiler and simple control systems with no pumping. Relatively slow transient response. Cavity may reduce impact of cloud cover transients. Replacement of panels is more difficult for cavity than external configuration.	Conventional boiler with forced pumping and control system. Ribbed tube design enhances stability. Continuous pumping power is required. Panel concept enhances replacement time.	Most complex system with complex control and pumping system to react to transients. Small orificed tubes may be susceptible to plugging.	Conventional boiler with forced pumping and control system. Continuous pumping power is required. Superheater exposed to larger heat flux gradients with orificing required to match flow with gradient.

TABLE A.2-2 (Cont)

Criteria	Receiver Alternatives: Cavity Configuration Natural Recirculation Boiler	External Configuration Forced Recirculation Boiler Screened Tube Concept	External Configuration One Pass Once-Through Steam Generator	External Configuration Forced Recirculation Boiler High Temperature Concept
Reliability	Highest reliability due to simplest design with passive pumping and control. Natural circulation may be susceptible to reverse or stagnant flow leading to a burnout in low heat flux area.	Intermediate reliability with forced pumping and control system for recirculating boiler. Screen tube design reduces and flattens superheater heat flux and enhances lifetime.	Lowest reliability due to complex orificing. Pumping and flow control system for once-through boiler. Most susceptible to DNB.	Intermediate reliability with forced pumping and control system for recirculating boiler. Higher quality of 0.5 makes tube design more susceptible to DNB, although ribbed tube concept may offset problem.
Safety Factors	Exposure due to potential stagnation in low heat flux zones.	Steam exposure due to failure in recirculating pump and control system are failures peculiar to forced circulation system.	Greatest potential for failure - most complex pump and control system add failure modes leading to steam exposure.	Steam exposure due to failure in recirculating pump and control system are failures peculiar to forced circulation system.
New Technology Demonstration	First system demonstration of cavity concept. Natural recirculation boiler in solar application.	Forced recirculation boiler in solar application.	Repeat of Barstow demonstration.	Forced recirculation boiler in solar application.

FLOW SCHEMATIC

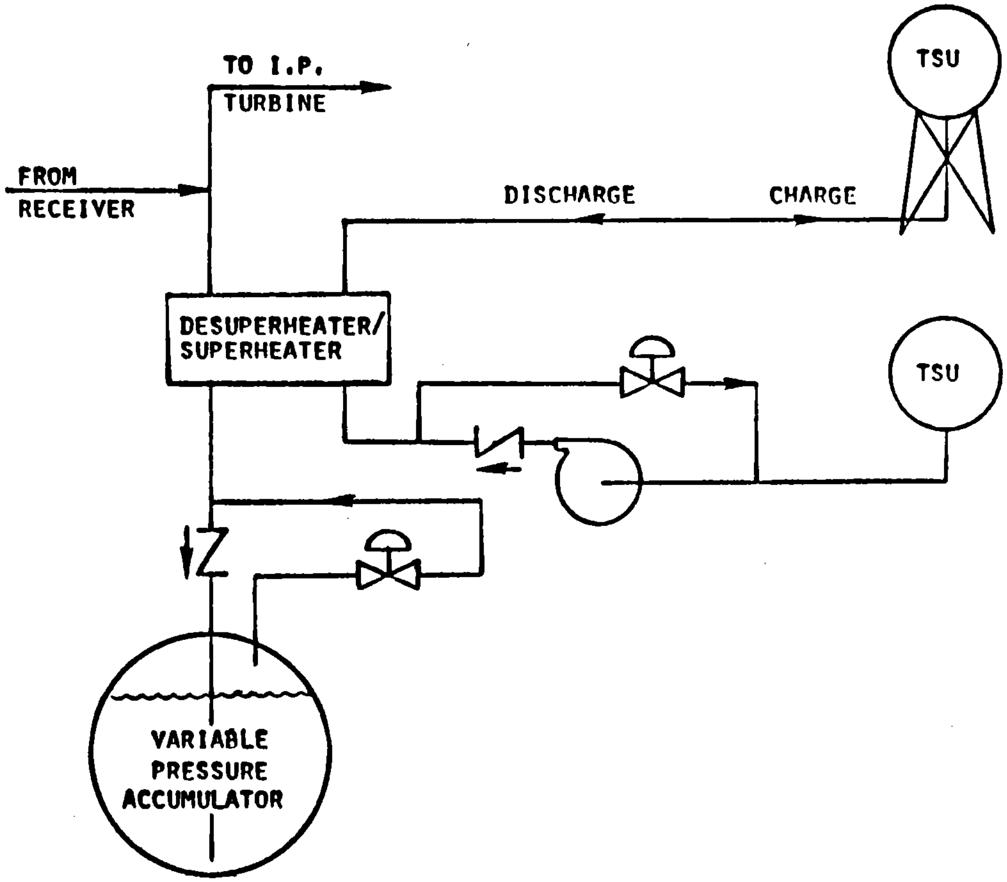


COST ESTIMATE (1980 M $)

Desuperheater	1.19
Boiler	1.88
Superheater	1.02
Reheater	0.79
High Temperature Storage Tank	0.22
Low Temperature Storage Tank	0.16
Hitec	0.61
Hitec Pumps	0.12
Piping	0.03
Total	6.02

FIGURE A.2-1
LOW VAPOR PRESSURE STORAGE MEDIA CONCEPT USING DESUPERHEAT TO CHARGE SYSTEM

FLOW SCHEMATIC



COST ESTIMATE (1980 M $)

Variable Pressure Accumulator	3.94
High temperature storage tank	0.13
Low temperature storage tank	0.09
Hitec	0.06
Hitec Pump	0.02
Condenser/superheater	0.76
Piping	0.02
Total	5.01

FIGURE A.2-2
VARIABLE PRESSURE ACCUMULATOR
HEAT STORAGE CONCEPT

A.3 SYSTEM ANALYSIS RESULTS

The integration of solar repowered units into electric utility systems raises a number of questions as to the value of the repowered units, problems they might introduce, and requirements that should be placed upon them. In addition to technical feasibility, economic and reliability impacts are a major concern to EPE. This involves the cost of repowering, the quantity of fossil fuels displaced, a potential capacity credit for unit life extension, and the reliability of the solar repowered unit.

A cost/value analysis was performed to evaluate solar repowering of Newman Unit 1 on the EPE system. The analysis was performed using the methodology and computer programs developed by Westinghouse as part of EPRI Contract RP-648. The following general assumptions were made for analyses:

- 1985 initial year of operation
- EPE planned system modeled
- Solmet weather data for El Paso/typical meteorological year
- Solar plant model developed as part of EPRI RP-648
- Newman Unit 1 operated to maximize the benefit of solar repowering
- Newman Unit 1 operated from either solar, fossil, or a combination of solar and fossil modes
- Day's insolation profile and load demand known in advance
- Thirty-year operating life

The characteristics of the planned (1985) EPE system were modeled in detail. Hourly load demand, generation unit descriptions, and conventional fuel constraints were considered. Eighty-nine percent of the present EPE system generation capacity is composed of gas- and oil-fired units; however, by 1985 this percentage is expected to be reduced to approximately 50 percent by the planned addition of nuclear baseload units. The gas- and oil-fired units will be operated primarily on gas between 1985 and 1990. Because of the existing Federal regulations restricting the use of natural gas as a utility fuel after 1990, operation will be mostly on oil beyond this date. For the analysis it has been assumed that all gas- and oil-fired units operate on gas from 1985 to 1990 and on oil beyond 1990.

Two economic scenarios were defined by EPE for use in the analysis (Table A.3-1). Except for the escalation rate for gas and oil, the scenarios are identical. The A scenario assumes an 8 percent escalation rate and the B scenario a 12 percent rate.

The solar repowered Newman Unit 1 is dispatched on the EPE system to maximize the benefit derived from solar repowering. The ability to operate on fossil fuel has been maintained in the repowered unit. The unit can operate and produce rated power using steam generated from the solar receiver (primary and reheat), the fossil boiler, or a combination of solar produced steam and fossil during cloudy days. A cloudy day for the purpose of the cost/value analysis is defined as a day during which sky cover exceeds 0.5 for 2 or more consecutive hours.

In general, any day in which sky cover exceeds 0.3 can be classified as cloudy. As part of EPRI Contract RP-648-1, a comparison between insolation transients (for various degradation levels and time periods) and sky cover for a range of 0.3 to 0.7 for Albuquerque, New Mexico indicated that a correlation between these variables was not possible from the existing data base. For example, a sky cover of 0.3 on the data records may correspond with more insolation transients of greater magnitude and longer duration than a sky cover of 0.7 and vice versa. A sky cover value of 0.5 was selected until improved weather records and data on sky cover versus insolation transients are available for the El Paso region, or until planned pilot plant experiments for solar thermal electric plants produce data indicating a correlation between sky cover and plant operating capabilities on "solar only."

The operation scenario assumed for the fossil boiler is important in determining the economic benefit of solar repowering. In order for the existing Newman Unit 1 boiler to be capable of responding to insolation variations during periods of intermittent cloud cover and to produce 538°C (1,000°F) steam from both the primary and reheat sections, the boiler must be operating at a minimum of 36 percent of rated thermal output. The boiler response time to achieve 100 percent rated output (steam flow) from this operating level is less than 10 minutes.

Two boiler operating scenarios were evaluated for the repowered unit:

<u>Fossil Boiler Is Operated Only on Cloudy Days</u>

The fossil boiler is assumed to be started from a cold condition for each cloudy day and also on those days it is economical to dispatch the unit on fossil fuel relative to the balance of the EPE system. A 6-hour startup period is typical for the boiler in order to reach 36 percent of rated load. The fossil boiler is maintained in this minimum load condition (36 percent of rated load) throughout the cloudy day. The boiler firing rate is increased if it is economical to supplement the steam produced by the solar receiver (when compared to generating the equivalent power using units on the balance of the EPE system) or when it is required to overcome cloud-produced insolation transients in order to maintain rated steam conditions at the turbine inlet. With this scenario, the fossil boiler is shut down at the end of each cloudy day unless economic dispatch considerations would continue its use.

Fossil Boiler Is Operated Daily

This second scenario assumes that the fossil boiler is only shut down to a cold condition for routine or forced maintenance; three cold starts are assumed throughout the year. During cloudy days when the plant is operating from solar generated steam, the fossil boiler is maintained in a hot condition similar to the above scenario. At the end of the day, however, the boiler may be banked (pending economic dispatch of the unit on fossil fuel) and maintained in a warm standby condition overnight. The boiler is also banked during clear days or when it is not economical to operate the plant in either solar or fossil modes. No fossil energy is required to maintain the Newman Unit 1 boiler in a warm standby condition for periods as long as several days; for longer periods the boiler must be intermittently fired. The boiler can then be fired to achieve the 36 percent of rated output point from the warm standby condition in approximately 2 hours.

The latter boiler operating scenario was selected for Newman Unit 1 on the basis of requiring less fossil fuel to operate the unit and thus resulting in a more favorable cost/value ratio. This operating scenario was used for most of the cost/value analysis.

Table A.3-2 summarizes the results of the cost/value analysis for the Baseline Configuration (defined in Table A.1-1). These data indicate that the Baseline Configuration results in substantial fossil fuel savings that are equivalent to approximately 110,000 barrels of oil per year and has the potential (Nth unit) to be economically competitive (depending on the fossil fuel escalation rate) on the EPE system. In addition, the data show that the repowered Newman Unit 1 is economically dispatched using fossil fuel due to its high efficiency of operation.

The Baseline Configuration (Table A.1-1) was a solar repowering fraction of 75 percent. This repowering fraction was found to be close to optimum at 75 percent. Solar repowering fractions of 25, 50, and 100 percent were also considered; these fractions correspond to 1,578 heliostats having a glass area of 82 m^2/heliostat comprising the collector field, 3,155 heliostats, and 6,315 heliostats, respectively. Figure A.3-1 presents the results of this analysis. The results indicate that the lowest cost/value ratio is fairly insensitive to repowering fractions between 50 and 100 percent. The insensitivity of the cost/value ratio to repowering fraction (which was not observed in previous analyses performed for other southwestern utiliites) primarily results from a favorable economic dispatch of the repowered Newman Unit 1 on the EPE system on fossil fuel.

EPE operating personnel have established that, for a demonstration unit, the minimum repowering fraction considered acceptable to adequately demonstrate the engineering, operating, and maintenance aspects of solar repowering is 50 percent. As illustrated in Figure A.3-1, little economic incentive exists for considering repowering fractions greater than 50 percent. Therefore, the conceptual design of the preferred concept for the demonstration unit will be based on a 50 percent repowering fraction.

The operating scenario for the Baseline Configuration (Table A.1-1) assumes that the fossil boiler, as noted above, is maintained at a firing rate equal to 36 percent of rated electrical output in the hot condition. The sensitivity of the cost/value ratio to variation of firing rate percentage was evaluated by considering steam flows representing 28 and 50 percent of rated electric output; the former value corresponds to EPE's spinning reserve (23 MWe output) operating history for this unit.

The results of this analysis indicate that reducing the hot condition percentage to 28 percent reduces the cost/value ratio by approximately 2 percent and that an increase to 50 percent increases the cost/value ratio by less than 2 percent. Once again, the insensitivity of the cost/value ratio is attributed to the favorable economic dispatch of this unit on fossil fuel.

The value of thermal energy buffer storage was established by comparing the cost/value ratios for the Baseline Configuration and Alternative 1 (Table A.1-1). The capital cost of the thermal energy buffer storage subsystem for providing primary and reheat steam must be in the range of 1.5 to 2.5 million dollars to be cost effective for solar repowering Newman Unit 1; otherwise, it is more cost effective to utilize the existing fossil boiler to supplement the solar generated steam for operation of the unit during cloudy days.

The above analysis has primarily focused on the Baseline Configuration. To provide a comprehensive evaluation of the Baseline Configuration relative to the alternative configurations identified in Table A.1-1, a set of evaluation criteria were developed as follows:

- Cost
- Annual electrical energy output
- Cost/benefit ratio
- Annual fossil fuel savings
- Operating and maintenance
- Reliability
- Environmental, institutional, and safety factors

Technical risk for 1985
New technology demonstration

Characteristics of the Baseline Configuration and Alternatives 1, 3, and 4 relative to these criteria are summarized in Table A.3-3. Alternatives 1 and 4 which include buffer storage are considered less attractive than the configurations without buffer storage. The primary reason is that a buffer storage subsystem is not cost effective for solar repowering Newman Unit 1. A buffer storage subsystem is likewise not technically required to permit unit operation during intermittent cloudy days since firing of the existing fossil boiler can be increased at a rate sufficient (10-20 percent steam flow/minute) to offset most of the anticipated insolation transients. The inclusion of a buffer storage subsystem in the demonstration unit could be accommodated if desired by DOE to demonstrate this technology and would result in a modest savings in fossil fuel as indicated in Table A.3-3; however, the fuel savings are not expected to offset the anticipated capital cost (Section A.2). In addition, maintenance requirements will be increased, reliability will be reduced, and technical risks and costs associated with a system configuration utilizing a fast response buffer storage system will be increased in comparison to the Baseline Configuration.

In general, the Baseline Configuration is more attractive than Alternative 3 for this repowering application. Table A.3-4 summarizes the strengths and weaknesses of these two configurations relative to the evaluation criteria. The primary factors in the selection of the Baseline Configuration over Alternative 3 is that it has the more favorable cost/value ratio, it offers the greatest potential to conserve fossil fuel resources, and it provides the capability to demonstrate solar-only operation with relatively small penalties in terms of operating and maintenance constraints, and it is most reliable.

TABLE A.3-1

EPE ECONOMIC SCENARIOS (1985)

	A	B
Present Worth Discount Rate	12%	12%
Carrying Charge Rate	16%	16%
Capital Cost, $/kWe (c-t/c-c/coal/nuc)	300/600/1400/1700	300/600/1400/1700
Fuel Cost ($/MBtu)		
Gas/#6 Oil/#2 Oil/#4 Oil/ Coal/Nuc	3.66/6.5/7.5/7.53/1.5/1.0	3.66/6.5/7.5/7.53/1.5/1.0
Fuel Escalation Rate (%) (gas/oil/coal/nuc)	8/8/7/7	12/12/7/7
Capital Escalation Rate	8%	8%
O&M Escalation Rate	7%	7%

TABLE A.3-2

COST/BENEFIT ANALYSIS RESULTS FOR BASELINE CONFIGURATION FOR SOLAR REPOWERING NEWMAN UNIT 1 EPE SYSTEM/ECONOMIC SOLAR REPOWERING FRACTION (75 PERCENT)

(10^6 1980 Dollars)

	Demonstration Unit		Nth Unit	
Direct Plant Cost	123.3		52.1	
Plant Cost (PWRR, M$)				
Capital	206.6		87.3	
Operating	71.8		30.2	
Total	278.4		117.5	
Value (PWRR*, M$)				
Fuel Escalation Rate	8 Percent	12 Percent	8 Percent	12 Percent
Fuel Savings	110.6	186.0	110.6	186.0
Fuel Cost	-28.5	-48.3	-28.5	-48.3
Variable O&M	3.5	3.5	3.5	3.5
Capacity Credit	10.2	10.2	10.2	10.2
Total	95.8	151.4	95.8	151.4
Cost (mills/kWh)	190.0	212.0	94.6	107.5
Cost/Benefit Ratio	2.91	1.84	1.23	0.78
Energy (10^6kWh)	191.3		191.3	
Capacity Factor	0.265		0.265	

* Present worth of revenue requirements method

TABLE A.3-3

CHARACTERISTICS OF ALTERNATE SOLAR REPOWERING SYSTEMS

	System Alternatives			
Criteria	Baseline Configuration Primary Steam - Solar Reheat Steam - Solar Buffer Storage - None	Alternate 1 Primary Steam - Solar Reheat Steam - Solar Buffer Storage - Primary/Reheat	Alternate 3 Primary Steam - Solar Reheat Steam - Aux Heater Buffer Storage - None	Alternate 4 Primary Steam - Solar Reheat Steam - Aux Heater Buffer Storage - Primary
Cost (Total Capitalization)	Demo Plant 192M $ Nth Plant 81M $	Demo Plant 201M $ Nth Plant 91M $	Demo Plant 166M $ Nth Plant 71M $	Demo Plant 176M $ Nth Plant 80M $
Annual Electrical Energy Output	191×10^6kWh	173×10^6kWh	191×10^6kWh	173×10^6kWh
Cost/Benefit Ratio (8% Fuel Escalation)	Demo Plant 2.91 Nth Plant 1.23	Demo Plant 2.92 Nth Plant 1.31	Demo Plant 3.04 Nth Plant 1.29	Demo Plant 3.25 Nth Plant 1.48
Annual Fossil Fuel Savings				
Equivalent Barrels of Oil/Year	109,400	115,700	80,000	99,600
Operating and Maintenance Factors	Next to fewest added components More complex heliostat control system Turbine inlet temperature control is complicated by solar reheat due to fractional variations in energy input Next to most impact on operator training	Most added components More complex heliostat control system Turbine inlet temperature control is complicated by solar reheat due to fractional variations in energy input. Usage of buffer storage increases complexity. Requires most training of operators	Fewest added components Less complex heliostat control system Turbine inlet temperature control is less complex with auxiliary boiler for reheat Least impact on training of operators	Next to most added components Less complex heliostat control system Turbine inlet temperature control is less complex with auxiliary boiler for reheat. Use of buffer storage increases complexity. Next to least impact on training of operators
Reliability Factors	Intermediate impact on reliability Most heliostats Control system for focusing on 2	Greatest impact on reliability Most heliostats Control system for focusing on 2 receivers	Least impact on reliability Fewest heliostats Control system for focusing on 1 receiver	Intermediate impact on reliability Fewest heliostats Control system for focusing on 1 receiver

TABLE A.3-3 (Cont)

	System Alternatives			
Criteria	Baseline Configuration Primary Steam - Solar Reheat Steam - Solar Buffer Storage - None	Alternate 1 Primary Steam - Solar Reheat Steam - Solar Buffer Storage - Primary/Reheat	Alternate 3 Primary Steam - Solar Reheat Steam - Aux Heater Buffer Storage - None	Alternate 4 Primary Steam - Solar Reheat Steam - Aux Heater Buffer Storage - Primary
	receivers 2 receivers	2 receivers Buffer storage and connections to 2 receivers	1 receiver Oil fired auxiliary heater may be less reliable for fast transient application	1 receiver Buffer storage and connection to 1 receiver Oil fired heater may be less reliable for fast transient application
Environmental, Institutional and Safety Factors	Less failure modes Larger terrestrial field for heliostats Greatest reduction in air pollution	Most failure modes Largest terrestrial field for heliostats and buffer storage Greatest reduction in air pollution	Least failure modes Smallest terrestrial field for heliostats Reduction in air pollution Requires Texas Air Control Board Licensing and National Energy Act variance for new heater.	Less failure modes Smaller terrestrial field for heliostats and buffer storage Reduction in air pollution Requires Texas Air Control Board Licensing and National Energy Act variance for new heater.
Technical Risk for 1985	Development of low cost heliostat in progress Primary solar receiver requires design and test to spec. Reheat receiver requires design and test to spec.	Development of low cost heliostat in progress Primary solar receiver requires design and test to spec. Reheat receiver requires design and test to spec. Needs development of low cost, high temperature, fast response buffer storage.	Development of low cost heliostat in progress Primary solar receiver requires design and test to spec. Fast response auxiliary heater requires design and test to spec.	Development of low cost heliostat in progress Primary solar receiver requires design and test to spec. Fast response auxiliary heater requires design and test to spec. Needs development of low cost, high temperature, fast response buffer storage

TABLE A.3-3 (Cont)

Criteria	System Alternatives: Baseline Configuration Primary Steam - Solar Reheat Steam - Solar Buffer Storage - None	Alternate 1 Primary Steam - Solar Reheat Steam - Solar Buffer Storage - Primary/Reheat	Alternate 3 Primary Steam - Solar Reheat Steam - Aux Heater Buffer Storage - None	Alternate 4 Primary Steam - Solar Reheat Steam - Aux Heater Buffer Storage - Primary
New Technology Demonstration	Low cost heliostat	Low cost heliostat	Low cost heliostat	Low cost heliostat
	Total solar input capability	Total solar input capability	Partial solar input capability	Partial solar input capability
	Primary receiver	Primary receiver	Primary receiver	Primary receiver
	Reheat receiver	Reheat receiver	Auxiliary heater	Auxiliary heater
		Buffer storage		Buffer storage

TABLE A.3-4

COMPARATIVE EVALUATION OF SYSTEM ALTERNATIVES

	Baseline Configuration	Alternative 3
STRENGTHS:	Most favorable cost/ benefit ratio	Lowest total capital costs
	Additional annual fossil fuel savings (over 30 percent)	
		Least requirements for operating and maintenance
	Little impact on reliability	Least impact on reliability
	Very little impact on safety and environment	Very little impact on safety and environment
	Very little technical risk	Very little technical risk
	Demonstrates total solar input capability	
WEAKNESSES:	Control of turbine inlet temperature with solar reheat may require further consideration.	Does not demonstrate total solar input capability
		Increases fossil fuel consumption

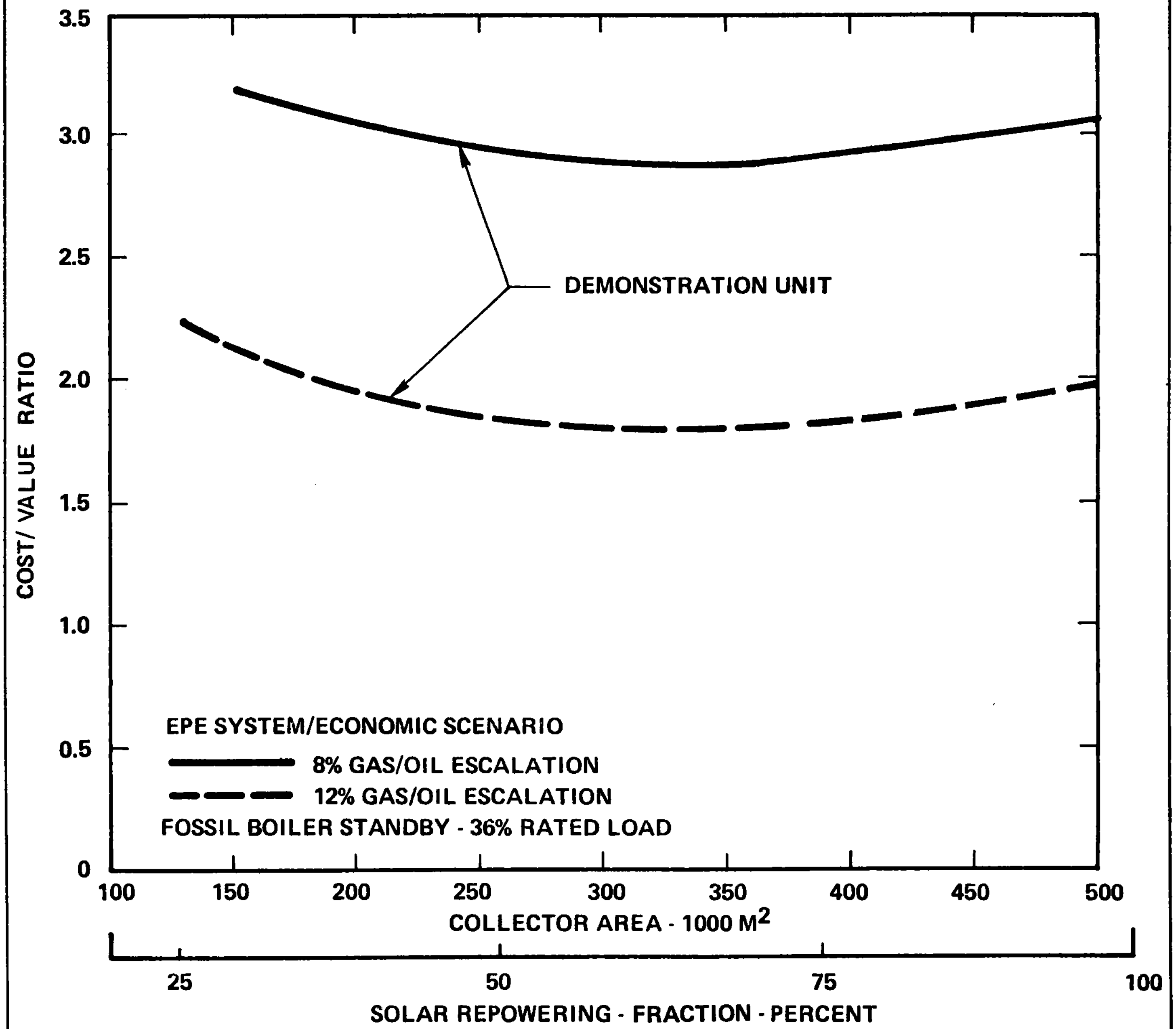


FIGURE A.3-1
REPOWERING FRACTION ANALYSIS
FOR THE BASELINE CONFIGURATION

A.4 CHARACTERISTICS OF PREFERRED SYSTEM

The Preferred Configuration for solar repowering Newman Unit 1 is identical to the Baseline Configuration in that solar energy is used to provide steam to the high pressure and intermediate stages of the turbine generator. The system and subsystem analyses summarized in Sections A.2 and A.3, however, have resulted in numerous modifications to the Baseline Configuration to be incorporated into the Preferred Configuration.

Table A.4-1 summarizes the characteristics of the Preferred Configuration for the solar repowering demonstration at Newman Station. The Preferred Configuration, based on a solar repowering fraction of 50 percent, utilizes a north field (160° arc) of heliostats. A single tower housing the primary and reheat receivers is located adjacent to the turbine building. The primary receiver design is a drum type boiler with pumped recirculation, using an external screened tube concept, which is being developed by DOE as part of the Advanced Water/Steam Receiver Program.

TABLE A.4-1

SOLAR REPOWERED NEWMAN UNIT 1
CHARACTERISTICS OF PREFERRED CONFIGURATION

Unit Type	Reheat steam turbine
Unit Rating	82 MWe
Solar Repowering Percentage*	50 Percent
Plant Operating Scenario	Maximize solar benefit Fossil operation only on cloudy days Economic dispatch on fossil energy
Collector Subsystem	
Field configuration	North field (160° arc)
Field area	1.5 km^2 (includes exclusion area)
Heliostat area	246,000 m^2
Number of heliostats	2,776
Receiver/Tower Subsystem	
Primary receiver type	External (pumped, recirculation boiler/screened tube concept)
Primary receiver size	12 m dia x 16.5 m long (210° arc)
Reheat Receiver	
Type	External
Size	12 m dia x 16.5 m long (210° arc)
Tower Height	
Number of towers	1
Primary receiver C/L	155 m
Reheat receiver C/L	138 m
Electrical Power Generation Subsystem	
Cycle	Steam Rankine (reheat)
Net unit efficiency (solar/fossil)	37.5/39.5
Turbine inlet	10.1 MPa/538°C
Heat rejection	Wet cooling tower
Fossil Boiler	
Type	Gas/oil
Rate load efficiency	84.4%
Automatic operation	Minimum 28% of rated unit electrical output
Startup energy/cold condition	106 x 10^6 kJ/startup
Warm standby	15.8 x 10^6 kJ/startup

NOTE:

* Based on an insolation level of 950 watts/m^2

APPENDIX B

APPENDIX B

NEWMAN UNIT 1 SOLAR REPOWERING SYSTEM SPECIFICATION

B.1 GENERAL

B.1.1 Scope

This specification defines the system and subsystem characteristics, design requirements, and system environmental requirements for solar repowering of Newman Unit 1 which is operating on the El Paso Electric Company (EPE) system. This unit has a reheat steam turbine rated to produce 82 MWe with a 10.1 Pa/538°C (1,450 psig/1,000°F) main steam condition and a 2.93 MPa/538°C (420 psig/1,000°F) reheat steam condition. The solar subsystem will be designed to supply steam in sufficient quantity and quality to generate 50 percent of the rated electrical power output (at the design point of noon winter solstice). It will operate in parallel with the present gas/oil fired boiler.

In general, the level of detail presented in this specification is consistent with the conceptual design phase of a large power plant project. Engineering information is developed to the extent necessary to support the development of a conceptual plant cost estimate and the determination of technical and economic feasibility of the project.

B.1.2 System Description

The system for solar repowering of Newman Unit 1 will consist of the following major elements, which are described in the following sections.

- Site
- Site Facilities
- Collector Subsystem
- Receiver Subsystem
- Master Control Subsystem
- Fossil Boiler Subsystem
- Electric Power Generating Subsystem
- Specialized Equipment

The repowering system will be designed for a 30-year life.

B.1.2.1 Site

Newman Station is located at the north end of the city of El Paso, 24 km (15 miles) northeast of the downtown area, and 19.3 km (12 miles) from the El Paso SOLMET station. The site is near the New Mexico border on the east side of the Franklin Mountains.

The Newman site is nearly flat with a downward slope of approximately one percent from west to east. A road to the west provides storm drainage, although some minor natural runoff gulleys (arroyos) exist northwest of the existing station. The site is in the Tularosa Basin, bounded by fault block mountains to the east and west, with 305 to 610 meters (1000 to 2000 feet) of underlying sediments. Approximately 14.2 km^2 (3500 acres) of public land around the site are available.

