PIP PCCLI001
Level Measurement Design Criteria
PURPOSE AND USE OF PROCESS INDUSTRY PRACTICES

In an effort to minimize the cost of process industry facilities, this Practice has been prepared from the technical requirements in the existing standards of major industrial users, contractors, or standards organizations. By harmonizing these technical requirements into a single set of Practices, administrative, application, and engineering costs to both the purchaser and the manufacturer should be reduced. While this Practice is expected to incorporate the majority of requirements of most users, individual applications may involve requirements that will be appended to and take precedence over this Practice. Determinations concerning fitness for purpose and particular matters or application of the Practice to particular project or engineering situations should not be made solely on information contained in these materials. The use of trade names from time to time should not be viewed as an expression of preference but rather recognized as normal usage in the trade. Other brands having the same specifications are equally correct and may be substituted for those named. All Practices or guidelines are intended to be consistent with applicable laws and regulations including OSHA requirements. To the extent these Practices or guidelines should conflict with OSHA or other applicable laws or regulations, such laws or regulations must be followed. Consult an appropriate professional before applying or acting on any material contained in or suggested by the Practice.

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1. **Scope**

This Practice provides requirements criteria for level measurement equipment selection and for the design of level measurement systems. This Practice describes the design requirements for differential pressure, radar, ultrasonic, displacement, capacitance, nuclear level measurement systems and switches for level gauges. This Practice does not include requirements for tank gauging systems or weighing systems.

2. **References**

Applicable parts of the following Practices, industry codes and standards, and references shall be considered an integral part of this Practice. The edition in effect on the date of contract award shall be used, except as otherwise noted. Short titles are used herein where appropriate.

   2.1 **Process Industry Practices (PIP)**
      
      – PIP PCCEL001 - *Instrumentation Electrical Requirements*
      – PIP PCCGN001 - *General Instrumentation Design Basis*
      – PIP PCCGN002 - *General Instrument Installation Criteria*
      – PIP PCEL1001 - *Level Measurement Guidelines*
      – PIP PCIL1000 - *Level Transmitter Installation Details*

   2.2 **Industry Codes and Standards**
      
      • American Society of Mechanical Engineers (ASME)
        – ASME Boiler Pressure and Vessel Code, Section I, Part PG-60 - *Requirements for Miscellaneous Pipes, Valves and Fittings*
      • The International Society of Automation (ISA)
        – ISA TR20.00.01 - *Specification Forms for Processing Measurement and Control Instruments*

3. **Requirements**

   3.1 **General**
      
      3.1.1 A data set shall be provided for each level sensor in either electronic or hard-copy format and contain a minimum data set in accordance with *ISA TR20.00.01* specification forms.
      
      3.1.2 Level instrument wetted materials of construction shall be compatible with the process.
      
      3.1.3 Level instruments shall be connected to vessels or standpipes and not to process flow lines.
      
      3.1.4 Piping from the vessel to the standpipe shall have no traps or pockets. Level gauges and cage-type level transmitters shall be installed above or level with the vessel connection such that they will drain into the vessel.
      
      3.1.5 Block, vent, and drain valves shall be provided on level gauges or external cage-type level instruments. Certain process fluids may prevent the use of block, vent,
and drain valves. The elimination of block, vent, or drain valves shall require owner approval.

3.1.6 Ease of maintenance shall be considered when choosing between internally and externally mounted instruments.

3.1.7 Level instrument installation that cannot be calibrated, tested, and maintained during process operation shall require owner approval (e.g., internal level displacers).

3.1.8 Flush diaphragm instruments may be installed without valves if approved by owner.

Comment: If a block valve is not provided, the instrument can be maintained only if the vessel can be removed from service.

3.1.9 Float or probe chambers and standpipes shall be in accordance with the most stringent piping specifications of the piping connected to the vessel.

3.1.10 The vessel design group shall be informed of any instruments that may require evaluation for weight stress and additional support.

3.1.11 All equipment shall be in accordance with the specified electrical area classification.

3.1.12 Differences in specific gravity between the vessel contents and the external level piping or sealing fluids shall be taken into consideration for calibration of the level instrument.

3.1.13 Level bubbler dip tubes, guided wave radar probes, and stilling wells shall be situated to allow sufficient overhead clearance for their installation and removal.

3.1.14 Independent process connections shall be considered for each level measurement.

3.1.15 Dimensional level calculations shall be provided to owner.

Comment: See PIP PCELI001 for sample level sketches.

Comment: See PIP PCCWE001 for weighing systems criteria.

3.1.16 The appropriate piping classification shall be followed for instrumentation connected to piping.

3.2 Differential Pressure Instruments

3.2.1 For applications in which the specific gravity of the process fluid varies, compensation shall be provided.

Comment: See PIP PCELI001 for a discussion of the applications of normal specific gravity versus minimum or maximum specific gravity.

