PERIODICAL INSPECTION

FOR

INSTRUMENTATION

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APPENDICES:

1. SCOPE

This Standard covers detailed requirements relating to the inspection to be performed regularly as recommended herein for the Iranian Petroleum Industries. It is not intended as a maintenance manual, but however, the inspection procedures suggested can be used in the preventive maintenance program.

Particular attention should be given to inspection of those instruments which affect safety and continuity of operation. Throughout this Standard, the use of the term "inspector" shall be construed to mean a person or body qualified to perform the instrument inspection.

The instrument inspector and the instrument maintenance department of the plant should collaborate in the inspection of the control valves, level-float gages, instrument air, hydraulic systems, and any other similar instrument equipment where metal thickness measurement or pressure testing are required.

2. REFERENCES

Throughout this Standard the following standards and codes are referred to. The edition of these standards and codes that are in effect at the time of publication of this Standard shall, to the extent specified herein, form a part of this Standard. The applicability of changes in standards and codes that occur after the date of this Standard shall be agreed upon by the Company and the Vendor.

API (AMERICAN PETROLEUM INSTITUTE)

RP 500 A	"Recommended Practice for Classification of Areas for Electrical Installation in Petroleum Refineries"
RP-521	"Recommended Practice for Electrical Installation in Petroleum Processing Plants"
RP-550	"Manual on Installation of Refinery Instruments and Control Systems"
RP-14C	"Analysis, Design, Installation and Testing of Basic Safety Systems on Offshore Production Platforms"

ISA (INSTRUMENT SOCIETY OF AMERICA)

RP 7.1	"Pneumatic Control Circuit Pressure Test"

3. UNITS

International System of Units (SI) shall be used, except for temperature which shall be in degrees Celcius and for pipes and fittings thread which shall be in inches and NPT, respectively.

4. GENERAL

Periodic inspection should be made on all instruments to check installation details, calibration, materials of construction, and operation of the instrument involved. The knowledge obtained by inspection shall be used for maintaining safety, improving continuity of operation, assuring product quality, reducing the rate of deterioration, and predicting and scheduling the repair or replacement as required. The physical condition of equipment as well as the type, rate, and cause of deterioration shall be determined by the inspectors.

4.1 Reasons for Inspection

4.1.1 Safety of instrumentation

Through the inspections performed, the bad conditions and malfunctions, that if left uncorrected might cause failure of the instrument or serious process upsets or other conditions determental to equipment and personnel, shall be revealed.

4.1.2 Continuity and efficiency of operation

External inspections (visual inspections) performed during operating periods may result in the detection of the following deficiencies:

- mechanical defects in the instrument devices
- plugged lines
- bent valve stems
- loose packing
- loose connections
- undue vibration
- or any other evidences of malfunction

Proper analysis and evaluation of these conditions shall be performed to be followed by corrective maintenance to obtain prolonged equipment life, extended continuous running periods, general improvement of operations and increased overall efficiency.

4.2 Frequency and Time of Inspection

4.2.1 The need and frequency of instrument inspection shall be primarily determined by severity of the service encountered and overall effect on the plant operation, considering whether the instrument can be readily isolated or can be inspected during shutdowns.

4.2.2 When suggestions made in this Standard do not fit a particular set of individual needs as judged by the inspection body, it is recommended to make frequent inspections initially and based on the information obtained by these inspections, adjust the inspection interval as a pattern of experience and cost effectiveness. The inspection body shall consider the fact that:

"Those instruments inspected too infrequently may suffer costly failures between inspections while on the other hand, it is impractical to conduct frequent inspections on some types of instruments."

4.2.3 To ensure that inspections, particularly those involving critical instruments, are carried out at established intervals, a formal scheduling and reporting program shall be prepared for each plant. It is usually practical to set up such a program on computer, if available.

4.3 Causes of Deterioration

Deterioration may be expected by one of the following causes.

4.3.1 Corrosion

Corrosion may be expected on the surface of all instrument equipment exposed to process fluids and on the unprotected surface of equipment subject to attack by moisture, salt air, fungi, or any corrosive vapors might be present in a refinery atmosphere.

4.3.1.1 Internal corrosion

Corrosion may occur on any instrument part that contacts process fluid. The severity of the corrosion depends upon the nature and concentration of the corrosive agents in the fluid and the construction material's resistance to corrosion.

In general, corrosion of instrument parts that contact process fluid is not a serious problem because these parts are normally made of corrosion-resistant material or are suitably protected by using seals or purge systems. Corrosion is most often encountered in control-valve bodies, orifice plates, analyzers, chambers of certain level instruments, gage glasses, or other devices that must be installed so that they are directly exposed to the process fluid.

The effects of corrosion are usually apparent from visual inspection. Obvious signs are pitting and rust formation.

Internal corrosion is the most probable source of deterioration in the pneumatic instruments which have not been in service for a long period and have been exposed to humid air instead of instrument air.

4.3.1.2 External corrosion

Deterioration resulting from attack by moisture, salt air, fungi, or corrosive vapors in the atmosphere is the most common form of external corrosion. In hot, humid climates, these factors are the major causes of instrument component failure. This type of deterioration is especially prevalent in electronic instrument components.

Oxide or salt formation on metal surfaces subject to such corrosion can usually be detected by visual observation. In addition, electrical components may also show symptoms of corrosion such as fungus growths. A leaking or distorted capacitor is usually a sure sign of such deterioration.

4.3.2 Erosion

Orifice plates, control valves, thermowells, and other components exposed to flowing fluids may be subject to erosion, depending upon the characteristics of the fluid and the operating conditions. Some causes of erosion are:

1) High-pressure drop.
2) High velocity.
3) Solids-bearing streams.
4) Fluidized solids streams.
5) Flashing liquids.
6) Cavitating liquids.

4.3.3 Mechanical deterioration

Mechanical deterioration is not readily apparent to the inspector, and in most cases the cause can only be determined after failure has occurred. The exception to this is mechanical abuse, which can usually be detected by visual inspection.

4.3.3.1 Fatigue failure and wear

Fatigue failure and wear of moving parts are usually caused by oscillatory operation over a narrow portion of the instrument range. This condition is usually encountered where mechanical vibration or process oscillations are present.

Any device inserted into the process stream is subject to fatigue failure and wear caused by high fluid velocities and flow.

4.3.3.2 Mechanical abuse

Mechanical abuse usually results in obvious damage, such as broken glass, bent valve stems, and dented or cracked instrument housings. In general, failure from mechanical abuse is caused by accidents, misuse, or careless handling of equipment. Control-valve stems have been bent or distorted from excessive torque as a result of the use of valve wrenches on the handwheel. Many failures have also been caused by the use of various instrument components as step stools when climbing or when trying to reach inaccessible locations, or by the use of components as supports for additional equipment.

4.3.3.3 Exceeding instrument limits

Overranging or exceeding the mechanical or electrical limits of an instrument or instrument component is often a cause of instrument damage. It is usually the result of improper operation of the instrument or use of an improper specification for it. A common failure of this type results from the use of a pressure gage without sufficient consideration for its intended operating range. During hydrostatic testing, instruments must be isolated from the pressure.

4.3.3.4 Overheating or freezing

Exposure of an instrument to hot process fluids or to external heat sources, such as sunlight, flash fires, or adjacent hot equipment, can cause overheating and resultant damage to the instrument. Inspection should include a check of instrument components vulnerable to overheating, such as electronic components, gaskets, and packing. Insufficient heat tracing and insulation can result in damage due to freezing.

4.3.4 Fouling

Fouling, or build-up of foreign material on instrument system components, can occur on parts exposed to certain process fluids. The effect of fouling can be to impair operation of the instrument involved. Visual inspection of internal parts will usually reveal build-up.

4.4 Preparation for Inspection

4.4.1 General

Unlike major pieces of equipment, such as vessels and furnaces, many measurement and control devices may be inspected and replaced or repaired, if necessary, while the process plant is in operation. In most cases the device will have to be blocked off, vented, and drained. These operations shall be attempted only by a person familiar with both the process and the safe handling of the equipment and fluids involved. Generally, operating personnel of the unit involved will handle this task. During such operations, knowledge of trouble symptoms is needed to determine if special precautions need to be taken, or if protective devices may be required. Fluids at elevated temperatures and toxic chemicals present particular problems. If a device is part of an automatic control system, the plant operator must be in a position to place that portion of the plant affected on manual control.

4.4.2 Precautions

During any inspection or calibration in classified areas, the area classification shall not be violated. Incorrectly classified test instruments shall not be used unless suitable safety permits have been obtained.

