CONSTRUCTION AND INSPECTION STANDARD

FOR

GENERAL INSTRUMENT

FIELD INSPECTION, CALIBRATION

AND

TESTING OF INSTRUMENT

AND

INSTRUMENT SYSTEM

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1. SCOPE

1.1 General

This procedural Standard gives guidance for construction field inspection, calibration and testing of instruments and instrument systems prior to plant commissioning. It is intended for use in Petroleum Industries of Iran.

1.2 Types of Activity

Field inspection generally refers to the following three types of activity, where occur at different periods and which may require different grades of inspection.

1.2.1 Pre-commissioning inspection and testing

This activity should be carried out prior to the commissioning of new equipment after completion of erection or after major repairs to existing equipment. This category of inspection, which is the primary concern of this Standard is discussed here most extensively.

1.2.2 Maintenance inspection

This activity should be carried out after maintenance overhauls. This category is the routine type of inspection and may be carried out using the appropriate procedures of this Standard.

1.2.3 On stream inspection

This activity should be carried out during normal operation of the equipment. This category requires mainly visual inspection with strict application of test procedures especially for:

- Safeguarding systems,
- Logic systems,
- Safety systems,
- Systems subject to control by customs or local authorities.

On stream inspection may be carried out using the relevant procedures of this Standard.

2. GENERAL

2.1 Actions Prior to Pre-Commissioning Inspection

All instruments and instrument systems, including those supplied with equipment packages, should be inspected immediately upon receipt from the Manufacturer/Supplier to ensure they are free from defects. Any defects or deficiencies shall be brought to the attention of the user.

However, certain instruments and instrument systems will still need to be checked, tested and/or calibrated, either before installation in the instrument workshop or in the field during the pre-commissioning inspection.

2.2 Calibration

All instruments that need to be calibrated before their installation and instruments which have been installed but require calibration or re-calibration, provided that they can be removed, shall be calibrated in accordance with the requirements of Section 7 of this Standard.

Installed instruments that cannot be removed for whatever reason, shall be calibrated in accordance with the requirements of Section 8.

2.3 Pre-Commissioning Inspection

Instrument installations and equipment in plants engineered and/or erected by contractors and, in general, any equipment which has been completed and is ready for operation, shall be subject to pre-commissioning inspection which shall be carried out in accordance with the requirements of Sections 4 and 5.

2.4 Documentation

An essential requirement for an inspection system is the keeping of up to date, precise and detailed records of all inspection, testing and calibration activities.

The results of all inspection, testing and calibration activities shall be recorded on standard forms. The completion of all these activities shall be clearly indicated by attaching labels to each instrument or instrument system.

The labels should be colored, as follows:

- blue:	leak test.	- completed.
- yellow:	pressure test.	- completed.
- orange:	cable test.	- completed.
- green:	calibration test.	- completed.
- red:	incomplete.	- components are missing.
- pink:	calibration fault.	- in temporary use only.
- white:	test failed.	- waiting for further action.

The condition indication label shall be attached to each main component of the loop to show the current status of the installation.

2.5 The Instrument Field Workshop

The instrument field workshop shall be adequately equipped with inspection and test facilities corresponding to the type of instrumentation involved in the plant. It shall be provided with an electrical power supply and utilities such as water, steam and compressed air.

The facilities shall allow for the inspection and testing of heavy equipment such as control valves, including when applicable 3-way valves. This should consist of a control valve test bench for leak and hydraulic testing having also electronic and pneumatic test calibration features.

2.6 Instruments, Tools and Equipment for Inspection

All equipment which will be used for the testing and calibration of instruments shall be calibrated in the units of measurement selected for the project, normally SI units. Each item of this equipment shall have a calibration certificate signed by an accepted independent authority.

The standard of accuracy of test and calibration equipment shall be better than or at least equal to the Manufacturer's stated accuracy for the instrument(s) to be tested. For list of typical test and calibration equipment and additional information and guidance on lay-out, equipment and tools, refer to IPS-E-IN-105.

2.7 Safety Aspects

All inspection activities shall be carried out in accordance with plant safety regulations.

3. INSPECTION AND TESTING AFTER INSTALLATION

3.1 General

3.1.1 After the instruments have been installed they shall be inspected and tested for correct operation as part of the system. This procedure covers the complete inspection and testing of all instruments and instrument systems received on site up to and including the pre-commissioning.

3.1.2 The inspection and testing shall be carried out in accordance with the requirements of following sections and paragraphs.

Note:

The progress of inspection and testing shall be indicated on a bar chart. The bar chart shall be updated at least weekly to indicate the state of readiness and the remaining workload.

3.1.3 At an early stage of the installation the contractor shall inform the responsible Instrument Engineer when the testing of the instrumentation will start, to enable the instrument personnel to attend the tests. Faults found in the Contractor's work shall be corrected by the Contractor at his own expense.

3.1.4 The results of inspection and testing shall be recorded by the Contractor and made available to the construction team instrument engineers.

3.2 Inspection

3.2.1 Field visual inspection shall ensure that each instrument:

- has the correct tag number, range, etc.;
- is in the proper place;
- is correctly and rigidly installed;
- is properly earthed where necessary;
- is suitably protected against adverse environmental conditions.

3.2.2 Attention shall also be paid to the final accessibility of the instrument and the free space necessary for removal or partial disassembly.

3.3 Testing of Impulse Lines

3.3.1 With the process isolating valve closed, all instruments and impulse lines shall be pressure-tested to a pressure of 1.5 times the intended operating pressure.

Note:

Local regulations may specify a higher pressure, e.g., two times the intended operating pressure.

3.3.2 Pressure testing shall be done with demineralized water. After pressure testing, the impulse lines shall be disconnected from the process connections, after which the instrument and the impulse lines shall be carefully drained and blown out. For safety reasons stainless steel tubes shall be used for testing purposes and not copper. Gas cylinders may be used for high pressure testing.

3.4 Testing of Sampling Systems

3.4.1 Sampling systems for on-line process analyzers and impulse lines shall be blown out, pressure-tested and leak-tested using dry air or nitrogen, after which the sampling systems shall be disconnected from the process connections.

3.4.2 Where necessary the sampling systems shall be cleaned, e.g., by solvent washing and dry gas (e.g. nitrogen) purging.

3.4.3 All sample take-off/return connections shall be kept closed until the analyzer is commissioned.

3.5 Testing of Pneumatic Tubing

3.5.1 Leak testing of pneumatic tubes shall be carried out using the bubble method and soap test; after the test the pneumatic signal loops shall be subjected to a full operational test. Special attention shall be paid to the correct line-up between 3-way or 4-way solenoid valves and the relevant final control element.

3.6 Testing of Instruments

3.6.1 All individual instruments will have been tested and (re)calibrated before installation, and a detailed testing of the instrument should therefore not be necessary at this stage unless the function testing (3.7), reveals an abnormal behavior.

