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INSTRUMENTATION DESIGN CRITERIA

(PROJECT STANDARDS AND SPECIFICATIONS)

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SCOPE

This Project Standard and Specification defines the design criteria for the instrumentation and control system envisaged on the new platforms and under the new project.

REFERENCES

Throughout this Standard the following dated and undated standards/codes are referred to. These referenced documents shall, to the extent specified herein, form a part of this standard. For dated references, the edition cited applies. The applicability of changes in dated references that occur after the cited date shall be mutually agreed upon by the Company and the Vendor. For undated references, the latest edition of the referenced documents (including any supplements and amendments) applies.

1. American Gas Association (AGA)

AGA Report No. 3	Orifice Metering of Natural Gas
AGA Report No. 8	Compressibility and Supercomressibility for Natural Gas and other Hydrocarbons.
AGA Report No. 9	Measurement of Gas by Multipath Ultrasonic Meters

2. American National Standards Institute (ANSI)

ANSI B 2.1	Pipe Threads
ANSI B 16.5	Steel Pipe Flanges, Flanged Valves and Fittings
B 16.10	Face to Face and End to End Dimensions of Ferrous Valves
B 16.34	Hydrostatic body and leak testing of isolation valves
B 16.37	Hydrostatic Testing of Control Valves
B 16.104	Control Valve Leakage
FCI 70.2	Leak Testing of Control Valves
ANSI C 96.1	Temperature Measurement Thermocouples
ANSI B 1.20.1	Pipe Threads, General Purpose
MC 96.1	Temperature Measurement Thermocouples

3. American Petroleum Institute (API)

API 6D	Specification for pipeline valves
API 6FA	Fire Test for Valves
API RP 14C	RP for Analysis, Design, Installation and Testing of Basic Surface Systems on Offshore Production Platforms

API RP 14F	RP for Design and Installation of Electrical Systems for Offshore Production Platforms
API RP 14G	RP for Fire Prevention and Control on Open Type Offshore Production Platforms
API RP 500	Classification of Locations for Electrical Installations at Petroleum Facilities Classified as Class 1, Division 1 and Division 2
API RP 520	Sizing, Selection and Installation of Pressure Relieving Devices in Refineries, Part I and Part II
API RP 521	Guide for Pressure Relief and Depressing Systems
API RP 526	Flanged Steel Safety Relief Valves
API RP 527	Commercial Seat Tightness of Safety Relief valves with Metal to Metal Seats
API RP 550	Manual on Installation of Refinery Instruments and Control Systems (out of print)
API RP 551	Process Measurement Instrumentation
API RP 552	Transmission Systems
API RP 554	Process Instruments and Control
API RP 555	Process Analyzers
API 598	Valve Inspection and Testing
API Standard 2000	Venting Atmospheric and Low Pressure Storage Tanks: Non-refrigerated and Refrigerated
API 1101	Measurement of Petroleum Liquid Hydrocarbons by Positive Displacement Meter
API RP 2001	Fire Protection in Refineries
API 2534	Measurement of Liquid Hydrocarbons by Turbine Meter Systems
	API Manual of Petroleum Measurement Standards – Measurement of Crude Oil by Coriolis Meter

4. American society of Mechanical Engineers (ASME)

ASME PTC 19.3	Performance Test Code Temperature Measurement
ASME Section VIII	Sizing and Selection of Pressure Relief Valves

5. American Society for Testing and Materials (ASTM)

ASTM A269	Stainless Steel Tube
ASTM A276.316L	Stainless Steel Fittings
ASTM 370	Standard Test methods and definitions for Mechanical Testing of steel products
ASTM 450	General Requirements for Carbon, Ferritic Alloy, and Austenitic Alloy Steel Tubes

6. British Standards

BS 1904	Specification for industrial platinum resistance thermometer sensors
BS 4937	International Thermocouple Reference Tables
BS 5501	Electrical Apparatus for Potentially Explosive Atmospheres
BS EN 60529	Specification for degrees of protection provided by enclosures (IP) codes