The person involved in the inspection and testing of instruments should also be alert to the hazards of handling mercury, which is used in some instruments and test equipment, and shall be aware of how to contain and dispose of mercury spills.

Devices used in dirty service (such as crude oil, slurry, bottoms, and the like) must be thoroughly cleaned before the inspection can be effective. Special care must be exercised in cleaning devices used in acid or caustic service.

4.4.3 Recommended tools

4.4.3.1 In addition to the common hand tools, such as; screwdrivers, assorted wrenches, and pliers, some necessary useful tools and test equipment for performing the inspection work are presented in Appendices A and B.

5. FLOW INSTRUMENTS

5.1 Description of Types

Industrial flowmeters are generally categorized based upon principle of operation. The more common categories include head or differential pressure meters, variable area meters, positive displacement meters, turbine or propeller meters, and vortex shedding meters. Components of each flowmeter can be classified as primary or in-line flow devices and secondary flow devices. Examples of primary devices are orifice plates, flow nozzles, and venturi tubes. Typical in-line devices are variable area meters, positive displacement meters, turbine meters, and vortex shedding meters. Secondary devices include differential pressure transmitters, bellows meters, and variable area transmitters.

5.2 Frequency and Time of Inspection

5.2.1 Most flow elements and in-line flow devices cannot be isolated from the process and shall be checked only when the line, in which they are mounted, is not in service. Exception is when orifice holders (senior type) are installed and allow removal and inspection of orifice plates without interrupting service or retractable vortex and pitot tube devices where inspection can be carried out with energised line.

5.2.2 When a flow element cannot be isolated from the process, only previous experience can be used to determine its general condition. Further detailed checks, measurements, calibrations, or repairs of such instruments shall be scheduled to be performed at the next shutdown of the plant.

5.2.3 Secondary devices, such as transmitters, recorders, and controllers, shall be checked for compatibility with their pertinent primary elements and for conformance with original designs, each time they are inspected.

Additional routine checks and calibrations by qualified personnel will depend upon the process requirements, plant practice, and previous experience.

5.2.4 Equipment that is remotely located, or that for some other reason is subjected to a complete inspection infrequently, shall be checked visually at regular intervals.

5.2.5 The routine inspection frequency for flow instruments shall be considered once per month initially. However, if a high degree of accuracy is required, the frequency may be increased accordingly or the inspection interval may be considered longer as determined by previous experience.

5.3 Methods of Inspection

5.3.1 Primary devices

5.3.1.1 Inspection of the primary elements requires careful measurement of orifice throats and critical points on flow nozzles or venturi tubes, and comparison with the original design dimensions. Pipe approaches to the primary element and the leads from the element to the first block valves shall be carefully cleaned of all foreign matter.

5.3.1.2 Costly units, such as flow nozzles and venturi tubes, can sometimes be corrected for even, smooth wear by recomputing the meter factor and making use of the measured element dimensions. This shall be done when throat wear increases the area dimensions from 0.2 to 1 percent depending upon the importance of the measurement. Before recomputing a meter factor, it is good practice to recheck other base meter data, such as viscosity, temperature, and pressure for the fluid being measured.

5.3.1.3 Orifice plates shall be inspected for sharpness and squareness of edges. When the sharp edge of an orifice becomes nicked or noticeably rounded, the plate shall be replaced or remachined and recomputed.

5.3.1.4 Pitot tubes in the various forms that are available shall be inspected on a regular basis to ensure there is no deterioration from the original installation.

5.3.1.5 For vortex instrument where formation of wax present in the fluid may cause erratic measurement, periodical inspection shall be carried out for indication of this wax formations.

5.3.2 In-line flow devices

5.3.2.1 Field inspection of positive displacement meters consists of observing register operation and visually inspecting for leakage. Strainers shall be checked for clogging or breakage, and air eliminators shall be checked for proper operation. Shop inspection consists of dismantling and inspecting component parts for binding, wear, erosion, corrosion, and dirt accumulations. All worn parts shall be replaced, since repair of parts is seldom economical or satisfactory. Calibration shall be made by comparison with a standard meter or by passing a measured volume through the meter to a calibrating tank or prover.

For process work, accuracy is usually held to 1 percent on the test run. Some of these instruments can be calibrated to within 0.1 percent or less, if required, and normally are so calibrated for custody transfer applications.

5.3.2.2 Inspection of variable area meters, turbine meters, and vortex meters usually consists of checking for fouling, wear, and binding of critical parts.

5.3.3 Secondary devices

5.3.3.1 Differential pressure devices are checked for plugged lead lines and accuracy of calibration. This is usually accomplished by means of water-column head tests.

5.3.3.2 Complete inspection of motion-producting devices usually consists of checking the meter bearing shaft for freedom of movement and proper lubrication, cleaning, and checking for mercury quantity and proper sealing (if required).

5.3.3.3 Normal inspection of the variable area meter secondary device consists of checking and calibrating the transmitter.

5.3.4 Orifice holders

5.3.4.1 When orifice holders (senior type) are installed for orifice plates, they shall be checked for openning and closing slide valve operation, and lubricant of the holder every thirty days, even if the orifice plate inspection is not required.

5.3.4.2 The orifice holders shall be checked according to the manufacturer recommended method and frequency of inspection.

6. LEVEL INSTRUMENTS

6.1 Description of Types

Level is measured by observing gage glasses, by sensing float buoyancy or position, and by observing head or differential pressure. Electronic devices employing the principles of sonic measurement or detecting changes in conductivity, capacitance, or nuclear phenomena are also commonly used. With the exception of gage glasses, which serve only to indicate level, most instruments may indicate, record, transmit, or control, in any combination, liquid-levels or liquid liquid interface levels in open and closed vessels.

6.2 Frequency and Time of Inspection

6.2.1 Level instruments installed within process vessels under pressure can be checked only when the vessels are not in operation. They shall be examined and the general condition noted as determined by previous experience. The need for further detailed checks, measurements, calibrations, or repairs may then be determined and accomplished at the next shutdown.

6.2.2 Gage glasses, external displacers, differential-head-type devices, and the like which can be isolated by means of block valves shall be visually inspected not less than once a year. More frequent inspection of these devices is needed only if extreme accuracy is required, if they are in severe service, or if they are essential to proper unit operation.

6.3 Methods of Inspection

6.3.1 General

Block valves and piping used with level instruments are discussed elsewhere in inspection standards. Valves and piping will be subject to pressure tests with other equipment, and any leaks or defects will usually be detected and eliminated.

6.3.2 Gage glasses

Glasses shall be inspected visually. Cracked glasses and those etched or sandblasted shall be replaced with the properly specified glass. The vendor's recommendations for torquing-up the bolts should be followed carefully to avoid stressing the glass. Check packing glands and valve seats (and ball checks, if used) in gage cocks.

6.3.3 Float tank gages

Float, cable, or tape seal (if used) as well as pulleys, may be inspected visually for defects. Binding or friction can be detected by manually bumping the gaging system and observing its operation.

6.3.4 Differential pressure instruments

The inspection procedure is the same as outlined for flowmeters (see 5.3.3).

6.3.5 Floats

Dismantle the unit and visually inspect the float, float shaft, bearings, and seals for defects. Check for binding or friction in seals.

6.3.6 Displacers

Dismantle the unit as required to visually inspect the displacer, torque tube, and bearings or flexure element for defects. Make sure the torque tube or flexure element is holding the displacer in proper suspension and that the displacer is not rubbing against the side of the case.

6.3.7 Electronic instruments

Most capacitance or conductivity probes and probe insulators must be free of deposits and dirt, and the probe must not touch any part of the vessel in which it is suspended. Relay action may be checked by shorting the probe to ground or by actually varying the liquid level in the vessel or piping. The manufacturer's literature generally outlines specific trouble-shooting and checking procedures and should be referred to, when inspecting the instrument.

6.3.8 Nuclear-type instruments

Nuclear-type instruments require a radioactive source mounted on a vessel or a line. These sources are a possible radiation hazard and shall be identified by suitable signs as prescribed by OSHA, or atomic energy agency regulations. Manufacturers' instruction manuals should be followed closely in checking nuclear-type instruments in order to prevent undue radiation exposure to personnel.

Only those individuals trained (and licensed, where necessary) in the handling of radioactive materials and cognizant of agency regulations should be permitted to work directly with the source of radiation. These individuals shall also be responsible for the radiation source and for measurement of radiation levels before work is performed in the immediate area by anyone. It is important that all Iranian Atomic Energy Regulation be observed in handling and testing radioactive devices.