3.6.2 Control valves and shut off valves equipped with actuators (complete with associated tubing, solenoid valves quick exhausts, boosters and positioners) shall be tested for full-stroke time.

3.6.3 Actuators for variable-pitch fans on air-cooled heat exchangers shall be tested for smooth stroking in situ before plant commissioning. Final adjustment shall be done when the plant is operating at its design duty and the heat exchanger is at operating temperature, such that:

- minimum pitch (usually negative to compensate for air flow due to heat conduction) shall cause zero air flow;
- maximum pitch shall not cause the maximum allowable motor current to be exceeded.

3.7 Testing of Instrument Loops

3.7.1 All instrument loops shall be fully tested for correct functioning, where necessary by simulating the signals (refer to Clause 9).

3.7.2 All controllers shall have their settings for proportional, integral and derivative actions adjusted to a calculated value. Loop check forms, of a format to be agreed with the user, shall be applied for recording the results.

Note:

The following equipment shall also receive attention at this stage:

- **special high-signal or low-signal selectors calculating relays, etc. shall be adjusted;**
- **the mechanical min/max stop on control valves shall also be adjusted;**
- **the position of limit switches shall be checked and adjusted;**
- **selector switches shall be checked.**

3.8 Testing of Electric/Electronic Systems

3.8.1 All electric/electronic equipment, systems and cables shall be subject to earth-fault tests, continuity tests and a full operational test, if necessary by simulating process conditions. Special attention is required to ensure the correct voltage of the electricity supply.

3.8.2 Thermocouples and their cabling shall be checked for correct connection with regard to polarity.

3.8.3 All connections for cable screening shall be carefully checked, especially with regard to earthing at one point only.

3.8.4 High-voltage insulation testing shall not damage the instrumentation.

3.8.5 Programmable Logic Control (PLC) equipment and DCS systems shall be tested in accordance with the Manufacturer's re- commendations.

3.8.6 Systems for binary logic functions, such as those for alarm annunciation, safeguarding and/or sequential control, shall be fully tested for correct operation by simulating process conditions at the transmitter.

3.8.7 Connections to (single-pole) double-throw initiating switches shall be carefully checked for correct action. all settings for initiators, time delays, etc., shall be adjusted at this stage.

3.8.8 For programmable logic control systems (PLC'S) especially, it is advisable that plant operators make dry runs with the plant and related systems in order to familiarize themselves with these, and to debug the programme.

Note:

The method of testing and the recording of the results shall be agreed with the user.

3.9 Testing of Utility Supplies

3.9.1 The instrument electricity supply shall be fully tested, including automatic switch-over actions. The batteries shall be subjected to a discharge capacity test under full load conditions.

3.9.2 The instrumentation of the instrument air supply station shall be fully tested, including automatic starting of the stand-by compressor(s).

Note:

Under no circumstances shall air from other sources be used for the instrumentation.

3.9.3 All air supply piping shall be blown out and leak-tested with air or nitrogen at a pressure of 10 bar (with valves to individual consumers closed).

3.9.4 Leak testing of joints shall be done with a suitable leak detector.

Notes:

1) Pressure testing of these pipes with water or other liquids is not allowed.

2) In view of personnel safety, testing shall be done outside normal working hours All personnel engaged in the testing procedure shall wear face masks.

3) To avoid unauthorized shut-off of instrument air, it is advisable to lock all (main) valves in open position, or to remove the hand wheel.

4. PRE-COMMISSIONING ACTIVITIES

4.1 Plant Flushing

During plant flushing, each isolating valve on instrument process connections shall be opened to flush the connection and be checked for tightness after closure.

4.2 Plant Pressure Testing

Before pressure testing of process equipment and piping takes place, it shall be ensured that:

4.2.1 Spacers and spool pieces have been installed in the place of all other in-line instrumentation.

4.2.2 All impulse lines and sampling systems are disconnected from the process connection and the isolating valves are closed (3.3) and (3.4).

4.2.3 Retractable probes are withdrawn and the isolating valves are closed. During plant pressure testing, all isolating valves on instrument process connections shall be checked for tightness.

4.3 Re-installation of Instruments

4.3.1 General

After plant flushing, the impulse lines and sampling systems shall be reconnected. The instrument and associated impulse lines shall be filled as follows:

- with water for all steam services;
- with sealing liquid as required by other application.

Note:

A mixture of 50 percent ethylene glycol and 50 percent water (freezing point -40°C approximately) is normally a suitable sealing liquid for cold services protections.

Where temporary spacers or spool pieces have been used, these shall be removed after plant flushing and all in-line instrumentation shall be installed by mechanical engineering, using new gaskets of the prescribed type. Before installing in-line instrumentation the upstream piping shall be inspected to ensure that it is free from any materials which might later damage the instrumentation; where present such materials shall be removed.

Note:

Where solid particles can be expected later (e.g., in those lines where sufficient flushing velocities could not be obtained) it is advisable to install temporary strainers between the flanges upstream of the equipment during the first weeks of plant operation. These strainers form part of mechanical engineering.

Where required for plant safety, all instrumentation installed after plant flushing shall be blocked-in and individually pressure-tested, taking care that the maximum allowable pressure is not exceeded.

4.3.2 Flow instruments

All orifice plates shall be installed under the supervision of instrument engineering, taking into account the direction of flow in the pipe and observing the location of the bleed hole in the plate. Where counters and pulsers for positive displacement meters have been received in separate packing, they shall be mounted after the meters have been installed.

4.3.3 Level instruments

Displacers shall be installed in the relevant instruments.

4.3.4 Control valves

During the installation of control valves, attention shall be paid to the following:

- the valve shall be clean internally and the flange faces shall be undamaged;

- the valve shall be installed in the prescribed position with the flow passing in the correct direction. This applies in particular to those (safety) shut-off or depressurizing valves where the process pressure is intended to assist in keeping the valve closed.

Warning plates shall be installed on or close to those control valves:

- of which the trim size affects the relief system capacity;
- which may cause high noise levels;
- where CV's are mounted in 'back flow protection.

4.4 Testing

All testing prescribed in (3) which could not be done earlier shall be completed after the instruments have been installed.

4.5 Preparation for Plant Commissioning

All instruments shall be made ready for plant commissioning, i.e.:

4.5.1 All isolating valves for instrument shall be in correct position.

4.5.2 Impulse lines and instruments shall be filled with sealing liquid where required (4.3).

4.5.3 Air supply for pneumatic instruments shall be checked for correct pressure.

4.5.4 Electricity supply shall be switched on and instruments checked for proper operation.

4.5.5 Recording instruments shall be checked for proper chart graduation, chart transport and ink supply.

4.5.6 All analyzers shall be calibrated, e.g., by using a certified calibration sample.

Note:

The calibration sample should have a certificate from an authorized laboratory.