Newman Station is surrounded by land owned by El Paso Water Utilities Public Service Board, with one residential and no commercial buildings within a 3.2 km (2 mi) radius. The site is accessible by road from all directions.

Figure B.1-1 illustrates the location of the site relative to El Paso, Texas. Figure B.1-2 shows the arrangement of the Newman Station's major existing facilities. Newman Station consists of four oil and gas-fired units capable of generating 498 MWe. Newman Unit 1 is located at the northern end of the station.

Figure B.1-3 describes the proposed site arrangement for Solar Repowering Newman Unit 1. The concrete tower supporting the primary and reheat receivers will be located adjacent to the Newman Unit 1 turbine building, with a 160° north heliostat field. The approximate land area that will be utilized by the heliostat field is 1.09 km^2 (269 acres).

Site preparation acitivites for repowering Newman Unit 1 will include primary grading, surface preparation, and construction of roads. The collector field will be graded and will include north-south drainage trenches covered with crushed stone to channel rainwater from the site. The natural arroyo at the northwestern part of the field will be diverted north of the field perimeter to preclude erosion of the graded surfaces. The main entrance to the Newman Station will be from an existing highway west of the site and an asphalt paved road will surround the field to provide access to the heliostats. A 61 m (200 ft) exclusion zone is provided outside this perimeter road. The solar main and reheat receivers will be mounted on a tower accessible from the main entrance road. Exclusion areas will be provided to avoid interferences with the inspection and maintenance of existing equipment and piping situated in the heliostat field area.

B.1.2.2 Site Facilities

New structures and facilities associated with Solar Repowered Newman Unit 1 will include an addition to the existing control room, a solar feedwater pump house, and an addition to the existing maintenance building. The control room and maintenance building additions and the solar feed water pump house will be metal sided enclosures. The control room additions will house the Master Control Subsystem, collector and receiver controls, operator control panels, beam characterization system, and data acquisition system. A new equipment room will be provided near the top of the receiver tower. The rooms will be air conditioned to maintain the correct temperature for the electronic equipment.

Evaporative cooling of the maintenance building addition and the solar feed water pump house will be provided by propeller type fans which will draw the outside air into the enclosures through inlet louvers and air filters. The existing fire protection system will be extended to provide suitable protection to the enclosures. Hydrants and hose stations will be located at strategic points in the collector field; a fire water booster pump and hose stations will be located inside the solar receiver tower. Lighting will be provided along the perimeter road surrounding the heliostat field and at the tower operating levels.

B.1.2.3 Collector Subsystem

The Collector Subsystem will be composed of an array of heliostats and supporting power and control elements which interact with the Master Control Subsystem. The heliostat array will be arranged in a 2.79 radian (160°) fan shaped configuration north of the single receiver tower (Figure B.1-3). The heliostat array will reflect solar radiation onto the elevated absorbers (boiler, superheater, and reheater) of the Receiver Subsystem in a manner which will satisfy the receiver incident flux requirements. The Collector Subsystem is sized for a solar multiple of 1.0 at the design point. The Collector Subsystem components will include the following:

a. 2,998 heliostats, including reflective surface, structural support, drive units, control sensors, pedestals, foundations, cabling, and cable array installations.

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

The Collector Subsystem description is based on the characteristics of a generic second generation heliostat. The design description, performance characteristics, and cost data for this heliostat are incorporated in the specification as representative of the class of heliostat configurations that will be available for solar repowering Newman Unit 1.

B.1.2.4 Receiver Subsystem

The Receiver Subsystem provides a means of transforming the incident radiant flux energy from the Collector Subsystem into superheated steam. The receiver fluid is water/steam. The Receiver Subsystem will consist of primary and reheat receivers to intercept the radiant flux reflected from the Collector Subsystem, a single tower structure to support the two receivers, receiver header piping and riser, and downcomer piping for the primary receiver.

The receivers will be of external type configuration with a forced recirculation boiler. The Receiver Subsystem will include the pumps, valves, and control system within the tower structure necessary to regulate the flow, temperature, and pressure; and the required control system components necessary for safe and efficient operation, startup, shutdown, and standby. Also included in this subsystem will be an elevator, platforms, stairs, etc, to provide for observation and maintenance.

B.1.2.5 Master Control Subsystem

The Master Control Subsystem (MCS) is used to sense, detect, monitor, and control all system and subsystem parameters necessary to ensure safe and proper operation of the entire integrated repowered plant. Specifically, this subsystem will provide for stable plant operation during startup, steady-state, shutdown, transient, or emergency conditions in the fossil only, solar only, or combined operating modes. It will provide for an effective operator/plant interface to allow for automatic or manual control and permit comprehensive plant performance evaluation. This subsystem will consist of a central computer, computer peripheral equipment, time code generator, control and display consoles, and solar/non-solar electric power control interfaces and software.

B.1.2.6 Fossil Boiler Subsystem

The Fossil Boiler Subsystem provides a fossil energy source which is retained to enhance performance and/or maintain normal plant operation during periods of reduced or no insolation. The Fossil Boiler Subsystem consists of the Newman Unit 1 fuel handling, boiler, and related equipment. It also consists of the control system necessary to regulate the steam flow, temperature, and pressure; and the required control necessary for safe and efficient operation, startup, shutdown, and standby of the Fossil Boiler Subsystem. Essentially all of the existing Newman Unit 1 boiler equipment will remain after being retrofitted with a solar steam supply system, although most of the existing pneumatic control system will be replaced with electronic combustion and feedwater controls.

B.1.2.7 Electrical Power Generating Subsystem

The Electrical Power Generating Subsystem (EPGS) provides the thermal output from the receivers and/or the Fossil Boiler Subsystem for converting to electrical power. The output from the EPGS will be regulated for integration into El Paso Electric Company system network. The EPGS consists of the existing balance-of-plant equipment at Newman Unit 1.

B.1.2.8 Specialized Equipment

No specialized equipment required to service, maintain, repair, clean, or overhaul any of the solar repowered plant equipment has been identified during the conceptual design effort.

B.1.3 Definitions of Terms

Beam Pointing Error

The angular difference between the aim point and measured beam centroid for any tracking aim point (on target or at standby) under the specified operating conditions.

Capacity Factor, Annual - Non-Solar

Annual non-solar MWh divided by the product of 8760h and plant or unit rating in MW.

Capacity Factor, Annual - Overall

Annual solar and non-solar MWh divided by the product of 8760h and plant or unit rating in MW.

Capacity Factor - Solar

Annual solar MWh divided by the product of 8760h and plant or unit rating in MW.

Conversion Efficiency (Gross)

The gross output provided by a conversion device divided by the total input power at specified conditions.

Conversion Efficiency (Net)

The actual net output (after deducting parasitics) provided by a conversion device divided by the required input power at specified conditions.

Demand

The power versus time profile of the energy required to satisfy the energy needs of the final consumer or end use consuming process.

Design Point

The time and day of year at which the system is sized with reference direct insolation, wind speed, temperature, humidity, dew point, and sun angles.

Direct Insolation

The non-scattered solar flux falling on a surface of given orientation (W/m^2).

Fluid, Receiver

The fluid used to cool the solar receiver and distribute the absorbed solar energy to other parts of the system; heat transport fluid of the receiver.

Fluid, Working

The fluid used in the turbine or other prime mover.

Hybrid System

A combination of solar and non-solar technology to provide a single plant system that is capable of continuous operation.

Levelized Busbar Energy Cost

That cost per unit of energy which, if held constant throughout the life of the system, would represent the total required life cycle costs, assuming that all cash flow interim requirements or excesses are borrowed or invested at the utility's internal rate of return.

Nameplate Rating

The full-load continuous rating of a generator, prime mover, or other electrical equipment under specified conditions as designated by the manufacturer.

Present Value

The present value of capital and operating costs (or annual savings, brought over a given time period such as the life of the plant) represents a single payment at a reference year that would yield the necessary cash flow at a given interest rate.

Receiver Efficiency

The ratio of thermal power absorbed by the fluid flowing through the receiver to the solar power incident upon the receiver.

Repowered Plant

A plant that uses central receiver technology and solar energy to partially displace non-renewable (fossil) fuels.

Repowering Percent - Design Point

The percentage of the unit's rated net electrical power output produced as a result of the steam generated by the solar receivers at the design point.

Solar Flux

The rate of solar thermal radiation per unit area (W/m^2).

Solar Fraction (Annual)

The annual average fraction of thermal energy to the turbine delivered by the solar steam supply system.

Solar Fraction (Design Point)

The fraction of thermal energy to the turbine delivered by the solar steam supply system at the design point.

Storage Capacity

The amount of net energy which can be delivered from a fully charged storage subsystem (MWhe or MWht).

Thermal Power, Fossil Boiler Output

Thermal power in steam generated by the fossil boiler after stack and miscellaneous losses.

Thermal Power, Turbine

Thermal power input required by the turbine at the design point.

Thermal Power, Receiver Output

The thermal power in steam generated by the receiver measured at the receiver outlet.

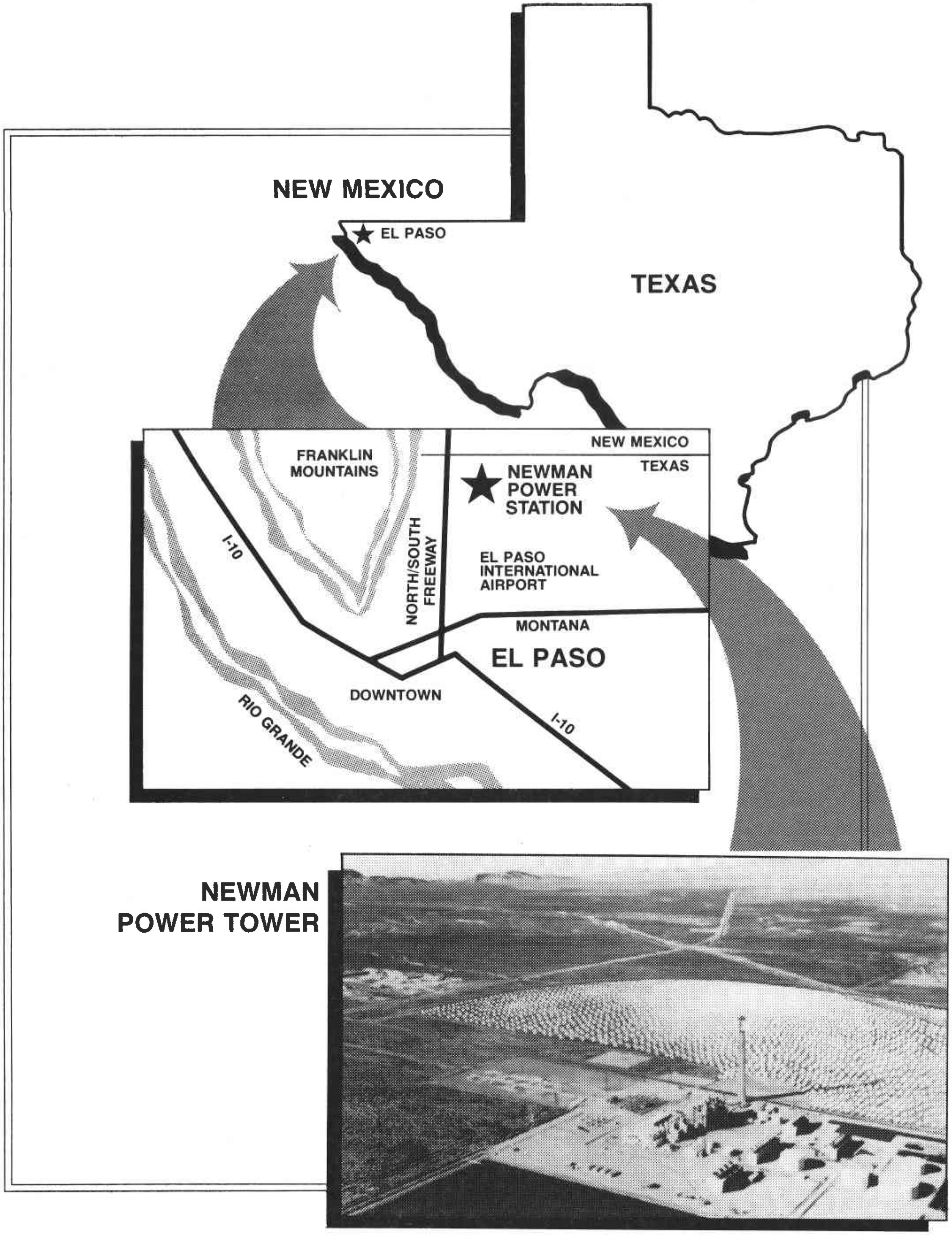


FIGURE B.1-1
LOCATION OF NEWMAN STATION

The Electric Company
El Paso Electric

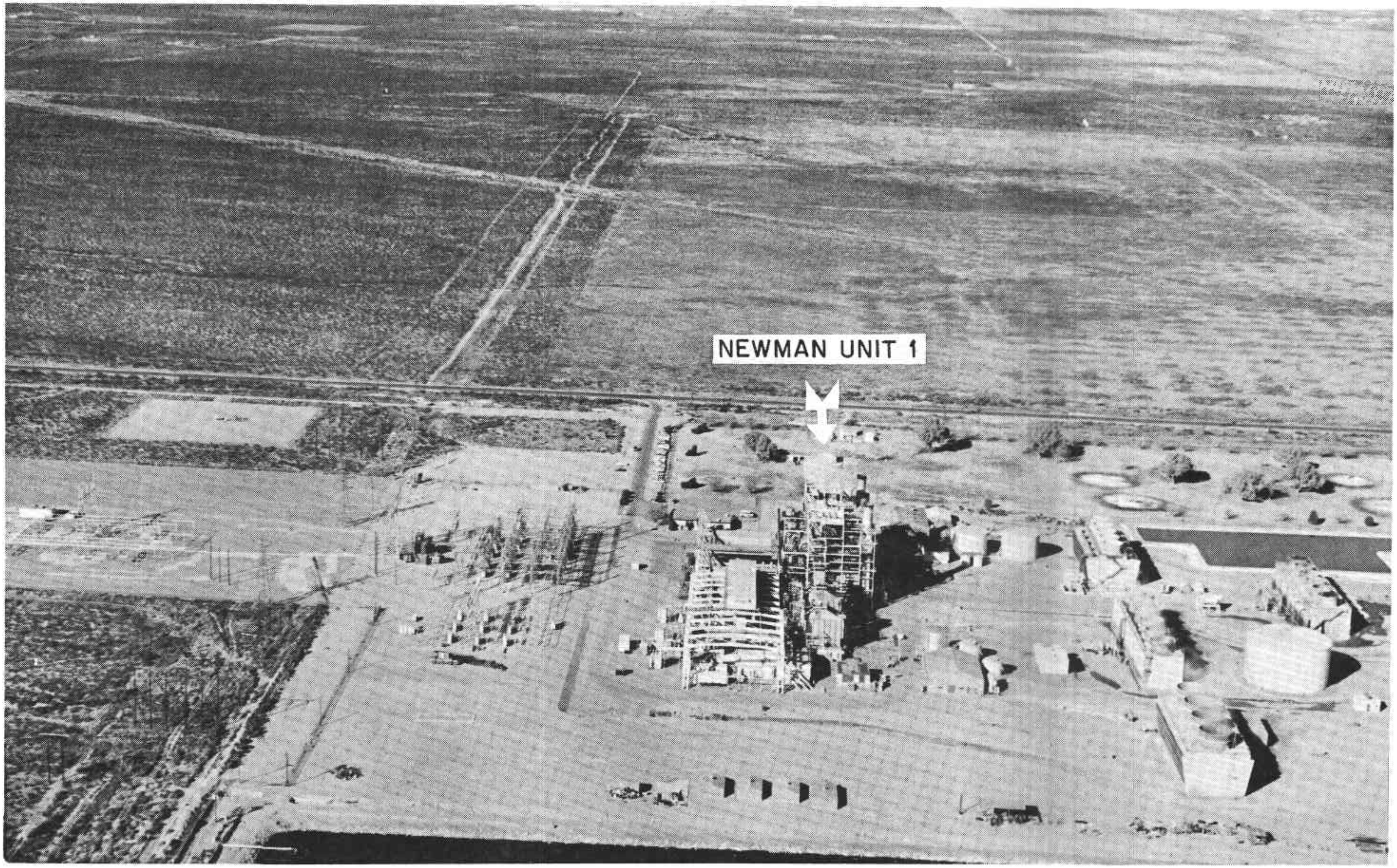


FIGURE B.1-2
NEWMAN STATION SITE AND SURROUNDINGS

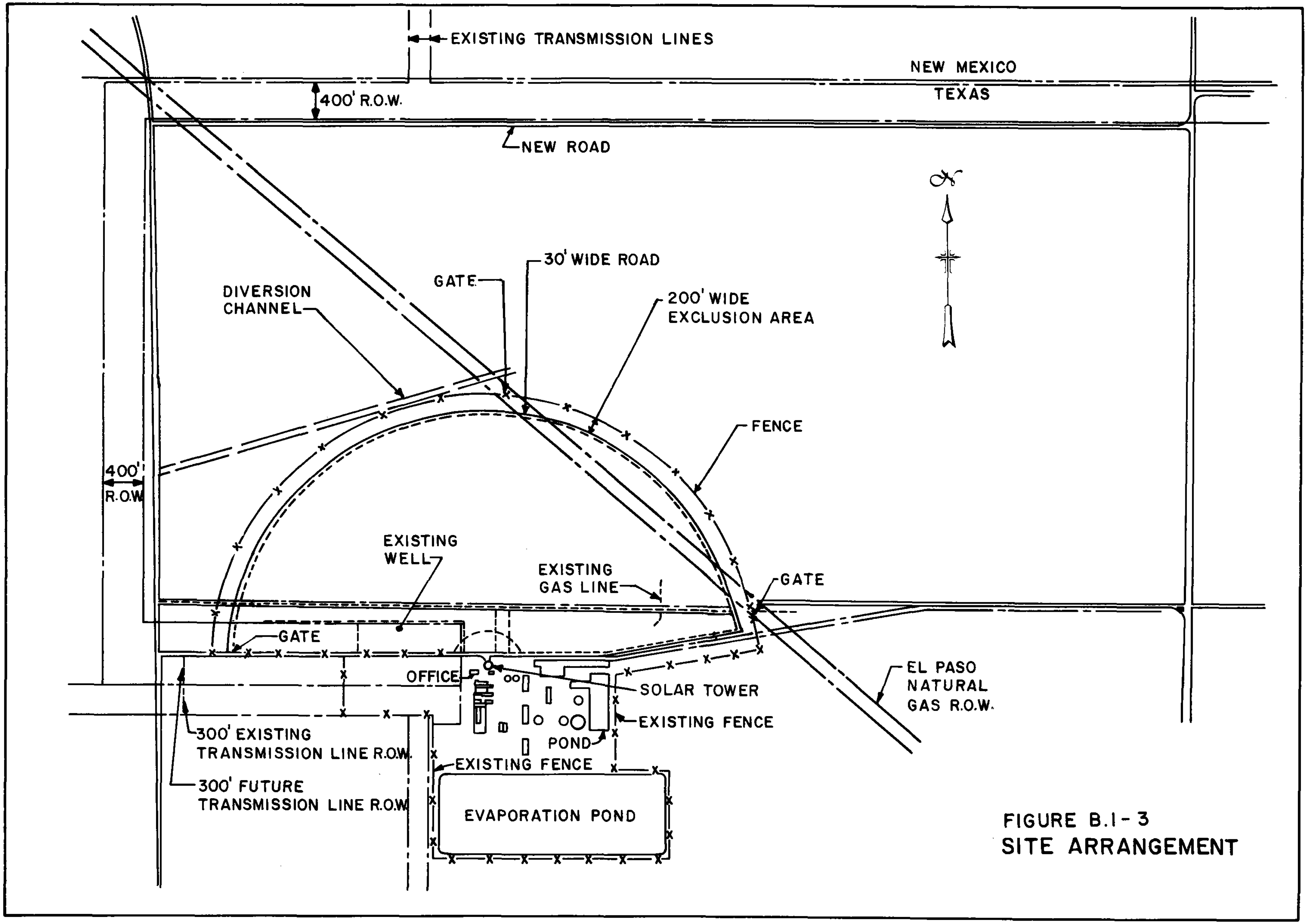


FIGURE B.1-3
SITE ARRANGEMENT

B.2 REFERENCES

The following references will provide the guidelines for development of designs that are presented in this specification. These references will influence the design and selection of vessels, heat-transfer equipment, mechanical equipment, structures, civil work, piping, instrumentation, and electrical items that are used in the utility industry.

B.2.1 Standards And Codes

The latest revisions of each of the following codes in effect during final design will be used.

Uniform Building Code - 1976 Edition by International Conference of Building Officials

OSHA Regulations

- OSHA Title 29, Part 1910 - Occupational Safety and Health Standards ASME Boiler and Pressure Vessel Code
- Section I - Power Boilers, including: ANSI B31.1-1977 Power Piping
- Section II - Materials Specifications
- Section VIII - Pressure Vessels

NRC Regulatory Guides 1.60 and 1.61.

Institute of Electrical and Electronic Engineers (IEEE) Codes, as applicable. National Fire Protection Association (NFPA) National Fire Codes Human Engineering Design Criteria

- MIL-STD-801C
- MIL-STD-1472

Design, Construction, and Fabrication Standards

- Standards of AISC (American Institute of Steel Construction)
- Standards of ACI (American Concrete Institute)
- Standards of TEMA (Tub: Exchanger Manufacturer's Association)
- ANSI A58.1 - Building Code Requirements for Minimum Design Loads in Buildings and Other Structures

B.2.2 Other Publications And Documents

National Energy Conservation Policy Act of 1978

Power Plant and Industrial Fuel Use Act of 1978

Public Utilities Regulatory Policy Act

Energy Tax Act of 1978

Environmental Legislation

- National Environmental Policy Act (NEPA)

B.2.3 Permits And Licenses Required

Construction Permit

Waste Water Discharge Permit (NPDES)

SPCC (Spill Prevention Containment Countermeasure)

Air Navigation Approval (FAA)

Elevator Permit/Certificate

State (Highway Connector)

Local (land use, general construction, private road construction and use)

B.2.4 Applicable Laws And Regulations

Texas Clean Air Act of 1973 (Air Control Board)

Texas Water Quality Act of 1977 (Dept of Water Resources)

Federal Aviation Regulation, Part 77 (FAA)

El Paso Building Law

Department of Transportation, State Highway Dept Regs

El Paso Zoning Laws; Building Laws; Texas Regulation, Control of Air Pollution from Visible Emissions of 1975.

B.3 REQUIREMENTS

The Solar Repowered Newman Unit 1 shall be designed to meet the requirements of this section. The solar steam generating system shall be sized to produce steam at conditions necessary to generate 50 percent of the rated net electrical output, 82 MWe, at the design point solar conditions corresponding to noon winter solstice. The solar multiple at the design point is 1.0. The design lifetime shall be 30 years. The repowering system shall include both a primary and reheat receiver mounted on a single tower which will supply 10.1 MPa/538°C (1,465psia/1000°F) steam to the high pressure turbine inlet and 2.93 MPa/538°C (425 psia/1000°F) reheat steam to the intermediate pressure turbine inlet of Newman Unit 1. The solar receiver subsystem will operate in parallel with the existing gas/oil fired boiler to meet the total daily electrical demand requirements. The performance and operating requirements of the solar retrofit subsystems are defined below:

B.3.1 Site

The collector field and other facilities associated with Solar Repowering Newman Unit 1 will require approximately 1.09 km^2 (269 acres) of land. Site preparation will include minor grading and surface preparation. A state highway and a transmission line that currently transect the site will be rerouted. A new access road to the Newman Station and a perimeter road around the heliostat field will be provided to support vehicular traffic.

Heliostats shall be excluded from portions of the collector field where existing equipment and piping rights-of-way are required, and where future transmission line rights-of-way will be located.

Drainage ditches are required to channel rainwater from the solar collector field to minimize erosion of the graded surfaces and protect foundation integrity. The solar repowering site shall include paved roads and fences to provide access to the solar collectors and receivers and protect against unauthorized entry to the site.

The characteristics of the Newman Station site shall satisfy all the necessary siting requirements for a successful repowering application.

B.3.2 Site Facilities

New site facilities will require additions to the existing control room and maintenance building, and a new solar feed water pump house.

The control room will require a second level to house the solar repowering electronic equipment. The extended control room areas shall be air conditioned to maintain the correct ambient temperature for the new computers and associated equipment. The second level will require new toilet facilities. An addition to the maintenance building will be required to enable plant personnel to repair and test complete heliostat assemblies. Additional evaporative coolers will be required to circulate fresh air through the maintenance area.

A solar feed water pump house will be required for the solar feed pumps and the solar repowering equipment switchgear.

The existing fire protection system must be extended to protect the new site facilities. Hydrants and hose stations will be necessary around the solar field water pump house and maintenance area. Hose stations shall be provided at the various levels inside the solar receivers tower.

Outdoor lighting shall be provided along the solar collector field perimeter road and at the base and upper levels of the tower.

B.3.3 Collector Subsystem

The Collector Subsystem shall reflect solar radiation onto the Receiver Subsystem in a manner which satisfies receiver incident heat flux requirements specified in Section 3.4.2. In addition, the Collector Subsystem shall respond to commands from the Master Control Subsystem for emergency defocusing of the reflected energy or to protect the heliostat array against environmental extremes. The heliostats shall be properly positioned for repair or maintenance in response to either master control or manual commands. Heliostat design shall provide for a stored or safe position at night, during periodic maintenance, and during adverse weather conditions. The Collector Subsystem shall be designed to match the receiver design and provide energy to the receiver working fluid consistent with the input energy requirements of the existing turbine.

Meterological and insolation data corresponding to the Typical Meteorological Year for El Paso, as supplied on the SOLMET Weather Tapes, shall be used as a design basis for the subsystem.

B.3.3.1 Collector Field

The collector field shall be designed so that 103 MWt of the redirected solar energy will impinge on the primary receiver and 26 MWt will impinge on the reheat receiver at noon winter solstice with a direct normal insolation value of 1000 W/m^2.

The collector field design shall provide the optimum heliostat layout considering (as an example) the following:

a. Heliostat capital cost

b. Operating and maintenance cost

c. Field wiring cost

d. Land availability

e. Land cost

f. Heliostat performance

g. Receiver size

h. Receiver tower height

i. Plant availability

j. Shading and blocking

k. Atmospheric attenuation

l. Sun position

m. Piping cost

n. Foundation requirements

The Collector Subsystem shall function as appropriate for all steady-state modes of plant operation. This shall include the capability of controlling the number of heliostats in tracking mode so as to vary the redirected flux to either receiver between zero and the maximum achievable level with step changes no larger than 10 percent of the total collector field output.

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

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

The drive system shall provide for cost effective stowage of the reflective surface to minimize reflected beam safety hazards and dust or dirt build-up on the mirrors. Heliostat orientation shall be available to the Master Control Subsystem at all times. Calculated gimbal angles are acceptable: orientation sensors are not required.

Heliostat control shall be by computer. Control functions shall be accomplished as follows:

Heliostat Array Controller (HAC) shall:

- Initiate operational mode commands to Heliostat Field Controller (HFC)
- Address commands to HFC groups or individual Heliostat Controller (HC)
- Respond to Master Control Subsystem (MCS) commands and requests
- Interface with beam characterization system
- Provide time base

Heliostat Field Controller (HFC) shall:

- Determine sun vector
- Transmit sun vector to HC
- Transmit status and data to HAC
- Initiate safe stowage command
- Control groups of HCs

Heliostat Controller (HC) shall:

- Determine heliostat azimuth and elevation position requirements
- Control drive motors
- Provide heliostat axis position data to HFC

The Collector Subsystem 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 seconds.

Heat fluxes on tower and normally unirradiated portions of the Receiver Subsystem are limited to 25 kW/m² (7880 Btu/ft²).

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

The collector subsystem will be designed to satisfy the environmental conditions specified in Section B.4.

B.3.3.2 Heliostats

In order to attain overall plant field performance such that 95 percent of the redirected energy approaching the receivers will impinge on the receivers with an incident angle of less than

60, the following requirements have been established for designing and evaluating individual heliostats.

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° 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 stow
- Sun location - at least 0.26 rad above horizon, any time of year
- Heliostat location - any position in the field

b. 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 maintained for 60 days without realignment. Beam quality requirements are applicable under the following conditions:

- Wind - none
- Temperature - 0° to 50°C (32° 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 any slant range
- Operating mode - tracking on a BCS calibration target
- Facet alignment - as planned for the plant
- Theoretical beam shape - the theoretical beam contour, determined by HELIOS, is the isoflux contour that contains 90 percent of the total power. This isoflux contour will be increased by 1.4 mrad fringe. The HELIOS computer code is available through Sandia Laboratories.

c. Overall structural support shall limit reflective surface static deflections to an effective 1.7 mrad standard deviation for a field of heliostats in a 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 is 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 (see B.3.3.2.d) from the total surface slope error (1.7 - 0.5 = 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)
- Gravity effects - not included
- Mirror module waviness - none
- Facet alignment error - none

d. The allowable tilt and/or torsional rotation of a heliostat foundation shall not exceed ± 1.5 mrad total angular deflection per axis, when the heliostat is subjected to a 12 m/s (27 mph) operational wind load. This total deflection, in addition to elastic response, includes the amount of plastic or permanent deflection, including any wobble (looseness) resulting from a prior 22 m/s (50 mph) wind load, and shall not exceed ± 0.45 mrad.

Both deflection allowances are 3-sigma limits expressed for a single heliostat/foundation field position, and are computed under the worst condition of wind and heliostat orientation. For a full field of heliostat foundations, the effective limits will result in a standard deviation of 1/3 of the deflection allowances specified for a single foundation.

The deflections specified are applicable at the foundation-to-heliostat interface located on a plane parallel to and approximately 50.8 mm (2 inches) above the pier concrete surface, which is represented by the underside of the heliostat pedestal mounting flange.

B.3.4 Receiver Subsystem

The Receiver Subsystem shall include a primary receiver and a reheat receiver mounted on a single tower and shall provide a means of transferring the incident radiant flux energy from the Collector Subsystem into superheated steam and transport of the steam to the high pressure 10.1 MPa/538°C (1450 psig/1000°F) turbine and the intermediate 2.93 MPa/538°C (410 psig/1000°F) turbine.

B.3.4.1 Structural Design

The receiver and tower shall be designed to provide access for maintenance and inspection of tower structure, receiver, working fluid, instruments and controls, hydraulic equipment, etc. Consideration shall be given to ease of maintenance. Adequate provisions shall be made to ensure crew safety at all times for required operations, inspection, maintenance, and repair. The receiver design shall be consistent with Section 1 of the ASME Boiler Codes and appropriate sections of the construction codes. The design lifetime shall be 30 years. Seismic criteria will be based on a peak ground acceleration of 0.125 g combined with the response spectrum given by NRC Regulatory Guide 1.60 and the operating basis earthquakes given in NRC Regulatory Guide 1.6.