7. TEMPERATURE INSTRUMENTS

7.1 Description of Types

Temperature measurements are usually made using thermocouple, resistance bulb, bimetallic, and filled system primary elements. Temperature instruments may indicate, record, control, or transmit, in any combination, by means of pneumatic or electronic systems.

7.2 Frequency and Time of Inspection

Primary devices are generally installed in wells so that they can be removed for inspection whenever they appear to be malfunctioning. In highly corrosive or erosive service, the well should be checked during each turnaround. The measuring instrument or secondary device usually can be inspected at any time without a shutdown.

7.3 Methods of Inspection

7.3.1 Visual inspection shall be made for mechanical defects, loose wires, moisture, and corrosion. Such items as missing thermocouple head and conduit covers shall be replaced. Accuracy checks shall be made by comparison with accepted standards. Thermocouple and resistance-bulb systems can usually be calibrated in place using portable electronic test equipment.

Bimetallic and filled primary element systems must usually be checked in a shop using a heated bath test unit.

7.3.2 Resistance bulbs, except when used for temperature-difference measurement, shall be accurate to within 0.5°C.

7.3.3 Thermocouple extension wires normally keep its original characteristics when used within recommended temperature limits, but thermocouples which are exposed to high temperature in various atmospheres may change characteristics. To avoid the continous use of thermocouples with excessive deviations from original characteristic due to such exposure or contamination, it is good practice to check the thermocouples at regular intervals.

The purpose of checking the installed thermocouple is not to determine its temperature EMF characteristics, but to determine the temperature error in actual service, this can most readily be done by temporary installing a new or checking thermocouple alongside the service thermocouple or in its place and comparing the readings.

Thermocouples that calibrate to within 1.5°C in the range of -20°C to 600°C are considered satisfactory for process work. Other primary elements shall be able to produce an accuracy of 1 percent of full-scale deflection of the secondary element.

8. PRESSURE INSTRUMENTS

8.1 Description of Types

Pressure measurements are made by using bourdon tube, diaphragm, and bellows-type primary elements. Gage pressure, differential pressure, absolute pressure, and vacuum can each be measured with variations of the basic primary elements.

Secondary devices may indicate, record, control, or transmit, in any combination, by means of pneumatic, electronic, or hydraulic systems.

8.2 Frequency and Time of Inspection

8.2.1 Primary devices are generally installed with block valves so that these instruments can be isolated from the process. Secondary indicating, recording, or controlling instruments can usually be isolated from the primary device. This allows the instrumentation to be inspected, maintained, and calibrated as necessary.

8.2.2 The frequency of inspection required to maintain an instrument's serviceability and calibration will generally be determined by experience. Instruments that are subjected to severe process operating conditions or that must be maintained at peak performance will probably require more frequent inspections.

8.2.3 Often the process impulse connections can be checked only during a plant shutdown. They should be inspected for evidence of plugging or corrosion.

8.3 Methods of Inspection

8.3.1 Pressure-measuring instruments and their connecting leads shall be inspected for leaks, distortion, vibration, plugging, and maintenance of seals. The racks, pinions, and linkages shall be inspected for excessive wear and misalignment. Cracked or distorted bourdon tubes, bellows, and diaphragms, as well as worn racks, pinion assemblies, clips, and linkages, shall be replaced. Broken glass shall be replaced in order to protect the instrument from corrosion, moisture, and dirt. Instruments with a range of more than 2.5 meter of water shall be checked on a dead-weight tester, with a mercury column, or by comparison with an indicating or recording test gage.

8.3.2 Indicating or recording test gages are frequently used as secondary standards, both in the shop and in the field, as a basis of comparison. In the field the test gage is connected to the same pressure as the service gage. This method of testing is often used when it is undesirable to remove the service gage from its mounting. Test gages shall be calibrated by the most accurate methods available. Wherever possible, maximum error shall be not more than 0.5 percent of the full-scale gage reading. Differential pressure bellows or diaphragm instruments shall be checked with a water column, using an air-loading system. Remote transmission receivers shall be calibrated as outlined in the manufacturer's service manuals.

8.3.3 Insofar as practical, the plant instrument workshop shall calibrate all pressure instruments to the accuracy of the manufacturer's guarantee before returning them to service, giving special attention to test gages and gages intended for critical service. Exact calibration should be obtained in the expected operating pressure.

9. RECEIVERS

9.1 Description of Types

Receivers most commonly used are analog indicators and recorders that are dedicated to one or more process variables. Usually, large case analog recorders are used in the field while miniature strip chart analog recorders are used in control panel displays.

Two or three pen trend recorders, which have the capability of selecting one variable per pen from a number of process variables, are sometimes used. Digital multipoint indicators are also used in many monitoring applications.

9.2 Frequency and Time of Inspection

Inspection of recorders and indicators is generally limited to observation of their performance on a day-to-day basis. Their construction often permits substituting spare components for faulty ones via plugin modules.

9.3 Methods of Inspection

Recorder chart drives shall be checked for time accuracy. Sprockets should engage the chart securely. Pens should be checked for proper inking and pressure on the chart. If circumstances permit, accuracy checks shall be made by comparison with proper standards.

10. AUTOMATIC CONTROLLERS

10.1 Description of Types

An automatic controller is a mechanism that measures or receives the value of a variable quantity of condition and corrects or limits the deviation of this measured value from a selected reference. an automatic controller includes both the measuring means and the controlling means.

10.1.1 Measuring means

The measuring means are those elements of an automatic controller involved in ascertaining and communicating to the controlling mechanism the value of the process variable. The effect produced by a deviation of the process variable may be a change of pressure, force, or position, or a change of electrical potential, resistance, or current. The measuring means of the automatic controller may indicate or record or may be a blind controller.

10.1.2 Controlling means

The controlling means are those elements of an automatic controller involved in producing a corrective action. The controlling means may be powered by a pneumatic, hydraulic, or electronic system.

10.2 Frequency and Time of Inspection

10.2.1 Inspection of automatic controllers requires both trained operating and instrument personnel to have a good understanding of the process and familiarity with the instrument.

10.2.2 Evaluation of control performance of the controllers shall be made each day unless the operating experience indicates longer frequency. Detailed checks, calibration, or maintenance shall be made either by operation request or during the shut-down period for overhaul of the plant.

10.2.3 Pneumatic controllers are reliable instruments and the only source of deterioration for these types of instruments is the supply air (must be clean and dry) and the surroundings atmosphere (therefore their case must be kept intact and tightly closed). Dirty and wet supply air has an adverse effect, since most pneumatic instruments are designed so that a nozzle bleed discharges within the case to purge the case interior. Despite the purge consideration of the pneumatic controllers, bad weathering and salt air will deteriorate the apparatus inside the case and possibly the piping connections thereto unless the materials are completely suitable for that specific environment. external visual inspection, as frequently as once a month, will usually be sufficient for maintenance planning and scheduling.

The inspector shall promptly report broken glass, defective doors or door gaskets, or other visual evidence that the case seal is unsatisfactory, since the internal mechanisms of pneumatic controllers may be seriously damaged by continued exposure to surrounding atmosphere.

Motion balance instruments require more frequent inspection than the force balance systems as motion of the levers can cause erosion at the bearings.

10.2.4 Inspection of electronic controllers shall be generally limited to observing their performance. The controller modular construction often permits substituting a plug-in circuit board or component in place of the faulty one.

10.2.5 Hydraulic controllers are ruggedly built and will give good results with infrequent attention. The visual inspection shall be performed for leakage of hydraulic fluid evidences once a month.

Annual inspection shall be performed for checking the contamination of hydraulic fluid and component deterioration specially the seals by qualified personnel unless operating experience indicates longer intervals of inspection.

10.3 Methods of Inspection

10.3.1 The inspection of automatic controllers is almost invariably visual. If the instrument is a recording controller, an examination of control record will usually reveal erratic controller performance. It should be emphasized that a poor control record does not necessarily indicate trouble with controller, but an investigation should be made for possible disturbances elsewhere in the process before any adjustments or repairs are made to the controller. Trouble may also be caused by faulty operation of the control valve resulting from excessive stuffing box friction, foreign material in the body of the valve, leaks in the air line, or other causes. Therefore, valve operation shall be checked before any work is performed on the controller instrument.

The adjustment of the controller modes settings require good knowledge of the process, usually the increase of proportional band will eliminate the controlled variable fluctuation and increase of reset or integral (repeat per minute) setting will decrease the off set between the measurement and set-point.

10.3.2 If no trouble is located outside the instrument, the behavior of the output signal with respect to the movement of the pen or pointer shall be observed which will usually reveal sluggishness or lost motion in the control mechanism if either is present.