All pertinent documents such as up-to-date listings of flow factors, process instrumentation flow diagrams or logic diagrams of safeguarding systems and alarm and trip-setting, shall be available in the control room.

5. PLANT COMMISSIONING ACTIVITIES

5.1 During plant commissioning all instruments shall be commissioned as and when required by plant operations.

5.2 Impulse lines and instruments shall be flushed and drained or vented as required by the application.

5.3 Hand wheels or handles of isolating valves on cryogenic self-purging applications shall be removed after commissioning the instrument.

5.4 The performance of the instruments shall be observed; for flow transmitters the zero indication shall be checked under operating pressure.

5.5 Control loops shall be commissioned in close cooperation with plant operations, and any abnormal behaviour of the instruments (or process) shall be corrected. Controller settings for proportional, integral and derivative actions shall be optimized and recorded as soon as possible.

5.6 When required by plant operations, stand-by of instrumentation specialists shall be available round the clock and stores and workshops shall be open for emergency repairs and modifications.

6. ACCEPTANCE OF WORK

6.1 The instrumentation work shall be accepted only after the plant is in full operation and all instruments are working satisfactorily. The formal acceptance procedure shall include handing over all records made during the construction period such as test results, measured diameters of flow measuring elements, lists of field changes, hours worked and 'as-built' drawings.

6.2 If at the time of acceptance, certain parts of the work are still pending, then these shall be carefully listed and a financial agreement shall be made with the Contractor for incomplete work.

Note:

'Pending work' may be a component part(s) or a complete set of parts, etc. All items shall be included in an 'EXCEPTIONS LIST', countersigned by the Contractor and user.

7. CALIBRATION IN THE FIELD WORKSHOP

7.1 Standards of Calibration

Primary standards shall be maintained for the purpose of verifying and calibrating secondary laboratory and or workshop standards. Primary calibration standards shall be used only for the purpose of calibrating these secondary standards. Every piece of calibration equipment shall be identified by a unique serial number.

On each occasion that a primary or a secondary standard is calibrated, a label shall be fixed to it bearing the following information:

- serial number of the instrument;
- name of the tester;
- date of the test;
- date of the next scheduled test.

This information shall also appear in the calibration records maintained for all primary and secondary test instrument calibrations. The records shall also contain a description of the instrument and values obtained both before and after calibration. The records shall be available for inspection at all times.

7.1.1 Pressure

Primary Calibrating Instruments:

a) Dead weight tester

- This instrument shall be certified prior to its application on calibration work and re-calibrated every year against a recognised standard.

b) Water manometer

- For pressures below 1 bar (gage).

c) Mercury manometer

Secondary Calibrating Instruments:

a) Pressure gage (0.1% accuracy)

- These gages shall be checked against primary instruments, re-calibrated as necessary, or at a maximum interval of one week.

b) Precision pneumatic calibration pressure gage (0.05% accuracy)

7.1.2 Temperature

Primary Calibrating Instrument:

Mercury in glass thermometers (0.1% accuracy). Reference bath with 0°C cold junction (if thermocouple is used for measuring element).

- The accuracy of these thermometers shall be certified by an approved organization.

Secondary Calibrating Instruments:

Digital thermometers (including PT 100-RTD):

- These thermometer's shall be checked against a primary instrument and re-calibrated as necessary at a maximum interval of once every month.

7.1.3 Voltage and current (refer to Appendix A)

Primary Calibrating Instruments:

Voltage and current calibrators (±0.5% accuracy):

- These instruments shall be re-calibrated against a recognised standard every six months.

Secondary Calibrating Instruments:

- These instruments should have a digital read out and be checked against the primary instrument every week.

Digital voltmeters used in the workshop to calibrate instruments shall not leave the workshop. They shall be identified by marking with red paint or an equivalent easily visible indication.

Separate digital voltmeters, as described above, shall be applied for testing circuits in the field. They shall not be used for calibrating applications.

7.1.4 Resistance (refer to Appendix A)

Primary Resistance Instruments

Resistance calibrator:

- This instrument shall be re-calibrated against a recognized standard every 6 months.

Secondary Resistance Instruments:

Decade box:

- These resistance boxes shall be compared with the primary standard every month, using a potentiometer circuit.

7.2 Calibration of Process Instruments

SI Units shall be used for all calibration of instruments and for the recording of such information. Except for temperatures which shall be in degree celsius.

After calibration, each instrument shall have a color coded label securely attached to it (2.4) containing the following data:

- tag number of the instrument;
- date of calibration;
- signature of the person who carried out the calibration.

7.2.1 Calibration procedures

For the following types of instruments, calibration procedures shall be applied (refer to Appendix D):

- pressure transmitters;
- differential pressure transmitters;
- filled temperature transmitters;
- electronic and/or pneumatic controllers;
- computing relays;
- torque tube transmitters;
- pressure switches;
- level switches;
- pressure and drought gages;
- temperature gages;
- temperature switches;
- thermocouples;
- resistance temperature devices (RTD);
- recorders;
- indicators;
- converters;
- monitor switches;
- solenoid valves;
- 4 way valves;
- control valves;
- control valve positioners.

Notes:

1) All transportation stops, where fitted, shall be removed from the instruments before starting the tests. Miscellaneous components such as charts etc.,. shall be correctly installed.

2) Dislocation of PCBs shall be prevented during transportation of electronic instruments.

3) Tests shall not be carried out on electronic instruments until an adequate warming-up period according to Manufacturer's recommendation, has elapsed and a visual inspection of the PCBs has been made.

4) For instruments not covered in this list, the calibration procedure shall be mutually agreed with user.

5) Upon completion of the tests the instruments shall be drained and, if necessary, blown through with dry air or Nitrogen.

6) Where water is used for testing in locations where freezing can occur, the instrument shall be drained and drown dry with air or Nitrogen Furthermore the medium used for testing shall be approved by the user.

7) Where applicable transportation stops shall be replaced after the tests and clearly marked to avoid damage during installation commissioning and start-up.

8) After testing, all openings and connections shall be protected with temporary covers.

8. CALIBRATION IN-SITU

8.1 General

In general, in-situ calibration is applied only for certain specific instruments and instrument systems, (see 8.1.1 and 8.1.2 below), and for those instruments that cannot be easily removed to the workshop.

These instruments and or instrument systems shall be inspected as part of the installation and pre-commissioning procedure, and then calibrated strictly in accordance with the Manufacturer's recommendations. Typical instruments and instrument systems which shall be calibrated in-situ are as follows:

8.1.1 Field instruments

- Radioactive level detectors.
- Meter runs fabricated for custody transfer or process flow measurement.
- Tank gaging systems, including:
    - tank gage transmitter;
    - local and remote receivers;
    - temperature elements.
- Ultrasonic flow meters.
- Target and Vortex flow meters.
- Vibration and axial displacement monitors.
- Speed monitors.
- Flame detectors.
- Lock-hopper controller systems.
- Prover loop systems.
- Variable-area (rotameter type) and mass flow meters.
- Process analyzers (see specific procedure as Manufacturer's recommendation).
- Laboratory analyzers.
- Weighing systems (bridges, belts, etc.)