B.3.4.2 Receiver

The primary receiver shall be an external panel configuration with a forced recirculation boiler and shall face a 160 degree north field of heliostats. The primary receiver shall be capable of operating safety and reliably for 30 years with heat flux levels not exceeding 660 kW/m² for water-cooled tubes and 300 kW/m² for the superheater tubes at noon winter solstice with an incident power level of 117 MWt.

At the noon winter solstice (design point),the primary receiver shall be capable of absorbing 91.3 MWt with a receiver incident power of 103.2 MWt and shall at least generate the steam at the rate of 129,000 kg/hr (284,000 lb/hr) with outlet conditions of 11.72 MPa/549°C (1,700 psia/1020°F). The maximum allowable pressure drop in the superheater shall not exceed 1.93 MPa (280 psi).

The reheat receiver shall be an external panel configuration capable of operating safely and reliably with an absorption heat flux level not exceeding 149 kW/m². At the noon winter solstice, the reheat receiver shall be capable of absorbing 17.5 MWt with a receiver incident power level of 25.8 MWt. Steam flows at the rate of 115,400 kg/hr (254,500 lb/hr) (including attemperation) with outlet conditions of 2.97 MPa and 549°C (416 psig and 1,020°F). The corresponding inlet steam temperature is 373°C (703°F), and the maximum allowable pressure drop shall be 193 kPa (28 psig).

The receivers shall be designed to be subjected to 10,000 start up/shutdown cycles and 50,000 cloud transient cycles. The Receiver Subsystem shall include a control system to maintain the HP at IP turbine inlet conditions within tolerances to be set by plant operators and equipment manufacturers while being subjected to fluctuations in solar heat fluxes due to normal daily/hourly variances and partial cloud transients. At those times when the solar system is not capable of meeting turbine inlet requirements, the receivers shall be maintained in standby mode. The receivers will be designed to satisfy the environmental conditions specified in Section B.4.

B.3.4.3 Working Fluid

The working fluid shall be water/steam for the primary receiver and superheated steam for the reheat receiver. Specifications and quality for the working fluid are as follows:

Solar Main Steam

TDS	<100	ppb
Na	30	ppb
SiO_2	20.0	ppb

Solar Feedwater

pH	8.7	
Conductivity	0.3	mmho
SiO_2	3	ppm

B.3.4.4 Receiver Tower

The receiver tower must support the primary and reheat receivers, piping and other elements of the receiver subsystem. Tower design will require the following:

a. Tower height - 129.5 m

b. Elevation of primary receiver centerline - 155.0 m

c. Elevation of reheat receiver centerline - 140.1 m

d. Weight of primary and reheat receivers including support structure - 1.02×10^6 kg

e. Design wind load - 40.3 m/s (90 mph)

f. Seismic zone category - UBC Zone 1

g. Deflection limitations (TBD)

h. Soil conditions (TBD)

Structural design will include an analysis of dynamic wind stresses (vortex shedding) to determine the critical wind velocity.

The tower will be required to support feedwater, main steam, reheat and auxiliary piping and associated controls and provide access for maintenance and repair. In addition to internal ladders, platforms and walkways, the design of the tower shall include an elevator having a capacity of approximately 409 kg (900 lb).

B.3.5 Master Control Subsystem (MCS)

B.3.5.1 General Design Requirements

The Newman Unit 1 control system and existing power plant equipment shall be modified to provide daily cycling of the unit and utilize fossil and solar energy for generation of electrical power. The MCS shall control the solar steam supply system and the existing plant equipment in a safe and reliable condition under all modes of operation.

The MCS shall permit the operator to select one of three plant operating modes: fossil mode, solar mode, or combined solar/fossil mode.

The MCS shall operate the unit under all conditions including startup, shutdown, transient, steady state, and emergency operation.

B.3.5.2 Design Criteria

In order to satisfy the general design requirements the MCS shall meet the following design criteria:

a. High Availability

- High component/circuit reliability employing the latest solid state technology and conservative designs.
- Major control systems and components shall have full redundant backup.
- Modular architecture to enhance fault detection and maintenance.

- Self-diagnostic capability wherever possible.

b. Redundancy

The MCS will include full system redundancy where feasible. A failure of one computer processing unit (CPU) will not cause a reduction in control, monitoring, display, or other required plant control functions.

c. Comprehensive Operator/Plant Interface

- CRT displays are provided for the following:
  - Process monitoring
  - Trouble identification
  - Operator guidance
  - Interactive communications
  - Status information
  - Historical review
- Main control board with conventional analog displays, control stations, alarms, etc, providing the operator with a familiar operation/process interface.

d. Flexibility

All control logic functions and control algorithms are implemented in comprehensive direct digital control (DDC) software. The system is programmed in a basic language which allows changes to be made simply and quickly.

e. System Modifications

Existing control systems will be modified only where necessary. The following criteria will determine which controls are changed:

- Direct interface with MCS.
- Significant enhancement of the repowered unit's ability to meet the design requirements.
- Ability of the equipment to function properly for the required 30-year lifetime.

In general, all instrumentation that will be replaced meets two or more of the above criteria.

B.3.5.3 Operating Modes

B.3.5.3.1 Fossil Mode

When the fossil mode has been selected, the solar repowering system shall be isolated from the existing fossil fueled power plant. In this mode, the control system shall permit the unit to be placed in either boiler following, or turbine following, control.

B.3.5.3.2 Solar Only Mode

With clear day insolation available, the operator will select a solar only mode of operation. The fossil boiler will be shut down and isolated and the solar repowering system will be operated with the turbine placed in turbine following control. The solar primary receiver, solar reheat receiver, and the collector subsystem shall be automatically controlled to maximize thermal energy output from the solar steam supply system. The turbine inlet control valves will be automatically positioned to maintain stable steam conditions to the turbine inlets.

B.3.5.3.3 Combined Solar/Fossil Mode

When intermittent cloud conditions prevail or when it is economical to operate the unit at high load, the Master Control System shall control the plant in a solar/fossil mode. In the solar/fossil mode, the steam from the solar receivers and the fossil boiler shall be combined prior to being admitted to the turbine. The control system shall operate the solar steam supply system to maximize solar thermal output and uses the fossil boiler to supplement steam to meet the unit's load demand. In this mode the turbine can be operated in either turbine following or boiler following control, depending on the needs of the grid.

B.3.6 Fossil Boiler Subsystem

The Fossil Boiler Subsystem of Newman Unit 1 shall interface with the solar steam supply system according to the following boiler performance requirements:

a. Minimum automatic operation - 28 percent load (36 percent rated steam flow)

b. Maximum boiler ramp rate - 11 percent/min (change in boiler thermal output)

c. Energy required from cold startup to 28 percent load - 1.06×10^{11} J (100 MBtu) over 4 hours

d. Energy required from hot standby to 28 percent load - 1.58 x 10^{10} J (15 MBtu)

e. Boiler efficiency - 84.4 percent

f. Ability to maintain superheat and reheat temperature of 538°C (1000°F) to minimum load

B.3.7 Electric Power Generating Subsystem (EPGS)

The EPGS will be required to accept steam from either or both the solar or fossil steam supply systems.

Operating constraints imposed by the existing EPGS are as follows:

a.	Maximum gross electric output	85.8 MWe
b.	Rated main steam flow for guaranteed output	257,000 kg/hr (567,000 lb/hr)
c.	Main steam rated temperature	538°C (1000°F)
d.	Reheat steam rated temperature	538°C (1000°F)
e.	Main steam rated pressure	10.1 MPa (1450 psig)
f.	Rated reheat pressure drop	255 kPa (37 psi)

g. Steam temperature limitations (at turbine main stop valve)

1. Average over 12 months not to exceed 538°C (1000°F)

2. 552°C (1025°F) for not more than 400 hours for 12 months

3. 566°C (1050°F for up to 15 minutes: not more than 80 hours/year

h. Steam pressure limitations

1. 10.1 MPa (1450 psig) at rated output

2. 10.6 MPa (1523 psig) as turbine approaches zero output

3. 13.0 MPa (1885 psig) momentarily, not exceeding 12 hours/year

i. Load limitations

Rate of load change is limited by metal temperatures in critical areas of turbine. Normal turbine load change rates are limited to about 5 MWe/min. Faster load changes will require monitoring of turbine rotor and casting metal temperatures.

B.3.8 Service Life

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

B.3.9 Plant Availability and Reliability

Consideration shall be given in the design to achieving high reliability by providing design and operating margins and utilizing sound engineering design practices.

B.3.10 Maintainability

The solar repowered plant modifications and new installations shall be designed to be compatible with existing plant maintainability characteristics and practices. Potential maintenance locations shall be easily reached and components, such as electronic units, motors, drivers, etc, readily replaced. Elements subject to wear and damage such as supporting wheels, gears, etc, shall be easily serviced or replaced. The plant shall be capable of being serviced with a minimum of specialized equipment or tools.

B.4 ENVIRONMENTAL CRITERIA

This section addresses plant environmental design requirements and environmental standards.

B.4.1 Design Requirements

The system shall be capable of operating in and surviving appropriate combinations of the following environments:

a. Temperature: The plant shall be able to operate in the ambient air temperature range from −22° to +50°C (−8° to 122°F). Performance requirements shall be met throughout an ambient air temperature range of 0°C to 50°C (32°F to 122°F).

b. Wind: The plant shall be capable of operating given the following approximate wind profile as a frequency of function of height above ground level.

   Performance requirements shall be met for the most adverse combination of wind and temperature conditions selected to be consistent with efficient plant operation. Wind analyses shall satisfy the requirements of ANSI A58.1-1972.

c. Earthquake: This peak ground accelerations, as presented below, will be combined with the response spectrum given by NRC Regulatory Guide 1.60 and the damping values given for the operating bases earthquake in NRC Regulatory Guide 1.61.

   Peak Ground Acceleration Average or Firm Conditions = 0.125 g.

The system shall be capable of surviving appropriate combinations of the environments specified below:

a. Wind: The plant shall survive winds with a maximum speed, including gusts of 40.3 m/s (90 mph), without damage. A local wind vector variation of +10 degrees from the horizontal shall be assumed for the survival condition.

b. Snow: The plant shall survive a static snow load of 250 Pa (5 lb/ft²) and a snow deposition rate of 0.3 m (1 ft) in 24 hours.

c. Rain: The plant shall survive the following rainfall conditions at a maximum 24-hr rate of 75 mm (3 in).

d. Ice: The plant shall survive freezing rain and ice deposits in a layer 50 mm (2 in) thick.

e. Earthquake: The peak ground accelerations as presented below will be combined with the response spectrum given by NRC Regulatory Guide 1.60 and the damping values given for the operating bases earthquake in NRC Regulatory Guide 1.61.

Maximum Survival Ground Accelerations (Peak Ground Acceleration Average or Firm Conditions) = 0.125 g.

f. Hail: The plant shall survive hail impact up to the following limits:

Diameter	25 mm (1 in)
Specific Gravity	0.9
Terminal Velocity	23 m/s (75 fps)
Temperature	-6.7°C (22°F)

g. Sandstorm Environment: The plant shall survive after being exposed to flowing dust comparable to the conditions described by Methods 510 of MIL-STD-810B.

The plant shall be provided with a lightning protection system for the tower and receivers.

B.4.2 Environmental Standards

Federal, state, and local regulations applicable to solar repowering Newman Unit 1 are presented in Section B.2.4.

APPENDIX C

APPENDIX C

SOLTES 1 INPUT DATA
Full Load (82 MWe)
50% Solar Repowering

Solar Reheat

Parameter	Format	Columns	Description
NAME	A6	1-6	AUXBLR
NCOM	I10	11-20	2
NSTAI	I5	21-25	3
ETA	F10.0	51-60	68.
T2	F10.0	61-70	811

EOF

Downcomer

Parameter	Format	Columns	Description
MAME	A10	1-10	PIPE
NCOM	I10	11-20	5
NSTA1	I5	21-25	2
XL	F10.0	51-60	387
D1	F10.0	61-70	.257
SUMTHR	F10.0	71-80	999999999
NPIPE	I10	1-10	1
PLOSS	F10.0	11-20	.50
RUFF	F10.0	21-30	--
DELZ	F10.0	31-40	147
XKL	F10.0	41-50	--
TA	F10.0	51-60	333

EOF

VAPJNT

Parameter	Format	Columns	Description
NAME	A6	1-6	FLODIV
NCOM	I-10	11-20	9
NSTA1	I5	21-25	5
NSTAO1	I5	26-30	9
NSTAO2	I5	41-45	10
NSREF	I10	51-60	5
SCALF	F10.0	61-70	200.

EOF

EPGS

Parameter	Format	Columns	Description
NAME	A5	1-10	TURBG
NCOM	I10	11-20	13
NSTA1	I5	21-25	9
ETAG	F10.2	51-60	100.
X*	F10.2	61-70	--
ESTAM	F10.2	71-80	100.
ETA	F10.2	1-10	100.
TB	F10.2	11-20	655
EOF			

BFDPMP

Parameter	Format	Columns	Description
NAME	A6	1-6	BFDPMP
NCOM	I10	11-20	17
NSTA1	I5	21-25	13
P2	E10.4	51-60	9,997,750.
ETA1	F10.2	61-70	100.0
ETAM	F10.2	71-80	100.
PARMOD	A10	1-10	--
EOF			

FLODIV

Parameter	Format	Columns	Description
NAME	A6	1-6	FLODIV
NCOM	I10	11-20	18
NSTA1	I5	21-25	17
NSTAO1	I5	26-30	20
NSTAO2	I5	41-45	19
NSREF	I10	51-60	17
SCALF	F10.0	61-70	50.

PIPE

Parameter	Format	Columns	Description
NAME	A10	1-10	PIPE
NCOM	I10	11-20	21
NSA1	I5	21-25	20
XL	F10.0	51-60	39.6
D1	F10.0	61-70	.203
SUMTHR	F10.0	71-80	9999999999

PIPE (Cont')

Parameter	Format	Columns	Description
NPIPE	I10	1-10	1
PLOSS	F10.0	11-20	.5
RUFF	F10.0	21-30	--
DELZ	F10.0	31-40	0
YKL	F10.0	41-50	--
TA	F10.0	51-60	333
EOF			

RISER

Parameter	Format	Columns	Description
NAME	A10	1-10	PIPE
NCOM	I10	11-20	23
NSTA1	I5	21-25	21
XL	F10.0	51-60	244
DI	F10.0	61-70	.141
SUMTHR	F10.0	71-80	9999999999
NPIPE	I10	1-10	1
PLOSS	F10.0	11-20	.50
RUFF	F10.0	21-30	--
DEL2	F10.0	31-40	149
XKL	F10.0	41-50	--
TA	F10.0	51-60	333
EOF			

Pump

Parameter	Format	Columns	Description
NAME	A6	1-6	BFDPMP
NCOM	I10	11-20	24
NSTA1	I5	21-25	23
PZ	E10.4	51-60	9,997,750
ETA1	F10.2	61-70	100.
ETAM	F10.2	71-80	100.
PARMOD	F10.2	1-10	—
EOF			

Solar Boiler

Parameter	Format	Columns	Description
NAME	A6	1-6	AUXBLR
NCOM	I10	11-20	31
NSTA1	I5	21-25	24
ETA	F10.0	51-60	88.3
T2	F10.0	61-70	811
EOF			

Downcomer

Parameter	Format	Columns	Description
NAME	A10	1-10	PIPE
NCOM	I10	11-20	6
NSTA1	I5	21-25	31
XL	F10.0	51-60	387
D1	F10.0	61-70	.257
SUMTHR	F10.0	71-80	9999999999
NPIPE	I10	1-10	1
PLOSS	F10.0	11-20	.50
RUFF	F10.0	21-30	—
DEL2	F10.0	31-40	147
XKL	F10.0	41-50	—
TA	F10.0	51-60	333

EOF

VAPJNT

NAME	A6	1-6	FLODIV
NCOM	I10	11-20	30
NSTA1	I5	21-25	6
NSTAO1	I5	26-30	30
NSTAO2	I5	41-45	7
NSREF	I10	51-60	6
SCALF	F10.0	61-70	200.

EOF

EPGS

NAME	A5	1-10	TURBG
NCOM	I10	11-20	12
NSTA1	I5	21-25	9
ETAG	F10.2	51-60	100.
X*	F10.2	61-70	—
ESTAM	F10.2	71-80	24.3
ETA	F10.2	1-10	100.
TB	F10.2	11-20	426

FLODIV

NAME	A6	1-6	FLODIV
NCOM	I10	11-20	14
NSTA1	I5	21-25	12
NSTAO1	I5	26-30	4

RISER

Parameter	Format	Columns	Description
NSTAO2	I5	41-45	15
NSREF	I10	51-60	12
SCALF	F10.0	61-70	50.
EOF			
NAME	A10	1-10	PIPE
NCOM	I10	11-20	3
NSA1	I5	21-25	4
XL	F10.0	51-60	387
D1	F10.0	61-70	.257
SUMTHR	F10.0	71-80	9999999999
NPIPE	I10	1-10	1
PLOSS	F10.0	11-20	.50
RUFF	F10.0	21-30	
DEL2	F10.0	31-40	147
XKL	F10.0	41-50	
TA	F10.0	51-60	333
EOF			

AUXBLR

Parameter	Format	Columns	Description
NAME	A6	1-6	AUXBLR
NCOM	I10	11-20	7
NSTA1	I5	21-25	19
ETA	F10.0	51-60	84.1
T2	F10.0	61-70	811.
EOF			

RHTBLR

Parameter	Format	Columns	Description
NAME	A6	1-6	AUXBLR
NCOM	I10	11-20	10
NSTA1	I5	21-25	15
ETA	F10.0	51-60	84.1
T2	F10.0	61-70	811.
EOF			

TABLE C-1

SUMMARY OF PLANT EFFICIENCIES FOR SOLTES PROGRAM INPUTS

Boiler Efficiency
% Efficiency

Electrical Output (MWe)	% Plant Load	Fossil Boiler	Fossil Reheat	Solar Boiler	Solar Reheat
82	100	84.4	84.4		
61.5	75	84.2	84.2		
41	50	84.1	84.1	88.3	68.0
20.5	25	84.2	84.2	84.0	47.5

Turbine-Generator Efficiency
% Efficiency

Plant Output (MWe)	EPGS(1)	HP TURBG(2)	LP TURBG(3)
82	39.4	100	24.3
61.5	38.8	100	23.5
41	36.6	100	20.8
20.5	31.0	100	13.8

NOTES:

1. Overall EPGS efficiency, including all plant thermal, mechanical, isentropic, and parasitic losses except boiler efficiency.

2. HP Turbine-Generator provides 20 percent of electrical output and is assumed, for simplicity, to be 100 percent efficient.

3. Mechanical efficiency of LP Turbine-Generator. Incorporates all EPGS losses, including the condenser heat rejection but excluding the boiler efficiencies.

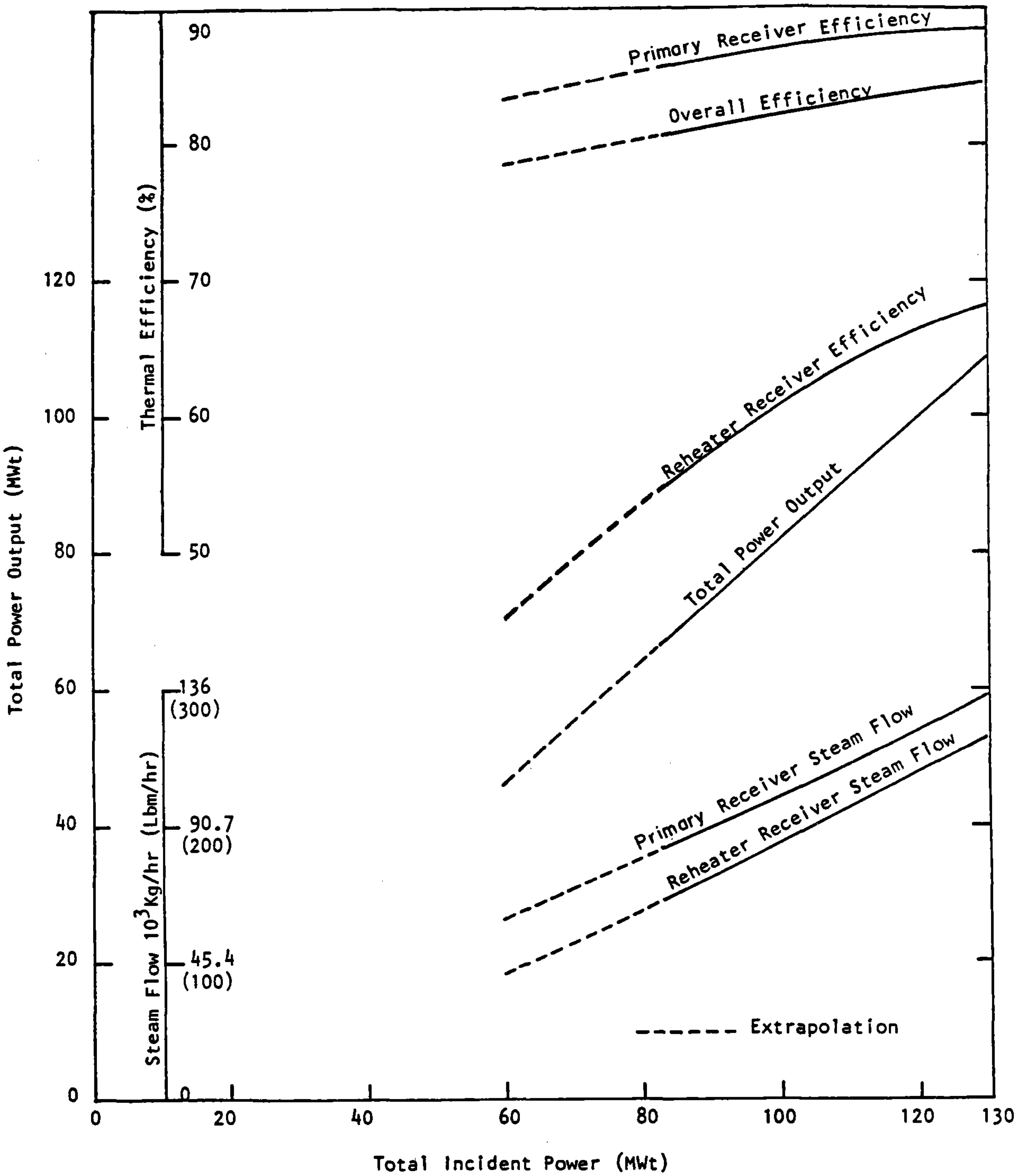


FIGURE C-1
RECEIVER PERFORMANCE AS
FUNCTION OF INCIDENT POWER

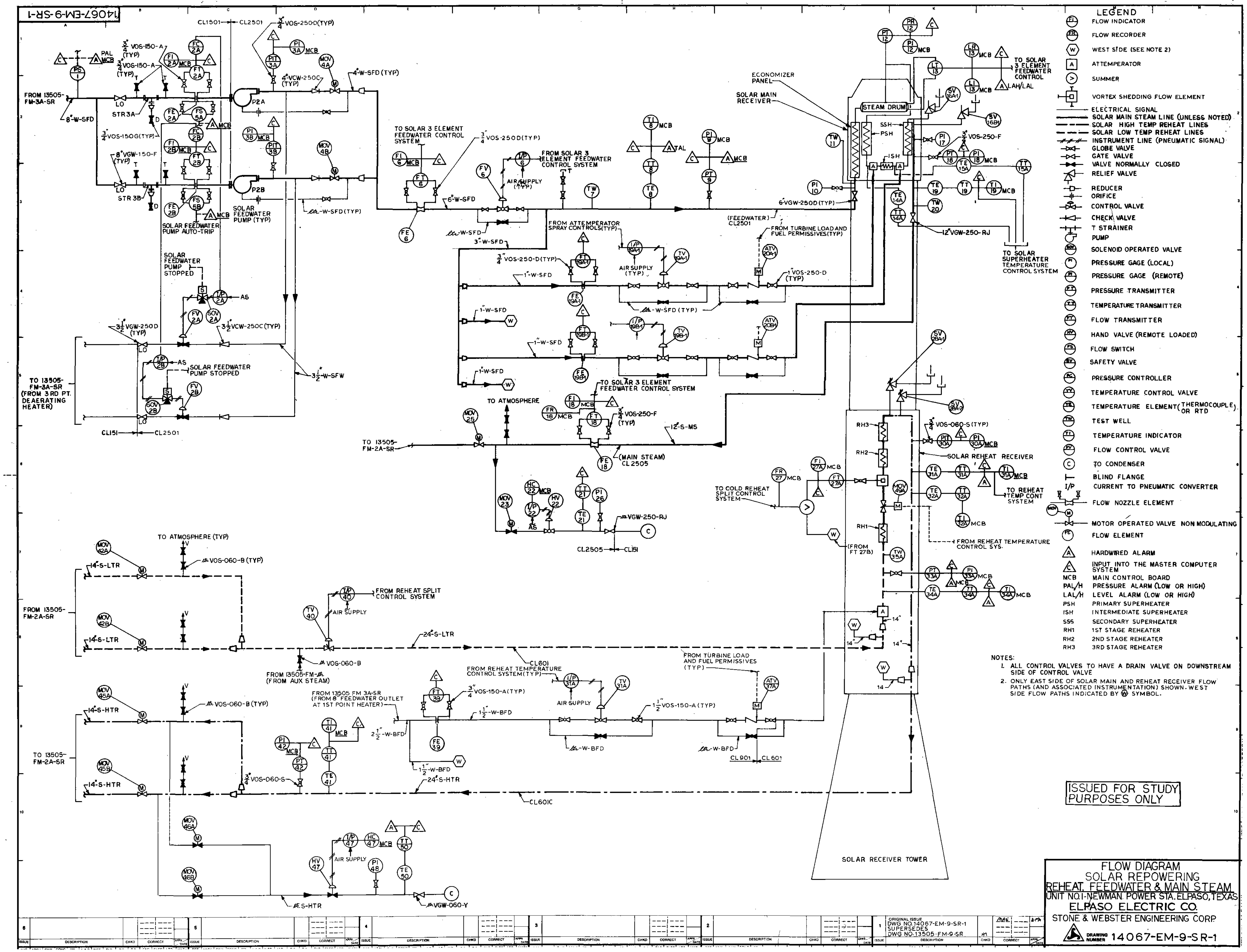
APPENDIX D

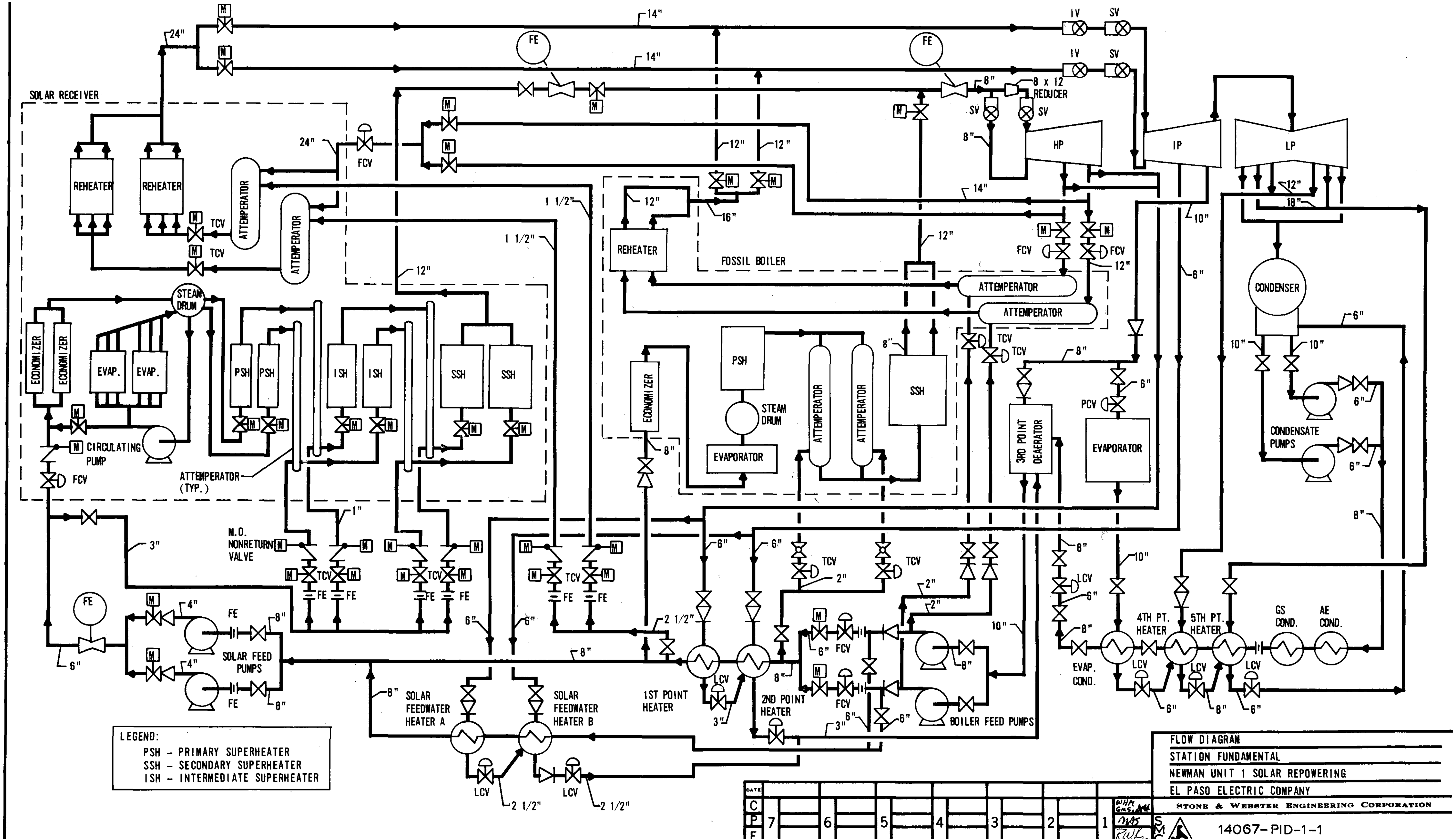
APPENDIX D

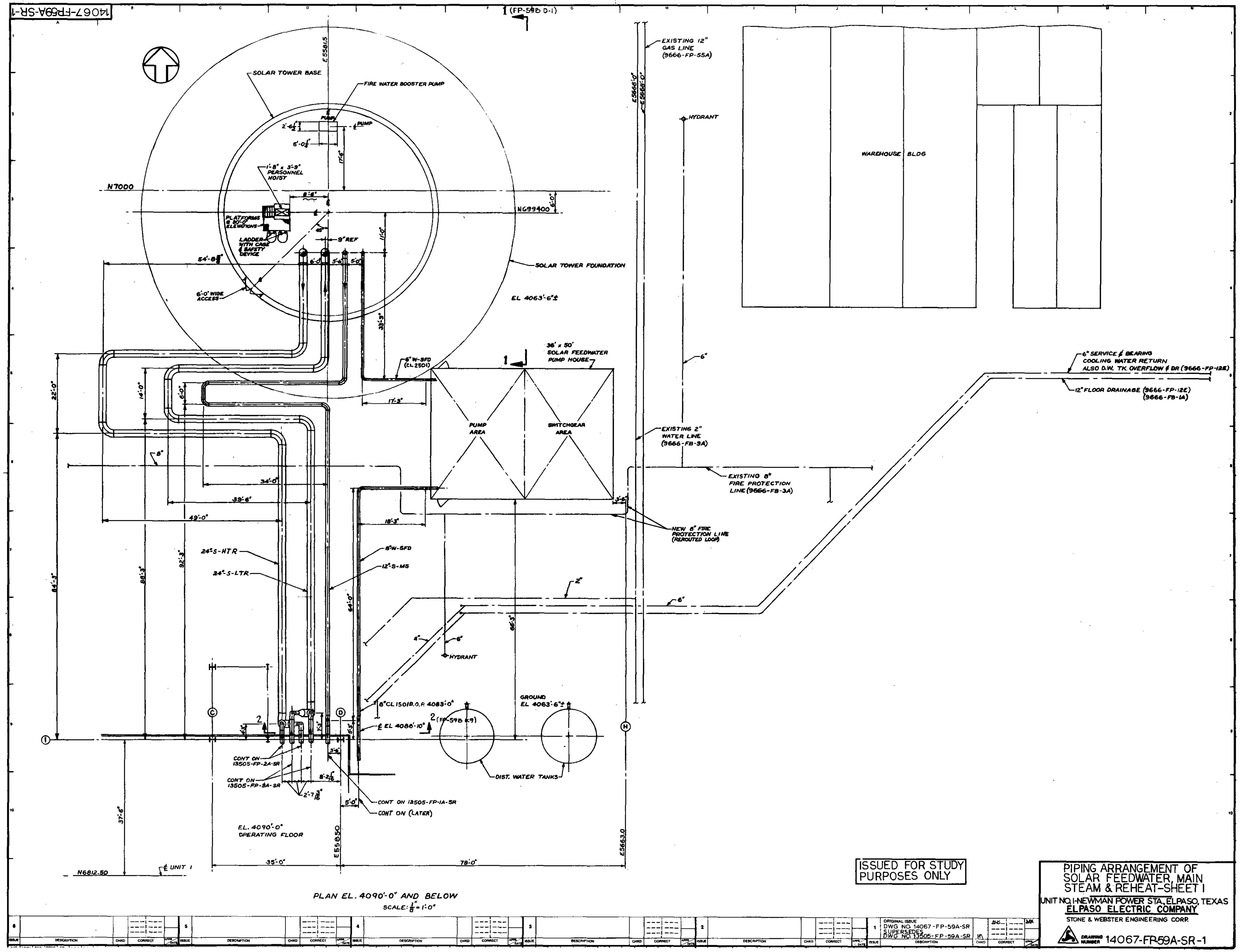
CONCEPTUAL DESIGN DRAWINGS AND DIAGRAMS

The following drawings, diagrams, and sketches are included in Appendix D:

14067-EM-9-SR-1	Flow Diagram - Solar Repowering, Reheat, Feedwater, and Main Steam
14067-PID-1-1	Flow Diagram - Station Fundamental
14067-FP-59A-SR-1	Piping Arrangement of Solar Feedwater, Main Steam, and Reheat - Sheet 1
14067-FP-59B-SR-2	Piping Arrangement of Solar Feedwater, Main Steam, and Reheat - Sheet 2
13505-FP-1A-SR	Main Steam Line - Sheet 1
13505-FP-1B-SR	Main Steam Line - Sheet 2
13505-FP-2A-SR	High Temperature Reheat Steam Line - Sheet 1
13505-FP-2B-SR	High Temperature Reheat Steam Line - Sheet 2
13505-FP-3A-SR	Low Temperature Reheat Steam Line - Sheet 1
13505-FP-3B-SR	Low Temperature Reheat Steam Line - Sheet 2
14067-EW-S1A-SR-1	One Line Diagram for Solar Repowering
13505-FY-3A-SR	Lot Plan
14067-FM-31A-SR-1	General Arrangement - Heliostat Field
14067-FM-31B-SR-1	General Arrangement - Heliostat Field
B&W 5328J	Arrangement Solar Receiver with Reheater for Advanced Repowering
B&W 268068 E	Solar Boiler Plan - Sections A-A and B-B


14067-EM-9-SR-1
LEGEND
FLOW INDICATOR
FLOW RECORDER
WEST SIDE (SEE NOTE 2)
ATTEMPERATOR
SUMMER
VORTEX SHEDDING FLOW ELEMENT
ELECTRICAL SIGNAL
SOLAR MAIN STEAM LINE (UNLESS NOTED)
SOLAR HIGH TEMP REHEAT LINES
SOLAR LOW TEMP REHEAT LINES
INSTRUMENT LINE (PNEUMATIC SIGNAL)
GLOBE VALVE
GATE VALVE
VALVE NORMALLY CLOSED
RELIEF VALVE
REDUCER
ORIFICE
CONTROL VALVE
CHECK VALVE
T STRAINER
PUMP
SOLENOID OPERATED VALVE
PRESSURE GAGE (LOCAL)
PRESSURE GAGE (REMOTE)
PRESSURE TRANSMITTER
TEMPERATURE TRANSMITTER
FLOW TRANSMITTER
HAND VALVE (REMOTE LOADED)
FLOW SWITCH
SAFETY VALVE
PRESSURE CONTROLLER
TEMPERATURE CONTROL VALVE
TEMPERATURE ELEMENT (THERMOCOUPLE OR RTD)
TEST WELL
TEMPERATURE INDICATOR
FLOW CONTROL VALVE
TO CONDENSER
BLIND FLANGE
I/P CURRENT TO PNEUMATIC CONVERTER
FLOW NOZZLE ELEMENT
MOTOR OPERATED VALVE NON MODULATING
FLOW ELEMENT
HARDWIRED ALARM
INPUT INTO THE MASTER COMPUTER SYSTEM
MCB MAIN CONTROL BOARD
PAL/H PRESSURE ALARM (LOW OR HIGH)
LAL/H LEVEL ALARM (LOW OR HIGH)
PSH PRIMARY SUPERHEATER
ISH INTERMEDIATE SUPERHEATER
SSS SECONDARY SUPERHEATER
RH1 1ST STAGE REHEATER
RH2 2ND STAGE REHEATER
RH3 3RD STAGE REHEATER
NOTES:
1. ALL CONTROL VALVES TO HAVE A DRAIN VALVE ON DOWNSTREAM SIDE OF CONTROL VALVE
2. ONLY EAST SIDE OF SOLAR MAIN AND REHEAT RECEIVER FLOW PATHS (AND ASSOCIATED INSTRUMENTATION) SHOWN. WEST SIDE FLOW PATHS INDICATED BY Ⓦ SYMBOL.
FROM 13505-FM-3A-SR
TO 13505-FM-3A-SR (FROM 3RD PT. DEAERATING HEATER)
SOLAR FEEDWATER PUMP AUTO-TRIP
SOLAR FEEDWATER PUMP (TYP)
SOLAR FEEDWATER PUMP STOPPED
TO SOLAR 3 ELEMENT FEEDWATER CONTROL SYSTEM
FROM SOLAR 3 ELEMENT FEEDWATER CONTROL SYSTEM
FROM ATTEMPERATOR SPRAY CONTROLS (TYP)
FROM TURBINE LOAD AND FUEL PERMISSIVES (TYP)
ECONOMIZER PANEL
SOLAR MAIN RECEIVER
STEAM DRUM
TO SOLAR 3 ELEMENT FEEDWATER CONTROL
TO SOLAR SUPERHEATER TEMPERATURE CONTROL SYSTEM
TO ATMOSPHERE
TO 13505-FM-2A-SR
(MAIN STEAM) CL2505
TO COLD REHEAT SPLIT CONTROL SYSTEM
SOLAR REHEAT RECEIVER
TO REHEAT TEMP CONT SYSTEM
FROM REHEAT TEMPERATURE CONTROL SYS.
TO ATMOSPHERE (TYP)
FROM 13505-FM-2A-SR
FROM REHEAT SPLIT CONTROL SYSTEM
FROM 13505-FM-(FROM AUX STEAM)
FROM 13505 FM 3A-SR (FROM 8" FEEDWATER OUTLET AT 1ST POINT HEATER)
FROM REHEAT TEMPERATURE CONTROL SYSTEM (TYP)
FROM TURBINE LOAD AND FUEL PERMISSIVES (TYP)
TO 13505-FM-2A-SR
SOLAR RECEIVER TOWER
ISSUED FOR STUDY PURPOSES ONLY
ORIGINAL ISSUE DWG NO. 14067-EM-9-SR-1
SUPERSEDES DWG NO. 13505-FM-9-SR
FLOW DIAGRAM
SOLAR REPOWERING
REHEAT, FEEDWATER & MAIN STEAM
UNIT NO. 1-NEWMAN POWER STA., ELPASO, TEXAS
ELPASO ELECTRIC CO.
STONE & WEBSTER ENGINEERING CORP.
DRAWING NUMBER 14067-EM-9-SR-1


SOLAR RECEIVER
REHEATER
REHEATER
ATTEMPERATOR
ATTEMPERATOR
TCV
FCV
STEAM DRUM
ECONOMIZER
ECONOMIZER
EVAP.
EVAP.
PSH
PSH
ISH
ISH
SSH
SSH
CIRCULATING PUMP
ATTEMPERATOR (TYP.)
M.O. NONRETURN VALVE
FE
SOLAR FEED PUMPS
SOLAR FEEDWATER HEATER A
SOLAR FEEDWATER HEATER B
LCV
FOSSIL BOILER
REHEATER
ECONOMIZER
PSH
STEAM DRUM
EVAPORATOR
ATTEMPERATOR
SSH
3RD POINT DEAERATOR
EVAPORATOR
PCV
1ST POINT HEATER
2ND POINT HEATER
BOILER FEED PUMPS
EVAP. COND.
4TH PT. HEATER
5TH PT. HEATER
GS COND.
AE COND.
CONDENSER
CONDENSATE PUMPS
HP
IP
LP
IV
SV
8 x 12 REDUCER
LEGEND:
PSH - PRIMARY SUPERHEATER
SSH - SECONDARY SUPERHEATER
ISH - INTERMEDIATE SUPERHEATER
FLOW DIAGRAM
STATION FUNDAMENTAL
NEWMAN UNIT 1 SOLAR REPOWERING
EL PASO ELECTRIC COMPANY
STONE & WEBSTER ENGINEERING CORPORATION
14067-PID-1-1



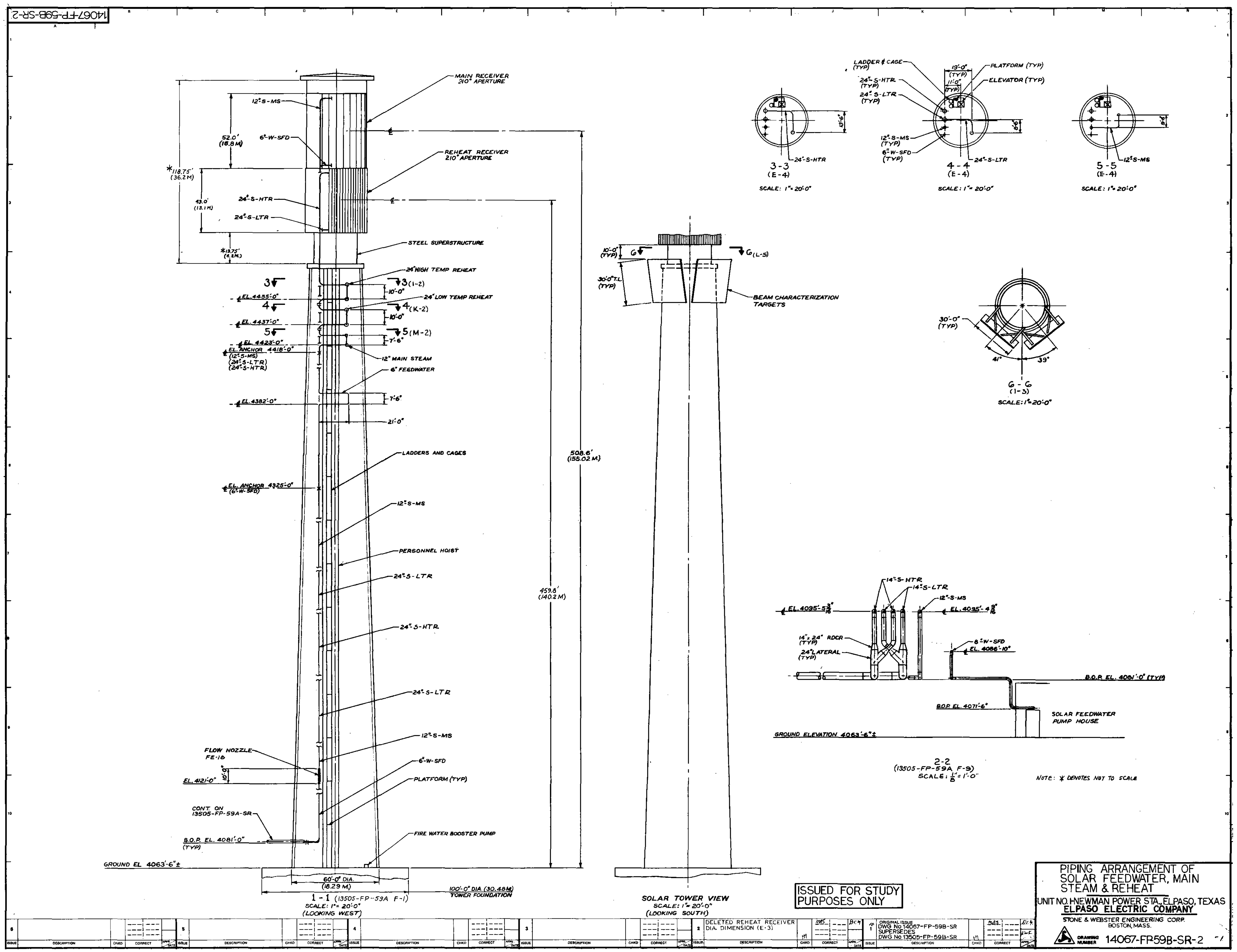
PIPING ARRANGEMENT OF SOLAR FEEDWATER, MAIN STEAM & REHEAT-SHEET 1

UNIT NO 1-NEWMAN POWER STA., EL PASO, TEXAS

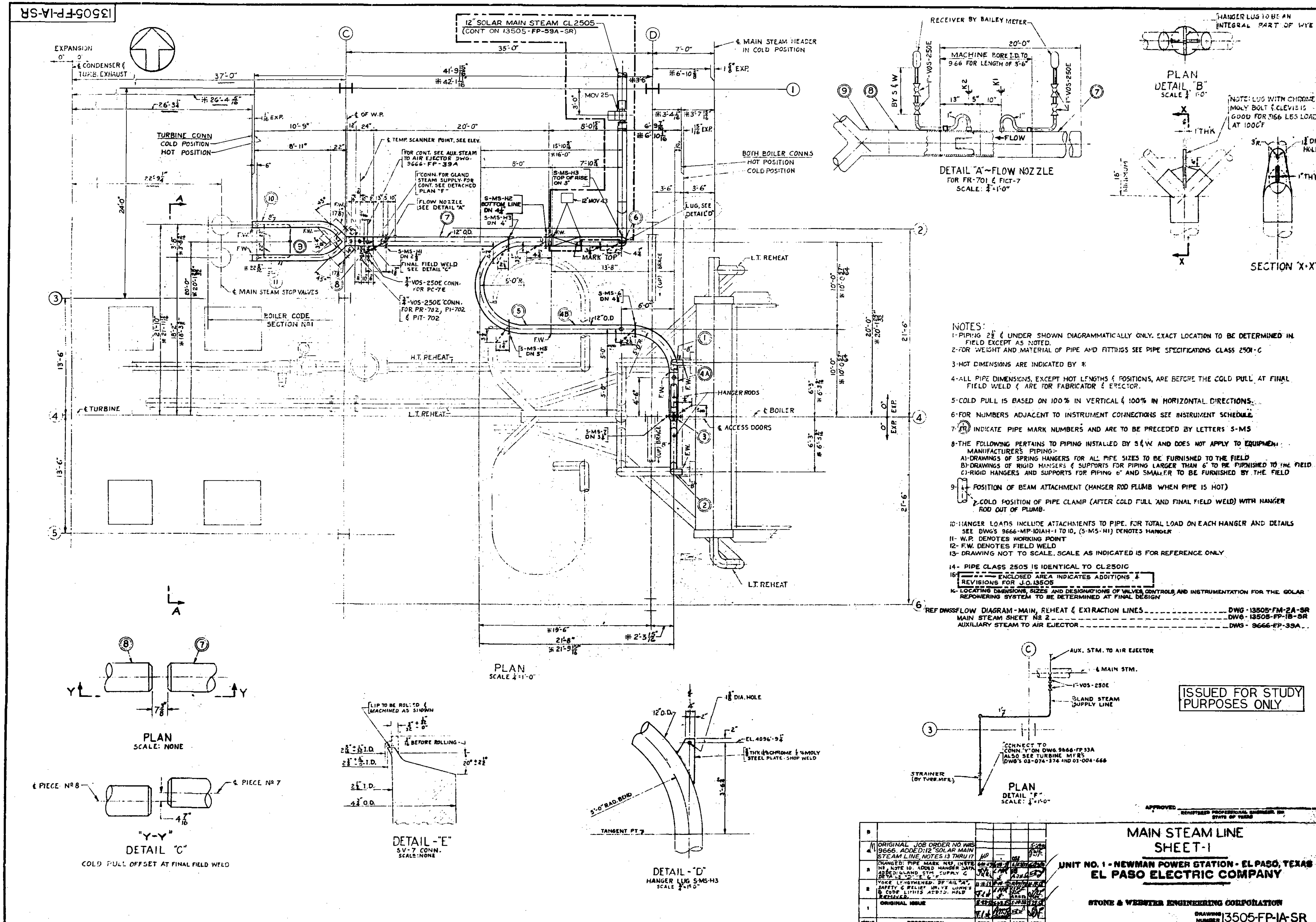
EL PASO ELECTRIC COMPANY

STONE & WEBSTER ENGINEERING CORP.

DRAWING NUMBER 14067-FP59A-SR-1



PIPING ARRANGEMENT OF SOLAR FEEDWATER, MAIN STEAM & REHEAT
UNIT NO. 1 NEWMAN POWER STA., EL PASO, TEXAS
EL PASO ELECTRIC COMPANY
STONE & WEBSTER ENGINEERING CORP. BOSTON, MASS.
DRAWING NUMBER 14067-FP59B-SR-2



NOTES:

1- PIPING 2½ & UNDER SHOWN DIAGRAMMATICALLY ONLY. EXACT LOCATION TO BE DETERMINED IN FIELD EXCEPT AS NOTED.
2- FOR WEIGHT AND MATERIAL OF PIPE AND FITTINGS SEE PIPE SPECIFICATIONS CLASS 2501-C
3- HOT DIMENSIONS ARE INDICATED BY *
4- ALL PIPE DIMENSIONS, EXCEPT HOT LENGTHS & POSITIONS, ARE BEFORE THE COLD PULL AT FINAL FIELD WELD & ARE FOR FABRICATOR & ERECTOR.
5- COLD PULL IS BASED ON 100% IN VERTICAL & 100% IN HORIZONTAL DIRECTIONS.
6- FOR NUMBERS ADJACENT TO INSTRUMENT CONNECTIONS SEE INSTRUMENT SCHEDULE.
7- (ETC) INDICATE PIPE MARK NUMBERS AND ARE TO BE PRECEDED BY LETTERS S-MS
8- THE FOLLOWING PERTAINS TO PIPING INSTALLED BY S&W AND DOES NOT APPLY TO EQUIPMENT MANUFACTURERS PIPING:-
   A)- DRAWINGS OF SPRING HANGERS FOR ALL PIPE SIZES TO BE FURNISHED TO THE FIELD
   B)- DRAWINGS OF RIGID HANGERS & SUPPORTS FOR PIPING LARGER THAN 6" TO BE FURNISHED TO THE FIELD
   C)- RIGID HANGERS AND SUPPORTS FOR PIPING 6" AND SMALLER TO BE FURNISHED BY THE FIELD
9- POSITION OF BEAM ATTACHMENT (HANGER ROD PLUMB WHEN PIPE IS HOT)
   COLD POSITION OF PIPE CLAMP (AFTER COLD PULL AND FINAL FIELD WELD) WITH HANGER ROD OUT OF PLUMB.
10- HANGER LOADS INCLUDE ATTACHMENTS TO PIPE. FOR TOTAL LOAD ON EACH HANGER AND DETAILS SEE DWG'S 9666-MP-101AH-1 TO 10, (S-MS-H1) DENOTES HANGER
11- W.P. DENOTES WORKING POINT
12- F.W. DENOTES FIELD WELD
13- DRAWING NOT TO SCALE. SCALE AS INDICATED IS FOR REFERENCE ONLY
14- PIPE CLASS 2505 IS IDENTICAL TO CL2501C
15- ENCLOSED AREA INDICATES ADDITIONS & REVISIONS FOR J.O. 13505
16- LOCATING DIMENSIONS, SIZES AND DESIGNATIONS OF VALVES, CONTROLS, AND INSTRUMENTATION FOR THE SOLAR REPOWERING SYSTEM TO BE DETERMINED AT FINAL DESIGN

REF DWGS:
FLOW DIAGRAM - MAIN, REHEAT & EXTRACTION LINES — DWG - 13505-FM-2A-SR
MAIN STEAM SHEET No 2 — DWG - 13505-FP-1B-SR
AUXILIARY STEAM TO AIR EJECTOR — DWG - 9666-FP-39A

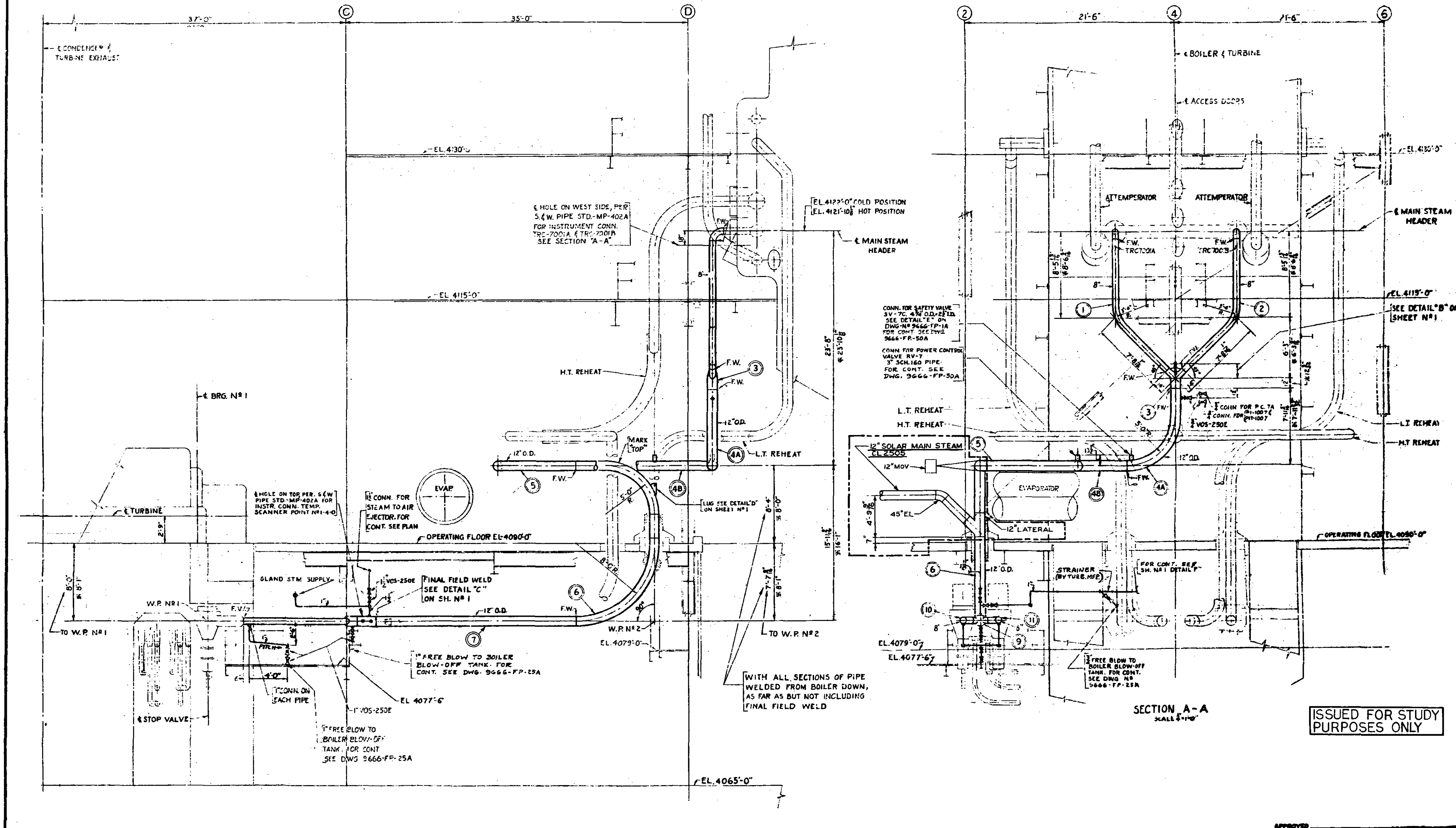
ISSUE	DESCRIPTION	CHKD.	INSP.	CORR.	APPR.
5					
4	ORIGINAL JOB ORDER NO. WAS 9666. ADDED: 12" SOLAR MAIN STEAM LINE, NOTES 13 THRU 17				
3	CHANGED: PIPE MARK NO, INSTR. NO, NOTE 10. ADDED HANGER DATA. ADDED: GLAND STM. SUPPLY & DETAILS "D", "E" & "F"				
2	YOKE LENGTHENED. DETAIL "A", SAFETY & RELIEF VALVE CONN'S & CODE LIMITS ADDED. HOLD REMOVED.				
1	ORIGINAL ISSUE				

MAIN STEAM LINE
SHEET-1

UNIT NO. 1 - NEWMAN POWER STATION - EL PASO, TEXAS
EL PASO ELECTRIC COMPANY

STONE & WEBSTER ENGINEERING CORPORATION

DRAWING NUMBER 13505-FP-IA-SR



NOTES:

1. FOR GENERAL NOTES AND REFERENCE DWG'S, SEE SH. Nº 1 DWG. 13505-FP-IA-SR
2. ENCLOSED AREA INDICATES ADDITIONS & REVISIONS FOR J.O. 13505
3. LOCATING DIMENSIONS, SIZES, AND DESIGNATIONS OF VALVES, CONTROLS, AND INSTRUMENTATION FOR THE SOLAR REPOWERING SYSTEM TO BE DETERMINED AT FINAL DESIGN.

ISSUE	DESCRIPTION	CHKD.	INSP.	CORR.	APPR.
5	ORIGINAL JOB ORDER NO. WAS 9666. ADDED 12" SOLAR MAIN STEAM LINE, NOTE 2,3				5-29-80
4	FIELD CHANGES				
3	CHANGED: S.V. & R.V. NOZZLES, PIPE MARK NO., F.W. & HGR. ARRST. ADDED HANGER LUG. ADDED: GLAND STM. SUPPLY				
2	YOKE LENGTHENED SAFETY & RELIEF VALVE CONN'S ADDED				
1	ORIGINAL ISSUE				

APPROVED ______

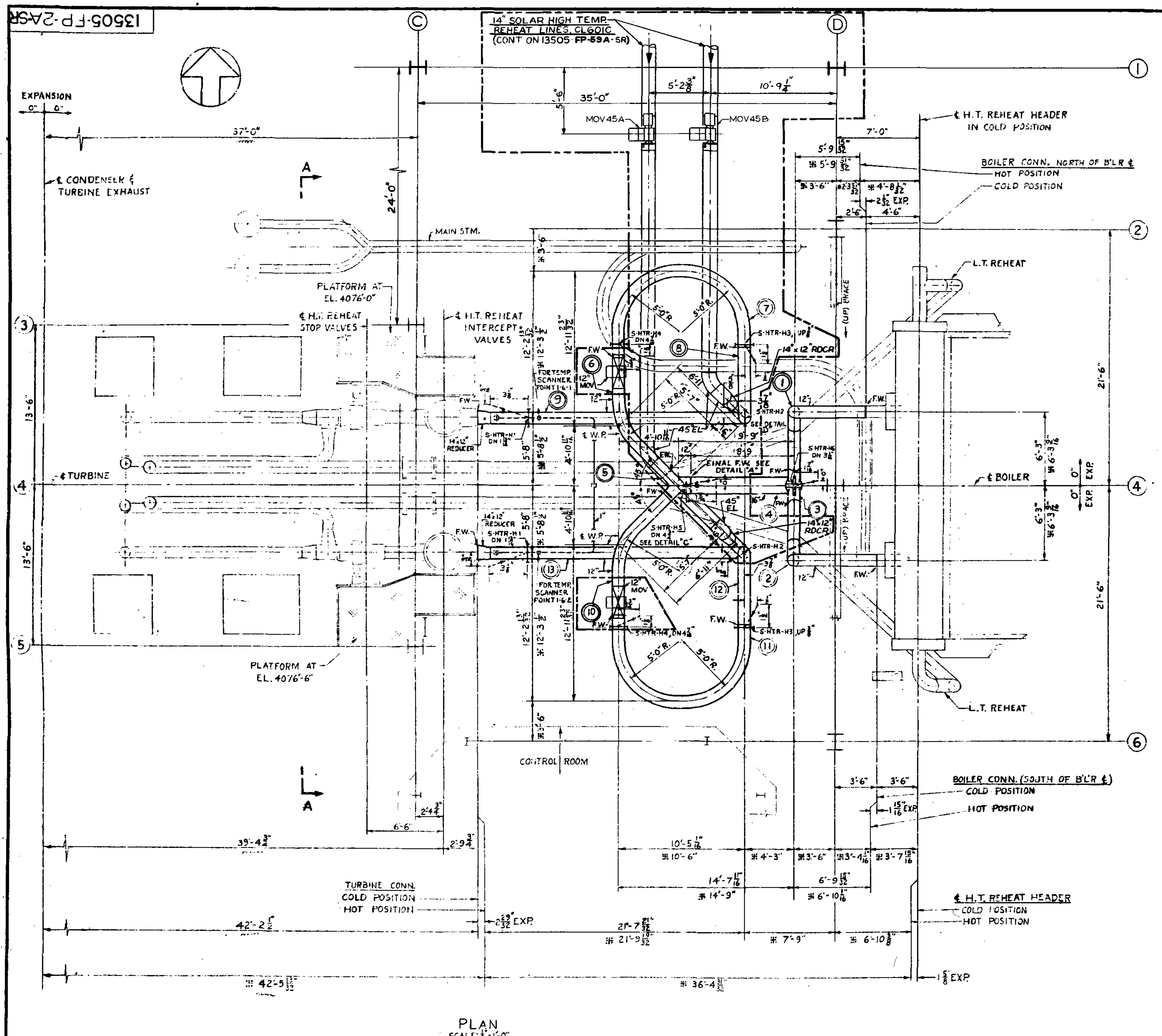
MAIN STEAM LINE
SHEET-2

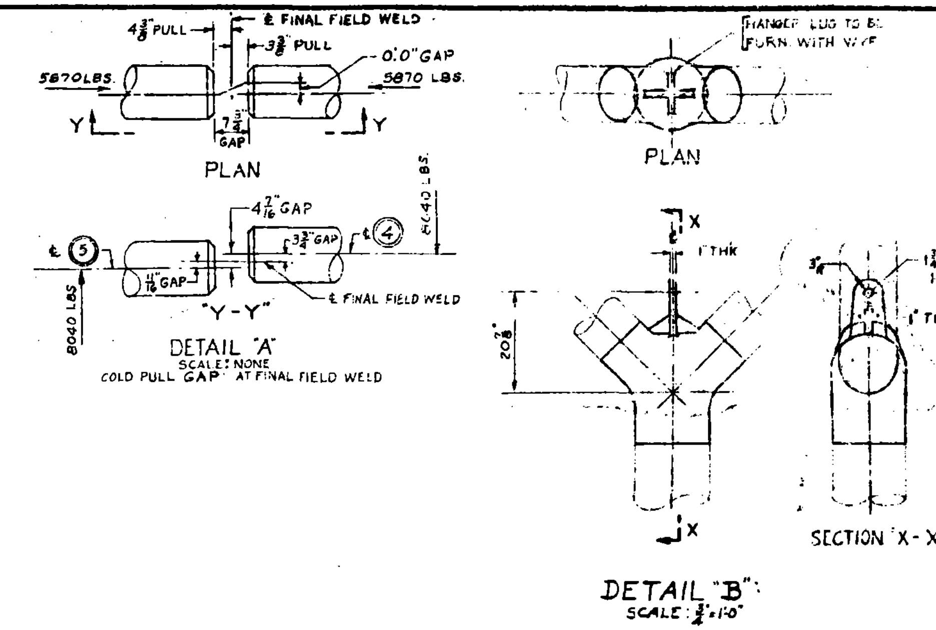
UNIT NO. 1 - NEWMAN POWER STATION - EL PASO, TEXAS

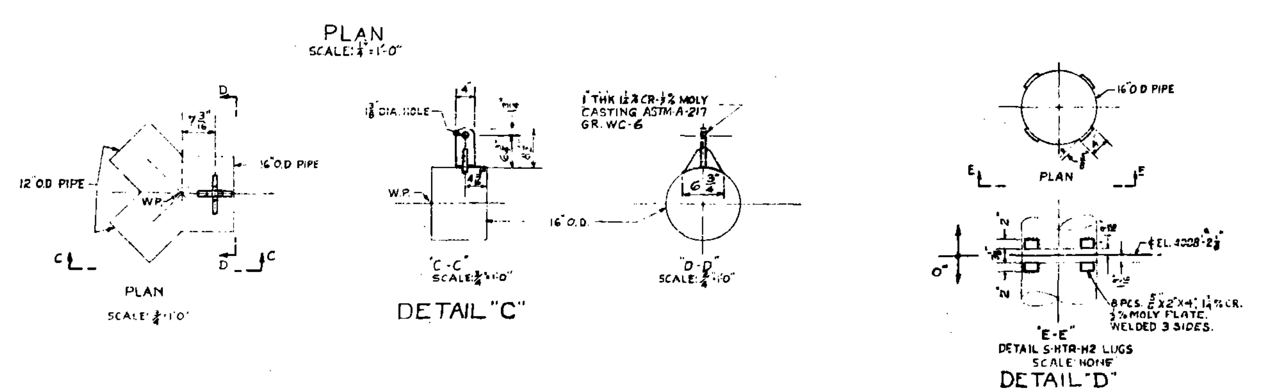
EL PASO ELECTRIC COMPANY

STONE & WEBSTER ENGINEERING CORPORATION

DRAWING NUMBER 13505-FP-IB-SR







NOTES:

1-PIPING 2 1/2" & UNDER SHOWN DIAGRAMMATICALLY ONLY. EXACT LOCATION TO BE DETERMINED IN FIELD EXCEPT AS NOTED.