11. TRANSMISSION SYSTEMS FOR MEASUREMENT AND CONTROL

11.1 Description of Types

11.1.1 Measurement transmission systems

Measurement transmission systems consist of lines connecting automatic controllers (usually mounted on a control panel) with locally mounted primary control elements and transmitters which may be pneumatic or electronic.

11.1.2 Control transmission systems

Control transmission systems consist of lines connecting automatic controllers to the locally mounted final control elements, which may be pneumatic or electronic.

11.2 Frequency and Time of Inspection

11.2.1 Problems can be encountered in pneumatic transmission systems as a result of component failure or leaks in the system.

The difficulty may appear as an erroneous instrument reading or no reading at all; or it may appear as instability or cycling of the measurement or controller, output or both. Properly installed pneumatic transmission lines that are protected against mechanical damage, damage from fire, or other abuses and that are constructed of suitably corrosion-resistant materials seldom fail in service.

11.2.2 Annual inspection of pneumatic transmission systems shall be performed unless operating experience indicates otherwise. If the presence of leaks is suspected, then pressure tests and other operational checks shall also be made during turnaround (overhaul) period.

11.2.3 Frequency and time of inspection of electrical transmission lines is the same as is covered under electrical systems 11.3.2, article 15 hereafter, and also in electrical inspection standard IPS-I-EL-215.

11.3 Method of Inspection

11.3.1 Pneumatic systems

11.3.1.1 Pneumatic measurement and control signal shall be in the range of 0.2-1 bar or within the range required for the operation of the equipment.

11.3.1.2 Transmission and control lines shall be inspected for continuity, tightness, leaks and plugging.

11.3.1.3 Tubing runs shall be checked for proximity to excessive heat source that might affect instrument performance.

11.3.1.4 If a more thorough inspection of pneumatic transmission lines necessitates an actual pressure testing, then procedures outlined in ISA RP7. 1 (pneumatic control circuit pressure test) shall be followed.

11.3.1.5 If a leak in a control line is suspected during operation of the unit, then its existence can be verified by putting the instrument in a sealed position (when seals are used) and noting the drop in the control valve air pressure.

11.3.2 Electrical systems

11.3.2.1 Electronic measurement and control signal shall be within 4-20 mA range for 2 wire systems.

11.3.2.2 Transmission and control lines shall be inspected for continuity, short, and ground.

11.3.2.3 Wire runs shall be checked for proximity to source of excessive heat or stray electrical fields which might affect the instrument performance and any physical damage to the insulation of the cables.

11.3.2.4 Electrical leads shall be inspected carefully in all cases where shielding and grounding are necessary for proper operation of the instrument.

11.3.2.5 The insulation megger test voltage shall be suitable for the system under test. Usually 500 V megger is used for pilot cables of on/off signals and OHM meters for signal wires, but this test voltage shall not, by any means, exceed the voltage specified of the cables.

12. SEALS, PURGES, AND WINTERIZING

12.1 Description of Types

12.1.1 Seals (liquid and mechanical)

12.1.1.1 Fluid seals consist of immiscible fluids that are nonreactive with the measured process fluid. Direct fluid seals (process fluid over seal fluid) are used when the seal fluid is heavier than the measured process fluid. Indirect fluid seals (process fluid under seal fluid) are used when the seal fluid is lighter than the measured process fluid.

12.1.1.2 Mechanical seals consist of metallic or non-metallic mechanical diaphragms in contact with the measured process fluid. They are connected to the instrument mechanism by means of filled system.

12.1.2 Purges

Purging is a pressurized fluid introduced into the process line at the primary element to prevent the process fluid from entering the instrument system. Therefore the purge media is selected of materials not harmful to the process or the instrument.

12.1.3 Winterization of instruments

Winterization of instruments and the instrument system is a preventive measure taken to ensure the proper functioning of instruments installed on equipment that handles process fluid that may be adversely affected by cold weather conditions. Cold weather may cause process fluids to freeze, congeal, or form hydrates within the instrument components or piping, or both.

Winterization is accomplished by one or a combination of the following methods:

1) Installation of instrument components in heated protection houses.
2) Use of steam jackets around instrument equipment.
3) Steam or electric tracing of instrument components or piping or both.
4) Use of integral heating elements within the instrument components.

Note:

In applications where, process fluid heating is applied for antifreeze of regulators, the inspection is similar to other instruments as mentioned herein.

12.2 Frequency and Time of Inspection

12.2.1 Liquid and mechanical seal systems

12.2.1.1 Routine preventive maintenance check procedures shall be arranged with desirable frequency determined by operating experience.

12.2.1.2 The suggested period for the above mentioned procedure is on annual basis for most instruments.

12.2.1.3 For very important process streams where material balance is critical or where the meter data are used for buying and selling, monthly intervals are recommended.

12.2.1.4 Filled-system mechanical diaphragm seals shall be inspected visually on an annual basis unless operating experience indicates otherwise.

12.2.2 Purge devices

12.2.2.1 Purge devices shall be inspected usually once a month for non-critical instruments.

12.2.2.2 Where instrument performance is adversely affected by loss of purge or hazardous condition may result in case of purge system deterioration, then daily inspection shall be considered.

12.2.3 Winterizing equipment

12.2.3.1 Since, proper functioning of the instrument system will depend on satisfactory condition of the winterization system, therefore, inspection of these systems shall be performed weekly during severe ambient conditions.

12.2.3.2 Inspection of winterization measures can be made concurrently with the inspection of the instrument systems in non-cold seasons of the year.

12.3 Methods of Inspection

12.3.1 Seals

12.3.1.1 Fluid seals shall be inspected for proper level of seal fluid in the pot.

12.3.1.2 Check shall be made to see that the process fluid (or the seal fluid) has not corroded the sealing pot and that the instrument lines between the primary and secondary elements slope continuously from the measured point to the instrument.

Pockets in such lines (resulted of accidental mechanical damages) are a common source of trouble and shall be removed immediately.

12.3.1.3 The valve in any sealing system shall be examined closely for leakage. Leaks in the packing around stuffing boxes in the valves of any sealing system are probably the greatest source of trouble in these type of equipment.

12.3.1.4 Mechanical seal systems shall be inspected for possible leaks. If the diaphragm seal assembly can be disconnected from the process, the diaphragms shall be inspected for cracks or other damages.

12.3.2 Purging

Purging system should be inspected to ensure that a continuous stream of purge medium is flowing at a constant rate through the lead lines. In the case of differential pressure instruments, the flow of purge medium shall be approximately equal and constant in each lead.

12.3.3 Winterizing

12.3.3.1 All steam-traced installations shall be checked for overheating, leaks or plugging in the steam lines, and for proper insulation.

12.3.3.2 Heat enclosures in winterizing systems shall be inspected for signs of deterioration from accidental physical abuse as well as from environmental conditions.

12.3.3.3 Steam traps on jacketing and tracing applications (if used) shall be checked for their performance.

12.3.3.4 Electrical trace systems panel box shall be checked for electrical failure periodically to detect the probable faults.

12.3.3.5 Thermostats (where furnished) shall be checked for proper setting and operation.

12.3.3.6 Insulation on winterizing systems (whether for heat conservation or for protection of personnel) shall be inspected for general physical condition as well as for firmness of attachment to the equipment or piping.

13. INSTRUMENT AIR-SUPPLY SYSTEMS

13.1 Description of Types

Instrument air-supply systems range from small systems for individual operating units to large control systems for serving more than one operating unit simultaneously. The number of users in any system, large or small, depends upon many factors which one of them is quality of the instrument air desired. Any number of variations can be found when comparing the instrument air supply systems of various refineries. For example:

1) Compressors can be electric motor driven or steam turbine driven type.
2) Compressor shall be non-lubricated oil free type.
3) Operating pressure levels vary to suit local conditions or preferences.
4) Sometimes, intermediate-pressure instrument air header systems are also employed.
5) Air driers may be heated or heatless types. They are detailed in instrument air system standard IPS-E-IN-200.

13.2 Frequency and Time of Inspection

13.2.1 Since working of pneumatic instruments depend on the quality of the air supply, it shall be clean, dry, and at a closely regulated pressure.

13.2.2 Observation of system pressure and oil or moisture content shall be done daily.

13.2.3 Inspection of the air system for anything more than visible faults shall be left to qualified expert personnel only.

13.2.4 A prewinter inspection shall be made to assure dryer operation at a sufficiently low dew-point to prevent freeze-ups.