8.1.2 Control room instruments

- Distributed Control System (DCS).
- Programmable Logic Control (PLC).
- Special systems, e.g.:
- Auxiliary Racks or Cabinets.
- Blending.
- Tank Gaging (microprocessor-based).
- Close Circuit Television (CCTV).
- Gas and Fire Detection System Cabinets.

8.2 Packaged Units

All instruments and instrument systems, included in packaged units shall be calibrated in accordance with the Manufacturer's recommendations.

9. FUNCTIONAL TESTING OR LOOP CHECKING DURING COMMISSIONING

9.1 General

Functional checking of all open and close loops, either locally mounted or in a control room, and other instruments such as indicators and recorders in separate control panels with field-mounted transmitters and switches, etc., is normally carried out by checking the instruments in a series of systems or loops.

Prior to the commencement of Loop checking it shall be ensured that:

- All installation, inspection and pressure/leak testing of instrument work is complete.

- Utilities, i.e., electricity and instrument air, etc., are available.

- The latest revision of the relevant drawings are available.

- Two teams are available, one in the field and one in the control room.

- Electronic equipment is allowed an adequate period warming-up before loop checking begins.

- The responsible Instrument Engineer is notified before loop checking begins. All completed inspection and test record forms shall be countersigned by this Engineer.

- The instrument installation complies with the P & IDs.

Notes:

1) Any errors found in the drawings and documents shall be reported to the responsible instrument engineer for corrective action to be taken.

2) The complete loop shall be tested including primary device, controlling equipment, final elements and associated alarms and trip functions.

3) Complex digital safeguarding or sequencing functions may be tested separately in this case, properly prepared test schedules shall be available.

9.2 Checking Procedure

9.2.1 Analogue loops with control room mounted equipment

- Check utility supplies for correct values.

- Inject signals of 0%, 50% and 100% of full scale at the transmitter primary, using a hand pump or gas bottle as appropriate. Observe and record the effects on other elements of the loop.

- Disconnect temperature elements in the instrument head and use a test box to inject signals of 0%, 50% and 100% of full scale. Observe and record the effects on other elements of the loop.

- If a controller is included in the loop, switch to manual and vary the controller output. Observe the effect on the final element. Check that auto to manual transfer is bumpless and observe the final element reaction to input signal changes. Record the results.

Note:

For controller checks it is advisable to reduce integral and derivative terms to minimum setting. Mid-range settings shall be restored after loop checking is complete.

9.2.2 Analogue loops locally mounted

The procedure is as described above except that the transmitter mechanism shall be actuated mechanically, either by injection of pressure or by manual actuation of the signal transmission mechanism.

9.2.3 Digital functions with direct action (i.e., having no logic functions)

- Actuate the switch mechanically, observe and record the results.

9.2.4 Logic functions checks

The tests shall follow the logic diagram, using a state diagram to represent all the necessary input and output conditions.

Logic functions shall be tested in two steps where practicable:

- Firstly, disconnect the input elements for example by opening the terminals in the cabinets and connect simulation switches and lights mounted on a simulation panel. Test all inputs, outputs and logic functions.

- Secondly, activate primary elements with terminals closed and check the complete system through to final element(s).

9.2.5 Special items

Items such as analysers and speed controllers, etc., shall be tested in accordance with the Manufacturers recommendations.

9.2.6 Completion of loop checking

Loop check sheets shall be signed by the supervisor and user.

9.3 Instrument Testing During Total Loop Check

9.3.1 General

The following typical instructions to the Contractor also provide information to instrument personnel to achieve that a consistent and uniform testing procedure will be applied for general and typical instrumentation during a total loop check.

For special instruments, the Manufacturer's procedures shall be scrutinized in order to determine testing methods which will be acceptable to the user.

9.3.2 Flow instruments

9.3.2.1 Flow transmitters (differential-pressure type measurement)

The test medium for injection into the primary side of the transmitter shall be suitable for the process e.g. dry Nitrogen or Air:

1) Close the manifold isolating valves.

2) Open the manifold equalising valve.

3) Open the vent/drain valves.

4) Close the manifold equalizing valve.

5) Connect suitable test equipment to the HP side of the transmitter using the vent/drain connection. Do not disturb the impulse lines.

6) With no pressure applied check for zero

7) Inject two signals between 10% and 90%:

e.g. 1) between 20% and 50%, and
2) between 50% and 90%.

8) Request readings from the control room and other locations as required i.e. local indicating/local panels and check synchronization (in engineering units).

9) Vent to atmosphere and check for zero.

10) For DCS alarms adjust set points on appropriate display and observe action (final settings by other).

11) For trip alarm points (trip amplifiers), check setting trip point (Calculate trip setting in mbar prior to signal injection).

12) Disconnect test equipment.

13) Close vent/drain and equalising valves.

14) Open isolating valves.

9.3.2.2 High-low range transmitters

The test for parallel transmitters shall be performed with all HP manifold valves open, by injection into one of the vent/drain valves with the LP vents disconnected.

The signals injected shall cover the range of all transmitters avoiding the switch-over points, signals between 40% and 60% of the transmitter range shall therefore be considered.

9.3.3 Level instruments

9.3.3.1 External-type displacer

The testing procedure is as follows:

1) For all liquid densities other than 1.0 calculate the liquid column equivalent water height.

2) Close process liquid connections (upper and lower).

3) Remove vent plug (upper).

4) Remove drain cap (lower) and open drain valve.

5) Connect water column to drain valve.

6) Observe zero (dry float). Care shall be taken, because when level is lowered, output may not return to zero because of liquid retained by the float.

7) Mark the 50% and 100% points from this zero.

8) Raise level to zero 50% and one point higher.

9) Request readings from the control room and other locations as required, i.e. local indicating/local panel and check synchronization.

10) Remove water column and drain water.

11) Close drain valve.

12) Replace drain cap.

13) Replace vent plug.

14) For DCS alarms adjust set points on face-plate and observe action.

15) For trip alarm points (trip amplifiers), check setting trip point.

9.3.3.2 Differential-pressure dry reference leg

Follow the same procedure as for flow measurement.

9.3.3.3 Differential-pressure wet reference leg

Follow the procedure for flow measurement with injection on the LP side of the transmitter. Reference leg shall be filled by the Instrument Contractor.

9.3.3.4 Level switches (Magnetic)

Fill the chamber to check the switch operation with a suitable medium approved by the user. If it is impracticable to use a suitable liquid to check either a displacer level transmitter or a level switch, the following test can be made:

1) dry calibration procedure;
2) switch activation.

For specialized and other level measurement the Manufacturer's recommended procedure shall be used.