3.2.2 The preferred mounting for transmitters shall be at or below the centerline of the high-pressure nozzle (lower vessel nozzle).

Comment: For alternate mounting see PIP PCELI001.

3.2.3 The diaphragm seal fluid, seal leg fluid, or purge fluid shall be compatible with the process and ambient temperature extremes.
3.2.4 Remote Diaphragm Seals

3.2.4.1 Provisions shall be made for relieving pressure between the block valve and the diaphragm seal.

*Comment*: Purge connections may be required on the process side of diaphragm seals in applications where plugging is likely.

3.2.4.2 Capillary tubing seal legs shall be mechanically protected and adequately supported to prevent sagging.

3.2.4.3 Remote diaphragm seals used in vacuum service applications shall be specifically designed for vacuum service by the manufacturer.

   a. Welded capillary connections shall be specified for vacuum applications.
   
   b. Fill fluid shall be rated for the maximum temperature and maximum vacuum conditions.

3.2.4.4 The length of the diaphragm seal capillary tubing shall be designed to take into account routing requirements.

3.2.4.5 Capillary tubing shall be manufacturer’s minimum required standard lengths.

3.2.4.6 Capillary lines shall be protected from exposure to sunlight.

*Comment*: Sunlight can cause temperature-induced errors in measurement even in compensated systems.

3.2.4.7 Capillary lines shall be routed away and/or insulated if they pass by steam or high-temperature heat transfer media jackets on a vessel or other high-temperature sources.

3.2.4.8 Capillary length of both seal legs shall be identical on a remote seal differential pressure transmitter.

3.2.4.9 Remote diaphragm seals without block valves shall not be installed until the flush and pressure test of the vessel is complete.

3.2.4.10 Electronic Remote Sensors may be considered in applications with long capillary tubes, or difficult installation of tubing, capillary tubes, heat tracing, etc. Manufacturer shall be consulted for each application.

3.3 Radar Instruments

3.3.1 Installation and design of a stilling well or standpipe shall meet manufacturer’s criteria for the probe and system used to avoid errors that are due to pipe diameter, connection sizes, branch connections, internal vessel obstructions, etc.

3.3.2 Free-space radar shall not be used in high-density vapor spaces that have high-hydrocarbon content, dusty fines, or droplets forming a heavy fog.

*Comment*: Guided wave designs should be evaluated for applications in such high-density vapor spaces.

3.3.3 Applications with foam or froth shall be reviewed with the manufacturer for applicability of radar measurement.
3.3.4 Installation location of the radar element (horn, wave guide) shall meet manufacturer’s criteria for distance from side wall and internal obstructions.

3.3.5 The probe must meet the electrical classification inside the vessel.

3.3.6 In the presence of agitators, vendor shall be consulted to ensure proper operation.

3.4 Ultrasonic Instruments

3.4.1 Ultrasonic transmitters shall be temperature and pressure compensated.

3.4.2 Installation and design of a stilling well or standpipe shall meet manufacturer’s criteria for the probe and system used to avoid errors that are due to pipe diameter, connection sizes, branch connections, internal vessel obstructions, etc.

3.4.3 Ultrasonic instruments shall not be used in vapor spaces that have dusty fines or droplets forming a heavy fog.

3.4.4 Applications with foam or froth shall be reviewed with the manufacturer for applicability of ultrasonic measurement.

Comment: See PIP PCCLI001 for considerations of electrical area classification for probes internal to the vessel.

3.4.5 Ultrasonic transmitters shall not be used in vacuum service.

3.5 Displacement Instruments

3.5.1 General

3.5.1.1 Displacement-type level instruments shall not be permitted for the following applications:

a. Extremely viscous materials

b. Services that require purging to prevent the following:
   (1) Plugging and/or sticking
   (2) Excessive condensation or vaporization of fluids in the chamber caused by vessel-chamber temperature differences

c. In liquids that coat or build up deposits on the displacer and/or rod

3.5.1.2 Displacement transmitters and switches in services with temperatures below 0°F (-18°C) or above 400°F (204°C) shall have air fins or some other means of isolating the transmitter from the process temperature in accordance with the recommendations of the transmitter/switch manufacturer.

3.5.2 Displacer Chamber

Displacer chambers shall have a maximum allowable working pressure (MAWP) equal to or greater than that of the vessel.

Comment: Typically the displacer chamber is isolated and vented or the level instrument is removed during a field hydrotest. The displacer may collapse if exposed to the high pressure of a hydrostatic test.
3.5.3 **Displacer**

3.5.3.1 All wetted parts (displacer element, hanger rod, torque tube or springs, and assembly components) shall be compatible with the process.