13.2.5 Stand-by air supply source shall be checked monthly.

13.3 Methods of Inspection

13.3.1 Inspection of air-supply systems shall include checks of filters and associated equipment for leaks and for proper operation.

13.3.2 The oil and moisture content of the air shall also be checked to ensure that; it is not above the tolerable limits.

13.3.3 Receiver air sets and low points in the headers shall be blown-down regularly.

Air driers are usually supplied with dew-point indicators or dew-point detectors, they should be checked visually on daily basis.

Heatless drier changes from drying to regeneration cycle in about 10 to 15 minutes, for heater type this period is about 8 hours. The change over cycle should be checked daily for air driers.

13.3.4 Where stand-by or emergency sources of air supply are provided, they shall be checked for proper operation by simulating the failure mode of the main source.

13.3.5 Piping shall be inspected as outlined in the piping inspection standards.

14. HYDRAULIC-PRESSURE SYSTEMS

14.1 Description of Types

Hydraulic-pressure systems usually consist of storage drums and an accumulator to store the fluid under pressure, pumps to supply the pressure, and assorted relief valves and controls to assure satisfactory performance.

Larger control systems may also include a low-pressure storage drum and spare pumps for operation during emergency conditions.

14.2 Frequency and Time of Inspection

14.2.1 Although visual observation usually does not show any potential failure, but a drop in the hydraulic system pressure may be a hint of impending trouble which shall be checked regularly.

14.2.2 The proper functioning of hydraulic components depends upon the availability of clean, regulated oil supply at all times. therefore monthly checks shall be made on the system oil reservoir level unless experience determines less frequent intervals to be adequate.

14.3 Methods of Inspection

14.3.1 Inspection of the hydraulic system shall be performed by checking for leaks, proper operating pressures, and cleanliness and physical condition of the filter.

14.3.2 Where stand-by or emergency sources of hydraulic supply are provided, they shall be checked for proper operation by simulating a failure of the main source.

15. ELECTRIC POWER SYSTEMS FOR INSTRUMENTS

15.1 Description of Types

15.1.1 Instruments that require electric power are normally connected to the plant power system. Many plants are also equipped with stand-by electrical power supplies for instrument circuits and for certain lighting circuits.

15.1.2 Some instruments commonly supplied from uninterruptable power supplies are computer installations, electronic instruments, flame safety instruments, and protective and shutdown devices.

15.1.3 Alternate power supplies can be standby generators, batteries, or other suitable devices arranged to cut in either automatically or manually.

15.1.4 Sources of descriptive information on power supply systems may be referred in API RP-540 and API RP-550, Part I, Section 11 or API, "Guide for Inspection of Refinery Equipment", Chapter XIV.

15.2 Frequency and Time of Inspection

15.2.1 Generally each manufacturer has his own special requirements for inspection of his equipment. Therefore, the manufacturer's literature shall be consulted for recommendations concerning frequency and time of inspection.

15.2.2 Standby electrical power supplies shall be inspected as frequently as the regular systems. In addition, the alternate power supply systems shall be operated at best once per month by simulating faults in the main supply systems.

Obviously, such tests shall be conducted carefully to minimize the possibility of plant upsets.

15.3 Methods of Inspection

15.3.1 Electrical power supply systems shall be checked for shorts, grounds, loose connections, damaged insulation, and corroded conduits to ensure that they are adequately protected against mechanical damages.

15.3.2 The operation of the system shall be checked to determine that it is at the proper frequency and voltage level and that the voltage regulation is within the limits required by the instruments that the system supplies the power.

15.3.3 Where standby or emergency source of power are provided, they shall be checked as carefully as the main source and, in addition, shall be checked for proper operation by simulating a failure of the main source.

16. INSTRUMENT PANELS

16.1 Description of Types

The purpose of an instrument panel is to enable operating personnel to maintain efficient and safe performance of the unit from a control location. There are three major types of instrument panels; conventional, semigraphic, and console type. Each of these types of panels can be electronic, pneumatic or a mixture of these two technologies. Panels have their piping and wiring for instruments behind the panel. For additional information, refer to API RP-550, Part I, Section 12.

16.2 Frequency and Time of Inspection

Generally, instrument panels and associated equipment are inspected by operating and instrument personnel in the course of their normal activities on a daily basis.

16.3 Methods of Inspection

16.3.1 Generally, any inspection of panelboards is primarily concerned with the piping and wiring of air or electric power and transmission leads to the individual instruments mounted on the panel. These leads shall be checked for leaks, shorts, grounds, or loose connections.

16.3.2 The main electrical ground on the panel shall be checked for tightness and proper installation.

16.3.3 Individual instrument mountings shall be checked for rigidity. Reference may be made to API RP-550, Part I, Section 7. (Transmission System).

17. ANALYZERS AND SAMPLING SYSTEMS

17.1 Description of Types

Analyzers and their pertinent sampling systems vary in complexity according to their application and they are two distinct subjects. Each could be treated in a very lengthy manner but however, to be practical, only some of the more important points will be discussed here.

17.1.1 Analyzers

An analyzer is a device that performs an analysis (chemical or otherwise) for some components in a stream (for example, oxygen in flue gas) or for some characteristic of a product or component (for example, initial boiling point or end point).

Analyzers can be simple, as in the case of a gas gravity meter wherein the gravity is determined either as a function of displacement of the fluid or as a function of fan motor torque. They can also be complicated, as in the case of a chromatograph or a distillation analyzer, which are actually complete systems in themselves. The analyzer manufacturer’s instruction manual shall be consulted for a complete description of the unit under consideration.

17.1.2 Sampling system

Sampling systems are an important part of any analyzing system mainly governing the success of analyzing process.

The sampling system may be only a piece of pipe or tubing bringing the process material to the analyzer, in their simplest form.

However, the sample must be conditioned before admitted to the analyzer in many cases. Pressure regulators, coolers, heaters, scrubbers, pumps, filters, and flow regulators are some of the items required in various sampling systems. For description of the type of sampling system furnished for each application, the manufacturer’s literature should be consulted. (Reference may be made to API RP-550, Part II).

17.2 Frequency and Time of Inspection

17.2.1 Proper maintenance of analyzers and sample system is extremely critical from a performance and reliability stand point and shall be handled only by thoroughly trained personnel because of their complicated nature.

17.2.2 Careful execution of maintenance and inspection by trained personnel is recommended since there are hazards due to the presence of combustible and dangerous materials.

17.2.3 The inspection frequency shall be considered to be daily unless experience dictates less frequently inspections.

17.3 Methods of Inspection

17.3.1 The proper operation of any analyzer depends upon the proper operation of its sampling system. Therefore, the sample system shall be checked for leaks and loose connections and a constant supply of air, water, or steam as required.

The sample system shall be checked to ensure that a continual flow of sample is delivered to the analyzer at the required operating pressure and temperature.

17.3.2 The analyzer shall be cleaned and serviced in accordance with manufacturer's recommendations as well as with methods learned through operating experience. For inspection of associated recording mechanisms, refer to article 9 herein.

18. ALARMS AND PROTECTIVE SYSTEMS

18.1 Description of Types

18.1.1 General

Because of the large number of process variables and equipment conditions that are measured or monitored in a plant, it is not always possible to keep them all under surveillance.

Consequently, alarms are provided to notify operators in the event that the more critical measurements exceed predetermined limits. If the alarm condition requires prompt action, the detection circuit is usually connected to a protective system which will automatically shut-down or start-up equipment to prevent damage, hazard, or loss of product.

Alarms or protective systems are actuated by the deviation of certain measured variables beyond accepted limits. The actuation can be initiated in a number of different ways. A recorder or indicator may cause a switch to be tripped because of the position of its pen or pointer.

Transmitter can activate the system by appropriate current switches or pneumatic pressure switches connected to their output or in the DCS controller function. Other systems are actuated by switches connected directly to the process.

18.1.2 Alarms

Alarms are usually announced audible or visual or both. The audible alarm can be a horn, buzzer, or similar device capable of creating a noise to attract the operator's attention.

Visual alarms take the form of steady or flashing lights mounted either individually or in groups. It is common practice to have the audible and visual alarms announcement actuated simultaneously.

18.1.3 Protective systems

The function of a protective system is to recognize a condition that may become hazardous and to act to eliminate the condition before it can cause injury to personnel or damage to equipment or the environment. In some cases the potential loss of product may justify a protective system.

Protective systems vary in design according to their application. Many systems employ valves that fully close or fully open to block or divert flow or pressure from the process. Other systems may shutdown or start up motors associated with pumps, compressors, conveyors, and so forth to ensure return to the safe conditions. Some common protective systems in the plants are; Burner Management Systems, Fire and Gas Panels, Emergency Shut-Down Systems.