7. International Electrotechnical Commission (IEC)

IEC STD 801	Part 3 – EMI and RFI Immunity
IEC 60092-373	Shipboard flexible coaxial cables
IEC 60092-359	Specification for insulation and sheath of electric cables
IEC 60227	Polyvinyl chloride insulated cables of rated voltages up to and including 440/750 V
IEC 60331	Fire resisting characteristics of electric cables
IEC 60332-1	Tests on electric cables under fire conditions Part I: Tests on single vertical insulated wire or cable
IEC 60332-3	Tests on electric cables under fire conditions Part II: Tests on single small vertical insulated copper wire or cable
IEC 61508-1-7	Functional safety on electrical / electronic / programmable electronic safety-related systems
IEC 61000-4-2	Electromagnetic Compatibility (EMC) – Part 4: Testing and Measurement Techniques – Section 2: Electrostatic Discharge Immunity Test
IEC 61000-4-3	Electromagnetic Compatibility (EMC) – Part 4: Testing and Measurement Techniques – Section 3: Radiated, Radio-Frequency, Electromagnetic Field Immunity Test
IEC 61131-3	1993 Programmable Controllers – Part 3: Programming languages

8. Institute of Electrical and Electronic Engineers (IEEE)

IEEE STD.472	Surge Withstand Capabilities
IEEE C37.90.1	Standard Surge Withstand Capability (SWC) Tests for Protective Relays and Relay Systems
IEEE 730	Standard for Software Quality Assurance Plans Revision of IEEE Std 730-84 and Redesignation of IEEE 730.1-89; IEEE Computer Society Document
IEEE 828	Standard for Software Configuration of Management Plans
IEEE 1042	Guide to Software Configuration management IEEE Computer Society Document

9. Instrumentation Systems and Automation Society (ISA)

ISA 5.1	Instrumentation Symbols and Identification
S 7.0.01	Quality Standard for Instrument Air
ISA/ANSI-S 84.01	Application of Safety Instrumented Systems for the Process Industry
ISA 912.13	Part I: Performance Requirements, Combustible Gas Detectors Part II: Installation, Operation and Maintenance of Combustible Gas Detectors
ISA S 71.01	Environmental Conditions for Process Measurement and Control Systems: Temperature and Humidity
ISA S 71.04	Environmental Conditions for Process Measurement and Control Systems: Airborne contaminants
ISA S 75.01.01	Flow equations for sizing control valves
S 75.03	Face to Face Dimensions for Flanged Globe Style Control valves

10. International Organization for Standardization (ISO)

ISO 5167	Measurement of Fluid Flow by means of Orifice Plates

11. National Association of Corrosion Engineers (NACE)

NACE MR 0175	Sulfide Stress Cracking resistant metallic materials for oilfield equipment

12. National Electrical Manufacturers Association (NEMA)

NEMA 250	Enclosures for electrical Equipment (1000 Volts maximum)

13. National Electric Code (NEC)

14. National Fire Protection Association (NFPA)

NFPA 70	National Electrical Code
NFPA 1	Fire Protection Code
NFPA 72 E	Automatic Fire Detectors
NFPA 496	Standard for Purged and Pressurized Enclosures for Electrical Equipment

15. Other Bodies

Report EE170E.98 ER & E Version 1.0, Alarm Management Guidelines
Engineering Equipment Materials Users Association (EEMUA) publication No. 191, Alarm Systems – a Guide to Design Management and Procurement
All goods and services supplied shall meet all applicable local and international regulations on health, safety and environmental issues.

INSTRUMENTATION SYSTEM PHILOSOPHY

Instrument Philosophy

1. All the offered instruments / equipment or equipment of similar design manufactured by the same supplier shall have been:
   - Type tested by the authority approved by the Company.
   - In continuous satisfactory service on offshore for a minimum period of two years.
2. Field Instruments

   All field instruments connected with well monitoring and control, and all facilities that are not to be operated from a central control room, shall be pneumatic except those that are connected to RTU, which shall be electronic, SMART type. The type of output for smart transmitter shall be in HART Protocol.
   All instruments connected to control room and remote unit control panels of related systems shall be electronic, SMART type.
   For remote control application, remote telemetry, telecontrol and data gathering, electronic instruments shall be used.
   All final actuation / control device, controlled from remote / Central Control Room (CCR) shall in general be pneumatically actuated.
   Instrument ranges shall be selected such that the normal operating point is between 35% and 75% of the instrument total range.
   Hand-held Intrinsically Safe calibration / configuration units shall be supplied to enable online diagnostics, configuration or calibration of electronic instruments from any point in the loop. The number of such calibration / configuration units shall be as per the Basic Bid Work.

   a. Pneumatic Field Instruments

      Each pneumatic instrument supply shall be provided with independent filter regulator. For pneumatic instruments, dry instrument gas / air supply shall be as follows:
      - 5.5 Kg/cm^2 (min.)
      - 7.5 Kg/cm^2 (nor.)
      - 10.5 Kg/cm^2 (max.)