9.3.4 Pressure instruments

9.3.4.1 Pressure transmitters

The test medium for injection on the primary side of the transmitter shall be suitable for the process, e.g., dry Nitrogen or Air.

For absolute pressure instruments care should be taken with respect to barometric conditions when testing these transmitters. Test shall be carried out as above using a vacuum pump. Under vacuum conditions spot check impulse line for leakage.

For procedures refer to Appendix D.

9.3.4.2 Pressure switches

The test medium for injection shall be suitable for the process (e.g., Nitrogen or Air). After by closing the process block valve the procedure is as follows:

1) Vent to atmosphere via the vent/drain valve.
2) Connect pressure equipment to vent connection.

3) With no pressure applied check alarm state.
4) Apply increasing pressure for high alarm and observe action.
5) Apply decreasing pressure for low alarm and observe action.
6) Remove pressure and disconnect test equipment.
7) Close the vent/drain valve.

9.3.5 Temperature instruments

9.3.5.1 Thermocouples

1) Disconnect 1st wire and check burn-out feature (upscale/downscale).

2) Disconnect 2nd wire and make short circuit. Reconnect and check ambient temperature with a thermometer on field.

3) Request readings in the control room and other locations as required, i.e. local indicating panels.

4) If necessary, use a MV source and check the corresponding reading and alarm point in control room and other locations as required, i.e., local indicating/local panel.

5) Check reading (ambient) after re-installation, when possible.

9.3.5.2 Resistance type

1) Open circuit to check burn-out feature, if applicable.
2) Simulate with decade resistance box 2 points within range.
3) Request readings in the control room and other locations as required, i.e., local indicating/local panels.
4) Check wiring, system.
5) Check reading (ambient) after re-installation when possible.

9.3.5.3 Filled-type temperature transmitter

1) Check capillary for damage.
2) Spot check output for ambient, if range permits.
3) Check loop injecting signal on output.

9.3.5.4 Temperature switch

1) Test circuit by actuating micro switch.

9.3.5.5 Differential temperature

1) Inject signal from both locations.
2) Vary signals from both locations.
3) Check reading after re-installation.

9.3.6 Control valves

9.3.6.1 The valve itself

With controller on manual, vary the output as follows:

1) 0% valve fully closed check starting point.
2) 25% valve 25% open.

3) 50% valve 50% open linkage level.
4) 75% valve 75% open.
5) 100% valve fully open.
6) Air fail valve check action against P&IDs.

Notes:

1) Care should be taken with reverse acting positioners and split range valves, check operation with P&IDs.

2) The correct mode of reverse relay only has to be selected in comparison with the input mA signal and not by the valve position.

3) Convertor can be either at the positioner or separately mounted.

9.3.6.2 Lock-up devices

1) Set control valve fully open, and fully closed.
2) Reduce air supply slowly to below the set point of the setting of the lock-up device.
3) Check no valve movement for a change in signal.
4) Reset regulator.

9.3.6.3 Tight shut-off (TSO) valves

These valves shall be closed at 3% (approximately) valve position signal to ensure closure.

9.3.6.4 Quick exhaust valves

Check functioning of the valve.

9.3.6.5 Stroking times

Should be checked with accessories, such as, positioner, signal booster, quick exhaust solenoid valve and suitable clock.

9.3.7 Typical for pre-alarm and common pre-alarm system

9.3.7.1 Process conditions

No flow no pressure/no level/ambient temperature.

9.3.7.2 Type of signals

a) Level alarm (LA): Switch
b) Pressure alarm (PA): Switch
c) Temperature alarm (TA): mV

9.3.7.3 Simulation of alarms

a) Level alarm : Bridge on the switch.
b) Pressure alarm: Bridge on the switch.
c) Temperature alarm: Disconnection of one wire (burn out protection).

9.3.7.4 Functional check operation

The procedure is as follows:

ITEM	ACTION	CHECK	REMARKS
1	Check initial status		
		1) Low-level alarm on (LCP) Local Control Panel 2) Low-pressure alarm on 3) High-level alarm off 4) High-pressure alarm off 5) High-temperature alarm off	
2	All alarms off		
	1) Place bridge on low-level alarm 2) Place bridge on low-pressure alarm	1) Low-level alarm off (LCP) 2) Low-pressure alarm off (LCP) 3) Common pre-alarm off (DCS/ADP) Alarm Display Panel	
3	Simulation of alarms		
	1) Remove bridge on low-level alarm	1) Low-level alarm on (LCP) Common pre-alarm on (DCS/ADP)	+ Horn + Accept
	2) Remove bridge on low-pressure alarm	2) Low-pressure alarm on (LCP) Common pre-alarm on (DCS/ADP)	+ Horn + Accept
	3) Place bridge on high-level alarm	3) High-level alarm on (LCP) Common pre-alarm off (DCS/ADP)	+ Horn + Accept
	4) Place bridge on high-pressure alarm	4) High-pressure alarm on (LCP) Common pre-alarm on (DCS/ADP)	+ Horn + Accept
	5) Remove bridge on high-pressure alarm	5) High-pressure alarm off (LCP) Common pre-alarm off (DCS/ADP)	
	6) Disconnect wire on high-temp. alarm	6) High-temp. alarm on (LCP) Common pre-alarm on (DCS/ADP)	+ Horn + Accept
	7) Reconnect wire on hightemp. alarm	7) High-temp. alarm off (LCP) Common pre-alarm off (DCS/ADP)	
4	Return to initial conditions		
	1) Remove bridge on low-level alarm	1) Low-level alarm on (LCP)	+ Accept
	2) Remove bridge on low-pressure alarm	2) Low-pressure alarm on (LCP)	+ Accept
	Checking Individual Instruments:		
	Each instrument which is part of a pre-alarm system shall be checked with injection at the primary element (check alarms at the appropriate places LCP/ADP/DCS).		

APPENDICES

APPENDIX A
LIST OF TYPICAL TEST EQUIPMENT FOR A FIELD INSTRUMENT WORKSHOP

The following is a list of typical test and calibration equipment which may be required by a Contractor for onsite instrument testing, and pre-commissioning. This list is not conclusive and shall be reviewed for each specific project.

Test and calibration equipment shall be calibrated in the units of measurement selected for the project. All test equipment shall, as a minimum, be approved by the responsible Instrument Engineer.

A. Pressure Testing and Calibration Equipment

1) Portable manually operated hydraulic pump (bucket pump).
2) Low pressure, hand-held pressure pump (range up to 1 bar).
3) Vacuum pump manually operated.
4) Dead weight tester.
5) Pressure gage comparison test pump.
6) Precision air filter/regulator sets (minimum of 3).
7) Liquid filled manometer (ranges below 10 mbar).
8) U-tube manometer (ranges approx. +/-25 mbar).
9) Precision-inclined manometer (ranges below 10 mbar).
10) Precision-sealed mercury manometer (ranges up to approximately 1000 mbar).
11) Certified test gauges, 0.25% accuracy or better.
12) Portable pneumatic calibration boxes (minimum of 3).
13) Portable air compressor (when an air supply is not available).