18.2 Frequency and Time of Inspection

18.2.1 Inspection of alarm and protective devices shall be made at least once at each shut-down or every 6 months, whichever comes first.

18.2.2 Alarm lights shall be checked once per each shift.

18.2.3 Important level switches such as compressor knock-out drum, boiler steam drums, etc. shall be inspected once a week.

18.2.4 Because the consequence of failure of an alarm and shutdown system vary from unit to unit and plant to plant, it is recommended that each system be studied carefully for the risks involved and a suitable inspection interval developed accordingly.

18.3 Methods of Inspection

18.3.1 General

18.3.1.1 Inspection of alarm devices such as signal lights and howlers,consists of checking for shorts, grounds, loose connections, damaged insulation, and corroded conduits. Alarms not housed in explosion-proof or hermetically sealed containers shall also be checked to ensure that all relays are clean and dust-free. Any pitted or burned contact points shall be replaced.

18.3.1.2 Protective systems may be electrical, pneumatic, mechanical, hydraulic, or a combination thereof. Inspection of electrical emergency devices shall be the same as for the aforementioned alarms. Other emergency devices shall be inspected for leaks, freedom of movement of all moving parts, proper air or hydraulic supply pressure, and operating voltages.

18.3.2 Alarms

18.3.2.1 The best method of checking alarms is through simulated operation of the alarm sensors, by means of control panel terminals.

18.3.2.2 When the alarm sensor is a contact in an instrument, or is operated by the transmission medium, ranging of the instrument is a convenient way of verifying the alarm points.

18.3.2.3 Pressure switches in pneumatic lines can be disconnected and calibrated with air from another source.

18.3.2.4 Independent actuating devices such as; level switches, can often be piped so that they can be flooded or drained to simulate alarm conditions.

18.3.3 Protective systems

18.3.3.1 The best method of checking protective systems is through simulated operation of the entire system. A means of periodically checking while the process unit is operating should be provided.

18.3.3.2 When an actual shutdown cannot be tolerated during the test, some provisions must be made temporarily to prevent the final device (valve, motor, starter) from performing the shutdown function. In the case of shut off valves, a piping bypass with a car-sealed closed valve may be employed to ensure that the bypass valve is not inadvertently left open to nullify the whole system.

As a further precaution, a limit switch can be mounted on the bypass valve to operate a signal light as soon as the valve is cracked open. This light could be located in the instrument panel and could be colored or flashing to alert the operator that the protective system is bypassed.

18.3.3.3 Where a motor control circuit is involved, an electrical bypass system is recommended. Keylock switches or switch locations which discourage tampering shall be used in this application. A panel-mounted light is required, indicating that the protective circuit is bypassed. In the case of normally de-energized systems, it is recommended to locate the bypass switch as close to the motor starter as possible to assure a check on the transmission lines.

18.3.3.4 The actual system checks shall be performed through simulated operation of the sensors. The method outlined in API RP-14C Table D2 can be used to verify sensor trip points. At the same time, all other components of the system through the final device shall be observed for proper operation.

19. DCS AND DIGITAL EQUIPMENT

19.1 Description of Types

The term digital equipment is generally applied to electronic measurement, computing, and/or control devices and systems that function using discrete signal pulses. Digital systems are usually composed of a number of separate components including a central processing unit connected to peripheral units required for input and output signal conditioning and for operator interfacing. Examples of devices or systems that can be included in this category are digital computers, distributed control systems, programmable logic controllers, and microprocessor based systems.

19.2 Frequency and Time of Inspection

19.2.1 Because of the complex and highly specialized nature of most digital equipment, inspection shall normally be handled by thoroughly trained personnel. Those not familiar with the design, operation, maintenance, and function of this type of equipment should restrict their inspections to the visual methods listed in 19.3. These inspections can normally be made at frequent intervals such as daily or weekly.

19.2.2 The more detailed inspection methods normally handled by specially trained personnel should be made at intervals recommended by vendors or established through operating experience. For example, selected diagnostic routines can be run as frequently as is practical during the early stages of system operation. By evaluating system performance and results obtained from running the diagnostics, a more realistic interval can then be established for that inspection method. A similar procedure shall be followed to establish an inspection frequency for each of the other methods suggested in 19.3.

19.3 Methods of Inspection

19.3.1 Many meaningful checks of digital systems can be made by visual observation while the equipment is in operation. Doors and covers should be inspected to ensure that they are properly secured, and ventilating fans and filters shall be inspected to verify that they are operating and are in good condition. Interconnecting cables and the equipment grounding system shall be inspected for external physical damage and for loose connectors. Components throughout the system shall also be checked for dust accumulations and for indications of corrosion damage.

19.3.2 The environment in the digital equipment room shall be measured to ensure that temperature, humidity, vibration, and the amount of dust and corrosive vapors in the air are within acceptable limits. Internal equipment temperatures shall also be checked to assure that they are within the manufacturer's specifications.

19.3.3 A digital equipment inspection program shall include other checks that are of a more specialized nature. Units composed of plug-in components shall be inspected for loose cards and connectors, and voltage level of power supplies shall be checked. Backup or redundant systems and devices shall also be tested.

Most systems contain routine analog-to-digital converter checks which shall be observed for indications of converter malfunction. Card status indicators, when provided with the system, shall also be observed for failure signals. Many systems include some level of self-diagnostic routines which can be run to test the system and/or peripherals. It is usually practical to use certain of these routines within the inspection program.

19.3.4 Vendor-supplied information shall be considered to supplement the recommendations outlined above. This information will usually outline additional checks which shall be included in the inspection program.

20. CONTROL VALVES AND POSITIONERS

20.1 Description of Types

20.1.1 Control valves

Control valves are available in a variety of sizes, body designs, and actuator types. The type of control valve selected for a particular application depends upon the process requirements. Some of the more common types used in petroleum industries applications are globe valves, butterfly valves, ball valves, and eccentric spherical plug valves, each usually equipped with pneumatic diaphragm or piston actuators.

20.1.2 Valve positioners

20.1.2.1 Valve positioners encountered in petroleum industry fall into the following categories:

1) Pneumatic.
2) Electro-pneumatic.
3) Electronic-hydraulic.
4) Pneumatic-hydraulic.

20.1.2.2 Pneumatic positioners are furnished either as side-mounted accessory items or built onto or into the control valve itself. When furnished as accessory items, they can be provided with bypasses in some models that allow a controller to operate its control valve directly while the positioner is inspected or serviced, or both. This feature is not always available if a positioner is used to characterize valve position to input (other than linear) or is a double acting design used with a piston actuator.

20.1.2.3 Electropneumatic valve positioners combine the functions of electric-to-pneumatic converter and pneumatic valve positioners. These are available in side-mounted styles and in styles built into the top diaphragm case of the control valve. Most electropneumatic positioners do not incorporate bypass valves.

20.1.2.4 Pneumatic-hydraulic valve positioners are usually installed in combination with hydraulic valve actuators where the large force capability of a hydraulic system is required to operate large valves or dampers in accordance with the signals from pneumatic controllers. Catalyst slide valves on fluid catalytic-cracking units are frequently actuated by a pneumatic-hydraulic positioner and actuator.

20.2 Frequency and Time of Inspection

20.2.1 Control valves

20.2.1.1 Control valves are frequently installed with block and bypass valves for isolation. This permits repair or replacement without process shutdown. Where this is done, an inspection can be made during operation without seriously affecting the process. When isolating valves are not provided, the portion of the valve exposed to the process stream can be checked only when the process equipment has been prepared for opening.

20.2.1.2 Factors that affect inspection frequency are:

1) Erosiveness of the flowing stream.
2) Corrosiveness of the flowing stream.
3) High-pressure drop.
4) Extreme ambient temperatures at the valve operator.
5) Abnormal vibration.

The severity of these factors, the construction materials used in the valve, operating requirements, and experience in the particular service should govern the frequency of inspection.

20.2.1.3 The frequency range of inspection shall be considered from once a week for highly erosive or corrosive services to once every 5 years for mild services. Until a pattern develops, it is good practice to inspect the control valves at least once a year.

20.2.2 Valve positioners

Valve positioners generally require infrequent inspections. The initial adjustment, either at the time of installation or after servicing the control valves, will usually ensure good results for a long period of time. If malfunctioning does occur, it will probably be due to mechanical damage or excessive vibration. A good practice is to inspect the valve positioner when the control valve is inspected.