      All related equipment shall be suitable for operating in the above-specified range. For pneumatic analog control applications, the actuating signal range shall be 0.2 to 1 Kg/cm^2g.
      For pneumatic on-off applications, the actuating signal shall be 0 or 5.5 Kg/cm^2g

b. Electronic Field Instruments

All electronic transmitters shall be 24 V DC loop-powered type with 4 –20 mA Smart analog output signal. Electronic Transmitters shall have integral LCD display. Where this is not possible, a suitable separate local loop indicator shall be provided.
Local electrical control and field alarm switches shall be hermetically sealed SPDT Micro Switch activated. The switches shall be rated for 110 V AC 5 Amps. or 24 V DC – 2 Amps.

3. Control Room Instrumentation

All signals to and from the Central Control Room shall be electric / electronic. The standard signal shall be analogue 4-20 mA using 2-wire system, standard thermocouple, RTD output, and / or suitable pulse signal.
Instruments located on control panels and central control room (CCR) shall be microprocessor based.
On platforms with processing facilities, a Distributed Control System (DCS) shall be provided for monitoring and controlling the process, and for generating alarms in case of process upsets.

4. Safety Instrumentation System

The new platforms shall be provided with the following safety systems:

a. Emergency Shut Down (ESD) System: The ESD system shall initiate process shutdown in case of abnormal condition of the specified process parameter.
b. The F&G system: The F&G system shall initiate emergency shutdown (ESD) upon detection of appropriate level of hydrocarbon and/or H_2S and fire shutdown (FSD) upon accumulation or fire
c. Manual ESD & FSD Stations: The ESD & FSD stations shall be provided at all strategic locations on the platform for manual initiation of ESD and FSD.

All shutdown and alarm switches shall be “Fail Safe” and the targeted abnormal conditions shall cause a loss of actuating signal to the final control element.
Parameters used for shutdown shall be sensed by independent / individual sensors at independent tapping points. Such sensors and tapping points shall not be shared by any other loop.

Instrument Power System Philosophy

1. Pneumatic Supply

   For pneumatic instruments, dry instrument gas / air supply shall be as follows:
   - 5.5 Kg/cm^2 (min.)
   - 7.5 Kg/cm^2 (nor.)
   - 10.5 Kg/cm^2 (max.)

2. Electric Power Supply

   Components of power supply system shall be of highest available quality for reliability and long service life.
   Power supplies for all transmitters, controllers, signal converters, electric system and components in shutdown system shall be supplied from uninterruptible power supplies.
   Power distribution to each consumer shall be through proper, independent switch and fuse. Protective fuses shall be of indicating cartridge type mounted in fuse holders.
   In general, the following Power Supplies shall be used for instrumentation and Control:
   - For Process Platforms: 110V AC + 5%, 50HZ + 1% (UPS) for all instruments control. However, all components / instruments / system shall be suitable for 110 V + 10% AC, 50 Hz + 3%
   - For Process & Well Platforms: 24V DC + 5% Battery Negative earthed for Platform interlock system, solenoid valves, Fire and Gas system and status lamp.

Instrument Earthing System Philosophy

Three separate earthing systems shall be provided:

a. Electrical Safety Earth – Bonded to the site structure and utilized for electrical safety of metal enclosures and chassis on all instruments and electrical components.
b. Instrument Clean Earth – Insulated from the site structure and other metal work, utilized for instrument cable screens and bonded to the main electrical earthing system at a single point.
c. Intrinsically Safe Earth – Insulated from the site structure and other metal work, utilized for termination of IS zener barrier earth connections, and bonded to the main electrical earthing system at a single point.