2-FOR WEIGHT AND MATERIAL OF PIPE AND FITTINGS SEE PIPE SPECIFICATIONS CLASS 601-C

3-HOT DIMENSIONS ARE INDICATED BY ※

4-ALL PIPE DIMENSIONS, EXCEPT HOT LENGTHS & POSITIONS, ARE BEFORE THE COLD PULL AT FINAL FIELD WELD & ARE FOR FABRICATOR & ERECTOR.

5-COLD PULL IS BASED ON 100% IN VERTICAL & 100% IN HORIZONTAL DIRECTIONS.

6-FOR NUMBERS ADJACENT TO INSTRUMENT CONNECTIONS SEE INSTRUMENT SCHEDULE

7-(etc) INDICATE PIPE MARK NUMBERS AND ARE TO BE PRECEDED BY LETTERS S-HTR

8-THE FOLLOWING PERTAINS TO PIPING INSTALLED BY S&W AND DOES NOT APPLY TO EQUIPMENT MANUFACTURER'S PIPING:-
 A)-DRAWINGS OF SPRING HANGERS FOR ALL PIPE SIZES TO BE FURNISHED TO THE FIELD
 B)-DRAWINGS OF RIGID HANGERS & SUPPORTS FOR PIPING LARGER THAN 6 TO BE FURNISHED TO THE FIELD
 C)-RIGID HANGERS AND SUPPORTS FOR PIPING 6" AND SMALLER TO BE FURNISHED BY THE FIELD

9- POSITION OF BEAM ATTACHMENT (HANGER ROD PLUMB WHEN PIPE IS HOT)
 COLD POSITION OF PIPE CLAMP (AFTER COLD PULL AND FINAL FIELD WELD) WITH HANGER ROD OUT OF PLUMB

10-HANGER LOADS INCLUDE ATTACHMENTS TO PIPE. FOR TOTAL LOAD ON EACH HANGER AND HANGER DETAILS SEE DWG'S 9666-MP-102-AH-1 TO 12.

11-W.P. DENOTES WORKING POINT
12-F.W DENOTES FIELD WELD
13-S-HTR-H1 DENOTES SPRING HANGER
14. DRAWING NOT TO SCALE. SCALE AS INDICATED IS FOR REFERENCE ONLY.

15. ENCLOSED AREA INDICATES ADDITIONS & REVISIONS FOR J.O. 13505

16. LOCATING DIMENSIONS, SIZES, AND DESIGNATIONS OF VALVES, CONTROLS, AND INSTRUMENTATION FOR THE SOLAR REPOWERING SYSTEM TO BE DETERMINED AT FINAL DESIGN.

REF. DWGS:
HIGH TEMP. REHEAT LINE SHEET NO. 2 ____ DWG 13505-FP-2B-SR
FLOW DIAGRAM - MAIN, REHEAT & EXTRACTION LINES ____ DWG 13505-FM-2A-SR

APPROVED ____ REGISTERED PROFESSIONAL ENGINEER NO. 18776 STATE OF TEXAS

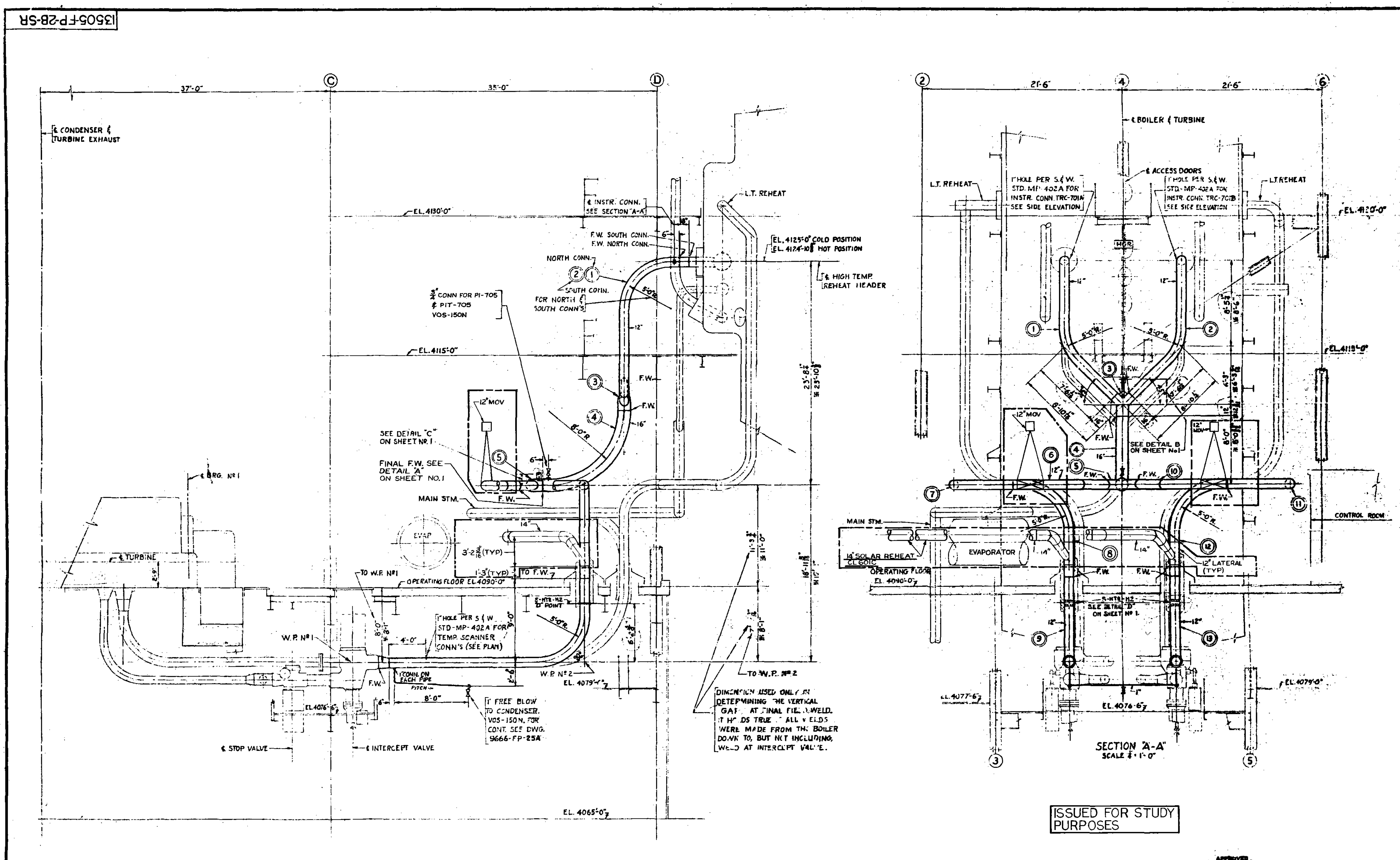
ISSUE	DESCRIPTION	CHKD.	INSP.	CONS	APPR.
5					
4					
3	ORIGINAL JOB ORDER NO WAS 9666. ADDED 14" SOLAR HIGH TEMP REHEAT LINES, NOTE 14,15,16,17	[illegible]	—	[illegible]	5-29-87 [illegible]
2	DIMENSIONS CHANGED. DETAIL "B" REVISED. HOLDS REMOVED. HANGER DATA AND NOTE 13 ADDED. NOTE 10 [illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1	ORIGINAL ISSUE	[illegible]	[illegible]	[illegible]	[illegible]

HIGH TEMP REHEAT STEAM LINE
SHEET 1

UNIT NO. 1 • NEWMAN POWER STATION • EL PASO, TEXAS
EL PASO ELECTRIC COMPANY

STONE & WEBSTER ENGINEERING CORPORATION

DRAWING NUMBER 13505-FP-2A-SR



NOTES:

1. FOR GENERAL NOTES AND REFERENCE DWG'S. SEE SHEET No 1 DWG 13505-FP-2A-SR
2. ENCLOSED AREA INDICATES ADDITIONS & REVISIONS FOR J.O. 13505
3. LOCATING DIMENSIONS, SIZES, AND DESIGNATIONS OF VALVES, CONTROLS, AND INSTRUMENTATION FOR THE SOLAR REPOWERING SYSTEM TO BE DETERMINED AT FINAL DESIGN.

ISSUE	DESCRIPTION	CHKD	INSP.	CORR.	APPR.
5					
4					
3	ORIGINAL JOB ORDER NO. WAS 9666. ADDED: 14" SOLAR HIGH TEMP REHEAT LINES, NOTE 2,3	[illegible]		[illegible]	5/29/80 RWK
2	DIMENSIONS CHANGED. HANGER DATA ADDED. NOTE CHANGED	[illegible]	[illegible]	[illegible]	[illegible]
1	ORIGINAL ISSUE	[illegible]	[illegible]	[illegible]	[illegible]

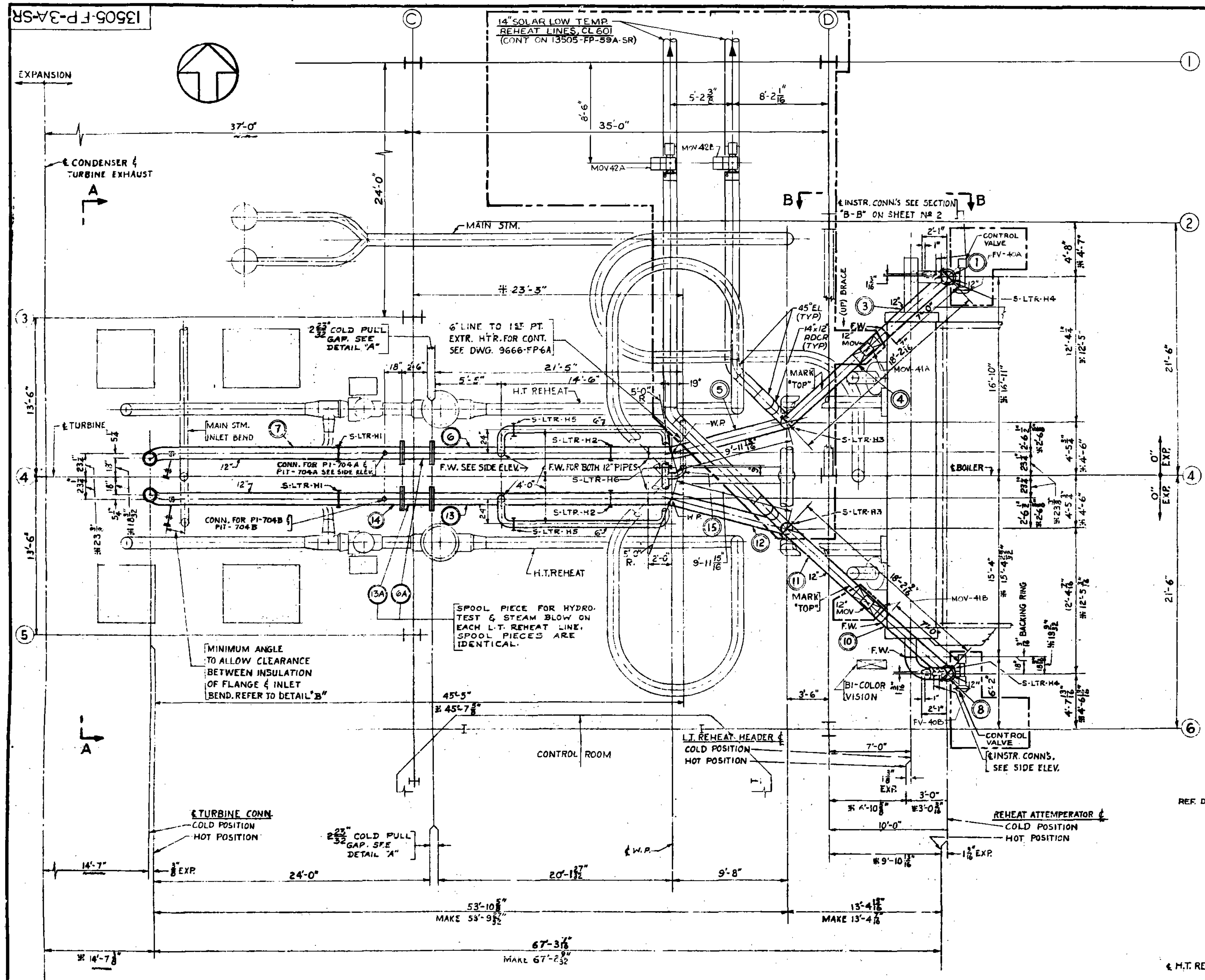
APPROVED

HIGH TEMP. REHEAT STEAM LINE SHEET 2

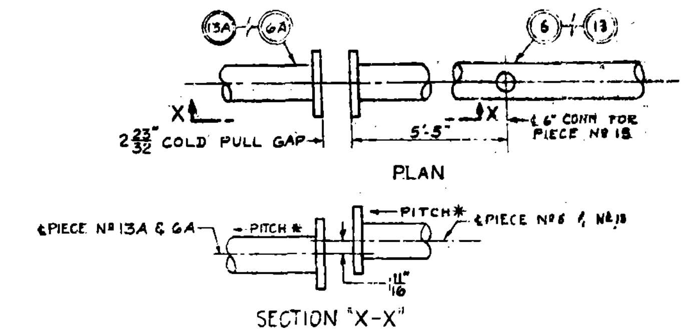
UNIT NO. 1 • NEWMAN POWER STATION • EL PASO, TEXAS
EL PASO ELECTRIC COMPANY

STONE & WEBSTER ENGINEERING CORPORATION

DRAWING NUMBER 13505-FP-2B-SR



PLAN
SCALE 3/8"=1'-0"



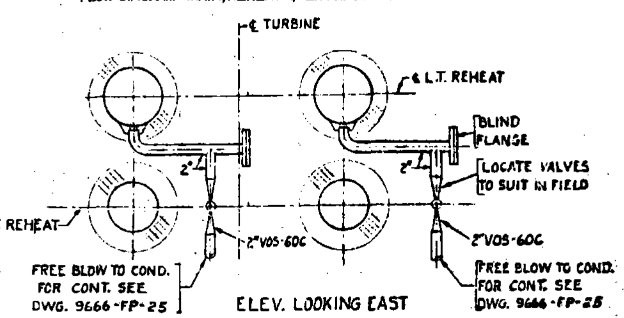
DETAIL "A"
SCALE: NONE
COLD PULL GAP & OFFSET

* NOTE:
FOR ANGLE OF PITCH REFER TO
W.P. Nº 2 ON SIDE ELEV. SH. Nº 2

NOTES:

1- PIPING 2½" & UNDER SHOWN DIAGRAMMATICALLY ONLY. EXACT LOCATION TO BE DETERMINED IN FIELD EXCEPT AS NOTED.
2- FOR WEIGHT AND MATERIAL OF PIPE AND FITTINGS SEE PIPE SPECIFICATIONS CLASS 601
3- HOT DIMENSIONS ARE INDICATED BY *
4- ALL PIPE DIMENSIONS, EXCEPT HOT LENGTHS & POSITIONS, ARE BEFORE THE COLD PULL AT FINAL FIELD WELD & ARE FOR FABRICATOR & ERECTOR.
5- COLD PULL IS BASED ON 50% IN VERTICAL & 50% IN HORIZONTAL DIRECTIONS.
6- FOR NUMBERS ADJACENT TO INSTRUMENT CONNECTIONS SEE INSTRUMENT SCHEDULE.
7- (⑯) INDICATE PIPE MARK NUMBERS AND ARE TO BE PRECEDED BY LETTERS S-LTR
8- THE FOLLOWING PERTAINS TO PIPING INSTALLED BY S.&W. AND DOES NOT APPLY TO EQUIPMENT MANUFACTURER'S PIPING:-
A)- DRAWINGS OF SPRING HANGERS FOR ALL PIPE SIZES TO BE FURNISHED TO THE FIELD.
B)- DRAWINGS OF RIGID HANGERS & SUPPORTS FOR PIPING LARGER THAN 6" TO BE FURNISHED TO THE FIELD.
C)- RIGID HANGERS AND SUPPORTS FOR PIPING 6" AND SMALLER TO BE FURNISHED BY THE FIELD.
9- HANGER PIPE CLAMP AND ITS BEAM ATTACHMENT TO BE LOCATED IN THE COLD POSITION SO THAT THE HANGER ROD WILL BE PLUMB WHEN PIPE IS HOT.
10- HANGER LOADS INCLUDE ATTACHMENTS TO PIPE. FOR TOTAL LOAD ON EACH HANGER AND DETAILS SEE DWG. 9666-MP-AH-1 TO 12. (S-LTR-H1) DENOTES HANGER.
11- W.P. DENOTES WORKING POINT.
12- F.W. DENOTES FIELD WELD.
13- PIPE FABRICATOR TO ALLOW FOR A 3/16" SPACE BETWEEN WELDING ENDS (SEE DWG. STD.-HP-4[illegible]) [illegible] AT ALL FIELD WELDS EXCEPT AT THE BOILER CONN'S AND TOP OF REHEAT ATTEMPERATOR. [illegible] OF REHEAT ATTEMPERATOR TO BE SHORTENED BY ⅛" AS INDICATED ON SIDE ELEVATION. TO [illegible] AT TOP AND BOTTOM OF REHEAT ATTEMPERATOR
14 DRAWING NOT TO SCALE. SCALE AS INDICATED IS FOR REFERENCE ONLY.
15. ——— ENCLOSED AREA INDICATES ADDITIONS & REVISIONS FOR J.O. 13505
16 LOCATING DIMENSIONS, SIZES, AND DESIGNATIONS OF VALVES, CONTROLS, AND INSTRUMENTATION FOR THE SOLAR REPOWERING SYSTEM TO BE DETERMINED AT FINAL DESIGN.

REF. DWGS:
REHEAT ATTEMPERATOR ———— BOILER MFR'S DWG. [illegible]-2
L.T. REHEAT STEAM LINES SHEET NO.2 ———— DWG. 13505-FP-3B-SR
FLOW DIAGRAM-MAIN, REHEAT & EXTRACTION LINES ———— DWG. 13505-FM-2A-SR



DETAIL "B"
DRAIN CONNECTIONS
SCALE ¾"=1'-0"

ISSUED FOR STUDY PURPOSES ONLY

APPROVED

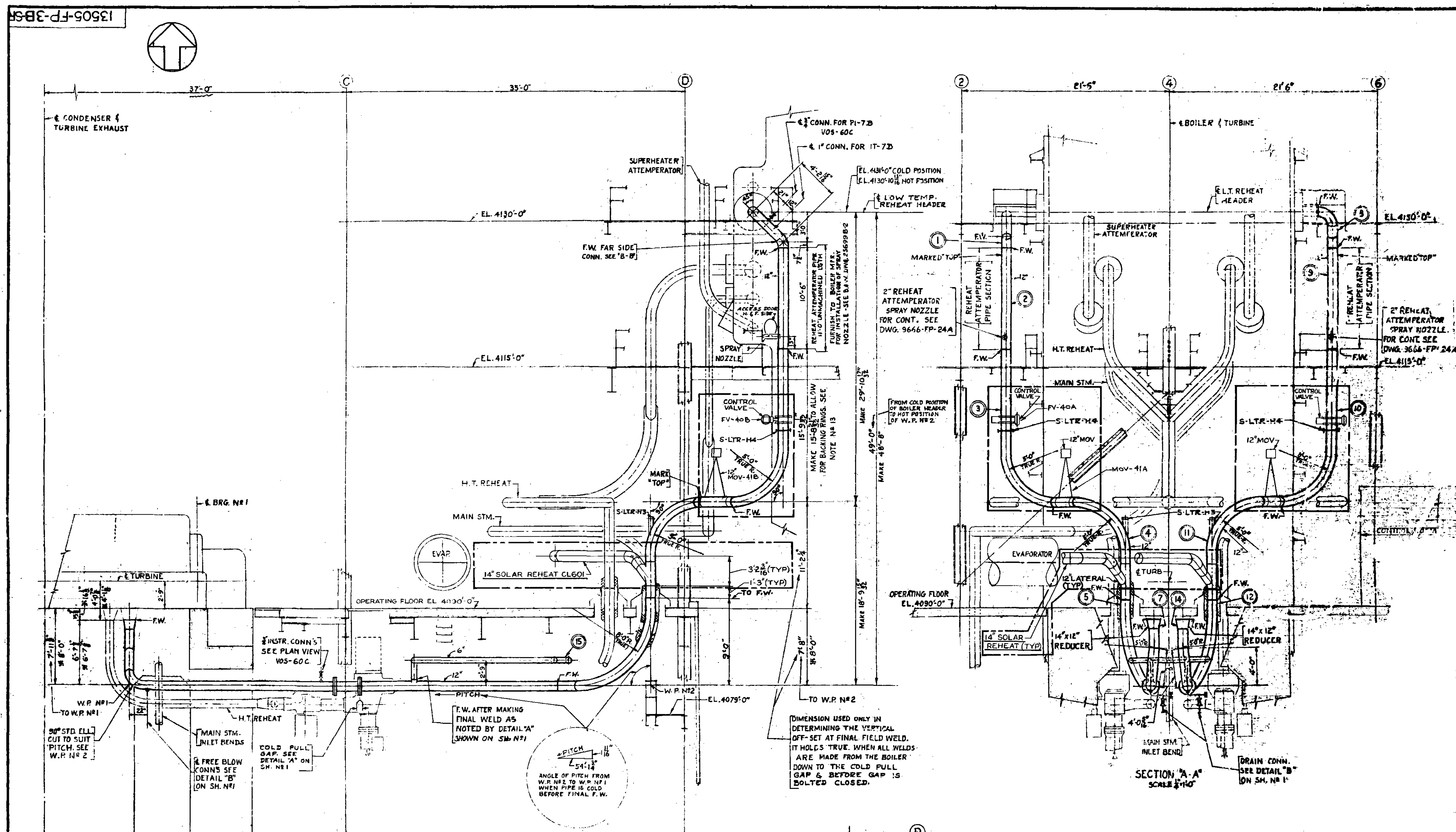
ISSUE	DESCRIPTION	CHKD	INSP	CORR	APPR	ISSUE	DESCRIPTION	CHKD	INSP	CORR	APPR
						5	FIELD CHANGES	[illegible]	LMK	[illegible]	[illegible]
						4	HANGERS ADDED & NOTES CHANGED TO SUIT. "HOLD" REMOVED.	[illegible]	[illegible]	[illegible]	[illegible]
						3	SPOOL PIECE ADDED & DETAIL "B" CHANGED.	[illegible]	[illegible]	[illegible]	[illegible]
						2	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
6	ORIGINAL JOB ORDER NO. WAS 9666. ADDED 14" SOLAR LOW TEMP REHEAT, NOTE 14,15,16,17	HP	—	[illegible]	5-29-80 RWK	1	ORIGINAL ISSUE	[illegible]	[illegible]	[illegible]	[illegible]

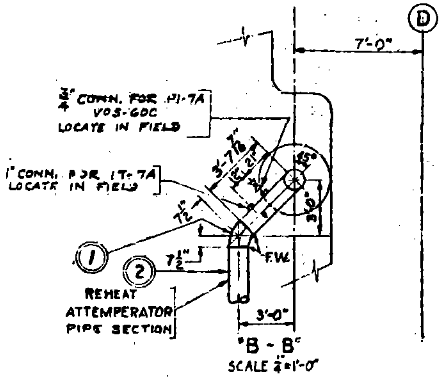
LOW TEMP. REHEAT STEAM LINE SHEET - 1

UNIT NO. 1 • NEWMAN POWER STATION • EL PASO, TEXAS
EL PASO ELECTRIC COMPANY

STONE & WEBSTER ENGINEERING CORPORATION

DRAWING NUMBER 13505-FP-3A-SR





ISSUE	DESCRIPTION	CHKD	INSP	CORR	APPR
6	ORIGINAL JOB ORDER NO. WAS 9666. ADDED: 14" SOLAR LOW TEMP REHEAT LINES, NOTE 2,3				

ISSUED FOR STUDY PUROSES ONLY

NOTES:

1. FOR GENERAL NOTES AND REFERENCE DWG'S SEE SHEET Nº1 DWG. 13505-FP-3A-SR
2. ENCLOSED AREA INDICATES ADDITIONS & REVISIONS FOR J.O. 13505
3. LOCATING DIMENSIONS, SIZES, AND DESIGNATIONS OF VALVES, CONTROLS, AND INSTRUMENTATION FOR THE SOLAR REPOWERING SYSTEM TO BE DETERMINED AT FINAL DESIGN.