20.3 Methods of Inspection

20.3.1 Control valves

Control valves shall be examined visually for leaks on the packing glands and valve body and for general packing conditions. The valve actuator shall be inspected for travel, action, and wear. The valve body, stem, and inner valve shall be inspected for wear, corrosion, or erosion. The wall thickness of the valve body shall be checked at several points, and the measurements shall be compared with the original values to determine losses resulting from wear, for corrosive and erosive services.

20.3.2 Valve positioners

20.3.2.1 Valve positioners shall be checked for leakage and plugging in the air circuit, for grounds, shorts, and loose connections in the electric circuits, and for wear or failure of mechanical parts, including gages. In the force-balance type of valve positioner, particular attention must be given to the rigidity of the connection between the valve stem and the valve positioner.

20.3.2.2 The action of the valve positioner shall be checked. The full travel of the valve shall correspond to the full range of the actuating medium as delivered by the controlling instrument. A check shall be made to ensure that the valve stem starts to move at the lowest specified signal delivered by the control instrument and that the valve completes its travel at the highest signal delivered by the control instrument. Any deviation from these conditions, unless specifically mentioned in the valve specifications, should be considered the result of possible defects. All defective parts shall be replaced. Leaking connections shall be tightened or replaced. The valve positioner shall be adjusted so that valve travel corresponds to the signal range of the control instrument.

20.3.2.3 Hydraulic positioners should assume a definite position for each value of the control signal applied by the controlling instrument. The pilot shall be cleaned of foreign matter and examined for wear. The large, main hydraulic piston member shall be examined for piston leakage and wear when unsatisfactory performance indicates wear. Worn parts shall be replaced.

21. MOTOR OPERATED VALVES

21.1 Inspection Requirements

21.1.1 All limit switches' compartments shall be inspected to be clean and dry with no dust on the limit switch contacts.

21.1.2 Geared limit switch and torque switch contacts shall be cleaned by means of suitable contact cleaner on a lint-free cloth.

21.1.3 The valve stem shall be clean and properly lubricated, there shall be no grease weeping around shaft seals.

21.2 Frequency and Time of Lubrication Inspection

21.2.1 General

The frequency of lubrication inspection shall be based upon historical data on installed equipment. Every MOV operator application has its own effect on lubricants and each facility will pattern its inspection around its particular needs. The following schedule of lubrication inspection should be followed untill the operating experience indicates otherwise.

21.2.2 Main gear case

Lubrication shall be inspected every 18 months. The grease fitting in the housing cover shall be lubricated at the same time.

21.2.3 Geared limit switch

These limit switches shall be inspected every 36 months.

21.3 Lubrication Inspection Procedures

The three primary consideration in a lubrication inspection are:

quantity;
quality;
consistency.

These consideration are more explained hereunder.

21.3.1 Quantity

The level quantity of oil content parts shall be checked by the "fill"and "drain" plugs provided on the operator housing.

21.3.2 Quality

A small amount of lube oil shall be removed from the "fill" or "drain" plug when plugs are removed for level inspection. This sample shall be inspected to ensure that it is clean and free of any contaminate including water. Should dirt,water,or other foreign matter be found, the units shall be flushed with a commercial degreaser/ cleaner which is non-corrosive and does not affect seal materials and the unit shall be repacked with fresh vendor recommended lubricants.

21.3.3 Consistency

The consistency of the lubricating oil shall also be inspected to conform to the original fluid consistency.

22. MISCELLANEOUS INSTRUMENTS

22.1 Description of Types

There are many devices not discussed in this standard specification. Examples of some of the more common types are:

1) Speed indicators, recorders, and governors.
2) Electrical voltmeters, ammeters, frequency meters, and wattmeters.
3) Time indicators, running time meters, and cycle or program timers.
4) All types of monitors and detectors
5) Line break valve system
6) Surface and subsurface safety valve wellhead panels.

22.2 Frequency and Time of Inspection

22.2.1 Most miscellaneous devices do not require frequent inspection. Visual inspection can be made as often as the instruments are used or read. Inspection of mechanical elements for wear or corrosion can be accomplished at a turnaround. Inspection that includes calibration, such as inspection of electrical meters, speed instruments, and spring-operated timing devices, shall be performed once a year or the first time the equipment can be taken out of service after a year of operation.

22.2.2 After the initial inspection, the frequency of inspection depends upon the service, the manufacturer's recommendations, and past experience.

22.3 Methods of Inspection

22.3.1 In general, miscellaneous equipment, such as cycle or program timers, electrical meters, or speed controllers, consists of various mechanical, electrical, or pneumatic components or any combination thereof. The inspection procedures, therefore, are generally concerned with checking for any leaks, shorts, grounds, loose connections, or friction between moving parts. This type of equipment is usually adversely affected by dust, high temperatures, and humidity. Care shall be taken to see that all open contacts are clean and free from pitting or corrosion. It is usually possible to check this type of equipment without adversely affecting its normal operation.

23. RECORDS AND REPORTS

23.1 Records

23.1.1 General

Inspection records are important because they serve as a basis for a scheduled maintenance program. Their value, however, depends upon whether the information recorded is useful and sufficiently complete to determine maintenance requirements. Files with meaningless data serve no useful purpose. Therefore, judgment must be exercised in deciding the type and amount of detail requested in record forms.

23.1.2 Instrumentation record system

23.1.2.1 Record forms will vary somewhat with each type of instrument involved. For example, with a pressure gage, it would be of little value to record anything more than the size, range, service, location, and frequency of replacement. On the other hand, the record for a flowmeter should contain a full description of installation, including the primary device, line size, type of taps, serial number, and model numbers of the various components which make up the metering system. In addition, this record shall include notations of parts used, major repairs made, and comments concerning unusual problems which affect the reliability of the measuring system.

23.1.2.2 A complete record file may contain four types of records, namely:

1) Basic data.
2) Continuous record.
3) Loop diagram.
4) Field notes

Basic data shall include item number, manufacturer's serial number, model number, and all technical data necessary to determine the function and physical description of the equipment. These data, together with the manufacturer's drawings and instruction sheets, complete a permanent record file.

23.1.2.3 The continuous record shall include a history of all inspections performed on the equipment, the date and type of inspections performed, repairs made, materials used, and any other pertinent information helpful in determining future inspection requirements and equipment retirement.

23.1.2.4 Loop diagrams shall be complete enough so that any-one with this information alone would be able to understand how one part of the system affects and is affected by the remainder of the system. In some cases, the loop diagram will be simple, consisting of only a few symbols. Other cases will require several loops to explain fully the overall operation.

23.1.2.5 Field notes are taken by the inspector in the field concerning measurements, conditions as found, repairs made, and parts replaced. A method of retaining such data is to issue a loop diagram or sketch of the installation that contains all pertinent information concerning the inspection scope and procedures. This sketch or diagram would also contain space for the inspector's notes.

23.2 Reports

Upon concluding an inspection, it is desirable to make a report covering the inspection results, the work performed, and any recommendations for future repairs or replacements. This report shall be sent to appropriate departments for their information and necessary action.

23.3 Sample Record and Report System

Basic data include item number, manufacturer's serial number, model number, and all technical data necessary to determine the function and physical description of the equipment. These data together with the manufacturer's drawings and instruction sheets, complete a permanent record file. A sample permanent record file is presented in Appendix C for flow instruments.

24. TEST EQUIPMENT REQUIREMENTS

24.1 Instruments

24.1.1 Inspection and control equipment is usually small and rather complicated mechanically or electrically. Reliability and precision are of prime importance. The particular problems associated with measurement and control devices stem from the fact that such equipment operates under the influence of forces and movements of small magnitude.

Delicate parts, small clearances, and general complexity make the inspection and repair of such devices a special problem. Many of the tools required for inspection come under the definition of test equipment.

24.1.2 In addition to the common handtools (screwdrivers, assorted wrenches, and pliers), other useful tools and test equipment are listed in Appendices A and B.

