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History Sheet

Rev	Reason for revision	Revised by
0	Issued for Permitting Use	MCK/NJS
1	Total rewrite; Issued for Permitting Use	MCK
2	Issued to incorporate Open Pit Leak Pot	BAS
3	Format changes	BAS
4	Total rewrite; Incorporates and supersedes 24590-WTP-PER-J-02-001 Rev 5	NAG

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Acronyms, Executive Summary, etc.

AEA	Atomic Energy Act
DOE	US Department of Energy
DWP	Dangerous Waste Permit
HLW	high-level waste/ high-level waste vitrification facility
LAB	analytical laboratory
LAW	low-activity waste/ low-activity waste vitrification facility
LDB	leak detection box
P&ID	piping and instrumentation diagram
PCJ	process control system
PTF	pretreatment waste vitrification facility
WAC	Washington Administrative Code
WTP	Hanford Tank Waste Treatment and Immobilization Plant

1 Introduction

The purpose of this document is to describe the leak detection methodology that will be used to meet the requirements of Washington Administrative Code (WAC) 173-303-640(4)(c)(iii) and Dangerous Waste Permit (DWP) condition III.10.E.9.b. The scope of this document covers the description of the leak detection technology employed for secondary containment systems at the Hanford Tank Waste Treatment and Immobilization Plant (WTP) facilities. The installation and functional testing of the leak detection technology is described herein.

2 Applicable Documents

WAC 173-303 - Dangerous Waste Regulations.

3 Description

This document describes the leak detection methods and leak detection technologies currently used in dangerous waste secondary containment areas. Dangerous Waste Permitted WTP tanks, miscellaneous units, autosamplers, Pretreatment Facility (PTF) bulges, confinement enclosures, Low-Activity Waste (LAW) melter encasement assemblies, and underground waste transfer lines use leak detection methods and technologies described in this document.

3.1 Leak Detection Method

Low-point design features and local monitoring/indication are the two methods employed at the WTP for secondary containment leak detection.

- Low-point leak detection consists of a continuously monitored leak collection point located at the lowest point in a containment area.
- Local leak monitoring/indication uses sensing instruments arranged around regulated equipment or piping.

These leak detection methods are used in WTP secondary containment systems that include:

- sumps
- leak detection boxes
- drains with a weir
- melter encasement assemblies
- confinement enclosures
- rack rooms.

Leak detection technologies could be used to support daily inspection for regulated piping and equipment that have no secondary containment requirements.

3.1.1 Leak Detection in Sumps

Sumps are typically stainless steel structures located in the secondary containment areas for tank and miscellaneous unit systems that manage liquid dangerous waste where personnel access is restricted or limited due to high radiation exposure and/or radioactive contamination. Sumps serve as the low point for the containment area and provide a means of detecting leaks and collecting liquid for removal. Each sump is equipped with leak detection monitoring instrumentation. Most sumps are equipped with either fluidic ejectors or pumps for removal of liquid, but some are drained by an operator using a portable pump or are gravity drained and have a weir (Section 3.1.3). The sumps are sized to allow detection of liquids using a radar or bubbler type monitoring instrument.

Typical sump design features are shown in 24590-WTP-PER-CSA-02-001, *Secondary Containment Design*. The leak detection instrumentation for each sump is shown on the Piping and Instrumentation Diagrams (P&IDs).

3.1.2 Leak Detection Box

Leak detection boxes (LDB) are used to provide leak detection in the co-axial waste transfer lines. Leak detection boxes are provided at the low point on waste transfer lines so that a leak in the inner process pipe will drain to the annular space of the outer containment pipe and into the leak detection box. Leak detection boxes are located in vessel cells, waste transfer line piping pits at the interface with other systems, and process tunnels where coaxial piping terminates and becomes single-walled piping.

Each LDB is monitored for liquid using a level switch (for example, ultrasonic gap or thermal dispersion) to detect leaks. Once the sensing element of the switch detects a leak, the switch will send a signal to the Process Control System (PCJ) to activate a leak detection alarm.

Leak detection boxes are horizontal stainless steel enclosures provided with a normal drain, an overflow drain, and weir (Figure 1). The drain located on the side of the weir into which the transfer line drains (that is, the containment side of the weir), is normally closed by a plug attached to a rod extending to a area above the leak detection box. The overflow drain, located in the non-containment side of the weir, will have a similar apparatus. The leak detector is a level switch located in the containment side of the weir. The overflow drain remains open for leak detection boxes located in vessel cells and piping tunnels and drain to a sump. For leak detection boxes located in open pit installations, the overflow drain will remain closed and will be opened by operations personnel to drain as needed after placement of appropriate overflow containment receptacle.

Typical LDB design features are shown in Figure 1. The leak detection instrumentation for each LDB is shown on the P&IDs.