ISSUE	DESCRIPTION	CHKD.	INSP.	CORR.	APPR.
5	FIELD CHANGES				
4	HANGER DATA ADDED				
3	SPOOL PIECE ADDED DIMENSIONS CHANGED & REMOVED. NOTE CHG'D.				
2	RELOCATED 6" PIPE				
1	ORIGINAL ISSUE				

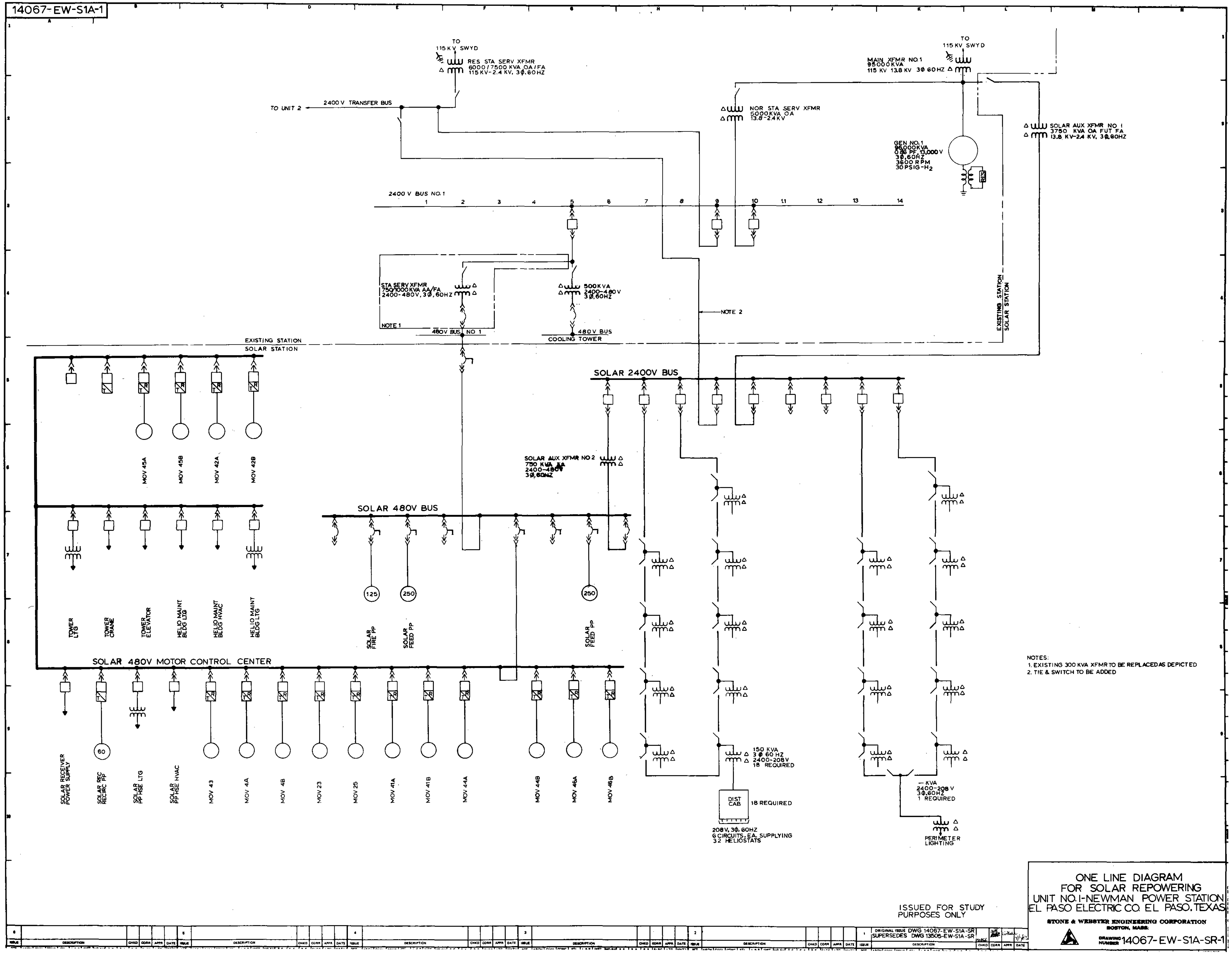
LOW TEMP REHEAT STEAM LINE SHEET-2

UNIT NO. 1 • NEWMAN POWER STATION • EL PASO, TEXAS

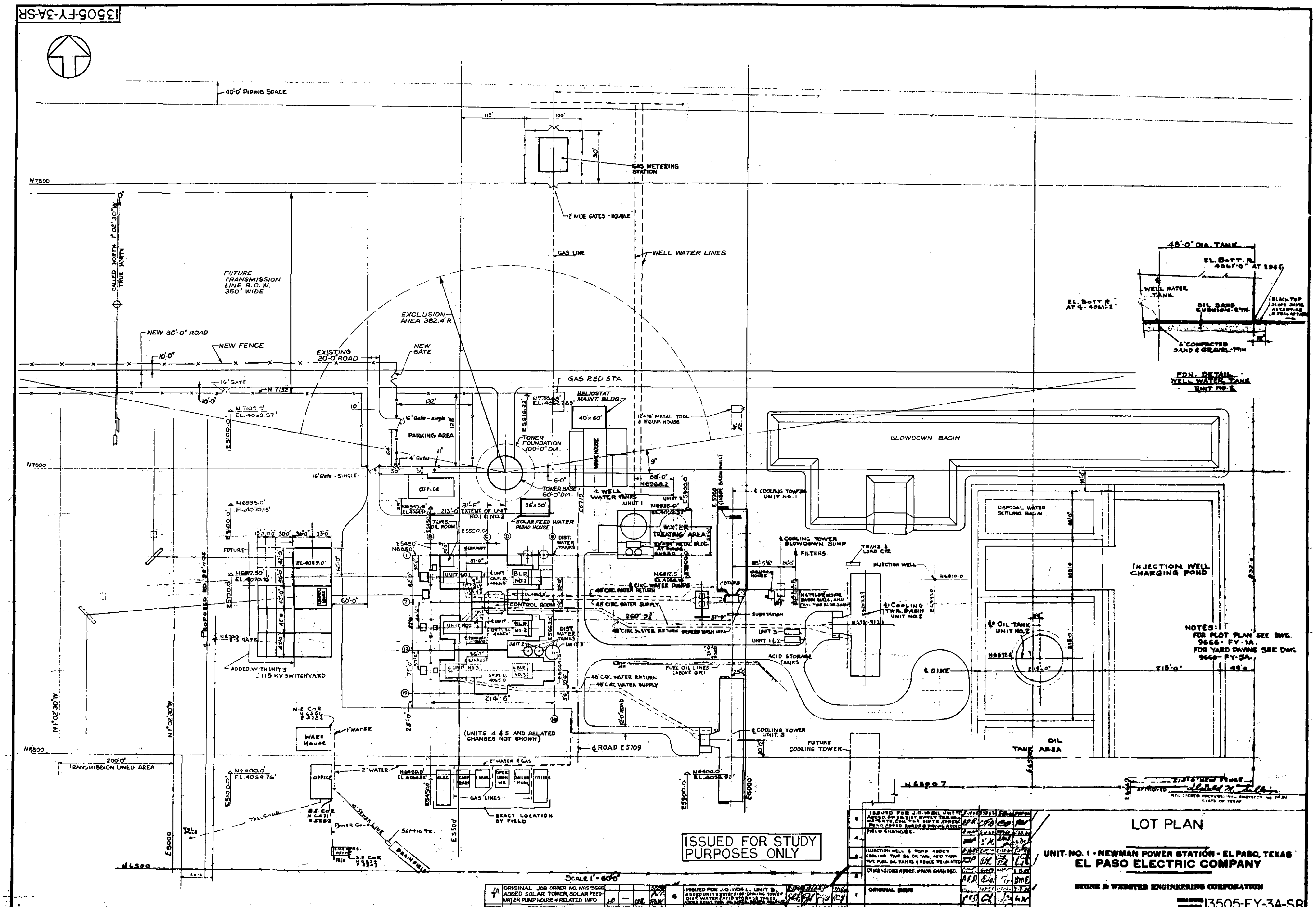
EL PASO ELECTRIC COMPANY

STONE & WEBSTER ENGINEERING CORPORATION

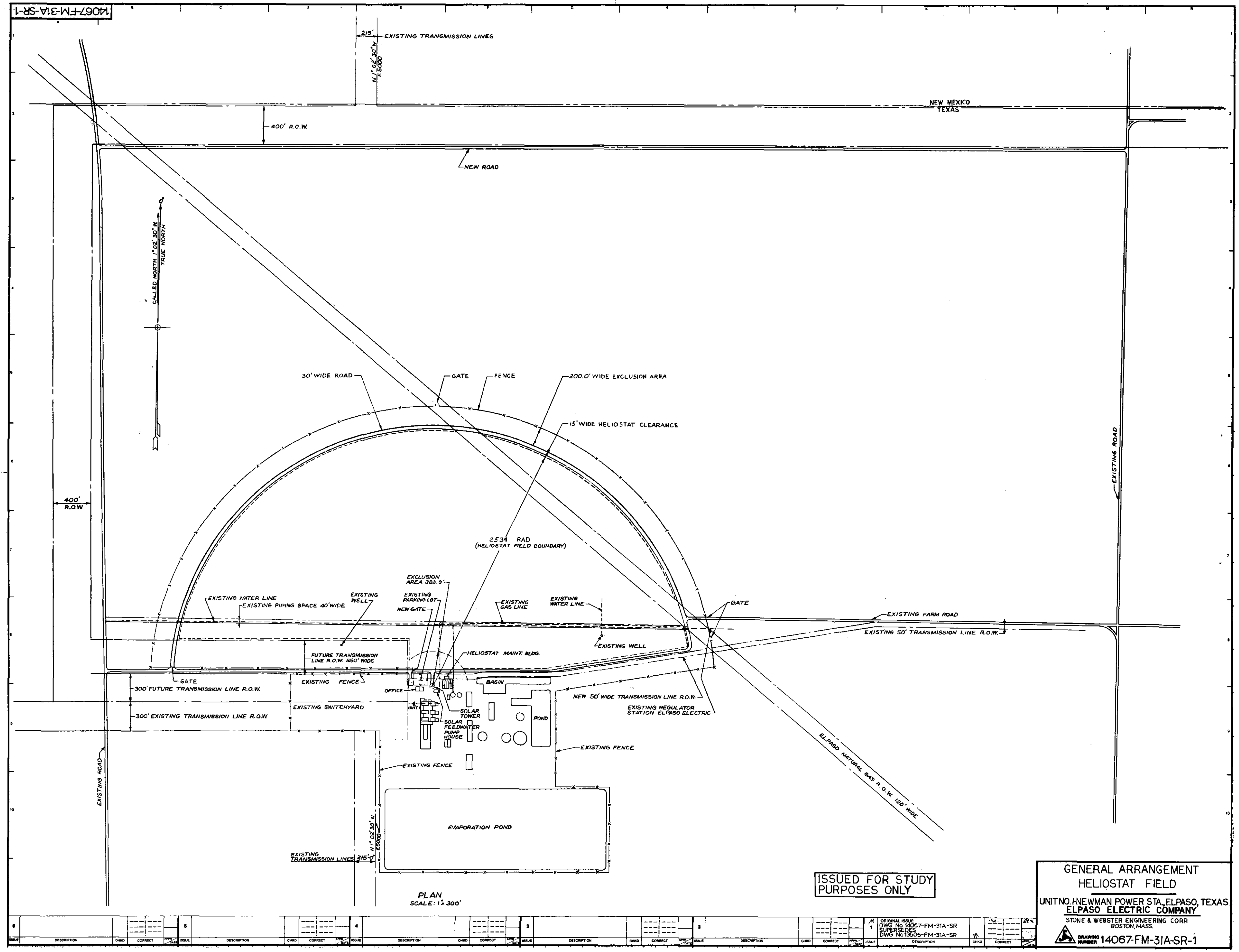
DRAWING NUMBER 13505-FP-3B-SR



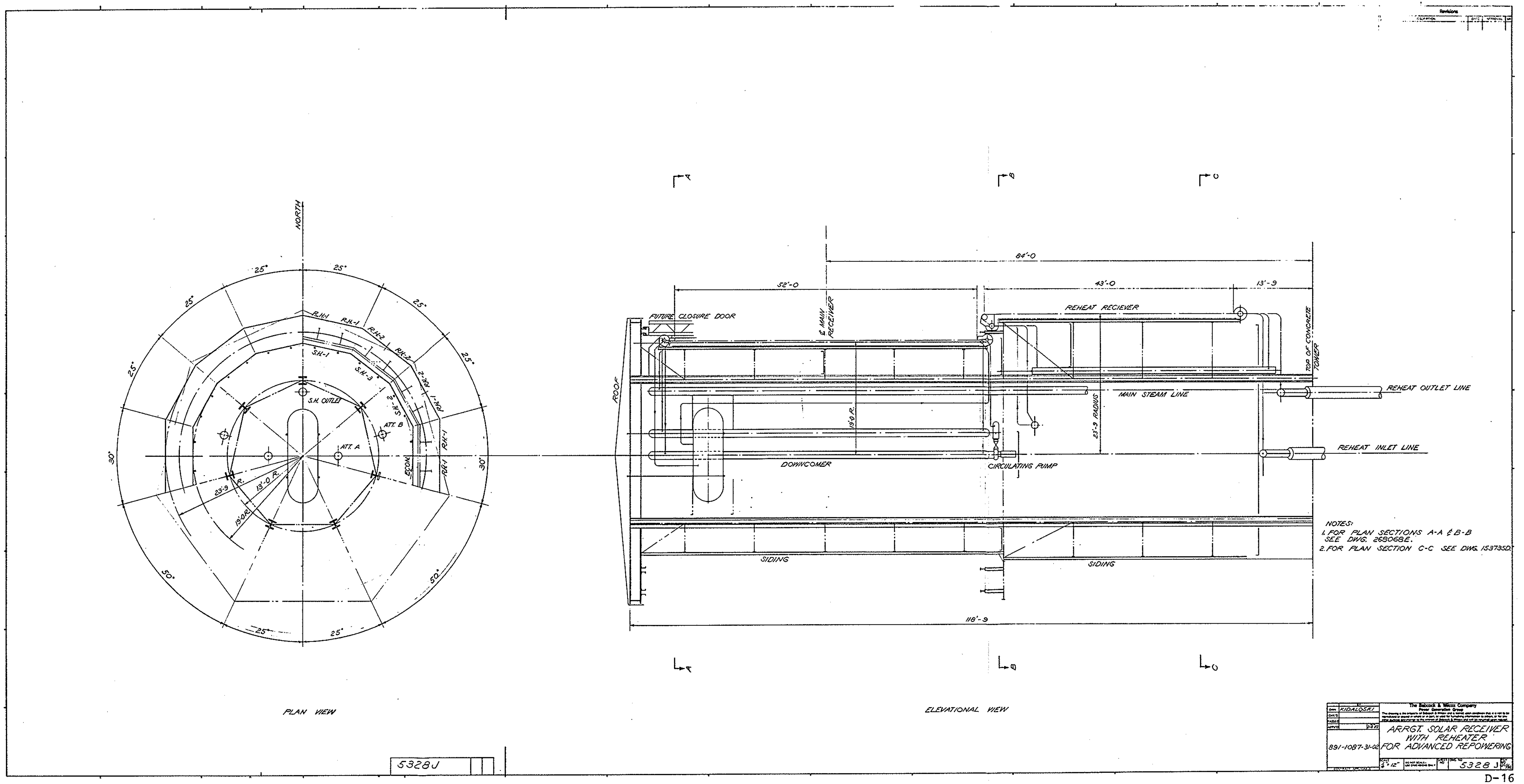
14067-EW-S1A-1
TO 115 KV SWYD
RES STA SERV XFMR 6000/7500 KVA OA/FA 115 KV-2.4 KV, 3Ø, 60 HZ
TO UNIT 2
2400 V TRANSFER BUS
NOR STA SERV XFMR 5000 KVA OA 13.8-2.4 KV
MAIN XFMR NO. 1 95000 KVA 115 KV 13.8 KV 3Ø 60 HZ
SOLAR AUX XFMR NO. 1 3750 KVA OA FUT FA 13.8 KV-2.4 KV, 3Ø, 60 HZ
GEN NO. 1 95,000 KVA 0.85 PF, 13,000 V 3Ø, 60 HZ 3600 RPM 30 PSIG-H2
2400 V BUS NO. 1
STA SERV XFMR 750/1000 KVA AA/FA 2400-480 V, 3Ø, 60 HZ
NOTE 1
500 KVA 2400-480 V 3Ø, 60 HZ
480 V BUS NO. 1
480 V BUS COOLING TOWER
NOTE 2
EXISTING STATION
SOLAR STATION
SOLAR 2400V BUS
SOLAR AUX XFMR NO 2 750 KVA AA 2400-480 V 3Ø, 60 HZ
SOLAR 480V BUS
MOV 45A
MOV 45B
MOV 42A
MOV 42B
TOWER LTG
TOWER CRANE
TOWER ELEVATOR
HELIO MAINT BLDG LTG
HELIO MAINT BLDG HVAC
HELIO MAINT BLDG LTG
SOLAR FIRE PP
SOLAR FEED PP
SOLAR FEED PP
SOLAR 480V MOTOR CONTROL CENTER
SOLAR RECEIVER POWER SUPPLY
SOLAR REC RECIRC PP
SOLAR PP HSE LTG
SOLAR PP HSE HVAC
MOV 43
MOV 4A
MOV 4B
MOV 23
MOV 25
MOV 41A
MOV 41B
MOV 44A
MOV 44B
MOV 46A
MOV 46B
150 KVA 3Ø 60 HZ 2400-208 V 18 REQUIRED
DIST CAB
18 REQUIRED
208 V, 3Ø, 60 HZ 6 CIRCUITS, EA. SUPPLYING 32 HELIOSTATS
— KVA 2400-208 V 3Ø, 60 HZ 1 REQUIRED
PERIMETER LIGHTING
NOTES:
1. EXISTING 300 KVA XFMR TO BE REPLACED AS DEPICTED
2. TIE & SWITCH TO BE ADDED
ISSUED FOR STUDY PURPOSES ONLY
ORIGINAL ISSUE DWG 14067-EW-S1A-SR
SUPERSEDES DWG 13505-EW-S1A-SR
ONE LINE DIAGRAM
FOR SOLAR REPOWERING
UNIT NO. 1-NEWMAN POWER STATION
EL PASO ELECTRIC CO. EL PASO, TEXAS
STONE & WEBSTER ENGINEERING CORPORATION
BOSTON, MASS.
DRAWING NUMBER 14067-EW-S1A-SR-1

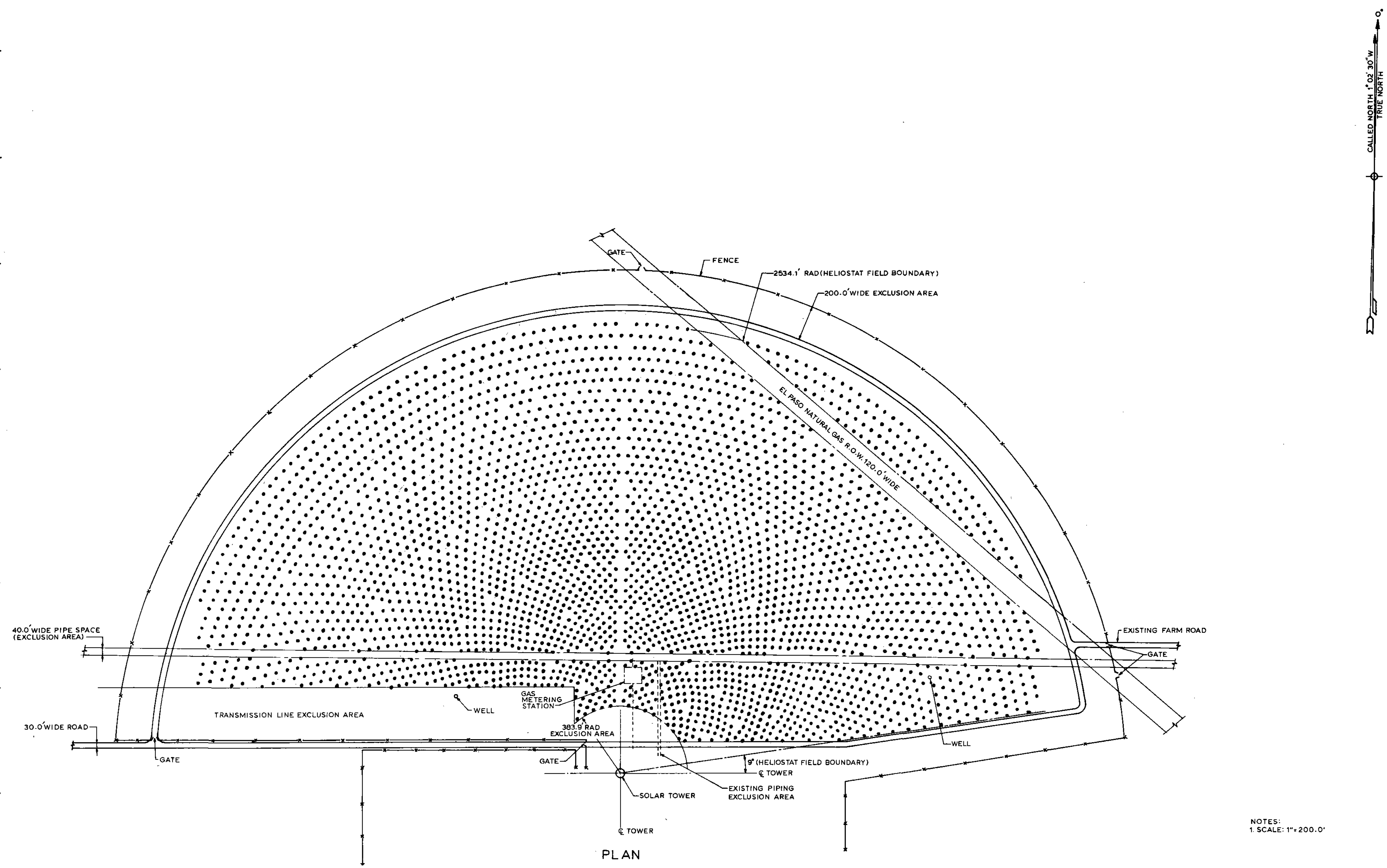


13505-FY-3A-SR
40'-0" PIPING SPACE
GAS METERING STATION
12' WIDE GATES - DOUBLE
GAS LINE
WELL WATER LINES
CALLED NORTH 1°02'30"W TRUE NORTH
FUTURE TRANSMISSION LINE R.O.W. 350' WIDE
EXCLUSION AREA 382.4' R.
NEW 30'-0" ROAD
NEW FENCE
EXISTING 20'-0" ROAD
NEW GATE
GAS RED STA
HELIOSTAT MAINT. BLDG.
TOWER FOUNDATION 100'-0" DIA.
TOWER BASE 60'-0" DIA.
PARKING AREA
OFFICE
SOLAR FEED WATER PUMP HOUSE
WAREHOUSE
4 WELL WATER TANKS
WATER TREATING AREA
BLOWDOWN BASIN
DISPOSAL WATER SETTLING BASIN
INJECTION WELL CHARGING POND
COOLING TOWER BLOWDOWN SUMP
FILTERS
INJECTION WELL
CONTROL ROOM
UNIT NO. 1
UNIT NO. 2
UNIT NO. 3
DIST WATER TANKS
48" CIRC. WATER RETURN
48" CIRC. WATER SUPPLY
SUBSTATION
ACID STORAGE TANKS
FUEL OIL LINES (ABOVE GR.)
OIL TANK UNIT No. 2
DIKE
OIL TANK AREA
FUTURE COOLING TOWER
ROAD E5709
(UNITS 4 & 5 AND RELATED CHANGES NOT SHOWN)
ADDED WITH UNIT 3 115 KV SWITCHYARD
TRANSMISSION LINES AREA
WARE HOUSE
GAS LINES
EXACT LOCATION BY FIELD
SEPTIC TK.
DRAIN FIELD
48'-0" DIA. TANK
WELL WATER TANK
OIL SAND CUSHION
6" COMPACTED SAND & GRAVEL
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.
ISSUED FOR STUDY PURPOSES ONLY
SCALE 1" = 60'-0"
ORIGINAL JOB ORDER NO. WAS 9666. ADDED SOLAR TOWER, SOLAR FEED-WATER PUMP HOUSE & RELATED INFO
FIELD CHANGES
DIMENSIONS ADDED, MINOR CHANGES
ORIGINAL ISSUE
LOT PLAN
UNIT NO. 1 - NEWMAN POWER STATION - EL PASO, TEXAS
EL PASO ELECTRIC COMPANY
STONE & WEBSTER ENGINEERING CORPORATION
13505-FY-3A-SR



EXISTING TRANSMISSION LINES
215'
NEW MEXICO
TEXAS
400' R.O.W.
NEW ROAD
CALLED NORTH 1°02'30"W
TRUE NORTH
30' WIDE ROAD
GATE
FENCE
200.0' WIDE EXCLUSION AREA
15' WIDE HELIOSTAT CLEARANCE
400' R.O.W.
2534 RAD
(HELIOSTAT FIELD BOUNDARY)
EXCLUSION AREA 383.9'
EXISTING PARKING LOT
NEW GATE
EXISTING WATER LINE
EXISTING PIPING SPACE 40' WIDE
EXISTING WELL
EXISTING GAS LINE
EXISTING WATER LINE
GATE
EXISTING FARM ROAD
EXISTING 50' TRANSMISSION LINE R.O.W.
EXISTING WELL
HELIOSTAT MAINT. BLDG.
FUTURE TRANSMISSION LINE R.O.W. 350' WIDE
GATE
EXISTING FENCE
300' FUTURE TRANSMISSION LINE R.O.W.
300' EXISTING TRANSMISSION LINE R.O.W.
EXISTING SWITCHYARD
OFFICE
BASIN
SOLAR TOWER
SOLAR FEEDWATER PUMP HOUSE
POND
NEW 50' WIDE TRANSMISSION LINE R.O.W.
EXISTING REGULATOR STATION-ELPASO ELECTRIC
EXISTING FENCE
EXISTING FENCE
EXISTING ROAD
EXISTING ROAD
ELPASO NATURAL GAS R.O.W. 120' WIDE
EVAPORATION POND
EXISTING TRANSMISSION LINES
PLAN
SCALE: 1" = 300'
ISSUED FOR STUDY PURPOSES ONLY
GENERAL ARRANGEMENT
HELIOSTAT FIELD
UNIT NO. 1 NEWMAN POWER STA., ELPASO, TEXAS
ELPASO ELECTRIC COMPANY
STONE & WEBSTER ENGINEERING CORP.
BOSTON, MASS.
ORIGINAL ISSUE
DWG No 14067-FM-31A-SR
SUPERSEDES
DWG No 13505-FM-31A-SR
DRAWING NUMBER 14067-FM-31A-SR-1
14067-FM-31A-SR-1


NORTH
25°
30°
50°
RH-1
RH-2
SH-1
SH-2
SH-3
S.H. OUTLET
ATT. A
ATT. B
ECON.
23'-9 R.
13'-0 R.
PLAN VIEW
84'-0
52'-0
43'-0
13'-9
FUTURE CLOSURE DOOR
℄ MAIN RECEIVER
REHEAT RECIEVER
TOP OF CONCRETE TOWER
ROOF
MAIN STEAM LINE
REHEAT OUTLET LINE
REHEAT INLET LINE
13'-0 R.
23'-9 RADIUS
DOWNCOMER
CIRCULATING PUMP
SIDING
118'-9
A
B
C
ELEVATIONAL VIEW
NOTES:
1. FOR PLAN SECTIONS A-A & B-B SEE DWG. 268068E.
2. FOR PLAN SECTION C-C SEE DWG. 153735D.
5328J
Revisions
DWN KIDALOSKI
CHK'D
PASS'D
APP'D
The Babcock & Wilcox Company
Power Generation Group
ARRGT. SOLAR RECEIVER WITH REHEATER FOR ADVANCED REPOWERING
891-1087-31-02
SCALE 1/4" = 12"
DWG NO 5328 J



PLAN

200 100 0 200 400 600
150 50
SCALE IN FEET

NOTES:
1. SCALE: 1"=200.0'

ISSUED FOR STUDY PURPOSES ONLY

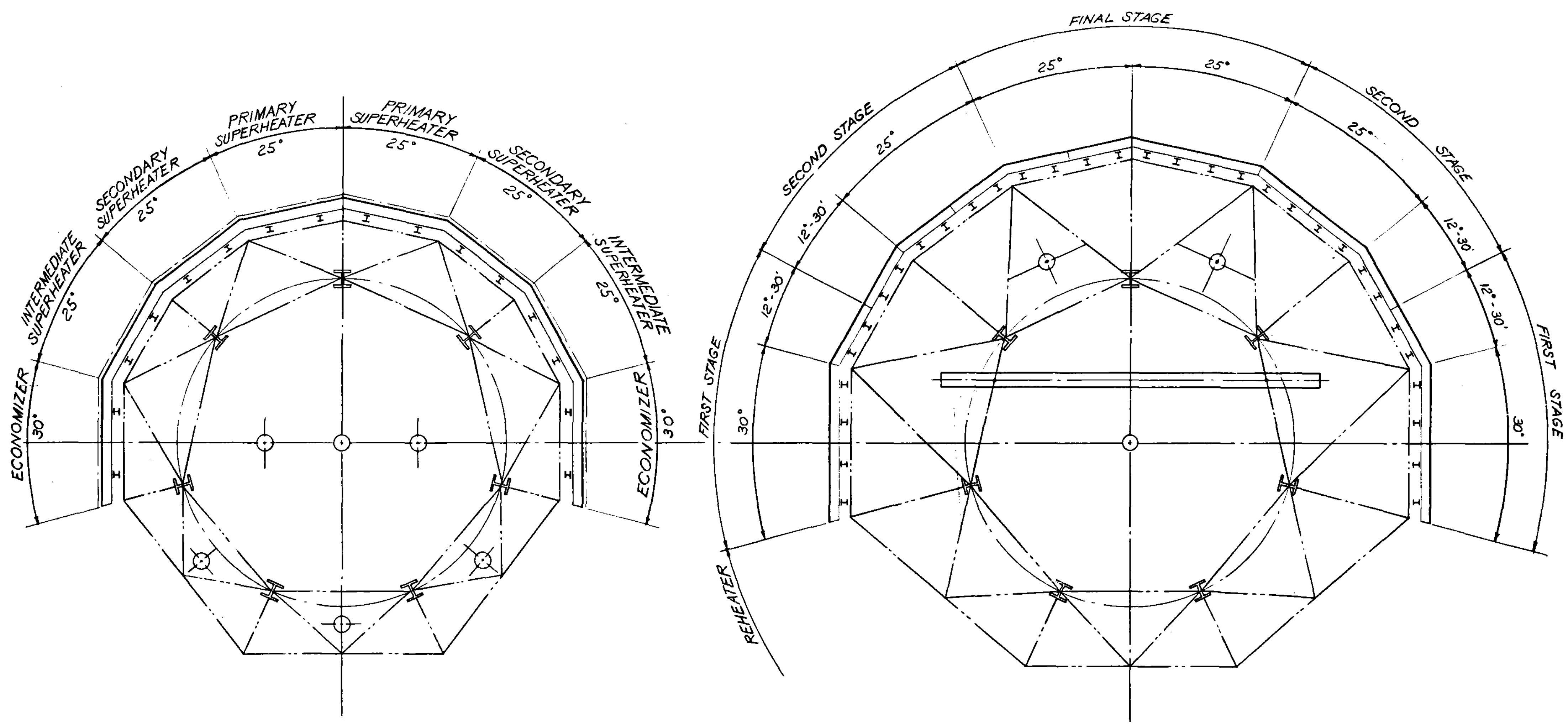
ISSUE	DESCRIPTION	CHKD	CORRECT	APPR / DATE
1	ORIGINAL ISSUE DWG NO. 14067-EM-31B-SR SUPERSEDES DWG NO. 13505-FM-31B-SR			2-12-8?

GENERAL ARRANGEMENT
HELIOSTAT FIELD

UNIT NO. 1-NEWMAN POWER STA., EL PASO, TEXAS
EL PASO ELECTRIC COMPANY

STONE & WEBSTER ENGINEERING CORPORATION
BOSTON, MASS.

DRAWING NUMBER 14067-EM-31B-SR-1



SECTION A-A
MAIN RECEIVER

SECTION B-B
REHEAT RECEIVER

NOTES:

1. FOR MAIN ARRGT. SEE DWG. 5328J

DWN. BY KIDALOSKI CHKD. BY PASSED BY APPVD. BY STD. SPL. DATE 2-3-82 891-1087-31-02	SOLAR BOILER PLAN SECTIONS A-A & B-B	THE BABCOCK & WILCOX CO. POWER GENERATION GROUP
DO NOT SCALE - USE DIMENSIONS ONLY.	SCALE 1/4" = 12"	DWG. NO. 268068E

APPENDIX E

APPENDIX E

EXISTING NEWMAN UNIT 1

E.1 DESCRIPTION

This section reviews the most important characteristics of the Newman Unit 1 boiler, turbine-generator, and control systems that could be modified when a solar repowering system is added to an existing unit. Other pieces of equipment and systems are discussed as appropriate. Figure E.1-1 illustrates the existing Newman Station. Construction of the unit was completed in 1960.

E.1.1 Boiler

Boiler design and operating constraints are summarized in the following sections.

E.1.1.1 Boiler Design

The existing boiler at Newman Unit 1 has a pressurized water-cooled radiant furnace, a two-stage drainable type superheater, and a drainable reheater and was fabricated by Babcock & Wilcox. The steam generator is designed to burn natural gas. The boiler was refitted in 1962 to allow residual fuel oil firing for limited periods of time under manual control. Experience with operating the unit on oil has been very limited, and further modifications will be required to allow operating on oil as a primary fuel. Water is circulated in the boiler by natural convection.