APPENDICES

APPENDIX A
TEST EQUIPMENT REQUIRED FOR INSPECTION OF INSTRUMENTS

1 Test gages (Ranges, as required. Accuracy of 0.25 percent of the full scale range).

2 Deadweight tester and/or comparator gage tester.

3 Hydraulic pressure pump.

4 Voltmeter/ohmmeter (digital and analog).

5 Temperature test bath.

6 Digital calibrator.

7 Reference cells to simulate ice-point reference for temperature instruments.

8 Loop calibrator that can measure, generate, and simulate analog control signals.

9 Manometer with a calibrated scale covering a range from 0 to 1000 millimeter of H_20.

10 Pressure regulators adjustable over a range from 0 to 3.5 barg.

11 Pneumatic calibrator.

12 Pulse generator.

13 Precision glass stem thermometers (Range as required).

14 RTD with digital read-out.

15 Ultraviolet light source.

16 Oscilloscope.

17 Digital probe.

18 Differential voltmeter.

19 Signal generator.

20 Frequency meter (with required range).

21 Impedance and resistance measuring bridge.

22 Capacitance bridge.

23 Potentiometer

24 Infra-red pyrometer

25 Portable vibrometer

26 Vacuum test equipment

APPENDIX B

TABLE 1 - INSPECTION TOOLS AND TEST EQUIPMENT FOR FLOW METERS

TYPE OF METER	TOOLS AND TEST EQUIPMENT
HEAD METER	**1)** MACHINIST'S INSIDE MICROMETERS
	2) PORTABLE MANOMETER CALIBRATED UP TO 1250 mm. H_20
	3) PORATABLE MERCURY MANOMETER WITH SCALE MARKED TO READ MILLIMETER OF H_20 (UP TO 12500 mm-H_20)
	4) PORTABLE MERCURY MANOMETER MARKED TO READ 0.2 TO 1.0 barg OR A PRECISION TEST GAGE OF THE SAME RANGE
	5) PERMANENTLY MOUNTED SHOP MANOMETER CALIBRATED UP TO 12500 mm-H_20
	6) PERMANENTLY MOUNTED SHOP MANOMETER CALIBRATED FROM 0.2 TO 1 barg
	7) SEAL FLUID PUMP
	8) PRECISION AIR REGULATOR
	9) PRECISION PORTABLE PRESSURE GAGES OF VARIOUS RANGES
ROTAMETER (1)	**1)** PRECISION COMPARISON ROTAMETERS FOR CALIBRATING SMALL ROTAMETERS, OR WEIGH-TYPE TANKS FOR CALIBRATION OF HIGHER VOLUME ROTAMETERS'
POSITIVE DISPLACEMENT(2) AND TURBINE METERS	**1)** PRECISION-CALIBRATED VOLUME TANKS, VOLUMETRIC PIPE PROVER(3), AND/OR STANDARD (CALIBRATED) METER
	2) STOPWATCH
	3) CLEARANCE GAGES

Notes:

1) Calibration of rotameters may also be made with air through the use of a volumetric flow prover tank.

2) Refer to API Standard 1101 and Manual of Petroleum Measurement Standards, Chapter 5.3.

3) In custody transfer applications, volumetric provers should be used to prove at normal operating pressure and temperature and with normal process fluid. Where pipe provers are used, an electronic counter is necessary.

TABLE 2 - INSPECTION TOOLS AND TEST EQUIPMENT FOR PRESSURE INSTRUMENTS

TYPES OF INSTRUMENTS	TOOLS AND TEST EQUIPMENT
MANOMETER, DIAPHRAGM, SPIRAL TUBE, HELICAL TUBE, AND BOURDON TUBE	**1)** DEAD WEIGHT TESTERS
	2) CALIBRATED TEST GAGES
	3) VACUUM TEST EQUIPMENT
	4) WATER AND MERCURY MANOMETERS
	5) POINTER PULLERS AND SET
	6) COMPARISON TESTERS

(to be continued)

APPENDIX B (continued)

TABLE 3 - INSPECTION TOOLS AND TEST EQUIPMENT FOR TEMPERATURE INSTRUMENTS

TYPES OF INSTRUMENTS	TOOLS AND TEST EQUIPMENT
FILLED-SYSTEM AND BIMETAL INSTRUMENTS	TEMPERATURE TEST BATHS
RESISTANCE ELEMENT	TEST THERMOMETER OR TEST BATHS, RESISTANCE BOX AND VOLT-OHMMETER, OR PRECISION CALIBRATOR
THERMOCOUPLE	TEST THERMOCOUPLE, TEST POTENTIOMETER
RADIATION PYROMETER	TEST POTENTIOMETER, MUFFLE FURNACE

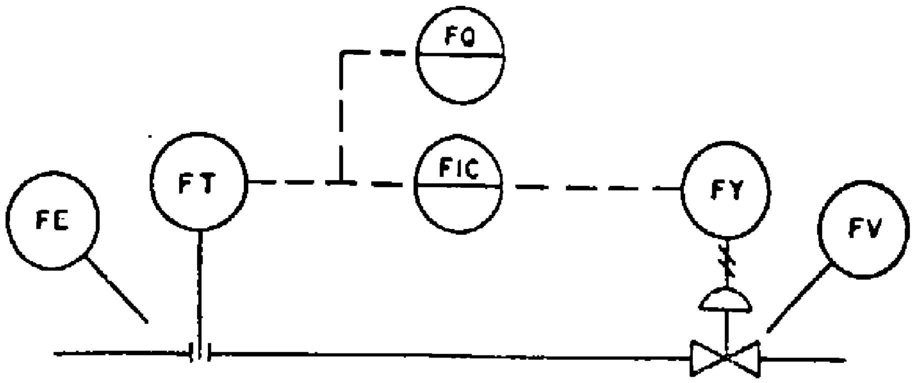
TABLE 4 - INSPECTION TOOLS AND TEST EQUIPMENT FOR LEVEL-MEASURING INSTRUMENTS

TYPES OF INSTRUMENTS	TOOLS AND TEST EQUIPMENT
FLOAT OR DISPLACER	STRAIGHT SPRING SCALE (FISH-WEIGHING TYPE)
	MERCURY MANOMETERS
HEAD OR DIFFERENTIAL	(SEE TABLES 1 AND 2)

TABLE 5 - INSPECTION TOOLS AND TEST EQUIPMENT FOR ELECTRONIC AND ANALYTICAL INSTRUMENTS

1) SPARE ELECTRONIC PARTS AND CIRCUIT BOARDS	**9)** CAPACITANCE BRIDGE
2) VOLT-OHMMETER (DIGITAL OR ANALOG)	**10)** PORTABLE POTENTIOMETER
3) DIFFERENTIAL VOLTMETER	**11)** PORTABLE POWER SUPPLY
4) OSCILLOSCOPE	**12)** ANALOG SIMULATOR (DIRECT CURRENT)
5) FREQUENCY SIGNAL GENERATOR	**13)** MAGNETIC FLOW SIGNAL SIMULATOR
6) FREQUENCY METER	**14)** MILLIAMMETER (DIRECT CURRENT)
7) IMPEDANCE MEASURING BRIDGE	**15)** HAND-OPERATED MEGGER
8) RESISTANCE BRIDGE	**16)** SOLDERING AND SOLDERING VACUUM SUCKER GUN
	17) LOGIC PROBE

APPENDIX C
FLOW INSTRUMENTS INSPECTION RECORD SAMPLE CARD FORM



DESCRIPTION OF INSTALLATION

Flow control consisting of orifice plate and transmitter, panel board mounted electronic controller, panel-board mounted flow totalizer integrator, current to pneumatic transducer and control valve.

TAG No.	ITEM	LINE SIZE	MODEL No.	SERIAL No.	MANUFACTURER	RECORD No.
FE-	ORIFICE PLATE ELEMENT					
FT-	Δ P FLOW TRANSMITTER					
FQ-	TOTALIZER INTEGRATOR					
FIC-	ELECTRONIC CONTROLLER					
FY-	I/P CONVERTER					
FV-	CONTROL VALVE					

Unit : Test interval:

Element Specifications:
Transmitter Specifications:
Control Valve Specifications:
Controller Specifications:
Other Instruments Specification:

(to be continued)

APPENDIX C (continued)

HISTORICAL RECORDS FORMS

ELEMENT

DATE TESTED	CONDITION	REPAIRS PERFORMED	PARTS USED	REMARKS

TRANSMITTER

DATE TESTED	CONDITION	CALIBRATION PERFORMED	REPAIRS PERFORMED	PARTS USED	REMARKS

(to be continued)

APPENDIX C (continued)

HISTORICAL RECORD FORMS

CACULATING RELAY

DATE TESTED	CONDITION	CALIBRATION PERFORMED	REPAIRS PERFORMED	PARTS USED	REMARKS

CONTROLLER

DATE TESTED	CONDITION	REPAIRS PERFORMED	PARTS USED	REMARKS

(to be continued)

APPENDIX C (continued)

HISTORICAL RECORD FORMS

I/P CONVERTER

DATE TESTED	CONDITION	CALIBRATION PERFORMED	REPAIRS PERFORMED	PARTS USED	REMARKS

CONTROL VALVE

DATE TESTED	CONDITION	REPAIRS PERFORMED	PARTS USED	REMARKS