APPENDIX D

INSTRUMENTATION AND CONTROLS DESIGN CRITERIA

D.1 GENERAL

D.1.1 Guidelines

D.1.1.1 General

The Instrumentation and Control (I&C) Design Criteria are prepared to present guidelines that will be followed in the design and installation of the I&C systems for Salton Sea Unit 6. It is intended that this document shall be used by the EPC Contractor as input to equipment specifications, installation drawings and instructions.

The design criteria are based upon the following design objectives:

1. Maintain the plant in a safe condition at all times. Automatic protection and plant trips shall be provided so that if a potentially dangerous situation should occur, the plant will be maintained in a safe and undamaged condition without the need for any operator action.

2. Prevent the violation of environmental regulations concerning air, land, and water quality requirements.

3. Provide for smooth startup and shutdown of the power plant and auxiliary systems in accordance with pre-planned operating procedures with a minimum of operator intervention.

4. Provide for efficient steady-state control of the power plant and auxiliary systems.

5. Provide reliable steady power plant operation at rated capacity (185MW).

6. Minimize the effects of abnormal process conditions, load upsets, and equipment malfunctions on power plant operations.

7. Provide operator interfaces that minimize the potential for operator error.

8. Minimize the number of plant forced outages and spurious trips.

9. Provide for reliable, economical/optimum operation of the turbine generator and related systems.

10. Provide for ease of construction.

11. Provide a control system that allows for maximum flexibility to expand the system and/or modify control functions that affect the performance of the unit during initial startup, testing and operation.

12. Minimize the effects of corrosion and scaling through proper equipment and material selection, equipment location, environmental control, and on-line maintenance capability.

D.1.1.2 Control System

In general, during normal operation of the plant all control and monitoring functions will be performed from the control room, however, startup and shutdown of equipment for maintenance will be performed locally at the equipment using a hand/off/auto select switch along with start/stop push buttons. These controls shall be wired directly into the MCC, eliminating the need for the DCS, should it be down. DCS control shall only be enabled if the H-O-A select switch is in the auto position. The circuits within the hardwired controls shall incorporate all necessary interlocks for safe operation of the equipment utilizing process mounted switches. The DCS shall not be used for these interlocks.

D.2 MAIN CONTROL ROOM AND POWER DISTRIBUTION CENTER

D.2.1 Control Room Area

The main control room for Unit 6 will be used in the control building. The control room will be designed in accordance with human factors engineering principles to the maximum extent possible for the comfort and efficiency of operations personnel. Control items not requiring operator attention such as protective relays, computer hardware, EHC and excitation control cabinets, will be located in the modular Power Distribution Center (PDC) adjacent to the Unit 6 turbine building.

The main control panel serves as the operator/plant interface, and it is essential that information be presented to the operator in a clear and simple form and in order of priority. The following design guidelines will be observed:

1. The control room area will be designed to permit two control room operators to control and monitor plant operation and identify plant abnormalities for the brine

flashing operation and power generation facilities for Unit 6. This will be accomplished by minimizing the length of the control panel and by minimizing the number of display devices which must be continuously monitored during plant operation.

2. Although the panel is designed to permit three operators to monitor plant operation, the size and arrangement of the new panels will accommodate additional operators, if necessary, during test operations or other periods of unusual operating conditions.

3. Testing and maintenance procedures involving control panel-mounted equipment will be possible with minimal interference with the plant operation.

4. All alarm functions will be handled by the DCS. No separate annunciator system will be provided.

5. One (1) additional color CRT's with keyboards will provide the operator interface with the plant distributed control system (DCS). All primary control and monitoring functions for the process will be done through the DCS. All of the CRT's will have access to the same data base.

6. The main control panel will be a bench type panel which will house the CRT stations alarm and operations keyboards.

7. A Contractor furnished fire protection monitoring panel for Unit 6 shall be located in the control room area.

8. Two graphic capable, laser jet type printers will be provided as part of the distributed control system. One printer shall be dedicated to alarm printing; one dedicated to event logging.

9. A separate mimic-type switchboard panel shall be provided for control and monitoring of all electrical system feeders and feeder breakers. This panel shall meet the following requirements:

    - Shall provide a location for the control of generator synchronizing, and generator and line breaker control.

    - Shall provide a location for the turbine-generator governor control interface panel

    - Shall provide location for all 13.8 kV breaker controls

- Shall be vertical in design and located in the control room.

The panel shall contain hardwired controls and a mimic panel for the electrical switchyard, monitoring panel inserts, and other Contractor furnished control equipment which is not included in the DCS. The mimic panel shall provide a location of the turbine-generator interface panel near the mimic bus.

In general, cables shall enter equipment from the bottom of the panels. There shall be no exposed conduits or cable tray in the control room.

Ambient temperature will be controlled at 75° t2°F. Relative humidity will be controlled to 50% ±10°%. The contractor shall increase the capacity of the existing air conditioning units, if necessary, to ensure ambient conditions are maintained with the additional equipment.

Non-electric signals of plant instrumentation and control shall not be connected direct to control room equipment.

D.2.2 Power Distribution Center (PDC)

The PDC shall be placed on concrete pillars with 6'-0" clearance between ground elevation and floor of the PDC. The Owner has found this to provide superior access for installation, maintenance and additions to existing PDC's with this clearance. In order to minimize the effects of corrosion on sensitive control equipment, the PDC environmental conditions will be controlled using redundant air conditioning units.

These rooms will also be designed to minimize the amount of unnecessary traffic and maintain the highest practical level of cleanliness.

Ambient temperature will be controlled at 75° ±2°F. Relative humidity will be controlled to 50% ± 10°%.

Non-electric signals of plant instrumentation and control shall not be connected direct to the PDC equipment.

In general, cables shall enter the cabinets from the top.

The following equipment shall be located in this room:

- DCS process control units and other equipment not otherwise required in the control room

- Vibration monitoring racks

- Turbine Generator governor controls

D.3 DISTRIBUTED CONTROL SYSTEM

D.3.1 General

The plant will generally be operated via a distributed control system (DCS). The DCS shall be complete with all necessary hardware and software.

Install a Foxboro IA system for the Unit 6 control only. Create a transparent interface of the new Foxboro IA system for Unit 5 with the existing Rosemount RMW 9000 system for Units 3, and 4.

The additional DCS hardware shall include one (1) operator interface station. The contractor shall review the need for a second operator interface station, and, if required, shall supply a second station.

Following modifications, any DCS screen shall be capable of accessing any information within the DCS for any unit.

The DCS for Unit 6 shall be provided with the following hardware and software accessories.

1. Sequential and discrete digital logic for motor control and interlocking as well as analog control for modulating control loops.

2. Sequence of events capability shall be provided within the DCS with time resolution of 1 msec.

3. All unit devices capable of communicating with one another on a redundant data highway.

4. CRT interactive graphics with dynamic data updating.

5. Efficiency calculation, custom report generation, and long term data archiving. This may be done in the DCS or in an auxiliary computer system dedicated to any or all of these function. Data archiving shall be done on optical disks. Any I/O points or internal alarms shall be capable of being logged.

6. spare rack space containing approximately 20% spare I/O hardware for each type of I/O will be provided.