Equipment Protection Philosophy

1. Environmental Protection

   All instruments / equipment and installation material shall be suitable for the overall climatic conditions, the position within the installation and the local environment, with particular attention to site ambient conditions. The conditions will include exposure to Hydrocarbons, H_2S (in case the process fluid is sour), moist salt laden atmosphere, sea spray, sunlight, monsoon rainfall, temperature, humidity, wind, fungal growth, vibration and shock, EMI and RFI. All equipment shall also be able to withstand these conditions during shipment, storage and installation prior to commissioning. Instrumentation shall withstand not only the quoted environmental conditions, but also the periodic testing of the Deluge or Fire Hose System.
   As all of the Company's sites are subject to seismic activity as indicated in the General Basic Bid Work and General Design Criteria, all instrument / electrical frames, panel and racks shall be fixed in position suitably secured.
   In view of the highly corrosive ambient conditions, all internal and external parts which are not inherently corrosion resistant by choice of material shall be prepared and finished by plating or paint finish in accordance with the General Specification for protective coating. Seals and purges shall be used as necessary, to ensure reliable instrument performance.
   All field instruments shall be provided with necessary weathering and anticorrosion protection. All field instruments shall be provided with plastic bags (min. 1.5 mm thick) to protect them during handling, installation and commissioning. The bags shall be kept in place at all times except during work on the devices. Drying agent (desiccant) with humidity indicator shall be put inside the bag and it shall be replaced when color of the indicator changes from blue to pink Additional protection by other means such as canvas shall be provided to prevent damage caused by welding during construction work at nearby location. Labels and tags that may be exposed to paint spray, shall be temporarily masked with a transparent material during construction activities, which shall be removed at the time of hand over of the work. Plastic plugs shall be fitted to all instrument tubing and air, process and cable entry ports until final connections are made.

2. Ingress Protection

   All field instruments shall have ingress protection to IP 65 or better. Pneumatic field instruments used for control applications shall have ingress protection to IP 55 or better. All instruments installed inside pressurized equipment / control rooms shall have ingress protection to IP 42 as a minimum.

3. Tropicalization

   All electrical components shall be tropicalized to protect against humidity, moisture and fungal growth by means of hermetically sealed units, protective coating on circuit boards, gold plated edge connectors, etc.

4. Hermetic Sealing

   All relays and switches shall be hermetically sealed, and those utilized in 24 V DC control logic circuits shall have gold plated contacts rated 0.5 Amp at 24 V DC. Those interfacing with field equipment shall be rated 2 Amp 24 V DC.

5. Hazardous Area Instrumentation

   The Contractor shall classify hazardous areas in accordance with API 500 and specify various equipments accordingly. All instruments which are mounted outside of normally pressurized control / equipment rooms shall be certified by bodies such as FM / UL / BASEEFA / CSA / DGMS / CMRS for use in Class I, Division I, Group D, T3 hazardous area, even if the instrument's location is classified as a normally non-hazardous area. Intrinsic safety approval shall be based on entity concept and necessary compatibility checks shall be carried out by Contractor before selecting any equipment.
   Intrinsically safe protection using external barriers shall be provided for all process transmitter loops (closed as well as open). Isolating barriers shall be of the plug-in type, mounted on modular back plane termination units. Each input and output in a loop shall have a separate barrier. No barrier shall be shared between two loops in input / output. All other instrument loops shall be provided with explosion proof / flame proof protection. Solenoid valves, electric hand switches, signaling lamps and Intercom / Paging system shall be Explosion proof / flame proof to Ex d or NEMA 7.
   If specialist instrumentation cannot be provided with the above methods of protection, then alternative methods suitable for the classified area and certified by an acceptable Authority may be proposed. The Contractor shall submit a technical report justifying the instrument selection for the Company's consideration.

6. R F Interference

   All equipment shall remain unaffected by radio transmissions (Levels of permissible RFI shall be as per IEC 801). Band-pass and / or band stop filers shall be fitted, as necessary.

7. Sealing

   Seal systems shall be used to isolate instrument from the process fluid encountered in the following services:

   a. Wet gas, which may condense in the instrument lines.

b. Process fluids that vaporize, condense or solidify under operating pressure and ambient temperature.
c. Process fluids that will subject the element to high temperature.
d. Process fluids that will subject the element to high temperature.
e. Viscous liquids.

Sealing may be accomplished with diaphragm seals.
All venting instrument and pilot valves shall have bug screens fitted to atmospheric vents.