3.1.3 Drain and Weir/Plug Assemblies

Drain and weir leak detection design is typically used in PTF bulges, WTP autosamplers , and the Laboratory piping and pump pit sumps. In these areas, the secondary containment liner slopes to a drain. A special weir or plug assembly at the drain retains the leaking fluid allowing the activation of the leak detection device. A leak will be detected by a sensing element such as a radar level detector, thermal switch, or ultrasonic gap switch. The leaking fluid is retained behind the weir or plug allowing detection before flowing over the weir/plug into the drain. Once the sensing element detects a leak, the level switch will send a signal to the PCJ to activate a leak detection alarm.

Typical drawings for drain and weir leak detection designs are provided in the *Engineering Specification for Process Bulge Design and Fabrication* (24590-WTP-3PS-MX00-T0001) and the *Secondary Containment Design* (24590-WTP-PER-CSA-02-001)

Specific design and instrumentation for each drain and weir/plug type leak detection system is shown on the P&IDs.

3.1.4 LAW Melter Feed Line Encasement Assemblies

The two LAW Melter Feed Line Encasement Assemblies provide leak detection for the LAW melter feed lines, between each process cell wall penetrations and each melter shield wall. The feed lines are surrounded by a sloped bellows assembly. Leak detection is provided by a conductivity cable located under the feed lines, in the lower portion of the bellows assembly. Once a leak is detected, the level switch will send a signal to the PCJ to activate a leak detection alarm. A low-point drain is provided to allow removal of potential leaks.

Melter Encasement Assembly design features are shown in 24590-WTP-PER-CSA-02-001, *Secondary Containment Design*.

3.1.5 Confinement Enclosures and Rack Rooms

A confinement enclosure is a walk-in, bulge-like area housing ancillary equipment, such as process piping, valves, and pumps. Confinement enclosures allow hands-on maintenance of equipment while controlling radioactive contamination and shielding personnel outside the enclosure. Rack rooms typically house piping racks; some of which are DWP ancillary equipment piping.

Typically, rack rooms and confinement enclosures provide secondary containment and leak detection for DWP ancillary equipment using a sensing element such as conductivity cable, or a combination of leak detection methods. Localized leak detection will be used primarily around ancillary equipment where either daily visual inspections are not feasible due to obstructed vision by an elevated grating or low-point leak detection is not available because of floor sloping requirements.

3.2 Leak Detection Technologies

Several leak detection technologies are utilized at the WTP, including the following:
- radar level detection
- bubbler
- thermal dispersion
- ultrasonic gap
- conductivity cable.

The leak detection technologies utilized at the WTP secondary containment areas are described below.

3.2.1 Radar

The radar level detection is provided for most of the WTP secondary containment sumps and some drain and weir assemblies. A typical radar level method employs a radar level transmitter. Radar transmitters are designed to transmit a signal using an antenna, and to receive the return signal with a cone designed to pick up radar high frequency, pulsed signals. Much of the transmitted signal is reflected by the liquid surface and received at its source. A waveguide is used to channel the signals through different geometry or to avoid nearby equipment that might affect signal quality. Additionally, waveguides are used to move the location of the transmitter out of a high radiation environment into one that can be accessed by service personnel. The transmitter compares the time when the signal was sent to the time when the reflected signal returns. This time difference is then transferred to the PCJ as a level signal. The radar leak detection method will use one radar level detection transmitter.

Secondary containment sumps are designed to be dry with a liquid normally not present. The PCJ will monitor and alarm at a high level. A high-level alarm permits the operator to determine if a breach in the primary containment has occurred and has allowed fluid to flow into the secondary containment sump.

The PCJ will constantly monitor and perform diagnostics on the transmitter/foundation fieldbus data-communications link, and an alarm will result from a number of conditions, including loss of signal power, as required. A transmitter bad-data-quality PCJ alarm will be provided, as required.

Typical configurations of the sump radar leak detection are illustrated in Figure 2.

3.2.2 Bubbler

The bubbler level detection is provided for some of the WTP secondary containment sumps. The air bubbler leak-detection uses a dip pipe that extends into the sump. The dip pipe serves as a conduit for air at the pressure slightly greater than the opposed by the hydrostatic head of the liquid being collected in the sump. A differential pressure transmitter measures differences in pressure across the transmitter diaphragm because one side of the diaphragm is connected to the bubbler dip pipe/sensing line and the other side is referenced by a sensing line to the atmospheric pressure above the sump. Presence of liquid in the sump creates a greater air pressure in the dip pipe/sensing line and on the high pressure (HP) side of the diaphragm, resulting in a higher differential pressure, which is converted into a higher level signal to the PCJ. Multiple bubblers will be installed if a lack of maintenance access after the start of operations is expected and no other means of leak detection is provided.

Sumps are designed to be dry with a liquid normally not present. The PCJ will monitor the level and alarm "high level". A high-level alarm permits the operator to determine if a breach in the primary containment has occurred and has allowed fluid to flow into the secondary containment sump.

Additional alarms will be evaluated during design for the leak detection system. The PCJ will constantly monitor and perform diagnostics on the transmitter/foundation fieldbus data-communications link, and an alarm will result from a number of conditions, including loss of signal power, as required. A transmitter bad-data-quality PCJ alarm will allow the operator to indirectly infer a number of conditions, including a loss of bubbler air-purge flow, as required.