7. The system should have the capability for future expansion.

8. The system should have the capability to interface through a modem with a personal computer for transfer of report data.

The alarm reporting system shall have the capability to group and prioritize incoming alarms as well as to disable individual or groups of alarms.

The system will have the capability to interface with the major brands of programmable logic controllers. Following summarizes the PLCs that could be expected on site:

- Modicon
- Chesel
- IPAC
- Bentley
- Woodward Micronet

D.3.2 Turbine Generator Governor / DCS Interface

The DCS will make provisions for the necessary I/O and displays to interface with the Turbine Generator control system. The turbine generator will utilize a Woodward Micronet Governor System.

All T/G controls and monitoring necessary for operation of the T/G shall be incorporated into the DCS. The DCS operator shall interface with the governor system through graphic displays on the DCS.

A separate T/G control interface shall be provided in the control room on the mimic panel. The primary purpose of this panel is to monitor the Woodward Micronet system. This panel shall not contain the actual governor controls, but will only be a monitoring window to the Woodward Micronet.

The T/G controls shall allow:

- Isochronous Control Mode
- Speed Control Mode
- Load Control Mode
- Pressure Control Mode
- Have provisions for Droop control

The DCS shall indicate and alarm all T/G alarms.

D.3.3 DCS Requirements

D.3.3.1 General

The DCS will be separate from the hard wired Station Electrical Protection, Metering System and the Turbine Generator control system, but will have access to select variables within these systems. (Refer to Electrical Design Criteria and the Turbine Governor Specification).

The DCS shall be capable of handling any normal logic complexity associated with plant interlocks and shall also be capable of being programmed in the field with minimum effect on plant operations. The application software (firmware) shall be non-volatile.

The DCS shall be designed and constructed so that it will not be affected by transient or continuous electro-magnetic interferences. This will include the capability to continue normal operations with RF emission from a handheld FM transceiver keyed adjacent to DCS equipment, including the process control units and the operator interface stations.

Credit may be taken requiring DCS enclosure doors to be closed. The engineering work station is exempt from this requirement.

All trips shall be alarmed on the operator interface and printed at the operations printer

DCS control nodes shall be equipped with dual power supplies and redundant control processors.

The DCS shall be of modular design, with a fault tolerant, redundant architecture such that the failure of one section will not affect the operation of other sections of the equipment. The reliability of each constituent part of the system, and the system as a

whole shall be such as to meet the overall plant performance criteria. This shall be achieved by suitable levels of redundancy on the equipment.

Critical I/O shall be duplicated implemented with redundant inputs. Digital inputs shall utilize a "1 out of 2" voting system to propagate the condition. Analog signals shall utilize a select feature, and the ability to switch primary controlling signal. An alarm shall be generated if redundant analog signals deviate by more than 10% of span.

There should be no process change resulting from the failure of a controller.

The final fully configured system shall have a total round-trip time for a command to be processed, including display of the feedback signal from the local processor, of less than 2 seconds.

D.3.3.2 I/O Requirements

D.3.3.2.1 Analog Input. The DCS shall be capable of accepting the following analog signals:

- Current inputs 4 to 20 mA with individual A/D conversion. The system shall be capable of supplying the 24 V DC loop power for 4 to 20 mA 2-wire or 3wire transmitters

- Current inputs of -1.2 - 0 - +1.2 mA (nominal) from standard SCADA compatible metering and relaying devices

- Voltage inputs within the range of -10 Vdc to +10 V DC

The choice of field or system power shall be user selectable for each point. Inputs shall be via a low-pass filter to reject high frequency interference. Common mode noise rejection shall be a minimum of 110 dB at 60 Hz. Normal mode rejection shall be a minimum 60 dB at 60 Hz. Accuracy shall be ±0.2% of full span or better.

As an option, the Contractor may utilize SMART field communications between field tranmitters and the DCS. The contractor may daisey-chain multiple transmitters one a single field bus type loop. Use of SMART communications must be done in such a way as to be fault tolerant (e.g.; ring topology).

D.3.3.2.2 Analog Output. The DCS shall be capable of driving 600 ohm standard or up to 750 ohms total loop resistance at 4 - 20 mA. The system shall be capable of supplying the 24 V DC loop power. The choice of field or system power shall be user selectable for each point.

The system shall also be capable of providing a user selectable default output state for each individual point in the event of an error. Accuracy shall be +0.2 % of full span or better.

As an option, the Contractor may utilize SMART field communications between field devices and the DCS. The contractor may daisey-chain multiple transmitters and/or final control elements on a single field bus type loop. Use of SMART communications must be done in such a way as to be fault tolerant (e.g.; ring topology).

D.3.3.2.3 Digital Input. The DCS shall be capable of receiving the following signals:

- 24 VDC
- 48 VDC
- 120 VAC or
- 110 VDC

All digital inputs shall be available with selectable filtering from 2 to 20 millisecond.

Inputs shall be high impedance type.

D.3.3.2.4 Digital Output. The DCS shall provide isolated contact rated at 125 V DC, 3A and 220 VAC and user selectable as normally open or normally closed, momentary or maintained.

The system shall be capable of providing a user selectable default output state for each point in the event of an error.

D.3.3.2.5 Temperature Inputs. The DCS shall be capable of receiving the following temperature detector inputs:

- RTD Input: Capable of receiving 100 ohm platinum resistance temperature detectors (RTDs) inputs directly. Lead length compensation for 3-wire RTDs shall be provided. Other types of RTDs such as 10 ohm copper RTDs shall not be used due to the presence of hydrogen sulphide.

- T/C Input Capable of receiving all types of thermocouple inputs directly. Cold junction reference compensation and open circuit detection shall be provided. Millivolt input ranges of -100 to +100 mV and 0 to +100 mV shall also be provided. Thermocouple reference junction temperature compensation shall be provided. The

thermocouple reference junction temperature compensation value shall be available for display to the operator and shall have alarm limits.

D.3.3.2.6 Pulse Input. The DCS shall be capable of receiving square wave or contact input of 1-10 volts and a pulse rate of up to 25 kHz.

D.3.3.3 General Guidelines

In general, the following signal standards shall be used:

- Analog input signals shall be 4 to 20 mA
- Analog output signals shall be 4 to 20 mA
- Digital inputs interrogated by the DCS shall be 24 VDC
- MCC monitoring and interrogation shall utilize MCC control power and shall be 120 VAC or 125 VDC as appropriate.
- For digital inputs, a minimum of one common terminal for each four digital inputs shall be provided. Common terminals supplying outgoing field power shall be individually fused
- Turbine trip circuitry shall be 125 VDC.
- Field cables shall not terminate directly onto electronic circuit boards
- For each analog input and output, two terminals plus isolated ground connection shall be provided

D.3.3.4 Spare Capacity

The DCS shall have spare capacity after the Unit is fully commissioned as follows

- Multi-loop controller - 50% of total processing capacity per module
- I/O - 20% of I/O per process control unit
- Cabinet space for expansion - 25%
- All spare I/Os shall be active and wired to terminations and clearly shown on the termination drawings

- The DCS shall allow for system expansion through the addition of controllers, operator work stations and I/O modules while system is on line

D.3.3.5 Distributed Control System Cabinets

A 19 inch rack mounting shall be provided for all DCS modules, modular power systems and terminations. The cabinets shall be able to accommodate either top or bottom cable entry. The cabinets shall provide front and rear doors to provide easy access for installation and maintenance of power systems and mounting assemblies.