3.5.3.2 For measuring liquid-liquid interface, the displacer shall be completely submerged. Consult manufacturer for level interface measurements.

3.5.3.3 The displacer shall be freely suspended in the liquid (i.e., the displacer shall not contact the bottom, sides, or any buildup on the vessel or chamber).

3.6 **Capacitance Instruments**

3.6.1 Capacitance level transmitters shall not be used if the liquid conductivity can change from nonconductive to conductive. Consult manufacturer for specific applicable values.

3.6.2 A special probe with a separate electrode for signal return shall be used on nonmetallic or lined vessels.

3.6.3 The probe shall be externally grounded to the vessel if polytetrafluoroethylene (PTFE) tape or other pipe thread coatings are used.

3.7 **Nuclear Instruments**

3.7.1 The use of level instruments which contain nuclear sources type shall require owner approval.

3.7.2 Nuclear instruments shall be specified in accordance with instructions of the instrument manufacturer and applicable regulatory agencies.

3.7.3 Requirement for installation, handling, and control of nuclear sources shall be in accordance with the owner's policy and regulatory agencies.

3.8 **Level Switches**

3.8.1 Level switches that contain mercury shall not be permitted.

3.8.2 Provisions shall be made for testing and maintaining level switches.

3.8.3 Level switches used in safety instrumented systems shall require owner approval.

3.9 **Level Gauges**

3.9.1 **Magnetic Gauges**

3.9.1.1 Magnetic gauges shall not be permitted in dirty or plugging service.

*Comment:* If the provision for flushing the gauge with a suitable liquid can be made, magnetic gauges may still be acceptable.

3.9.1.2 The float shall be designed for the range of process fluid specific gravity in accordance with the data set, including abnormal (start-up) operating conditions.

3.9.1.3 The float material of construction shall be compatible with the process. Special magnets shall be considered for use in high temperature applications where rapid demagnetization of standard magnets could be expected to occur.
3.9.1.4 The float shall be suitable for the maximum operating pressure of the vessel.

3.9.1.5 Magnetic level gauges constructed of stainless steel and containing flammable and/or toxic materials shall be provided with nuts, bolts, and other fasteners on the gauge and insulation of a compatible metallurgy such as stainless steel.

*Comment:* Direct contact between stainless steel and zinc galvanized or cadmium coated materials *in a fire* will cause liquid metal embrittlement of the stainless steel and brittle fracture leading to possible loss of containment.

3.9.1.6 Insulation materials for stainless steel magnetic level gauges shall be certified chloride free.

*Comment:* Insulation containing chlorides can result in chloride stress corrosion cracking of stainless steel, leading to possible loss of containment.

3.9.1.7 Gauges which may be subject to boiling or flashing liquid shall be designed with an oversized chamber and float guide rods to allow vapor to pass by the float.

3.9.1.8 Gauges shall be designed by the manufacturer as self-supporting from the main process connections. External support of the gauge shall only be permitted with owner approval.

3.9.1.9 Gauges shall be accessible both for reading of the gauge and for maintenance purposes. Allow sufficient clearance above and below the gauge for removal of plugs from vent and drain valves, removal of the float, etc. If necessary, provide permanent penetrations in the interfering platforms.

3.9.2 Reflex Glass Gauges

3.9.2.1 Reflex gauges shall have a pressure/temperature rating suitable for the application.

3.9.2.2 Tempered borosilicate, Pyrex® glass, or equivalent glass shall not be used in applications at or above 600°F (316°C).

3.9.3 Transparent-Type Glass Gauges

3.9.3.1 Boiler steam drums shall have transparent gauges designed for steam drum service in accordance with the *ASME Boiler and Pressure Vessel Code*, Section I, Part PG-60.

3.9.3.2 Transparent armored gauges shall have a pressure/temperature rating suitable for the application.

3.9.3.3 Gauges shall have plastic frost shields for applications in which the process liquid has a temperature below 32°F (0°C).

3.9.3.4 Mica shields shall be required on steam boiler glass level gauges (600 psig / 41.4 barg or greater) and in caustic services.
3.9.3.5 If illuminators are required, they shall be suitable for the specified electrical area classification.

3.9.3.6 Tempered borosilicate, Pyrex® glass, or equivalent glass shall not be used in applications at or above 600°F (316°C)

3.9.4 Gauge Cocks and Ball Checks

3.9.4.1 Gauge cocks and ball checks shall be installed in accordance with owner's requirements.

3.9.4.2 Gauge cocks and ball checks, if used, shall be purchased as assemblies as part of the level gauge.

3.9.4.3 Gauge cocks with ball checks shall not be permitted in vacuum applications.