B. Temperature Test and Calibration Equipment

1) Thermostatically controlled temperature bath(s).

2) Thermostatically controlled oven, for checking cold junction compensation.

3) Sets of standard (precision) mercury in glass thermometers.

4) Precision potentiometer and millivolt generator.

5) Precision Whetstone Bridge incorporating a detachable resistance box where resistance thermometers will be installed. Accuracy 0.05% on any resistance value.

6) Decade resistance box 0.1% accuracy.

Note:

All test instruments shall be provided with test leads complete with test probes, clips and distribution terminals.

(to be continued)

APPENDIX A (continued)

C. General Electronic/Electrical Test and Calibration Equipment

1) Digital voltmeters (DVM) portable (minimum of 3 portable types) with an accuracy of +/-0.1% of range or better and with a discrimination of 10 uv or better, incorporating an internal calibration, standardizing feature and 0.1% calibration resistors.

2) Precision millivolt, volt and milliamp, source measuring device.

3) Portable multimeters (analogue).

4) Insulation resistance testers.

5) Stop-watch and relay contact timing device.

6) Dual beam oscilloscope.

7) Portable, variable mA power supply unit (0 to 50 mA Mex.).

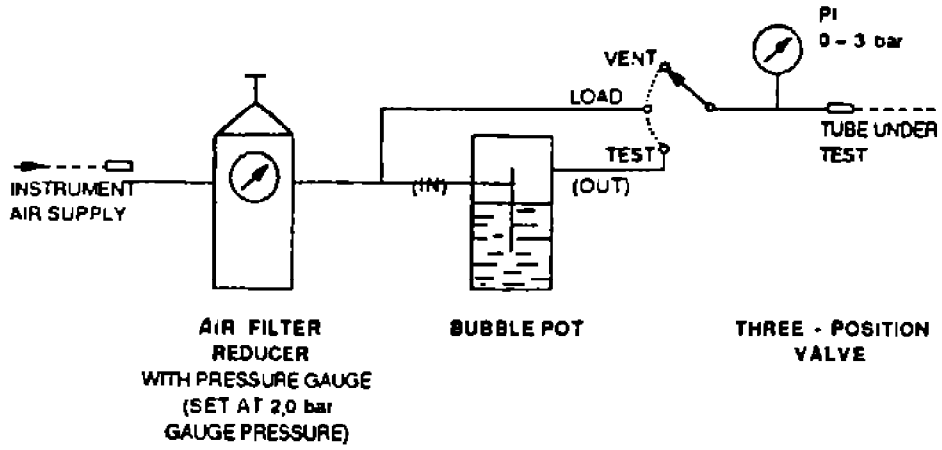
8) Portable multimeters (digital).

9) Signal generator.

D. General

1) Combined pneumatic/electronic portable tester (minimum of 2).
2) Control valve test bench or test rig.

APPENDIX B
LEAK TESTING OF PNEUMATIC TUBING



Test Procedure

1) Connect the test rig shown to the control room end of the tubing, with valve in the VENT position.

2) Open far end of tubing, blow out by turning valve to LOAD position, and check for correct line.

3) Close far end of tubing. When system is at 2.0 bar gage pressure, turn valve to TEST position.

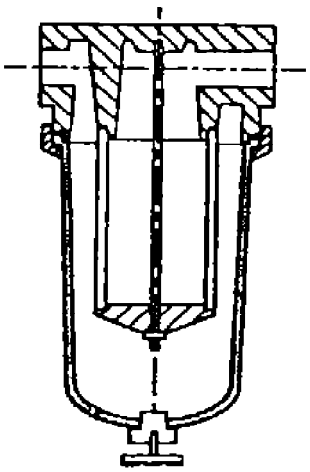
4) Observe rate of bubble flow. Up to 3 bubbles per minute is usually acceptable. If the rate is higher, fittings should be checked, if necessary with soapy water.

5) Turn valve via LOAD to VENT position and disconnect tubing from test rig.

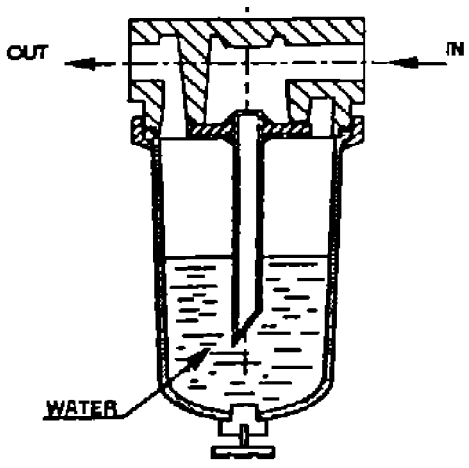
Materials Required (all threaded ¼ in. NPT female)

a) One drift-free air reducer with integral filter.
b) One three-position valve.
c) One air filter with high-impact transparent (polycarbonate) bowl. Modified as shown below:

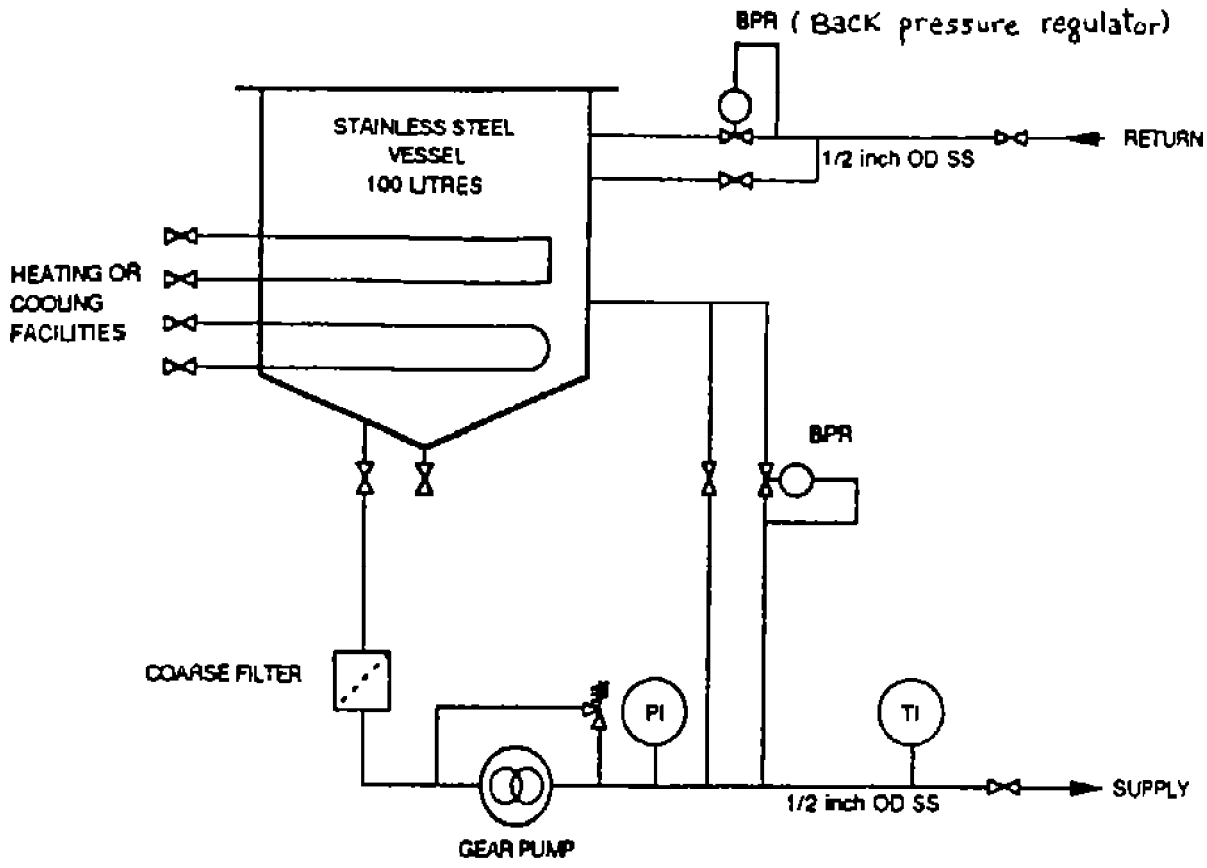
TYPICAL AIR FILTER
in original condition