D.3.3.6 Power Supplies and System Power Feeds

The DCS components within the power plant shall be supplied from two secure 120 VAC sources: one from an uninterruptible power supply (UPS) and the second from a reliable 120 VAC bus. The DCS shall monitor alarms from the internal power supplies
Redundant power supplies shall be provided to power process control modules and field termination devices. The power supply output voltages shall be well regulated and not fluctuate more than ± 1 % with input voltages of 120 V AC ± 10%.

D.3.3.7 Operator Work Stations

One (1) Operator work stations (OWS) and an engineering work station (EWS) shall be supplied and installed in a control desk to be located in the power plant control room. The engineering work station shall be used primarily for system maintenance, engineering and configuration functions.

D.3.3.8 Control Desk

All operator work stations shall be installed in the control room in a suitably designed control desk. The control desk design shall incorporate at least 2 work surfaces, each equal in floor space to the area allowed for an OWS, to provide workspace for plant operators.

D.3.3.9 Data Storage

At least two high density optical disk drives shall be supplied for redundant storage and retrieval of historical and trend data, system software, and system configuration files. Software shall be provided to allow easy tranfer of archeived data into MicroSoft compatible database or speadsheet format.

Tape Drives are not acceptable as backup devices.

D.3.3.10 Printers

Two industry standard non-impact, laser jet type printers shall be provided. This printer shall be a high resolution laser jet single color suitable for printing 8-1/2x11 and I 1x17 paper. These shall be desktop mounted in the Control Room on suitable furniture with space for paper, toner cartridges and other supplies. The printers shall include paper trays and feeders.

The two printers shall be utilized as follows:

- One dedicated to alarm printing
- One dedicated to event logging

The minimum print speed acceptable is 300 characters/second.

Printers shall operate without soundhoods in a quiet control room environment and printer noise level shall not exceed 47 dBA at distance of 3 feet from printer.

Sufficient toner cartridge set(s) for each printer suitable for one year's operation of the power plant shall be supplied with the equipment. Printers shall use commercially available printer paper which is readily available.

Printouts shall be spooled, and printouts intended for a printer which has failed shall be able to be re-routed to the other printer.

Each printer shall be able to be accessed via any operator work station. Printers shall be network interfaced. Printer "Failover Switches" shall not be used.

D.3.3.11 Operator Workstation Software/Display Subsystem

The system software shall be designed by the DCS provider. It shall be design in such a way as to provide a seamless, transparent connection to the existing plant. Graphics shall be designed with similar symbology, colors and styles

D.3.3.12 Historical Data Storage and Retrieval System

The system shall include a comprehensive historical storage and retrieval system for long term archiving of predefined digital and analog process data in a series of disk files. The number and the size of the disk files shall be user configurable. This data shall be stored on a

large capacity optical disk for long term storage. Disk capacity shall include at least two years storage of historical data collected from the system

It shall be possible to view the data logged to disk search for any desired portion of the file. Software shall be provided to allow easy tranfer of archeived data into MicroSoft compatible database or speadsheet format

Facilities shall be provided to both archive and restore log files to and from floppy or other backup media without taking the system off-line.

The data recorded by the historian shall be selected through the "event log" database.

D.3.3.13 Reports

The DCS shall generate reports similar in information and style for Unit 6 as is provided on other existing units.

D.4 INSTRUMENT APPLICATION

D.4.1 General Technical Requirements

No process or instrument air lines associated with any instrumentation shall be brought into the control room area or adjacent electrical/electronic equipment rooms.

No electrical voltages in excess of 125V nominal associated with any instrumentation shall be brought into the main control room area.

Instruments or other devices containing mercury shall not be used in any system.

Prime consideration will be given to the effects of corrosion and scaling on instrument selection and installation. Materials selection will be based on conditions of service and will be indicated on individual instrument data sheets. Bronze and other copper bearing alloys shall be avoided. Diaphragm seals shall be utilized on acid lines.

Engraved phenolic tags engraved with the instrument tag number shall be permanently attached to all instruments.

Outdoor electrical enclosures shall have a NEMA 4X rating and shall generally be of nonmetallic construction.

All instruments and control equipment will be readily available from U.S. suppliers and shall be approved by a national testing agency such as FM or UL.

All control and instrumentation items and associated valves shall be located for easy access by operating and maintenance personnel from a floor, permanent platform or walkway.

Portions of the process will contain fluids that are highly susceptible to precipitation of silica. The Contractor is responsible for the design and installation of heat tracing for instrument sensing lines as required to prevent precipitation. Implementation of the heat tracing shall be coordinated with the Owner

D.4.2 Instrument Electric Supply Systems

Electric power for all instruments shall be supplied from an Uninterruptible Power Supply (UPS) system.

Dual redundant instrument power supplies shall be provided and have the capability of being replaced on-line without affecting the operation of the instruments. The output of the instrument power supplies shall be 24 Vdc.

Field instrumentation shall be standardized as much as practical.

Redundancy for sensors as controls shall be provided to meet the design availability requirements for the Plant.

Multiple sensors shall be used in instances where a single sensor cannot be expected to provide an average true value because of conditions or where a single instrument cannot cover the expected range.

Generally, individual transmitters and controllers will be installed to permit isolation without upsetting the process.

Separate test taps or thermowells shall be provided as required for performance or acceptance testing.

Instruments dials and scales shall be white with black markings. The number of markings on all instruments dials shall be kept to a minimum consistent with easy reading to the required accuracy. All instrument dials shall be at least 4 inch diameter. Instrument ranges shall be selected so that the dial pointer is at the 2 o'clock position under normal operating conditions.

Measuring devices shall be complete with all necessary condensation chambers, isolating valves and seal pots.

One pair of tapping points with isolating valves only shall be made in the pipeline and any multiplication of signal output shall be carried out elsewhere.

Bellows-type meters shall be capable of taking full line pressure on one side only, without damage or loss of calibration.

Snubbers will be added only after their installation is shown to be required.

D.4.3 Instrumentation Design Implementation

D.4.3.1 General

In general, alarm contacts from field devices should be open during normal operation and close to alarm. The exception to this is in the case of fail safe items such as turbine tripping schemes.

Alarms shall generally be generated within the DCS off of the analog signal measuring the process variable.

In cases where additional reliability or redundancy of signals are required, the trip signals should be generated off of process switches.

Process switches monitoring critical process variables (such as liquid levels protecting against turbine water induction), redundant switches will be used in a 1 out of 2 switching scheme. Analog signals shall utilize a select feature, and the ability to switch primary controlling signal. An alarm shall be generated if redundant analog signals deviate by more than 10% of span.

D.4.3.2 Valve Limit Switches

Limit switches from on/off control valves shall be wired such that both contact are closed in mid-travel.

The closed limit switch is that limit switch that changes state at the valve closed position. Similarly, the open limit switch is that limit switch that changes state at the valve open position.