Instrument Material Selection Philosophy

All materials and equipment furnished shall be new and unused, of current manufacture and the highest grade and quality available for the required service, and free of defects.
Materials shall be selected with regard to the following criteria:

1. Suitability for the specified process conditions, with SS 316 as the minimum for use outside pressurized rooms, except for salt-water service, in which case, it shall be Monel.
2. Suitability for the corrosive effects of the atmosphere.
3. Galvanic compatibility between dissimilar materials, with isolating bushes, plates, used where necessary to prevent corrosion due to galvanic action.
4. Wherever process condition demands NACE quality Instrument fittings, the same shall be provided as per NACE, latest standard with appropriate material. For non NACE application, material for fitting shall be appropriate for relevant process fluid with SS-316 as minimum.
5. Company approval shall be obtained for the use of aluminium for any instrument component. Aluminium may only be used if no other suitable material is available but shall not be used for any component in contact with the process fluid. If aluminium is used for any housing or other component, it shall be suitably coated and certified as copper free i.e. less than 0.4% copper by mass.
6. Material for all junction boxes, and instrument electronics and termination housings shall be SS 316.
7. All proposed vendor standard plastic components if any shall be non-toxic and fire resistant, UV stabilized and compatible with the environmental conditions.
8. All spindles, bushings, bolting, screws, brackets, etc., shall be manufactured from a suitable grade of stainless steel as a minimum. All bolts and screws shall have a flat 316 SS washer under the nut, and the thread length shall be

such that there is complete full engagement of the nut, with a minimum of two threads protruding.

9. Stand pipes, supports for instruments and any other item directly welded to the structure shall be CS galvanized.
10. All material for instrumentation, in contact with process fluid containing CO_2 in excess of 2 psi partial pressure, shall be as follows:

Fluid Temperature	Material to be used
< 71^{o}C	ASTM A182-F316 (316SS)
> 71^{o}C	ASTM A182-F51 (2205 duplex steel)

11. Moulded polyester parts shall be anti-static for hazardous area locations, and in general be constructed from UV-stabilized glass reinforced polyester. Surface resistance shall not be less than 10^9 Ohms. Impact resistance to be -25%.

Instrument Installation Philosophy

All work shall be of the highest quality craftsmanship and shall conform to the best applicable engineering practices, and, relevant codes referred in the bid document.
All instruments shall be installed in a neat workmanlike manner ensuring ease of operation and maintenance.
The Contractor shall prepare hook-up and installation detail drawings regarding each type of instrument for the Company's approval, and shall carry out the installation in accordance with these approved drawings.
The Contractor shall install instruments and equipment with due consideration of the following:

1. No instrument with the exception of pressure gauges and temperature indicators, shall be installed in such a way that it depends on its impulse piping or electrical connections for its support.
2. Positioning of equipment shall not constitute a safety hazard. Where possible, instruments shall be mounted so that they are protected from the effects of rain and sun, while maintaining the requirements for access and visibility. Where this is not possible, the Contractor shall provide a fixed cover or hood to protect instruments, without impairing access or visibility.
3. Visibility and accessibility for both maintenance and operations purpose.
4. Ease of access for lifting heavy items of equipment such as valves.
5. All instruments and valves shall be free from vibration.
6. Instruments shall be mounted / connected so as not to stress vessel nozzles or pipe tapping.

7. All local process-connected instruments shall be located as close as possible to the point of measurement while still being accessible from the deck, ladder or a platform.
8. Instruments requiring frequent routine access (including hand-valves, manual resets, manual switches, etc) shall be mounted approximately 1.4m above the deck or platform for ease of accessibility.
9. Instruments shall be properly supported on brackets or mounted on subplates, or placed on a suitable pedestal, pipe stand or structural support. Pipe or structural stands may be welded directly onto platform plate, with a suitable penetration in the grating, where applicable.
10. Instruments, tubing, cables and cable ladder shall not be fixed to gratings or handrails.
11. Instruments (other than pressure instruments) shall not be mounted directly on process piping without the Company's written approval.
12. Instruments or instrument lines shall not be supported on handrails unless approved by the Company.
13. Fittings such as instrument isolating valves and instrument air or gas regulators shall be supported either on the instrument stand or closecoupled to the instrument in a manner that no undue stress is imposed o the tubing or instrument.

Instrument stands or panels shall be in accordance with the approved drawings, with consideration for:

- The most direct routes for tubing and piping to and from the stand, using common tubing runs and avoiding crossovers.
- Ease of inter-connections between instruments.
- Ease of access for on-site calibration and / or removal of instruments.
- Minimum interference between tubing, piping and cabling to instruments.