BUBBLE POT
made from air filter



APPENDIX C
TEST RIG PRINCIPLE FOR ANALYSER TESTING



If possible, use a pneumatic driven gear pump at:

- a pressure of 10 bar Approx., and
- a flow of 0.06 dm^3/s.

All parts shall be installed on a suitable frame to facilitate transport and operation. When used for viscous products, the whole system shall be steam or be electrically traced and insulated.

APPENDIX D
TYPICAL FIELD CALIBRATION PROCEDURES FOR PROCESS INSTRUMENTS

D.1 Pressure Transmitters

Apply a supply pressure of 1.4 bar or a supply voltage of 24 V according to the type of transmitter. Apply pressures of 0%, 50%, 100%, 50%, 0% of the range of the transmitter as indicated in the requisition and observe the transmitter output at each point.

If the transmitter output is not within the Manufacturer's tolerance, re-calibrate the transmitter in accordance with the Manufacturer's recommendations. After re-calibration, re-apply pressures and record the results on the calibration sheet.

D.2 Differential-Pressure Transmitters

Carry out the procedure given above for pressure transmitters and in addition:

Apply a static pressure, corresponding to the maximum operating pressure as indicated in the requisition, to both sides of the differential pressure cell and record the variation of zero output on the calibration sheet.

D.3 Filled Temperature Transmitters

Apply a supply pressure of 1.4 bar.

Place the capillary bulb in a temperature bath and apply three temperatures corresponding to 0%, 50%, 100%, 50%, 0% of scale and observe the outputs.

If the transmitter output is not within the manufacturer's tolerance, re-calibrate the transmitter in accordance with the Manufacturer'srecommendations.

After re-calibration, re-apply temperatures and observe the results on the calibration sheet.

D.4 Controllers

Apply a supply pressure of 1.4 bar or an appropriate supply voltage according to the type of controller. Apply measured variable signals of 0%, 50%, 100% 50%, 0% of full scale and record the controller reading.

If the result is not within the Manufacturer's tolerance re-calibrate the controller in accordance with the manufacturer's recommendations. After recalibration, re-apply the signals and record the results on the calibration sheet:

Switch the controller to the manual position. Adjust the out-put to give 0%, 50%, 100%, 50%, 0% of full scale and observe the corresponding output reading on the controller.

If the reading is not within the Manufacturer's tolerance re-calibrate the controller in accordance with the Manufacturer'srecommendations.

After re-calibration, manually adjust the output again and record the results on the calibration sheet.

(to be continued)

APPENDIX D (continued)

Alignment Check

- With the controller in manual operation, apply 50% of the measured variable signal to input and move set point to 50% of scale. Reset adjustment to minimum setting and rate adjustment to maximum setting. Set output to 50% and switch to auto. Adjust the proportional band setting to maximum and observe the deviation of output.

If the results are not within the Manufacturer's tolerance re-align the controller in accordance with the Manufacturer's recommendations. After re-alignment, repeat the manual adjustment of output and record the results on the calibration sheet.

Reset Test

- With the controller in auto and the proportional band at 100%, apply a 50% measured variable signal to input, with reset adjustment at the minimum setting and rate adjustment at maximum. Adjust the set point until output is 50% and increase reset adjustment. Output should increase to 100% or decrease to 0% over a certain period of time.

If the controller does not act as above, refer to Manufacturer's data for the corrective actions to be taken.

Rate Test

- With the controller in auto and the proportional band at 100%, apply a 50% approximately, measured variable signal to input, set reset adjustment to minimum setting and rate adjustment to middle of range, adjust set point to 50%. Change input signal rapidly to 25% of scale.

Output should fall to zero or near zero before increasing again to approximately 25% over a period of time. If the controller does not act as above, refer to Manufacturer's data for the corrective actions to be taken.

Manual/Auto Transfer Test

- Perform an auto/manual transfer test by switching repeatedly between the two controller modes after balancing the output.

D.5 Computing Relays

Apply a supply pressure of 1.4 bar.

For 2-input relays, apply 2 input signals. For 3-input relays, apply 3 input signals. Only one input signal shall vary at any one time, the other signal (s) shall be set at 50% of scale. Apply for each input 0%, 50%, 100%, 50%, 0% of scale and observe the outputs.

If an output is not within Manufacturer's tolerance for the desired function, then coefficients need to be changed in accordance with the Manufacturer's recommendations.

After re-setting coefficients, re-apply input signals as above and record the results on the calibration sheet.

(to be continued)

APPENDIX D (continued)

D.6 Torque Tube Transmitters

Notes:

1) Side-side or side-bottom torque tube transmitters shall be calibrated only after installation on their vessels.

2) Top mounted torque tube transmitters shall be calibrated in the workshop.

Apply a supply pressure of 1.4 bar or a supply voltage of 24 V.

Use a lever arm and calibrated weights to simulate the force which will be exerted on the float by the process fluid. Apply a force equivalent to 0%, 50%, 100%, 50%, 0% of scale to the torque tube float, and observe the outputs.

If the outputs are not within the manufacturer's tolerance then re-calibrate in accordance with the Manufacturer's recommendations.

After re-calibration, re-apply the forces and record the results on the calibration sheets.