The nominal full load superheater steam flow conditions are 254,000 kg/hr (560,000 lb/hr) with 10.5 MPa (1,525 psia) and 538°C (1,000°F) at the superheater outlet and 538°C (1,000°F) at the reheater outlet. The steam generator is capable of a maximum continuous superheater steam flow of 257,200 kg/hr (567,000 lb/hr).

The two-stage superheater has a total effective heating surface of 1,227 m^2 (13,205 ft^2). Water spray attemperators for final steam temperature control are located in the connecting pipes between the two stages. Superheater temperature is controlled by selection of burners and by attemperation at high loads.

The reheat section has a total effective heating surface of 644 m^2 (6,930 ft^2). Spray type attemperators are located in each low temperature reheat steam line just upstream of the reheat inlet header connections. Reheat temperature is controlled by varying excess air and by attemperation at high loads.

The economizer has a total effective heating surface of 1,519 m² (16,350 ft²) to absorb heat from the flue gas as it leaves the superheater primary section.

The boiler design is illustrated in Figure E.1-2.

E.1.1.2 Boiler Operation

Boiler operation is discussed in terms of temperature, pressure, load variations, startup, and banking (warm standby).

E.1.1.3 Steam Outlet Temperature

Boiler performance has exceeded predicted design values for steam temperature at partial unit loads.

The boiler was designed to maintain a superheat steam temperature of 538°C down to about half-load (126,980 kg/hr steam flow). Based on design data, a temperaure of 510°C can be attained at 40 percent load (104,310 kg/hr); and a temperature of 482°C can be attained at 26 percent load (86,170 kg/hr).

Based on design information, reheat steam temperature can be maintained at 538°C down to about two-thirds load (169,160 kg/hr). A reheat temperature of 510°C can be attained at 55 percent load (140,590 kg/hr). A reheat temperature of 482°C can be attained at 48 percent load (122,450 kg/hr).

However, EPE Newman Station operating personnel estimate that the full superheat temperature (538°C) can be maintained down to turbine-generator minimum load (automatic control) through appropriate burner selection and increased excess air.

E.1.1.4 Steam Pressure

Required steam pressure at the turbine steam throttle valves is maintained in accordance with steam demand by the pneumatically operated combustion control system which proportions the amount of air and fuel for maximum combustion efficiency. Changes in main steam flow to the turbine are accompanied by changes in steam pressure. Following an initial steam pressure change, the master pressure regulator automatically restores the steam pressure to the set value of 10.1 MPa (1,465 psia) by appropriately adjusting the furnace firing rate with proper pneumatic signals to the forced draft fan inlet vane control drive and the fuel gas (or oil) control valve.

A safety valve mounted on the main steam piping is set to blow at 11.1 MPa (1,590 psig) and reseat at 10.8 MPa (1,545 psig) to protect the superheater and main steam piping. Safety valves are located upstream and downstream of the reheat section. The outlet header safety valve is set to blow at 3.7 MPa (517 psig) and reseat at 3.5 MPa (500 psig).

E.1.1.5 Boiler Startup and Load Change Capability

According to estimates by EPE operating personnel at Newman Unit 1, the maximum boiler ramp rate (percent per minute rate of increase or decrease in steam flow, measured as a percent of rated steam flow) above minimum load (23 MWe) is estimated to be about 10-20 percent per minute.

The boiler should only be ramped at the 20 percent/minute rate during emergency conditions, but up to 10 to 20 occurrences per year are considered acceptable.

The boiler is capable of a maximum continuous superheater steam flow of 257,190 kg/hr (567,000 lb/hr). The minimum automatic operating level of the boiler is about 88,900 kg/hr (196,000 lb/hr) steam flow based on a turbine-generator output of about 23 MWe.

E.1.1.6 Startup and Standby

Warming the boiler and turbine from a cold (shutdown) condition to the minimum automatic operating level (88,900 kg/hr steam) requires burning approximately 2,830 m^3 at 16°C (100,000 scf) of natural gas, about 106 x 10^6 kJ (100 MBtu) over a 4-hour period. This warmup period is necessary to gradually increase boiler drum temperature and avoid damage due to thermal stresses.

The boiler can be "banked" at warm standby (316°-371°C) following the 4-hour warmup period for an overnight period. Neglecting losses during standby, about 63.3 x 10^6 kJ (60 x 10^6 Btu) are required for initial warmup, and 42.2 x 10^6 kJ (40 x 10^6 Btu) to bring the unit to the minimum automatic controlled load of 23 MWe.

Following operation, the boiler can be banked at a hot standby (427°-482°C) overnight. An estimated 15.8 x 10^6 kJ (15 x 10^6 Btu) is required to return the unit to the minimum automatic controlled load of 23 MWe.

E.1.1.7 Boiler Efficiency

The boiler efficiency varies slightly with different unit loads. Values of estimated boiler efficiency are shown at five loads on Table E.1-1. These values were predicted based on boiler design information provided by the manufacturer. Actual boiler performance at full and part load has shown higher boiler efficiencies.

E.1.2 Turbine-generator

The major design features and operating limitations of the Newman Unit 1 turbine-generator are described in the following sections. A cross section of the turbine-generator is shown in Figure E.1-3.

E.1.2.1 Design

The 75 MWe (nominal) Allis-Chalmers steam turbine-generator unit was designed to deliver 82 MWe continuously at 3,600 rpm. The tandem-compound, double-flow construction steam turbine is designed for throttle steam conditions of 10.1 MPa (1,465 psia), main steam temperature of 538°C (1,000°F), reheat temperature of 538°C (1,000°F), and 5.08 KPa (1.5 inches Hg) absolute backpressure.

The steam turbine is arranged for a single exhaust connection to the condenser and for extraction of steam at five points for feedwater heating and deaeration.

Two main steam stop valves are mounted on the front of the steam chest which is separate from the turbine proper. The steam chest contains six control valves with six inlet bend connecting pipes to the high pressure turbine. Two reheat intercept valves and two reheat stop valves are also included.

A turbine mechanical-hydraulic control system includes a hydraulic oil relay type constant speed governor. A steam chest control valve gear is automatically controlled from the load limit device and operating governor. The load limit is manually operated.

The alternating current generator is rated at 96,000 kVA, 0.85 power factor (lagging), 13,800 V, 3 phase, 60 Hz, 3,600 rpm, 4,017 amp per phase at 0.31 MPa (45 psia) hydrogen pressure.

E.1.2.2 Operation and Limitations

The performance of the turbine-generator and operating limitations associated with flow, temperature, and pressure are described in the following sections.

E.1.2.3 Performance

The turbine is designed to give the lowest heat rate when carrying a load of 81.5 MW at 85 power factor, 0.31 MPa (45 psia) hydrogen pressure, with an exhaust pressure of 5.08 kPa (1.5 inches Hg), and with steam extracted from the five extraction points to provide temperature of 235.7°C (456.3°F) for the feedwater leaving the first point heater.

The overall efficiencies of the generator and exciters are summarized in Table E.1-2.

E.1.2.4 Temperature Limitations

The steam temperature at the turbine main stop valve shall average not more than 538°C (1,000°F) over any 12 month operating period. In maintaining this average, the temperature shall not exceed 546°C (1,015°F). For abnormal conditions, maximum temperature shall be limited to 552°C (1,025°F) for operating periods of not more than 400 hours for a 12-month period. In addition, steam temperature may rise to 566°C (1,050°F) for a 15-minute duration or less, aggregating not more than 80 hours per 12-month operating period.

The turbine may be operated with one reheat valve closed as long as the pipe metal temperature differential between the operating and isolated reheat steam headers is maintained at or below 10°C (50°F).

During startup, it is recommended that the exhaust temperatures be kept below 66°C (150°F) by increasing exhaust vacuum or by using water sprays in the exhaust ends.

E.1.2.5 Pressure Limitations

The steam pressure at the turbine main stop shall be controlled so that it does not exceed 10.1 MPa (1,465 psia) at rated output, but it may increase to 10.6 MPa (1,538 psia) as the turbine output approaches zero. During abnormal conditions, the pressure may rise to 13.1 MPa (1,900 psia) momentarily, but the aggregate duration of such swings shall not exceed 12 hours per 12-month operating period.

E.1.2.6 Load Limitations

The allowable rate of load change is based upon the measurement of metal temperatures at certain critical areas of the turbine. The turbine generator is equipped with metal temperature thermocouples located at the high pressure cylinder, reheat bowl of the combined high pressure - intermediate pressure cylinder, low pressure cylinder exhaust hood, steam inlet bends, and the steam chest.

Rate of loading the unit should be controlled in order that the following conditions are not exceeded:

Condition	Temperature Limit
Rate of metal temperature increase	149°C (300°F) per hour
Temperature differential	

between outer cylinder wall and cylinder flange, outer surface:

(a) HP turbine	93°C (200°F) differential
(b) IP turbine	66°C (150°F) differential
Temperature differential between cylinder flange and corresponding bolt	66°C (150°F) differential
Rapid metal temperature change allowed providing the new temperature is held constant for 1/2 hour before further changes	38°C (100°F)

E.1.2.7 Future Modification

Modifications for the turbine are presently scheduled for the period December 1982 through March 1983. These modifications, including increased and updated instrumentation, will permit reliable cyclic operation of the turbine as the unit is relegated to peaking operation.

E.1.3 Boiler and Turbine Control Systems

The following sections describe the design philosophy and key design features of the control systems at Newman Unit 1.

E.1.3.1 Design Philosophy

The Newman 1 control system was designed for baseload operation, with automatic control available for loads as low as 23 MWe. Mechanical-hydraulic turbine controls interact with pneumatic boiler combustion controls in a boiler-following control mode. The boiler-following unit control concept is illustrated in Figure E.1-4. A boiler-following unit control scheme is one where the load is set at the turbine controls and the boiler controls react to maintain required steam pressure. This type control system is intended for units that are primarily baseloaded and change load gradually and infrequently.

E.1.3.2 Turbine Control System

Important elements of the turbine control system include the governing system, turbine steam valves, turbine trip system, and the load limit control and speed changer.

E.1.3.3 Governing System

The governing system consists of a main governor, an overspeed governor, and a load dump anticipator.

The turbine main governor is a centrifugal type, gear driven from the main turbine shaft. Decrease in generator load during normal operating conditions is maintained by increase in turbine shaft speed. Under these conditions, the governor causes the inlet valves to partially close and throttle steam flow. In the event of a generator load increase, which results in a turbine-generator shaft speed decrease, the governor and servomotor react in an opposite manner so as to open the steam inlet valves.

The overspeed governor is set to trip the machine at 110 percent of rated speed.

The load dump anticipator acts to close the reheat intercept valves and main inlet (control) valves to a position slightly in exceess of that required to carry the station auxiliary load. The speed governor assumes control of the intercept valves to hold speed and closes the intercept valves if the speed is in excess of 101 percent. A roll-back relay operates the speed changer motor which closes the control valves to reduce turbine speed until the intercept valves open. This system is anticipatory by design to limit turbine overspeed when the main generator circuit breaker is tripped, in distinction from the two governors described above which operate when speed is already above normal.

E.1.3.4 Turbine Steam Valves

The main stop valves are opened by admitting stop valve control oil pressure which causes a piston to move the valve stem against a spring.

There are six plug type inlet (control) valves mounted in a steam chest separate from the turbine proper. A common cam shaft, also mounted on the steam chest, has a separate cam for each inlet valve. These individual cams open and position the spring-loaded inlet valves, as required by turbine load, as a function of main cam shaft position. A mechanical linkage connects the main cam shaft to the controls and governor. When the turbine is carrying a load, the inlet valves are positioned by manual manipulation of the load limit control.

There are two reheat intercept valves: one located in each of the parallel high temperature reheat steam lines and immediately upstream of the reheat stop valves. Each intercept valve is a single seated globe type valve opened by the intercept valve operating oil pressure. If the reheat stop valves close because of a decrease in trip oil pressure, this closes the intercept valves automatically.

The intercept valves are wide open during normal turbine operation. Upon sudden load rejection, the turbine starts to increase shaft speed and the main governor reacts and causes the valves to begin to close. At 101 percent of normal speed, the intercept valves start to close and are fully closed at 103 percent speed. As the turbine shaft speed increases, the control system continues to close the intercept valves until the valves are tightly closed at approximately 103 percent of normal speed. If the shaft speed starts to decrease back toward normal operating speed before the intercept valves are completely closed, the control system reverses the action described above and opens the valves. There are two reheat stop valves: one in each of the two parallel high temperature reheat steam lines located just downstream of the reheat intercept valves. The stop valves are an unbalanced, wing check type, opened by trip oil pressure. Loss of trip oil pressure closes the reheat stop valves.

E.1.3.5 Turbine Trip System

The turbine-generator unit is, or can be, tripped by the following:

- Manual trip button in control room
- Manual trip button on starting panel at front of machine
- Automatic trip on low condenser vacuum (18 inches Hg abs)
- Automatic trip by solenoid valve
- Automatic trip by overspeed governor

The means for tripping the turbine is to drain oil back to the turbine oil tank which then permits the springs to close the main steam stop valves, reheat stop valves, and reheat intercept valves.

The vacuum trip mechanism is provided for the purpose of tripping the turbine upon loss of vacuum.

The solenoid trip can be actuated by the following:

- Boiler trip auxiliary relay
- Unit and generator differential relay
- Generator ground auxiliary relay
- Loss of field relay
- Negative phase overcurrent relay
- Control room benchboard mounted pushbutton
- Low relay oil pressure

The manual trip button on the turbine starting panel actuates the solenoid trip by a mechanical linkage.

The primary function of the boiler trip relay is to protect the reheater. The relay operates to trip the fuel to the boiler on load rejection if the turbine inlet (control) valves stay in the no-load position for more than 10 seconds. The relay operates instantaneously when the turbine main steam stop valves close. For operation of the unit at light loads and during startup, a setup circuit is provided that automatically puts the boiler trip relay in service after the unit reaches approximately 20-50 percent load. The boiler trip relay can be manually tripped by a control room benchboard pushbutton.

When the unit is tripped and after the intercept valves close, steam remains "bottled up" in the intermediate and low pressure sections of the turbine. To limit shaft acceleration due to this steam leaking through the shaft seals from the intermediate pressure to the low pressure turbines, a reheat diaphragm unloading valve and a balanced piston loading valve are provided. They discharge the steam to the main condenser.

E.1.3.6 Load Limit Control and Speed Changer

The load limit control is normally used to limit the maximum load to be carried on the unit and, as such, it is set at a load greater than the operating point or expected range. The load limit control may also be used to maintain a specific load on the unit and, at such times, the main governor does not act as a regulator and load increases cannot be made at the control board. The load limit device is a control oil flow regulator between the control oil supply from the main governor to the main servomotor which controls the inlet valves. The load limit device is operated from the starting panel at the front of the machine and the setting is indicated by a dial indicator above the control knob.

The load limit control is also used when starting the turbine and bringing it up to speed prior to loading the generator.

The speed changer can be controlled from either the knob on the starting panel at the front of the machine or by a control switch on the control room benchboard.

E.1.3.7 Boiler Control

The primary functions of the pneumatically operated combustion control system is to maintain required steam pressure at the turbine steam throttle valves by proportioning the fuel-air supply in accordance with steam demand for maximum combustion efficiency. Additional control functions include control of superheat and reheat temperture, and feedwater flow.

E.1.3.8 Steam Pressure Control

Changes in main steam flow to the turbine are accompanied by changes in the steam pressure. Following an initial steam pressure change, the master pressure regulator (sensitive to the pressure of steam to the turbine throttle) automatically restores the steam pressure to the set value of 10.1 MPa (1,450 psig) by appropriately adjusting the furnace firing rate with proper pneumatic signals to the forced draft fan inlet vane control drive and to the fuel gas control valve. The pneumatic signal to the former is biased as necessary by the fuel-air ratio controller to maintain the maximum combustion efficiency. However, the fuel-air ratio controller in turn may be biased slightly also by the excess air adjustment relay to alter fuel-air ratio for maintaining desired reheater outlet steam temperature.

E.1.3.9 Fuel-Air Ratio Control

The fuel-air ratio control receives pneumatic signals from the air flow transmitter and from the gas flow transmitter. The pneumatic signal from the air flow transmitter may be biased by another pneumatic signal from the reheat steam temperature control, prior to its being received by the fuel-air ratio control.

The fuel-air ratio control sends a pneumatic signal to bias the signal sent from the master pressure regulator to the forced draft fan inlet vane control drive, to provide for maximum combustion efficiency consistent with excess air alterations required for satisfactory reheat steam temperature control.

E.1.3.10 Fuel Control

Fuel flow to the burners is measured by a flowmeter which actuates a pneumatic transmitter. Signals from this transmitter are sent to the fuel-air ratio controller, the fuel gas flow recorder, and to a Standatrol relay installed in the pneumatic signal loading line from the master pressure regulator to the fuel gas control valve. The purpose of this relay, which also receives a pneumatic loading signal from the air flow transmitter, is to prevent the fuel-air ratio from rising to a dangerous value which could happen if the air flow was suddenly decreased to or near zero. This relay would cause the fuel flow to follow the air flow down, preventing the formation of a dangerously rich fuel-air mixture and resulting in a hazardous conditions.

To prevent the occurrence of a dangerously lean mixture, a fuel minimum flow control valve is installed in parallel with the aforementioned fuel control valve. Should the fuel control valve be closed sufficiently so that the fuel pressure downstream becomes too low for stable combustion in the furnace, the fuel minimum flow control valve opens to maintain a minimum downstream fuel pressure sufficient to prevent the burners from losing ignition.

E.1.3.11 Air Flow Control

As mentioned under steam pressure control, air flow to the boiler is controlled by the forced draft fan inlet vane control drive which responds to a pneumatic signal received directly from the master steam pressure regulator. However, this pneumatic signal passes through a limiting relay which also receives a pneumatic signal indicating fuel flow. This limits the minimum signal to the forced draft fan to match minimum gas flow. Should, on an increase in boiler load, the fuel flow not respond (within limits) as quickly as required, the pneumatic signal to the forced draft fan vane positioner is delayed to maintain a safe fuel-air ratio for preventing blowing out the furnace burners.

E.1.3.12 Superheat Temperature Control

With steam flows greater than half-load, measures must be taken to limit the final steam temperature to the maximum design value of 541°C (1,005°F).

Selection of fuel burners to be used.

Attemperator sprays in the connecting pipes between the primary and secondary superheater sections.

Use of the lower two or three burner rows at any steam flow tends to increase furnace heat absorption in relation to other heating surfaces and have a resultant effect on lowering final superheat temperature. Conversely, at loads below half-load, firing the upper row or two rows of burners as required helps to increase final superheat temperature.

At high loads the total steam temperature leaving the superheater cannot be controlled by burner position alone and attemperator sprays must be used.

E.1.3.13 Reheat Temperature Control

The reheater is designed to produce a final steam temperature of 541°C (1,005°F). Attemperator sprays located in the low temperature reheat steam lines just ahead of the connections to the inlet header are provided. Water to the attemperators is taken from the fourth stage of the boiler feed pumps. At low steam flows, steam temperature can be maintained at or near 541°C (1,005°F) by increasing the percentage of excess combustion air.

E.1.3.14 Feedwater Control

The flow of feedwater, to maintain proper boiler drum level and provide for steam flow requirements, is regulated by a three-element type controller. This control directs the operation of the two feedwater regulating control valves, one in each of the boiler feed pump discharge lines.

E.1.4 Feedwater System

The feedwater system includes the condensate pumps, steam air jet ejector condenser, gland steam seal condenser, five stages of feedwater heaters, evaporator condenser, and boiler feed pumps.

At full turbine load, the feedwater temperature is raised to approximately 236°C (457°F) and pressure is raised to approximately 11.0 MPa (1,600 psia). The flow of feedwater, to maintain proper boiler drum level and provide for steam flow requirements, is regulated by a three-element type controller.

E.1.5 Condensing and Circulating Water Systems

The circulating water system includes two circulating water pumps which discharge cooling tower basin water through the condenser back to the cooling tower. The cooling tower is a cross-flow induced draft type with five cells. Circulating water makeup is supplied from the well water tank or the well water supply line to the tank. Cooling water for the generator hydrogen coolers and turbine oil coolers is supplied from the circulating water system.

E.1.6 Compressed Air Systems

All pneumatic instrument and control equipment is supplied by the instrument compressed air system which includes a single-stage, double-acting horizontal reciprocating compressor, aftercooler, moisture separator, air receiver, and air dryer. The air compressor is rated at 0.04 m^3/s (80 scfm) and 793 kPa (100 psig). When instrument air pressure drops to 552 kPa (65 psig), service air is directed to the instrument compressed air system to ensure system requirements.

The service air system supplies compressed air for furnace door aspiration, blowing out fuel gas lines, and for general housekeeping purposes. The compressor is a two stage double-acting reciprocating unit capable of furnishing 0.2 m^3/s (450 scfm) at 793 kPa (100 psig).

E.1.7 Chemical Feed System

During normal operation, phosphate and caustic are supplied to the boiler drum and sulfite is delivered to the economizer feed line. Sulfite is an oxygen savenger used to minimize corrosion of the economizer tubes. Phosphate is fed to prevent scaling of the heating surfaces in the steam generator by precipitating any residual hardness which may be present in the feedwater. A sludge is formed which is removed via the continuous boiler blowdown line. Caustic is injected to control the alkalinity and pH of the boiler water in order to minimize the metal embrittlement of boiler surfaces and tubes.

Magnesium oxide is injected into the boiler drum during startup to combine with silica and form a magnesium silicate which is discharged through the boiler blowdown line.

E.1.8 Electrical System

Newman Unit 1 generator is rated 96,000 kVA, 13.8 kV, 0.86 Pf, 3 phase, 60 Hz, and is directly connected to a bus in the 115 kV switchyard through a 95,000 kVA, FOA, 115 13.8 kV step-up main transformer. The generator is also directly connected to a 5,000 kVA, OA, 13.8 kV/2.4 kV station service transformer which is the normal source of 2,400 V station power for the unit.

Startup station power is supplied from the 115 kV switchyard through a 6,000/7,500 kVA, OA/FA, 115/2.4 kV, reserve station service transformer connected to the 2,400 V station service bus through an air circuit breaker. The reserve station service transformer 2,400 V secondary is also connected to the Unit 2 2,400 V station service bus through an air circuit breaker, thereby providing an alternate startup power source for Newman Unit 1.

The 2,400 V station service system comprises a 2,400 V bus with feeder air circuit breakers rated 4.16 kV, 100,000 kVA interrupting capability at 2,400 V, and 40,000 amperes momentary. These supply power to large 2,400 V motors and to two 2,400/480 V station service transformers, one rated 300 kVA and the other 500 kVA. The transformers supply lighting, heating and ventilating, small motor, and all other low voltage loads associated with Newman Unit 1.

E.1.9 Fire Protection System

A fire protection system is provided for the general yard areas including the area adjacent to the cooling tower. The system consists of 20.3 cm (8 inches) underground main along the north side and east and west ends of the Newman Station. Water pressure to the system is boosted by a fire pump. Hydrants and hose stations are located at various points throughout the yard. The Newman Unit 1 main transformer, station service transformer, and the reserve station service transformer are provided with individual water spray systems.

TABLE E.1-1

VARIATION OF UNIT HEAT RATE AND BOILER EFFICIENCY AS A FUNCTION OF LOAD

Gross Generation, MWe	Net Unit Output, MWe	Net Unit Heat Rate KJ/kWhr (Btu/kWhr)	Boiler Efficiency, %	Superheat Temp °C (°F)	Reheat Temp °C (°F)
83.1	79.6	10,799 (10,235)	84.4	538 (1,000)	538 (1,000)
79.2	75.7	10,778 (10,215)	84.4	538 (1,000)	538 (1,000)
55.2	52.1	11,110 (10,530)	84.1	538 (1,000)	538 (1,000)
41.1	38.2	11,706 (11,095)	84.1	538 (1,000)	491 (915)
22.7	20.4	13,737 (13,020)	84.2	477 (890)	413 (775)

Basis: Gas firing

6,800 Pa (2.0 inch Hg) condenser backpressure

NOTE:

Maximum net unit output is 82 MW.

TABLE E.1-2

OVERALL EFFICIENCY OF GENERATOR AND EXCITERS AS A FUNCTION OF LOAD

Hydrogen MPa	Pressure Psig	kVA	kWe	Pf (Lagging)	Percent Efficiency
0.003	0.5	23,529	20,000	0.85	96.90
0.003	0.5	47,059	40,000	0.85	97.91
0.003	0.5	70,588	60,000	0.85	98.23
0.003	0.5	76,800	65,280	0.85	98.31
0.003	0.5	76,800	76,800	1.00	98.63
0.10	15	88,320	75,072	0.85	98.12
0.21	30	96,000	82,560	0.86	97.98