D.4.3.3 Initiating Devices

Trip signals shall be derived as directly as possible from the initiating device. Wherever possible, pending trip conditions shall be alarmed at the operator interface.

Critical process trip signal systems shall operate on a 2 out 3 voting system basis. When one signal is locked out of service, the trip signal system shall operate on a 1 out of 2 voting system basis. Analog signals shall utilize a select feature, and the ability to switch primary controlling signal. An alarm shall be generated if redundant analog signals deviate by more than 10% of span.

D.4.3.4 System Safety

The control and plant protection systems shall be designed to ensure that the plant reverts to a safe state upon failure of any individual plant item or power supply, and that the operator is notified of the failure. The following means may be used to ensure a "safe" state:

- Automatic switching to a standby device or power supply
- Shutdown of the affected plant
- Locking of the control system at the settings prevailing immediately prior to the failure

D.4.3.5 Subsystems

Individual systems comprising this power generation plant may have equipment which requires some form of proprietary control or monitoring system. The distributed control system shall provide as much of this control and monitoring as possible. Separate utilized only when the specialized nature of the task or subsystem requires it (e.g. AVR, governor controls, vibration and temperature monitoring subsystems).

Where such specialized electronic controls are utilized, they shall be fully interfaced with the DCS, using compatible communication hardware and by the provision of communication software as necessary. The interface to the DCS shall be made at the node allocated for the control of that local plant / subsystem

On/Off and start-up of back-up equipment shall generally be determined via discharge flow or pressure monitoring. Motor control circuit energized status shall be used where redundant motor/pumps combinations or other electrically driven redundant or standby equipment exists, or where discharge condition monitoring is inappropriate.

D.4.3.6 Electrical Noise

The field instrumentaion performance shall not be affected by electro-magnetic or radio frequency interference up to 3 V/m and according to IEC 255-22. In order to minimise the effects of generated or radiated electrical noise:

The DC power and signal cables shall not run parallel or in close proximity to AC power cables.

DC and AC control and instrumentation cables of differing voltages shall be segregated.

Proper grounding techniques shall be utilised

Shields shall be terminated on the monitoring system end only, and only to an isolated ground.

The primary AC power source shall be noise free.

D.4.4 Instruments Cables and Wiring

Power wiring to and from the instruments and power supply units shall be such that power supply units can be removed without total system shutdown.

Wire and cables of electronic instrument installation shall be single pair not less than 16AWG tinned copper conductors with PVC insulation, twisted, with aluminium shielded Mylar tape separators with drain wire, extruded PVC inner sheath, wire braid or armour, and overall PVC jacket.

Single pair wires shall be run in separate trays from the various transmitting and control devices to centrally located field terminal junction boxes in the process area. From the centrally located junction boxes, 20 pair cable shall be run to the DCS termination cabinets. If all pairs within a particular cable is not utilized, they shall be identified as spare. Cable sizes of less than 20 pair connecting field junction boxes and the DCS shall not be utilized.

AC power and signal wiring shall be separated by a minimum spacing of 4 inchesin all cases, and shall not under any circumstance be run in the same wireway.

Wiring between terminals shall be point-to-point and free from wire splicing and T connections.

When shielded cables or wires are necessary, an insulating sheath shall be included. Provision for termination of shields, or means to maintain the continuity of isolated shields shall be provided as required.

In general, the plant electrical system will be designed, built, and tested in accordance with the most recent NEC Standards. The basic design philosophy shall provide the most effective measures to ensure high reliability and low maintenance

D.4.5 Isolated Ground

Grounding of control systems and instrumentation equipment shall follow good industry practice and be such as to ensure that equipment operates reliably, safely and without damage in the presence of large electrical disturbances such as occur in power generation plant. A separate grounding system for control and instrumentation systems shall be established:

- The plant shall incorporate an isolated ground system for use by the instrumentation and control system
- The isolated ground system shall tie into the plant equipment ground system at only one point
- The system shall be isolated from the power system
- The isolated ground system shall not have any ground loops
- In general, shields shall be terminated in the rack or cabinet where the measurement is monitored. The shield at opposite end of the cable shall be cut and taped.

D.4.6 Instrument Requirements

D.4.6.1 Electronic Instruments

Electronic equipment offered shall be of a type having proven record of reliability under geothermal power station service conditions.

All remote control loops shall be solid state electronic and control signal transmission shall be current type, 4-20 milliamps d.c., and utilize a 2-wire circuit (ISA Type 2).

Dual-auctioneered, regulated power supplies shall be used in the distributed control system I/O cabinets and shall operate on 120V a.c., 60 HZ house power (with isolation transformer) and from the plant UPS.

Field mounted transmitters shall have a minimum load resistance capability of 300800 ohms at a corresponding power supply voltage of 23-32.7V d.c. (ISA Class U). Accuracy shall be 0.25% of calibrated span or better, including repeatability, linearity, and hysteresis

Signal reference and cable shielding ground connections shall be made at one point only and that point shall be the isolated grounding bus in the appropriate electronic cabinet in the relay room unless otherwise specified. The field end of the shielded cable shall have the shielding clipped off close to the outer layer of insulation and an insulating tape applied to assure that the shielding does not touch the local instrument or appurtenances at any point. (Refer to Electrical Design Criteria for additional details).

D.4.6.2 Transmitters and Transducers

All transmitters shall be as much as possible of the SMART variety and shall conform to the HART protocol requirements.

In general, the range for an analog input shall be sized such that the maximum process value is approximately 85% of the range. The range shall always be rounded to a convenient number such as 50, 100, 800, 1000, etc.

Accuracy shall be 0.10% of calibrated span or better, including repeatability, linearity, and hysteresis.

All wetted parts of the transmitter shall be at least 316 stainless steel construction.

Transmitter fill fluid, if used, shall be silicone.

Transmitters shall be provided with flange adapter kits and mounting brackets.

Transmitters shall be housed in a NEMA 4X rated enclosure.

A hand-held SMART transmitter calibrator shall be provided with the transmitters

Diaphragm seals shall be used where acidic liquids are in the process and require process isolation from the transmitter element. Seals shall be standardized as much as possible for interchangability.

Analog measurements from process plant and electrical power supply systems for remote indication and control purposes shall be transmitted as 4-20 mA do output signal. Alternately, the Contractor may utilize SMART field bus type communications.

Transmitters and transducers shall be solid state electronic devices suitably designed for the location and services required.

Appropriate measures shall be taken to prevent any impurities in the fluid being measured from affecting transmitter and transducer operations. This shall generally be achieved by providing double diaphragm seals.

D.4.6.3 Pneumatic Instruments

All modulating control valves and dampers, unless otherwise specified, shall be air operated. The conversion from an electronic control signal to a pneumatic control signal will be made at the final control element with a current to pneumatic (I/P) transducer with pneumatic valve positioner where necessary.

Critical final control elements will have a local pneumatic loading station for testing or emergency operation.

Pneumatic valve positioners shall have the following design features as required on a case by case basis:

- Characterizeable (feedback cams).
- Useable for double or single acting service.
- Direct or Inverse action.
- High capacity pilot valves
- Suitable for linear or rotary movement.