A 316 SS filter regulator with gauge shall be provided for each instrument requiring regulated gas or air supply.
All drains on field instruments shall be made to face downwards if it is already not so. All open ports (vents/drains) shall be fitted with bug screens.

Instrument Inspection & Testing Philosophy

1. General

   The Contractor's quality plan shall include a comprehensive fully documented inspection and testing plan specific to the project.

The procedures shall include inspection specifically for compliance with hazardous areas requirements, including current certificate, without which no circuit or loop shall be energized.
All testing, calibration and pre-commissioning shall be done by the Contractor. The Contractor shall also provide assistance as required during commissioning activities.
The Contractor shall provide suitable workshop facilities and shall provide all necessary test and calibration instruments and equipment.
The Company reserves the right to reject any or all test and calibration work if found not complying with the Specification requirement. The Contractor shall complete and submit documentation for all calibration, testing and precommissioning. Company Representative prior to shipment shall check out panels, consoles, and packaged instrument assemblies for their compliance with specification requirements.
The Contractor shall in the presence of the Company Representative, verify by inspection, calibration and loop testing, that, all instrumentation in field and control room including local and remote/central control panels, are complete and operable as per specification requirement. All testing and calibration shall be subject to approval of the Company.
In addition to calibration/testing, loop checking, setting for safety devices like process switches, safety valves etc. and simulation testing of all interlock and shutdown systems, done at fabrication yards, the same shall also be carried out at offshore site as well.
In general, the pipes and tubes shall be cleaned before testing. They shall then be subject to hydrotest (or other applicable tests) and then blow dried.

2. Flushing of Lines

   The Contractor shall remove in line instruments like flow meter, control valves/safety valves, if necessary, and provide spool pieces/flanges prior to flushing of lines.

3. Instrument Supply Lines

   Instrument air/gas piping and tubing shall be disconnected upstream of all filter/regulators before testing, the piping and tubing shall then be hydrotested as explained below and then shall be blown down to remove hydrotest water, slag and mill scale from lines.
   Instrument air supply lines shall be blown with instrument air prior to connecting to instruments. Instrument air/gas mains shall be isolated from the instrument and pressurized to 11/2 times maximum working pressure with instrument air, they shall be isolated from the pressure source and the pressure reading on a test gauge shall not fall by more than one psig in ten minutes.

4. Instrument Signal Lines

   Instrument signal lines shall be blown with instrument air prior to connecting to instruments. All air/gas tubing shall be tested and inspected by one of the methods given in Instrument System & Automation Society (formerly known as Instrument Society of America) Recommended Practice RP 7.1 "Pneumatic control circuit pressure test". Clean, oil free instrument air shall b e used for the test.

5. Impulse Lines

   All process impulse lines shall be disconnected and flushed with potable water. Air lines shall be blown down with filtered air. Hydraulic lines shall be flushed with hydraulic oil.
   After flushing process impulse lines shall be isolated from the instrument and pressurized hydraulically to 11/2 times maximum working pressure corrected for ambient temperature. They shall then be isolated from the pressure source and the pressure reading on a test gauge shall not fall at a rate exceeding one psig/hour.

6. Direct Mounted Instruments

   For direct mounted instrument such as level gauges, level transmitters (displacer type), level switches etc, the installations shall be pressurized to maximum operating pressure slowly and steadily with the instruments. The installations shall then be isolated from main pressure source. The pressure shall not fall at a rate exceeding one psig/hr.

7. Wiring

   Wiring shall be checked to ensure that it is correctly connected and properly grounded. Insulation test shall be carried out on all wiring taking necessary precautions. Correct connections of all electric or pneumatic switches shall be checked.

8. Calibration & Testing

   a. The Contractor's instrument personnel shall calibrate instruments. This calibration shall when possible, be done with the instrument or system in place, otherwise calibration prior to installation or removal for calibration shall be done. The Contractor shall provide written results of all instrument calibration in prescribed format and shall submit such formats well in advance for Company's approval. The Contractor shall submit document confirming that the testing equipment to be used for calibration purpose are certified and calibrated.
   b. In general, all tests shall simulate, as closely as possible, design process conditions by use of manometers, potentiometers, deadweight testers, test