D.7 Pressure Switches

Apply a pressure to the switch input and record the pressure which activates the switch.

If the switch does not operate at the pressure stated in the requisition, adjust the switch until correct operation is obtained.

Increase the pressure and record the result in the calibration report for the instrument.

Decrease the pressure and record the result.

D.8 Pressure and Drought Gages

Apply pressure of 0%, 50% and 100% full scale to the instrument and note the resulting indication.

If the results are not within the Manufacturer's tolerance, re-calibrate the gage in accordance with the manufacturer's recommendations.

After re-calibration, re-apply pressures and record the results on the calibration sheet.

D.9 Temperature Gages

Mount the gage with its stem in a temperature bath and apply temperatures at 0%, 50% and 100% of full scale and record the results.

If the results are not within Manufacturer's tolerance, re-calibrate the gage in accordance with the Manufacturer's recommendations.

After re-calibration, re-apply temperatures and note the results on the calibration sheet.

(to be continued)

APPENDIX D (continued)

D.10 Thermocouples

Continuity Test

- Connect the thermocouple to a digital temperature indicator, allow the thermocouple to stabilize at ambient temperature and note the reading. The thermocouple reading should be within +3°C of ambient temperature as indicated by the calibration standard.

Earth Insulation Test

- Measure the resistance between thermocouple and sheath, which shall be greater than 1 mega ohm.

Dimensional Check

- Measure and record the length and diameter of the thermocouple probe. Compare with the requisition data sheet and the corresponding thermowell dimensions and note any discrepancy.

Record all data on the calibration check sheet. Thermocouples not meeting the criteria given above shall not be installed.

D.11 Resistance Temperature Devices (RTD)

Continuity Test

- Allow the instrument to stabilize at ambient temperature then measure and note the resistance of the sensor with an ohmmeter. Also note ambient temperature as indicated by the calibrating standard. The resistance of the sensor shall be within +1 ohm of the value specified by the Manufacturer.

Earth Insulation Test

- Measure the resistance between all sensor leads connected in common, and the metal sheath, which shall be greater than 1 mega ohm.

Dimensional Check

- Measure and record the length and diameter of the sensor. Compare with the requisition data sheet and the corresponding thermowell dimensions note any discrepancy.

Record all data on the calibration check sheet. RTDs not meeting the criteria given above, shall not be installed.

D.12 Recorders

Apply the correct power supplies for the chart mechanism and recorder.

Apply an input signal corresponding to 0%, 50%, 100%, 50%, 0% of full scale to each recorder channel and note the indicated values.

If the results are not within the manufacturer's tolerance, re-calibrate the recorder in accordance with the Manufacturer's recommendations.

After re-calibration, re-apply input signals and record the results on the calibration sheet.

(to be continued)

APPENDIX D (continued)

D.13 Indicators

Apply the correct power supply as specified.

Apply an input signal corresponding to 0%, 50%, 100%, 50%, 0% of full scale and note the indicated values.

If the results are not within the manufacturer's tolerance, re-calibrate the recorder in accordance with the Manufacturer's recommendations.

After re-calibration, re-apply the input signals and note the results on the calibration sheet.

D.14 Converters

Apply the correct supply as specified.

Apply an input signal corresponding to 0%, 50%, 100%, 50%, 0% of the range and note the output values.

If the results are not within Manufacturer's tolerance, re-calibrate the converter in accordance with the Manufacturer's recommendations.

After re-calibration, re-apply the input signals and note the results on the calibration sheet.

D.15 Monitor Switches

Apply the correct power supply as specified.

Apply an input signal and vary it over the range of the monitor switch.

Note the value at which the switch operates.

If the result does not correspond to the trip point as stated in the requisition, adjust the trip point until the required value is obtained and record the value on the calibration sheet.

D.16 Solenoid Valves

Apply the correct power supply as specified.

Apply an air supply to the appropriate connection.

Check the operation of the SOV by operating the power supply switch and observe correct change-over action (pneumatic).

Check the shut-off tightness by using the bubble method at the stated design pressure.

If applicable, check manual or electrical reset, override and time delay features.

Check and record the electrical specification e.g. coil resistance.

Check the function of the SOV with the power supply at the specified minimum voltage, e.g., 16 V for correct change-over and tightness.

(to be continued)

APPENDIX D (continued)

D.17 Control Valves

Notes:

1) The use of a modern control valve test bench is fully recommended; if not available, a control valve test rig shall be installed in a clean and specific location. For more details see IPS-E-IN-105.

2) The calibration sheet shall be completed.

Inspection and Functional Test

The following tests shall be performed in a clean environment:

1) The valve shall be removed form its packing and mounted on a suitable support.

2) The valve shall be examined for damage and if necessary, it should be cleaned. Dismantling, if necessary shall be in accordance with the Manufacturer's instructions.

3) The material specification of the valve shall be checked and all differences shall be recorded.

4) For valves without positioners, apply clean dry air to the actuator at a pressure corresponding to the spring range and observe the stroking of the valve. Check that the valve strokes between 0 and 100% of the range for corresponding pressure variations.

5) For valves with pneumatic positioners, apply clean dry, air to the positioner at a signal pressure of 0.2 to 1.0 barg and check that valve strokes over its full range. Check that the positioner can be by-passed.

Note:

The positioner may be split range, in which case the control signal shall be adjusted accordingly.

6) For valves with electro-pneumatic positioners, supply clean dry air to the positioner and apply a signal of 4 to 20 mA and check that the valve strokes over its full range. For all valves, observe the stroking times from fully open to fully closed and from fully closed to fully open.

Note:

Positioner may be split-range.

7) For all valves, check that the control valve action is in the required direction.

8) Check operation of all accessories attached to the valve, e.g., lock-up relays, limit stops, limit switches, stem position transmitters, etc.

9) Any malfunction shall be investigated and the faulty component either replaced or serviced in accordance with the Manufacturer's recommendations.

Positioner Calibration

1) Valves shall be installed in a control valve test bench, a test stand, or otherwise suitably supported.

2) Check the positioner type against the requisition.

3) Visually check the linkage, for damage and repair if necessary. Follow the Manufacturer's recommendations for all dismantling operations.

(to be continued)

APPENDIX D (continued)

4) Apply the specified signal input to the positioner in order to obtain a fully closed valve. Then obtain 50%, 100%, 50% and 0% of the stroke, recording the input signal required to obtain these values. These signals shall be within 1% of theoretical values. The difference between actual and theoretical values necessary to obtain a closed valve shall not exceed 2%.

5) If the criteria given above are not met, adjust the positioner in accordance with the Manufacturer's recommendations.

6) Complete the calibration check sheet for control valves.

Note:

1) Control valve seat leakage shall be in accordance with IPS-G-IN-160, "Control Valves".

2) For safety valves calibration/installation reference should be made to IPS-G-ME-250.