All pneumatic instruments shall be fitted with inlet filters.

All vents off of pneumatic instruments shall be fitted with bug screens.

All pneumatic instruments shall be mounted in separate, non-metallic enclosures with an air purge from the instrument air supply.

Instrument air will be supplied In accordance with section 10.16. Instruments shall be designed to operate over an air supply pressure range of 80-125 PSIG. Pressure reduction to the level required by the instrument or valve will be done locally at the instrument.

Where appropriate for multiple runs of tubing, trays and/or tube bundles will be utilized.

D.4.6.4 Process Switches

Process switches, e.g. pressure, temperature, flow, limit, shall contain a minimum of two isolated Form C contacts, unless otherwise specified. Switches shall be snap-acting type.

The switch element shall be located in a hermetically sealed enclosure which prevents exposure of contacts to atmosphere.

Switch contact ratings for specific applications will be shown on the respective technical data sheets.

D.4.6.5 Temperature

D.4.6.5.1 Resistance Temperature Detectors (RTD). For general process applications, three lead, 100 ohm @ 32°F platinum RTD shall be used. These devices shall not be used for temperatures in excess of 650°F. They shall be duplex, sheathed, ungrounded, and ceramic insulated. The sheath O.D. shall be 0.250". They shall be furnished with terminal blocks and grounding lug.

Manufacturer supplied copper RTD's, (10 ohm @ 77°F), are not acceptable

RTDs monitoring process fluids shall be mounted in suitable thermowells.

D.4.6.5.2 Thermocouples. For applications not suitable for RTD's, chromel-constantan (Type E) thermocouples shall be used. These shall be duplex, sheathed, grounded, and ceramic or magnesium oxide insulated. They shall be furnished with terminal blocks and grounding lug. The sheath O.D. shall be 0.250". Thermocouple extension wire, of the same material as the attached thermocouple, shall always be used to interconnect the thermocouple to its transducer

Thermocouples monitoring process fluids shall be mounted in suitable thermowells.

D.4.6.5.3 Bimetallic Thermometers. For local temperature indication, not requiring high accuracy, bimetallic type thermometers with a universal angled, 5" nominal diameter dial and 0.250" O.D. stem shall be used. These shall be inserted in a thermowell.

D.4.6.5.4 Filled Thermal System. In general, filled thermal systems shall not be used. In those applications where no other technology is practical, filled instruments may be used. Instruments using filled systems include the sensor bulb and the readout device or switch as a complete system. The class of the system ad bulb diameter are generally determined by temperature range, length of capillary required and whether a uniform scale is required if there is a readout device. Thermowells compatible with a specific type of bulb will be specified with the thermal system.

D.4.6.5.5 Thermowells. Thermowells for use with filled thermal systems are not included in the scope of this section. (See previous Subsection on filled thermal systems.).

There shall be two means of attachment:

- Socketweld - 1" socketweld shall be preferentially utilized for clean, low pressure and temperature service.

- Flanged - The flanged means of attachment shall be used on all vessels and for all services where socketweld wells are not appropriate. In general, 1 1/2" RIF flanged wells will be used.

Thermowells shall be constructed of the following materials:

- Water and other benign fluids: 316SS

- Steam and Brine service: Alloy 625/Hastelloy C, or 2205 flange welded to Alloy 625/Hastelloy C probe

D.4.6.5.6 Test Wells. Test wells, where required, shall meet all the criteria for material, design, construction and certification specified for thermowells. Each test well shall be furnished with a stainless steel extension nipple and screwed cap. Extension nipple length shall be as determined by the manufacturer, unless otherwise specified by the A/E.

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D.4.6.6 <u>Pressure</u>

Local pressure indicators shall be bourdon tube type with an accuracy of ±0.5% of span. Dials shall be white with black markings and shall be 4 1/2" diameter with a dial arc of 270°

unless otherwise specified. Units of measurement shall be indicated on the dial face and the pointer shall be externally adjustable from the front of the gauge. The gauges shall be a solid front, blow-out back, hermetically sealed type. Gauge movements shall be stainless steel, geared type and the bourdon tubes and sockets ANSI 316 SS (Refer to ANSI B40.1-1974 for application guidelines).

Pressure gauges shall be Ashcroft or 3D gauges. 3D gauges shall be used on vibrating platforms such as near pumps and level control valves.

D.4.6.7 Flow

D.4.6.7.1 General. For general flow measurement applications, head type flowmeters shall be used. Where higher, wide range accuracies are required, or special operating conditions exist that preclude the use of head type meters, other types of metering systems will be specified. All steam flow measurements shall .have associated pressure and temperature measurements to be used for mass flow calculation in the DCS.

Differential pressure primary elements in hot liquid services shall be under sufficient hydrostatic head to prevent flashing at the lowest pressure point in the element outlet.

Differential pressure type flowmeters shall be fitted, as a minimum, with 5-valve manifolds including an equalising valve for zero check

Primary flow elements shall be readily accessible for maintenance or calibration.

D.4.6.7.2 Orifice Plates. Orifice plates shall be of the sharp, square-edged, thin plate, concentric bore, paddle type with flange taps. The differential pressure at design flow shall generally be 100" wc. Diameter ratio (Beta Ratio) shall not exceed 0.70. Sizing and installation practice will be in accordance with the American Gas Association (ANSI/API 2530). Plates shall be of alloy 625 or C-276 for SA, LA services. Plates shall be 316L for all other applications except steam service. All steam service plates will be the same as for SA and LA services.

Vent and drain holes shall be provided in orifice plates to prevent the build-up of vapor pockets in liquid service pipes and condensate in vapor service pipes.

D.4.6.7.3 Wedge Flow Meters. Wedge flow meter may be used where low loss and pluggage concerns exist. Wedge flow meter shall be used in brine service. Wedge flow meters shall have a H/D ratio between 0.2 and 0.5 with a nominal differential pressure at the taps at rated flow between 50 and 200 in H_20. Flow meters shall be calibrated prior to

installation. Wedge flow meters shall have an accuracy of 0.75% or better when operated within the calibrated range.

D.4.6.7.4 Magnetic Flow Meters. Magnetic flow meters may be used for slurry flows or other difficult flow measurements. Magnetic flow meters will be installed with a minimum of 10 diameters of straight pipe upstream and 2 diameters downstream. Lining and electrode materials shall be compatible with the requirements of the fluid. The electronics shall be separately mounted in a non-corrosive NEMA 4X enclosure. Meters shall be fed from the UPS should the meter require external power.

Magnetic flow meters shall be used for measurement of hotwell condensate, acid delivery individual injection points, NORMS injection rates, scrubber drain rates, purge water flow rates, and heat exchanger hot water flow to Region I IX and Region II IX, and heat exchanger cold water supply rate. Mag meters will be Krohne unless approved by the Owner

D.4.6.7.5 Mass Flow Meters. For applications where measurement of mass flow is required, the use of direct mass flow (Coriolis Effect) meters or thermal dispersion type will be considered.

Mass flow meters shall be used for the primary acid delivery feed pumps to compensate for differences in HCL metering and control due to variability in the HCL concentration from the Mineral plant R.O. system. Two meters are required, and must be available for use in all operating modes.