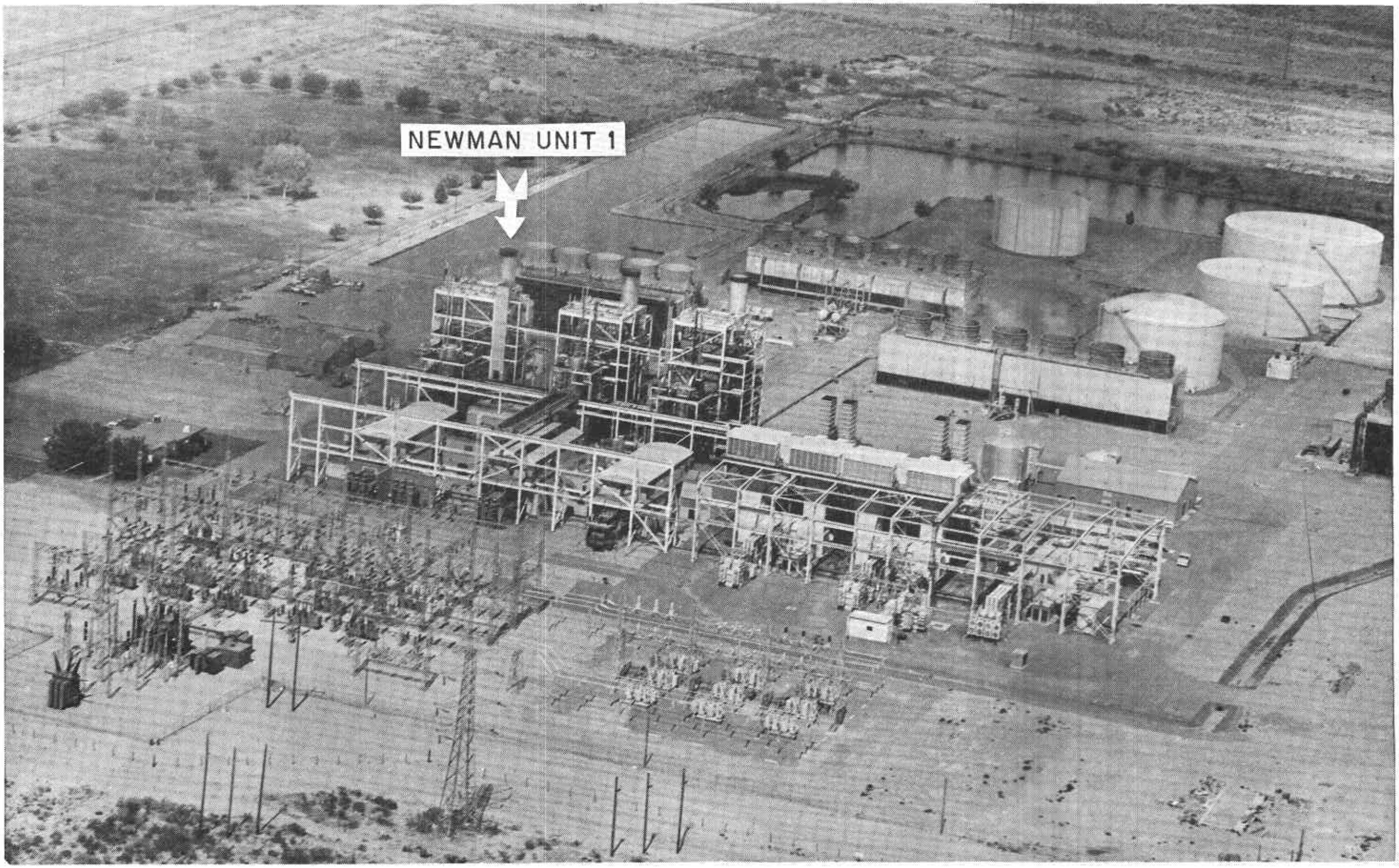


FIGURE E.I-I
NEWMAN STATION UNITS 1-4

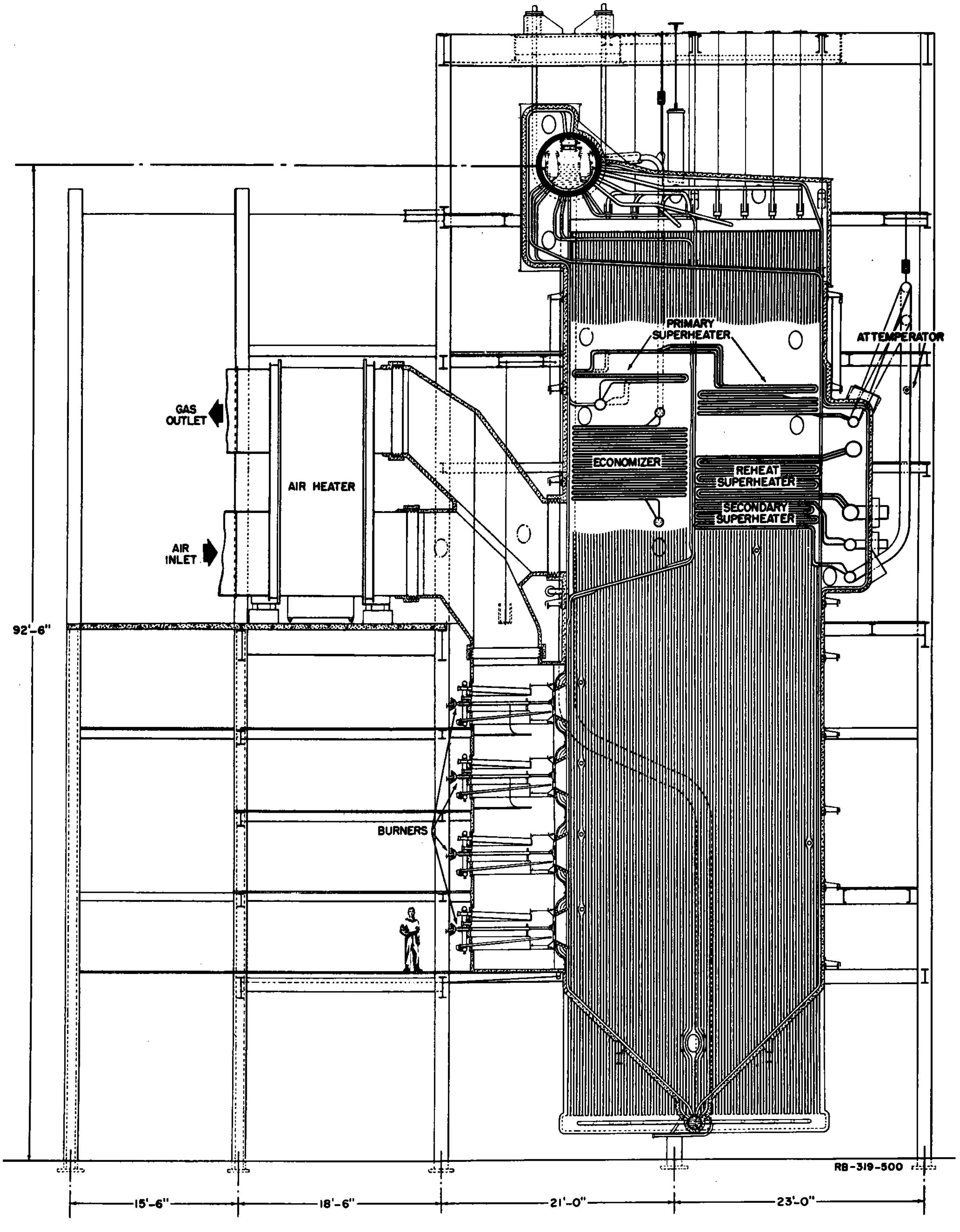


FIGURE E.1-2
BOILER CROSS-SECTION

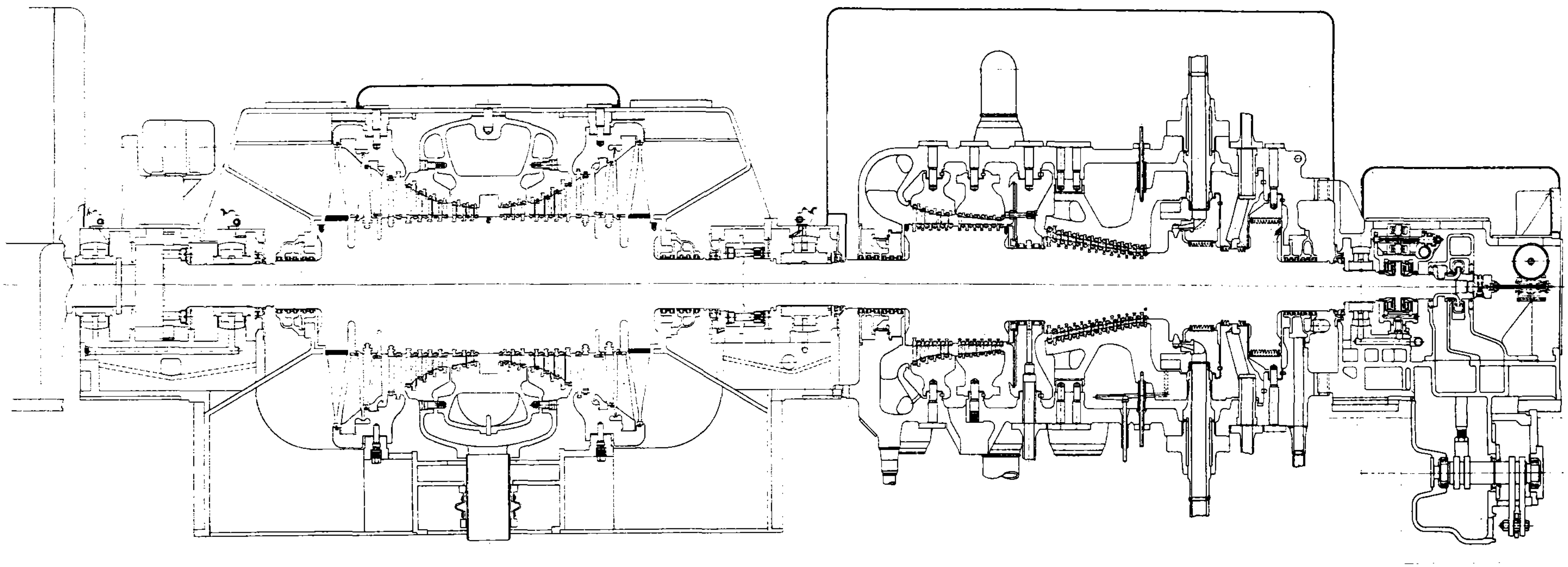


FIGURE E.1-3
TURBINE CROSS—SECTION

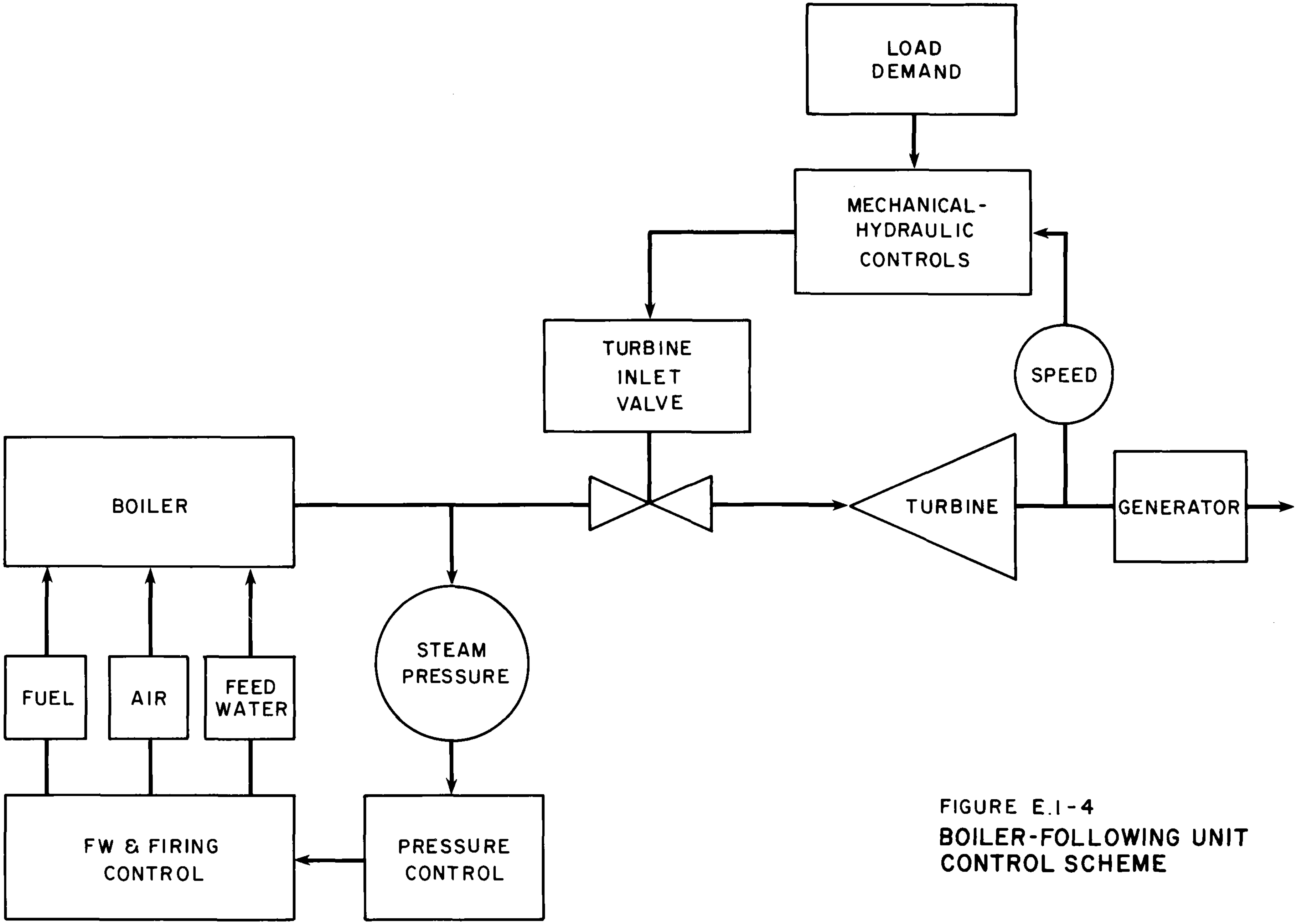


FIGURE E.1-4
BOILER-FOLLOWING UNIT CONTROL SCHEME

E.2 EXISTING UNIT PERFORMANCE SUMMARY

This section summarizes the operating characteristics and performance of Newman Unit 1.

E.2.1 Unit Characteristics

Newman Unit 1, currently an intermediate load unit, operated approximately 46 percent of 1981 with a 25 percent capacity factor. Last year the unit had a scheduled outage rate of 7.5 percent, and a forced outage rate of 12.0 percent. The major forced outage in 1981 was due to a boiler leak. Operating and maintenance costs (excluding fuel) for 1981 are estimated to be $669,000.

Newman Unit 1 consists of a 75,000 kW (nameplate) tandem-compound reheat turbine-generator and a 254,000 kg/hr (560,000 lb/hr) steam generator. This unit currently generates 82 MW (net) at full load. Steam conditions at the turbine throttle are 10.1 MPa (1,465 psia) and 538°C (1,000°F) with 538°C (1,000°F) reheat. The steam generator is designed to burn natural gas and occasional fuel oil.

The electrical output of the unit 96,000 kVA generator is delivered to the EPE system through a 95,000 kVA FOA 13.8/115 kV step-up transformer to the 115 kV substation transformer.

Table E.2-1 summarizes the design conditions of the plant components at maximum unit capability.

E.2.2 Unit Performance

The original plant design heat balances at 83 MW gross and approximately half unit capability (41 MW gross) are presented in Figures E.2-1 and E.2-2, respectively. Actual performance indicates that the maximum unit gross output is 86 MWe versus 83 MWe . The design heat balance for 41 MWe shows the reheat temperature at 491°C (915°F) due to the lower burner firing rate. In actual operation at low loads, the reheat is maintained at 538°C (1000°F) by increasing the excess air to the boiler.

Table E.1-1 summarizes the calculated unit heat rates, boiler efficiencies, and superheat and reheat temperatures at various loads. Overall efficiency of the generator and exciters as a function of load are tabulated in Table E.1-2. Tests will be conducted during the solar repowering system design phase to update the performance of the unit and the values given in Tables E.1-1 and E.1-2.

TABLE E.2-1

STATION DESIGN SUMMARY AT MAXIMUM UNIT CAPABILITY

Turbine-generator*		
Generation, kW (gross)	83,110	
Generation, kW (net)	79,585	
Steam at main stop valves		
Pressure, MPa (psia)	10.1	(1,465)
Temperature, °C (°F)	538	(1,000)
Steam at reheat intercept valves		
Pressure, MPa (psia)	2.9	(425)
Temperature, °C (°F)	538	(1,000)
Extraction pressures, MPa (psia)		
1st point (15th stage)	3.1	(452)
2nd point (21st stage)	1.2	(181.1)
3rd point (26th stage)	0.5	(79.3)
4th point (30th stage)	0.2	(24.7)
5th point (33rd stage)	0.05	(7.4)
Condenser vacuum, kPa (in Hg abs)	6.8	(2.0)
Flows, Kg/hr (lb/hr)		
To turbine main stop valves	257,200	(567,000)
To turbine intercept valves	230,900	(508,960)
1st point extraction	23,200	(51,110)
2nd point extraction	12,500	(27,570)
3rd point extraction[1]	12,600	(27,730)
4th point extraction	12,600	(27,750)
5th point extraction	11,200	(24,620)
To condenser	184,800	(407,370)
Circulating water to cooling tower, m^3/s (gpm)	2.3	(36,800)
Steam Generator		
Steam flow at secondary superheater outlet, kg/hr (lb/hr)	257,200	(567,000)
Drum pressure, MPa (psia)	11.1	(1,610)
Fuel gas consumed, m^3/hr (ft^3/hr)	21,200	(749,000)

TABLE E.2-1 (Cont)

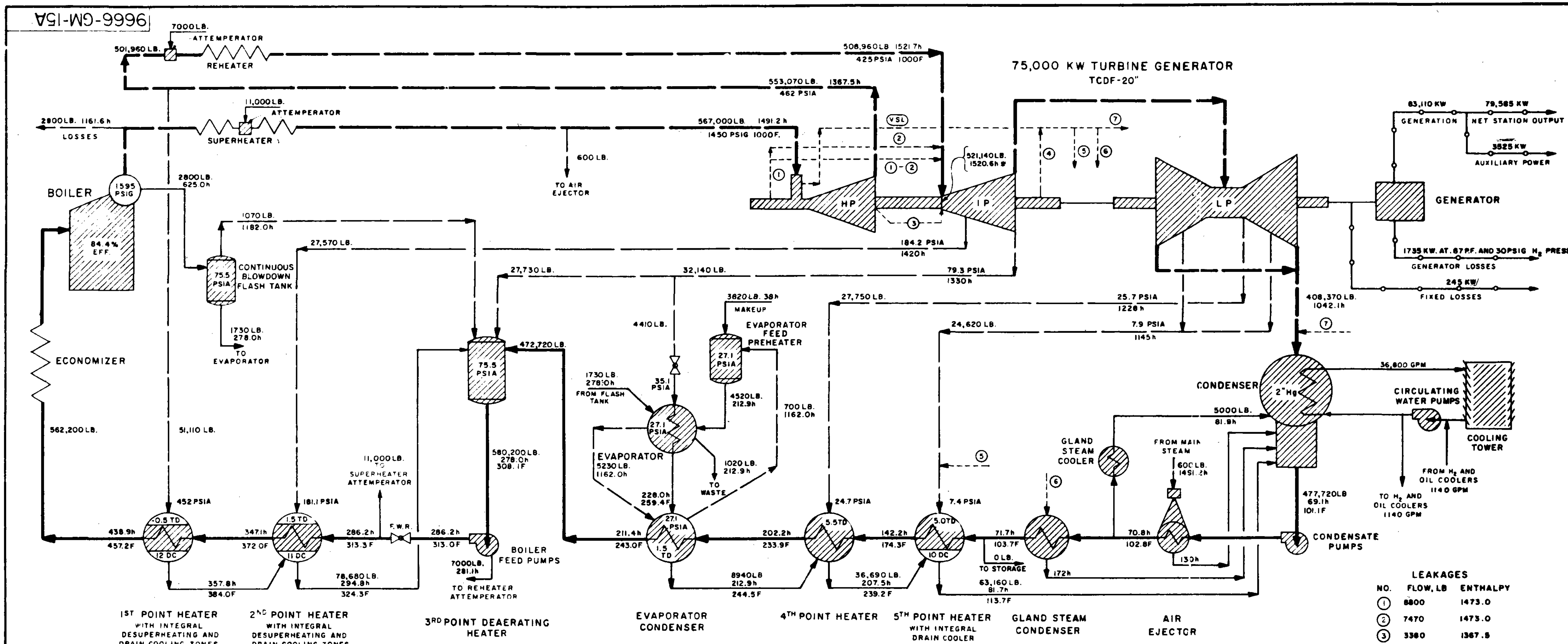
<u>Auxiliary Power</u>

Boiler feed pumps, condensate pumps, forced draft fan, circulating water pumps, cooling tower fans, air compressors, and miscellaneous, kWe	3,525	
Heat Rate (at 6.8 kPa 2 in. Hg backpressure)		
Turbine heat rate, kJ/kWh (Btu/kWh)	8,700	(8,290)
Station heat rate, kJ/kWh (Btu/kWh)	10,800	(10,235)

NOTES:

* When operating at 0.87 power factor and 0.31 MPa (45 psia) H_2 pressure

1. Includes normal operation of evaporator to just make up losses.



LEAKAGES

NO.	FLOW, LB	ENTHALPY
1	8800	1473.0
2	7470	1473.0
3	3380	1367.5
4	690	1330.0
5	1850	1445.6
6	360	1352.0
7	230	1352.0
VSL	1750	1491.2

BASIS OF HEAT BALANCE CALCULATIONS

ELEVATION: PLANT IS APPROXIMATELY 4065 FEET ABOVE SEA LEVEL
AIR TEMPERATURE: AVERAGE ANNUAL AMBIENT AIR TEMPERATURE IS 63.3F
FUEL: NATURAL GAS
STEAM LOSSES: 2800 LB, CONSTANT AT ALL LOADS
BOILER BLOWDOWN: 0.5% STEAM GENERATION
BOILER EFFICIENCY: ADJUSTED FOR ACTUAL INLET AIR TEMPERATURE AT 73.8
SUPERHEATER, REHEATER, MAIN AND REHEAT STEAM LINE PRESSURE DROPS CALCULATED AT ALL LOADS. REHEAT SYSTEM PRESSURE DROP EXPRESSED AS 8.0 PERCENT OF HIGH PRESSURE TURBINE EXHAUST PRESSURE AT THIS LOAD.
EXTRACTION LINE PRESSURE DROPS CALCULATED AT MAXIMUM LOAD AND EXPRESSED AS THE FOLLOWING PER CENT OF THE FLANGE ABSOLUTE PRESSURES FOR USE AT ALL LOADS

EXTRACTION LINE	1	2	3	4	5
PER CENT	2.2	1.7	4.8	4.0	6.4

EXTRACTION PRESSURES SHOWN AT OR NEAR THE TURBINE SYMBOL ARE TURBINE EXTRACTION FLANGE PRESSURES. PRESSURES SHOWN NEAR HEATER SYMBOLS ARE HEATER ENTRANCE PRESSURES.
EVAPORATOR SYSTEM IS OPERATED TO REPLACE ESTIMATED STEAM AND WATER LOSSES FROM THE CYCLE BY THROTTLING COIL STEAM SUPPLY PRESSURE AS REQUIRED, WITH SURFACE 50% CLEAN. EVAPORATOR BLOWDOWN QUANTITY BASED ON SOLIDS CONCENTRATIONS AS FOLLOWS: EVAPORATOR SHELL, 3500 PPM, BOILER BLOWDOWN, 325 PPM, MAKEUP, 780 PPM.
WET BULB TEMPERATURES SHOWN ARE REQUIRED TO PRODUCE CORRESPONDING BACK PRESSURES WITH 36,800 GPM OF CIRCULATING WATER.
BASE HEAT BALANCE COMPUTED FOR 2"Hg BACK PRESSURE. ALL FLOWS, PRESSURES, TEMPERATURES AND ENTHALPIES REMAIN UNCHANGED FOR OTHER BACK PRESSURES, EXCEPT AS FOLLOWS: VALUES SHOWN IN TABLE, ENTHALPY AND TEMPERATURE OF CONDENSATE TO THE AIR EJECTOR, GLAND STEAM CONDENSER AND 5TH POINT HEATER, ENTHALPY AND TEMPERATURE OF DRAINS FROM 5TH POINT HEATER.

*INLET ENTHALPY OF I.P. TURBINE DETERMINED BY TURBINE MANUFACTURER'S PROCEDURE FOR HANDLING LEAKAGE (2)

AUXILIARY POWER REQUIREMENTS ARE CALCULATED FOR ALL EQUIPMENT. THE MAJOR EQUIPMENT CONSIDERED IS AS FOLLOWS:

REQUIREMENTS VARIABLE WITH CHANGE IN LOAD ON UNIT

EQUIPMENT	NUMBER OPERATING
2 BOILER FEED PUMPS	2
2 CONDENSATE PUMPS	2
1 FORCED DRAFT FAN	1
STATION SERVICE TRANSFORMER LOSS	

AVERAGE DAILY REQUIREMENTS, CONSIDERED CONSTANT AT ALL LOADS.

EQUIPMENT	NUMBER OPERATING
1 INSTRUMENT AIR COMPRESSOR	1
1 SERVICE AIR COMPRESSOR	1
1 DEEP WELL PUMP	1
2 CIRCULATING WATER PUMPS	2
5 COOLING TOWER FANS	5

$$\text{TURBINE HEAT RATE} = \frac{3412.75(83{,}110+1735+245)+408{,}370(1042.1-69.1)+63{,}160(81.7-69.1)+5000(81.9-69.1)+230(1352-69.1)}{83{,}110} = 8290 \text{ BTU PER KWH}$$

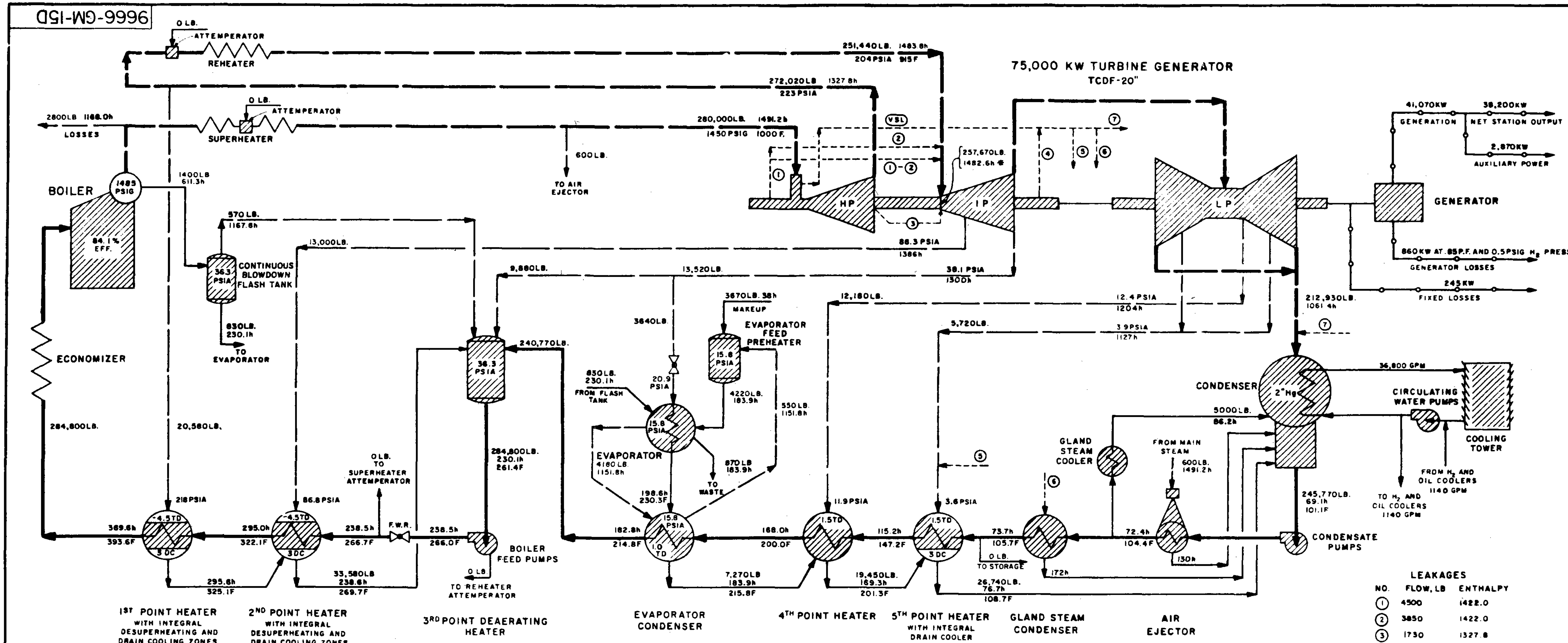
$$\text{STATION HEAT RATE} = \frac{556{,}600(1491.2-438.9)+11{,}000(1491.2-286.2)+2800(1161.6-438.9)+2800(625.0-438.9)+501{,}960(1521.7-1367.5)+7000(1521.7-281.1)}{.844 \times 79{,}585} = 10{,}235 \text{ BTU PER KWH}$$

CONDENSER BACK PRESSURE "Hg	5TH POINT EXTRACTION FLOW LB	TURBINE EXHAUST FLOW LB	L.P.T. END POINT ENTHALPY h	TURBINE EXHAUST ENTHALPY h	GENERATION KW	NET STATION OUTPUT KW	TURBINE HEAT RATE BTU/KWH	STATION HEAT RATE BTU/KWH	CIRC. WATER TEMP. F	WET BULB TEMP. F
2.5	21,680	411,310	1042.5	1049.6	82,295	78,770	8370	10,340	80.5	65.5
2.0	24,620	408,370	1032.0	1042.1	83,110	79,585	8290	10,235	72.5	51.5
1.5	28,210	404,780	1018.5	1035.3	83,805	80,280	8220	10,150	62.0	—
1.0	32,930	400,060	1000.0	1029.2	84,370	80,845	8165	10,075	47.5	—

LEGEND

— —	STEAM
——	WATER
—o—	POWER, KW
LB	FLOW, POUNDS PER HOUR
h	ENTHALPY, BTU PER POUND
F	TEMPERATURE, DEGREES FAHR.
TD	TERMINAL DIFFERENCE
DC	TERM. DIFF. DRAIN COOLER
KW	KILOWATTS
FWR	FEED WATER REGULATOR
Hg	PRESSURE, IN. OF MERCURY, ABS.
PSIA	PRESSURE, LB PER SQUARE IN., ABS.
PSIG	PRESSURE, LB PER SQUARE IN., GAGE

FIGURE E.2-1
HEAT BALANCE DIAGRAM - 83 MW LOAD



LEAKAGES

NO.	FLOW, LB	ENTHALPY
①	4500	1422.0
②	3850	1422.0
③	1730	1327.8
④	320	1300.0
⑤	1570	1461.8
⑥	280	1324.0
⑦	220	1324.0
(VSL)	1750	1491.2

BASIS OF HEAT BALANCE CALCULATIONS

ELEVATION: PLANT IS APPROXIMATELY 4065 FEET ABOVE SEA LEVEL
AIR TEMPERATURE: AVERAGE ANNUAL AMBIENT AIR TEMPERATURE IS 63.3F
FUEL: NATURAL GAS
STEAM LOSSES: 2800 LB, CONSTANT AT ALL LOADS
BOILER BLOWDOWN: 0.5% STEAM GENERATION
BOILER EFFICIENCY: ADJUSTED FOR ACTUAL INLET AIR TEMPERATURE AT 75.0
SUPERHEATER, REHEATER, MAIN AND REHEAT STEAM LINE PRESSURE DROPS CALCULATED AT ALL LOADS. REHEAT SYSTEM PRESSURE DROP EXPRESSED AS 8.5 PERCENT OF HIGH PRESSURE TURBINE EXHAUST PRESSURE AT THIS LOAD.
EXTRACTION LINE PRESSURE DROPS CALCULATED AT MAXIMUM LOAD AND EXPRESSED AS THE FOLLOWING PER CENT OF THE FLANGE ABSOLUTE PRESSURES FOR USE AT ALL LOADS.

EXTRACTION LINE	1	2	3	4	5
PER CENT	2.2	1.7	4.8	4.0	6.4

EXTRACTION PRESSURES SHOWN AT OR NEAR THE TURBINE SYMBOL ARE TURBINE EXTRACTION FLANGE PRESSURES. PRESSURES SHOWN NEAR HEATER SYMBOLS ARE HEATER ENTRANCE PRESSURES.
EVAPORATOR SYSTEM IS OPERATED TO REPLACE ESTIMATED STEAM AND WATER LOSSES FROM THE CYCLE BY THROTTLING COIL STEAM SUPPLY PRESSURE AS REQUIRED, WITH SURFACE 50% CLEAN. EVAPORATOR BLOWDOWN QUANTITY BASED ON SOLIDS CONCENTRATIONS AS FOLLOWS: EVAPORATOR SHELL, 3800 PPM; BOILER BLOWDOWN, 325 PPM; MAKEUP, 780 PPM.
WET BULB TEMPERATURES SHOWN ARE REQUIRED TO PRODUCE CORRESPONDING BACK PRESSURES WITH 36,800 GPM OF CIRCULATING WATER.
BASE HEAT BALANCE COMPUTED FOR 2"Hg BACK PRESSURE. ALL FLOWS, PRESSURES, TEMPERATURES AND ENTHALPIES REMAIN UNCHANGED FOR OTHER BACK PRESSURES, EXCEPT AS FOLLOWS: VALUES SHOWN IN TABLE, ENTHALPY AND TEMPERATURE OF CONDENSATE TO THE AIR EJECTOR, GLAND STEAM CONDENSER AND 5TH POINT HEATER, ENTHALPY AND TEMPERATURE OF DRAINS FROM 5TH POINT HEATER.

* INLET ENTHALPY OF IP TURBINE DETERMINED BY TURBINE MANUFACTURER'S PROCEDURE FOR HANDLING LEAKAGE ②

AUXILIARY POWER REQUIREMENTS ARE CALCULATED FOR ALL EQUIPMENT THE MAJOR EQUIPMENT CONSIDERED IS AS FOLLOWS:

REQUIREMENTS VARIABLE WITH CHANGE IN LOAD ON UNIT

EQUIPMENT	NUMBER OPERATING
2 BOILER FEED PUMPS	2
2 CONDENSATE PUMPS	1
1 FORCED DRAFT FAN	1
STATION SERVICE TRANSFORMER LOSS	

AVERAGE DAILY REQUIREMENTS, CONSIDERED CONSTANT AT ALL LOADS

EQUIPMENT	NUMBER OPERATING
1 INSTRUMENT AIR COMPRESSOR	1
1 SERVICE AIR COMPRESSOR	1
1 DEEP WELL PUMP	1
2 CIRCULATING WATER PUMPS	2
5 COOLING TOWER FANS	5

$$\text{TURBINE HEAT RATE} = \frac{3412.75(41,070+860+245)+212,930(1061.4-69.1)+26,740(76.7-69.1)+5000(86.2-69.1)+220(1324.0-69.1)}{41,070} = 8,665 \text{ BTU PER KWH}$$

$$\text{STATION HEAT RATE} = \frac{280,600(1491.2-369.6)+2800(1168.0-369.6)+1400(611.3-369.6)+251,440(1483.8-1327.8)}{.841 \times 38,200} = 11,095 \text{ BTU PER KWH}$$

CONDENSER BACK PRESSURE "Hg	5TH POINT EXTRACTION FLOW LB	TURBINE EXHAUST FLOW LB	LPT END POINT ENTHALPY h	TURBINE EXHAUST ENTHALPY h	GENERATION KW	NET STATION OUTPUT KW	TURBINE HEAT RATE BTU/KWH	STATION HEAT RATE BTU/KWH	CIRC. WATER TEMP. F	WET BULB TEMP. F
2.5	4,160	214,490	1064.5	1073.5	40,345	37,475	8820	11,310	94.0	—
2.0	5,720	212,930	1054.0	1061.4	41,070	38,200	8665	11,095	86.0	80.5
1.5	7,620	211,030	1040.0	1046.6	41,940	39,070	8485	10,850	77.0	69.0
1.0	10,110	208,540	1021.0	1030.9	42,830	39,960	8305	10,610	63.5	50.5

LEGEND

— — —	STEAM
———	WATER
—o—	POWER, KW
LB	FLOW, POUNDS PER HOUR
h	ENTHALPY, BTU PER POUND
F	TEMPERATURE, DEGREES FAHR
TD	TERMINAL DIFFERENCE
DC	TERM DIFF DRAIN COOLER
KW	KILOWATTS
FWR	FEED WATER REGULATOR
Hg	PRESSURE, IN. OF MERCURY, ABS
PSIA	PRESSURE, LB PER SQUARE IN., ABS
PSIG	PRESSURE, LB PER SQUARE IN., GAGE

FIGURE E.2-2
HEAT BALANCE DIAGRAM - 41 MW LOAD