D.4.6.7.6 Velocity Averaging Pitot Tubes lAnnubar (Dieterich Standard Corp.). These type meters may be used only with prior approval of the Owner. In general, the rangeability and accuracy of this element is comparable to an orifice plate. The permanent pressure loss is significantly less than orifice plates in most applications and the installation cost is less than an orifice plate. In particular, these devices may be used where permanent pressure loss is an important factor, where removal of the element for inspection and/or maintenance is required without interrupting flow in a process line, or where line size may make orifice plates uneconomical. Flow elements shall be calibrated prior to installation

Annubars shall be of Hast. C material construction for all steam and NC gas applications. They shall be either retractable or have a purge style head with purge water hooked up via 316L instrument tubing to periodically flush the Annubar. Due to the unique service and history, the only approved supplier of Annubars at the Salton Sea is Dieterich Std. Annubars.

D.4.6.7.7 Flow Test Ports. The flow test port (where required) consists of a single (1 ") pipe branch, (4") long with a (1 ") full port ball valve ((1'/2") pipe and (1'/2") ball valve with (1 ") minimum bore on lined pipe). The pipe branch shall be located just upstream of the

flow element or meter. It shall be perpendicular to the main pipe axis and shall be positioned on the circumference such that nothing obstructs the insertion of the pitot tube.

The ball valve materials shall be compatible with the fluid in the main line. On unlined pipe the full port ball valve shall be threaded. On lined pipe the ball valve shall be flanged.

D.4.6.7.8 Venturi Flow Elements. A steam flow measuring device, which shall be a venturi flow meter shall be installed after the interface point isolation valve. This device shall be connected to the Power Plant monitoring system and shall be used for measurement of steam flow during normal operation of the Power Plant and during performance testing. Performance testing of the plant shall be carried out using the calibrated venturi meter installed in the main steam line. The venturi meter and its installation shall comply with relevant ISA standards sufficient to give flow measurement with at least ±0.5% accuracy. Refer to Section 10.24.2.2 for additional requirements concerning venturi flow elements.

D.4.6.8 Level Measurement

Suitable bosses, stub pipes and isolating valves shall be provided on all tanks, and vessels where level measurements are required.

Wherever practical an external level bridle shall be provided wherever turbulence or other undesirable conditions are present to enable representative and stable level measurements to be made. Where a level bridle cannot be incorporated, a stilling well shall be provided for this service.

Wherever possible, liquid level measurements will have a gage glass for direct visual observation as well as transmitters or switches. Gages shall normally be of the armored reflex type, except that armored transparent type will be used for brine service.

In general, level measurements shall be made using electronic differential pressure transmitters. In applications where the differential pressure transmitter is undesirable, displacers, bubbler, capacitance or ultrasonic beam based devices may be used. Flange ratings shall be in accordance with vessel specifications. For multiple instruments connected to a vessel an external stand pipe will be utilized. Flange ratings shall be in accordance with vessel specifications.

Differential pressure type level transmitters shall be fitted, as a minimum, with 5-valve manifolds including an equalising valve for zero check.

For fluids with high solids content, high temperature, or other service conditions where float mechanisms are not appropriate, hydrostatic head, electric probes, or sonic type

level measurements may be utilized. Where feasible, purging of level taps will be considered to prevent pluggage.

In general, sonic or RF probes shall be used for solids level detection.

D.4.6.9 Level Switches

Locally mounted liquid level gauges shall be used for sight monitoring and measurement purposes. Locally mounted magnetic coupling glandless level switches shall be used for alarm and control purposes.

D.4.6.10 Chemical Analysis Equipment

Where specified for conductivity or pH measurement, the instruments shall be of the immersed electrode type, in-line for pipe measurement and dip type for measurement in open vessels. The measurement electrode, reference electrode and temperature compensation shall all be contained in the same probe.

D.4.7 Final Control Elements

D.4.7.1 Air Operated Control Valves - RPF Service. Control valves and all required accessories shall be provided as a complete assembly by the valve manufacturer. This shall include all solenoid valves, limit switches, valve actuators, valve position transmitters and other accessories as required by the installation. Where air actuation is not feasible and economically justifiable electric, hydraulic or electro-hydraulic actuators shall be used for modulating service.

The control valves shall be installed to the manufacturer's recommendations for minimum length of straight pipe upstream and downstream of the valve as well as the location of pipe reducers.

Except where specified or approved by the Owner, all control valves shall have upstream and downstream isolation valves. A bypass valve of a capacity equal to or greater than the control valve shall also be provided, where required by the mechanical design (refer to Section 8.6.10.3). The upstream and downstream connections of the bypass valves shall be made outside the isolation valves provided for the control valve. This would enable the bypass line to be placed in service while the control valve is isolated and serviced. In addition, a 3/4-inch drain line and valve (ball or gate) shall be installed upstream and downstream of all control valves mid-way between the control and isolation valve in an accessible area. Hydraulic and Motor operated valves shall have the same block, bypass and drain features.

Control Valves shall be designed to fail in the position that is safest for the process as defined by the P&IDs.

Unless the process requires otherwise, control actuators shall be pneumatic. Electric, hydraulic or electro-hydraulic may be used where necessary and where life-cycle costs show them to be competitive.

All drain valves in the RPF must be 1-1/2" min. size for both steam and brine service

Control valves or control valve accessories requiring air pressure tanks must meet all state requirements for pressure tanks (e.g.; safety valve, pressure indication).Eccentric disk type valves (Masoneilan Camflex II or equivalent) will be utilized for brine and steam services. Masoneilan Camflex II control valves must be used in flashing and cavitating services for brine and condensate. Refer to the pipe class specification sheets for additional valve specifications.

D.4.7.2 Air Operated Control Valves - PGF Service

Unless otherwise specified on the data sheets, all control valves shall have flanged ends or be lugged wafer type for insertion between line flanges. Minimum flange rating shall be 300 lb class for sizes 4" and under.

During the normal range of operating conditions the sound level at any point 3 ft. radially from the surface of the downstream pipe at a distance of 3 ft. downstream of the valve outlet should not exceed 85 dBA. Body outlet velocity should not exceed MACH 0.3. Should sound levels exceed 90 dBA, the valve vendor shall provide recommendations for mitigation of the problem.

The maximum allowable seat leakage must be determined from process design considerations and for a particular valve is dependent on body and trim construction. The permissable leakage rates shall be in accordance with ANSI FCI 70-2 1976, Classes 1-6 and will be specified on the valve data sheet.

Instrument air supplied to the air operated control valves will be at 100 PSIG nominal and a minimum of 75 psig. Air pressure reduction, as required for operation, will be accomplished at the valve location.

Control valves shall normally be sized with normal flow at approximately 70% of valve capacity. Pressure drop across the valve should be at least 25% of total system frictional losses or 10% of total system pressure whichever is greater. All sizing calculations will be verified by the valve manufacturer. Minimum size shall be 1 ".

Safe failure modes will be determined at the time of system design and indicated on the valve data sheets.

D.4.7.3 Valve Accessories

Local control valve accessories shall be mounted on the valve unless otherwise specified. Accessory items include the following:

- I/P transducer /Positioner Unit with gauges
- Air Pressure Regulator and Filter
- Solenoid Valve(s)
- Limit Switch(es) (on on/off service DCS controlled valves only)
- Volume Booster (as required)
- Position Transmitter (on DCS controlled modulating valves only)

Double acting cylinder actuators shall be provided with air accumulators when required to achieve required failure positions.

Solenoid enclosures shall be corrosion resistant IP 66 (NEMA 4X) unless otherwise specified.

Solenoid coils shall be Class H high temperature construction, at (120 VAC) and shall be suitable for continuous duty.

Three-way direct acting solenoid valves shall normally be used to actuate control valves when interlocked with fail safe or shutdown circuits, or when used for on/off service type control valves. Universal (reversible ports) are preferred.

The valve bodies for two-way solenoid valves shall follow the piping specification in the Mechanical Design Criteria when used in process lines.

I/P and hand stations shall be mounted in a Nema 4X enclosure.

The coil shall be molded design with waterproof housing and shall be furnished to meet area electrical code classifications.

Outdoor installations shall be weatherproof.

Solenoid vents shall have bug screens.

Those solenoids that have top mounted vents shall be piped so that moisture does not enter the valve.

Solenoid Valves shall be manufactured by Berkert. If an application such as high pressure hydraulic systems, cannot be serviced by Berkert, another valve may be substituted.

D.4.7.4 Limit Switches

Limit switches shall be supplied as an integral part of the valve-actuator assembly.

All limit switches shall be snap acting type limit switches and shall be provided and installed at the factory with mounting brackets and associated hardware. Switches shall have-two normally open and two normally closed contacts and a corrosion resistant IP66 (NEMA 4X) enclosure.

D.4.7.5 Pressure Gauges

Gauges for control air supply and signal pressures integral to the instrument shall be in accordance with the control manufacturer's standards. All other gauges shall be as specified herein.

D.4.7.6 Motor Operated Valves

All motor operated valves shall be equipped with a non-relaxing gear train and nonrotating handwheel during electric operation. A minimum of eight independently set limit switches shall be provided.

Torque seating and/or torque back seating requirements shall be determined by the type of valve and application. In general all valves, except rotary valves, will be torque seated.

If position indication is required, it shall be by resistance to current or angle to current (420 mA) 2 wire.

MOVs s shall be as manufactured by Limitorque for electro-mechanical applications and as manufactured by REXA for electro-hydraulic applications.

D.4.7.7 Safety Relief Valves

In general, line and vessel protection shall be accomplished by the use of rupture disks. However, for applications protecting against thermal expansion and low flows, safety relief valves may be used.

Safety relief valves shall:

1. Conform to the requirements of ASME VIII, Division 1, Pressure Vessel Code.
2. Be top guided.
3. Be supplied with lifting levers for steam and air service.
4. Be suitable for use on ANSI B31.1 piping.
5. The seat leakage test for all valves will be as follows:
6. Air and vapor service as per API-Std-RP-527.
7. Liquid service - 10 cc/hr per inch of valve size at 90 percent set pressure.
8. Bodies shall be constructed of 316 Stainless Steel with Stellite seats.
9. Relief valves shall be supplied with gags.
10. Bellows shall be specified where back pressures could affect proper operation.

For location and piping criteria see Mechanical Design Criteria.

D.5 EQUIPMENT INSTALLATION AND SERVICE CONNECTION

D.5.1 Instrument Tubing And Accessories

D.5.1.1 General

This criteria applies to all piping, tubing, fittings, and valves required for primary instrument, sampling, air supply, and pneumatic control systems in ANSI B31.1 installations.

Class, size, routing and valving shall be as shown on Stone & Webster Engineering Corporation Drawings, Standards, Technical Data Sheets, and Specifications. Instrument process connections will generally be 3/4" with 3" connections for level bridles.

Compression fittings and connections shall be used for all stainless steel primary sensing, air supply, and control tubing. Transition from welded to compression fittings will be made at the instrument root valve.

Instrument locations and connections shall be designed for maximum accessibility and for ease of operations and servicing. When several instruments are located in close proximity they will be grouped together on an instrument rack. In the resource production facility area these racks shall be nonmetallic closed cabinets with gasketed doors.

Instrument process connections shall be designed to be roddable and root and isolation valves shall have removable seats and straight through flow paths for ease of maintenance.

Nonmetallic tubing may be considered for services with severe vibration or corrosion problems.

D.5.1.2 Instrument Valves

Blowdown and drain valves are required in the connecting lines to all transmitters and instruments used on water, steam and condensable vapor services.

The method of attaching isolating valves to instruments shall be such that it is possible to disconnect the instrument from the connecting pipe without having to drain the pipe.

Manifold Valves - Differential pressure type flowmeters shall be fitted, as a minimum, with 3-valve manifolds including an equalising valve for zero check.

D.5.1.3 Instrument Pipework And Fittings

Instrument root connections at the process piping or process vessel shall generally be ('/4"). The Mechanical Design Criteria will detail the requirements for both the connections at the process piping and process vessel and the vessel instrument isolation valve associated with these connections.

Monel tubing, fittings, valves, and manifolds shall be used for all brine piping. Stainless steel tubing, fittings, valves, and manifolds shall be used for all other primary piping.

The Instrument Installation Diagrams will show the physical requirements for mounting and routing of the instrument tubing.

D.5.1.4 Instrument Fittings and Tubing Support

All tubing shall be (.25"), (.375"), or (.500") stainless steel; other sizes of tubing shall not be provided.

All tubing and capillaries shall be supported and protected from external damage using TubeTrack or similar product. Tubing support components shall be manufactured from materials which are suitable for the harsh chemical environments likely to be encountered. Tubing support systems shall be routed so as not to impede removal of adjacent equipment. Tubing support systems shall be mounted to structure only, not to equipment.

Flexible hoses or conduit shall be used to ensure that movement between actuator devices and stationary devices are absorbed in the flexible hose and not in the rigid tubing or conduit.

Ports for flushing instrument sensing lines shall be provided as required.

D.5.1.5 Primary Instrument Tubing Requirements

Compression fittings shall be used for all primary instrument sensing tubing.

Tubing runs greater than 50 feet should be avoided.

All tubing for this service shall have a minimum outside diameter of V2-inch and shall conform to the following requirements:

- ASTM A-213 Grade TP316 (S31600)

- Seamless Stainless Steel
- Cold Drawn Fully Annealed
- 10 ft. Lengths or Longer

Dimensions:

Actual O.D. Inches	Wall Thickness Inches	I.D. Inches @	MWP 1.000F
3/8*	0.049	0.291	4,261
1/2	0.049	0.402	3,070
5/8	0.072	0.481	2,690
3/4	0.083	0.584	2,575

*3/8-inch tubing may be used only for those parts of sampling systems that are located within a panel or a rack.

Weld repairs shall not be allowed on the tubing.

The supplier of the tubing shall verify that all requirements of the material specifications have been complied with and that the tubing meets these requirements.

D.5.1.6 Instrument Air Supply and Pneumatic Control Tubing Design

316 Stainless steel tubing, fittings, and valves shall be used for all instrument air and control pneumatic tubing.

Instrument and pneumatic pipe routing shall maintain adequate distances from outside walls, doorways, and areas of extreme heat to minimize ambient effects on control lines.

Lines in the instrument air supply distribution system shall be sized such that the maximum pressure drop from the air dryer to the most remote air user does not exceed 5 psid with a 100 psig supply when all users are taking air at approximately 2 to 5 scfm.

Instruments requiring air shall generally be supplied from a branch instrument air header. The maximum number of instrument air users that shall be taken off a (%2") branch shall be four. The maximum number of instrument air users that shall be taken off a (1 ") header shall be twenty. Separate connections shall be taken off the main instrument air header for instruments requiring large amounts of air for operation with a ("/2") minimum line being

used. Shutoff valves at the instruments shall be swing-out ball valves with compression fittings.

A separate reducing filter regulator shall be furnished for each instrument requiring a source of instrument air.

All tubing for this service shall have a minimum outside diameter of V2-inch (except as noted in the table below) and shall conform to the following requirements:

- ASTM A-213 Grade TP316 (S31600)
- Seamless Stainless Steel
- Cold Drawn Fully Annealed
- 10 ft. Lengths or Longer

The supplier of the tubing shall verify that all requirements of the material specification have been complied with and that the tubing meets these requirements.

The requirements for all instrument air piping above '/2" is covered in the Mechanical Design Criteria.

D.5.2 Material

D.5.2.1 Stainless Steel Fittings

D.5.2.1.1 Compression Type Fittings. This type of fitting shall be used for all of the following connections:

- Connection of a primary sensing line or sampling line from the root valve transition fitting to an instrument.
- Connection of an individual instrument air supply line between the air supply header shut-off valve and the instrument.
- Connection of instrument air supply headers assembled from stainless steel tubing (Not pipe).

- Connection of a pneumatic control line to an instrument, control valve, control drive or accessory device.

Compression fitting shall be furnished with the following specifications:

- Tube Size, O.D. inches: 1/4, 3/8, 1/2, 5/8, ¾
- Type: Compression
- Material: 316 Stainless Steel
- Manufacturer: Crawford "Swagelok"

3/8-inch tube fittings may be used only for those parts of sampling systems that are located within a panel and/or a rack.

Manufacturers recommended tools and installation procedures shall be strictly followed.

D.5.2.1.2 Socket Weld Fittings (Primary Sensing & Sample Lines). Socket weld fittings shall have full annular stops, a straight bore and shall be furnished in accordance with the following specifications:

- Tube size, O.D. inches: 3/8, 1/2
- Manufacturer: Cajon Company* or equal

*Swagelok to weld fittings are also available from Cajon which provide easy transition from welded to non-welded tubing systems.

D.5.2.2 <u>Stainless Steel Valves.</u>

The valves applicable to this section are the instrument valve, blowdown valve, test valve, backup root valve (when specified) and sample regulating valves. The valves for these applications shall be furnished in accordance with the following specifications:

- Style: Ball, full port
- Rating: 6,000 psi@ 100E
- Body Design: Replaceable seat roddable

- Body Material: 316 Stainless Steel, except for brine service which shall be Alloy 20.
- Construction: Union Bonnet, 316 Stainless Steel
- Stem: Stainless Steel
- Seat: Reinforced TFE
- Packing: Reinforced TFE
- Manufacturer: TBV

Exception: Low pH root valves shall be C276 or Inconel 625.

In general, 3/4" valves shall be used.

3/8-inch valves may be used only for those parts of sampling systems that are located within a panel and/or a rack.

Weld repair of defects on the pressure boundaries of a valve body shall not be allowed.

D.5.2.3 Instrument Air Supply Valves

The valves applicable to this section are the individual instrument air supply shut-off valves. They shall be furnished in accordance with the following specifications:

- Style: Ball, full port
- Working Pressure: 3000 psi @ 100F
- Body Material: 316 Stainless Steel
- Body Construction: Ball
- Construction: Screwed Bonnet
- Stem: Stainless Steel
- Sizes: 1/4, 3/8, 1/2 inch

- End Connections: Pipe to pipe, pipe to tube, tube to tube
- Manufacturer: Whitey Co., "43" Series, or equal

D.5.2.4 Manifolds

Three valve manifolds shall be supplied as follows:

- Body Design: Removable Seat, Roddable
- Body and Bonnet Material: 316 Stainless Steel
- Stem Material: 316 Stainless Steel
- Seat: Reinforced TFE
- Packing: Reinforced TFE
- Process and Instrument
- Port Connections: 1 /2 Inch NPT
- Manufacturer: HEX VALVE HM452 Series, or equal

D.6 RACKS AND PANELS

D.6.1 Field Enclosures

Unless otherwise specified, all indicating instruments shall have dust and moisture proof cases to NEMA 4X. All enclosures shall be specified to be corrosion resistant.

Enclosures will protect the field instrumentation from solids, hazardous conditions and washdowns with high pressure hoses. The enclosures will be designed to permit in-place calibration of instrumentation and instrumentation removal from the enclosure front. In all cases corrosion-resistant housings (NEMA 4X) are required with stainless steel or non-corroding hinge material.

In addition to the above requirements, panels will be provided with replaceable corrosions resistance ion emitters

An instrument air purge shall be provided on electrical or control enclosures with an interior volume greater than 1 cubic foot (1728 cubic inches). Design of panel purge and purge flow rates shall be sufficient to provide positive pressure within the enclosure under all conditions.

D.6.2 Local Control Panels

Local control panels shall meet the same requirements as for field instrument enclosures. The construction and finish of all local control panels shall conform to the requirements of the ambient conditions. In all cases corrosion-resistant housings (NEMA 4X) are required with stainless steel or non-corroding hinge material.

D.6.3 Terminal Blocks

Terminal blocks shall be rated at 600 volts and shall be provided for all external connections to cabinets and consoles. Terminations to compression type terminal blocks shall include a metal ferrule, compressed over all conductor strands. Termination of bare wires in compression terminal blocks is not acceptable. Alternately, terminations may be made to terminal blocks accepting locking ring tongue compression type lugs.

Thermocouple terminal blocks shall be of the same material as the thermocouple extension wire.

D.6.4 Control Panels And Relay Panels

In addition to the requirements set forth above, all control panels and relay panels shall have lights and receptacles installed within the cabinet. The lights and receptacles shall be wire to separate power entry terminal blocks such that a separate feed may be used to power these loads. Cabinets which are installed as a unit, such as the DCS, should have a single feed connection point for all the cabinets in the set.

D.6.5 Local Push Button Stations

All motors and loads controlled via the DCS will have an auxiliary local push button control station located adjacent to the equipment for local control of the equipment. The bush button station will have controls for start and stop of the equipment, as well as a local/remote select switch that enables DCS control of the load. The local start/stop control shall be wired directly into the associated MCC, along with the appropriate field instrumentation interlocks, to allow complete pump operation apart for the DCS. Modulating valves shall have local manual loading stations.

Design implementation of the local controls will provide for bumpless transfer from DCS to field control and from field control to the DCS. This includes motor on/off control stations as well as valve manual loading stations.

Local panels shall be NEMA 4X rated and constructed of stainless steel.