A typical configuration of the sump bubbler leak detection is illustrated in Figure 3.

3.2.3 Thermal Dispersion

The thermal dispersion level detection is provided for some of the WTP secondary containment systems, such as leak detection boxes and ASX sampler cabinets. The leak detection (level) switch method uses thermal dispersion technology. The measuring element of the level switch contains two temperature-sensitive probes. One probe contains a heated resistance temperature detector (RTD), and the other probe contains an unheated RTD reference at a thermal difference when no liquid is present.

When liquid contacts the probes, the thermal difference decreases and is measured, this will generate a high-level alarm to the PCJ.

A typical configuration of the thermal dispersion leak detection is illustrated in Figure 4.

3.2.4 Ultrasonic Gap

Ultrasonic gap leak detection uses a probe with two in-line crystals, a transmitter and a receiver, that have an air gap between them. The transmitting crystal typically sends an inaudible acoustic signal across the air gap to the receiving crystal. When the gap is filled with a liquid the signal strength increases, which causes the instrument to send a high level signal to PCJ.

A typical configuration of the ultrasonic gap leak detection is illustrated in Figure 5.

3.2.5 Conductivity Cable

Conductivity cable leak detection is provided for some WTP secondary containment systems, such as LAW Melter Feed Line Encasement Assemblies and may be used in other areas without low-point leak detection, such as rack rooms. Conductivity cable leak detection uses a cable and a resistance sensor to detect the presence of liquid. A conductive sensing cable is run through the area that is being monitored. The cable is terminated on both ends, one end is connected to a modular termination, while the other is connected to an alarm module. When liquid is present on any part of the cable, the resistance of the cable changes and is measured by the alarm module. The alarm module then sends a high-level signal back to the PCJ. The *Secondary Containment Design* (24590-WTP-PER-CSA-02-001), provides a typical configuration of the conductivity cable leak detection technology for the LAW Melter Feed Line Encasement Assemblies.

Conductivity cables can also be used to support daily visual inspection for regulated piping and equipment that is not provided with secondary containment and leak detection. For this application the conductivity cable is run along the bottom section of the pipe or equipment. Figure 6 shows this configuration in a pipe application.

3.3 Installation and Functional Testing

Prior to installation, the leak detection sensors will be tested for functionality and then installed and tested in accordance with manufacturer specifications. Leak detection instruments will be accessible for maintenance and periodically self-tested in-situ to verify functionality.

Once installed, the leak detection system, including all instrumentation and other associated equipment, will be tested as a system during initial startup testing. The system will be checked and verified for the proper alarm response.

After installation, instruments used for leak detection will be periodically tested per the manufacturer specifications to ensure they continue to operate per their design.

Figures 1 through 6 generally illustrate the typical installation of the leak-detection system.

3.3.1 Radar

The radar transmitter will be located in an area where maintenance will be performed under administrative control. The waveguide will be installed so that the waveguide enters the sump and is placed open-ended, with a gap from the sump bottom. Venting of the waveguide above the liner or berm is required; vent slots will be included as required. As shown in Figure 2, the radar waveguide will go through shielding (the floor or wall using a joggle in the waveguide) to protect the instrument, as well as personnel conducting maintenance operations on the transmitter from the radioactive environment of the cell.

The piping (waveguide) inserted into the process will primarily be welded pipe and will have the capability to be flushed.

3.3.2 Bubbler

The air bubbler differential pressure transmitter will be located at least 1 barometric head (approximately 34 feet) above the highest expected liquid surface level. This minimizes the possibility that the transmitter might be contaminated due to possible moisture collection or flow of the liquid up into the dip pipe/sensing line upon the loss of purge air. The transmitter will be located in an area where maintenance will be performed under administrative control.

Figure 3 shows a general sketch of the air bubbler leak-detection system. The sensing lines will go through radiation shielding to protect the instrument. Personnel conducting maintenance operations on the transmitter will be shielded from the radioactive environment of the cell. The bubbler sensing-line air-purge flow will be controlled to provide a minimum bubble rate.

The piping (bubbler dip pipe/sensing line) will have the capability to be flushed.

3.3.3 Thermal Dispersion & Ultrasonic Gap

Figures 4 & 5 show general sketches for the level switch configuration to detect liquid in a normally dry sump. The level switch electronics and element connector will be located in an area where maintenance will be performed under administrative control. A pipe protects and supports (and physically guides replacement of) the level switch element from the connector to the pit sump. The level element probes are positioned to properly monitor for liquid at the open end of the pipe.

3.3.4 Conductivity Cable

Conductivity cable installed in areas such as the LAW Melter Feed Line Encasement Assemblies is configured in a way such that all low points contain a part of the cable. Typically this means that the cables will lay across the bottom of the encasement assembly.

Conductivity cable used on piping to support daily visual inspection is installed along the bottom of the pipe, with care taken to ensure that all low points are covered.

Figure 1 Typical Leak Detection Box Level Measurement

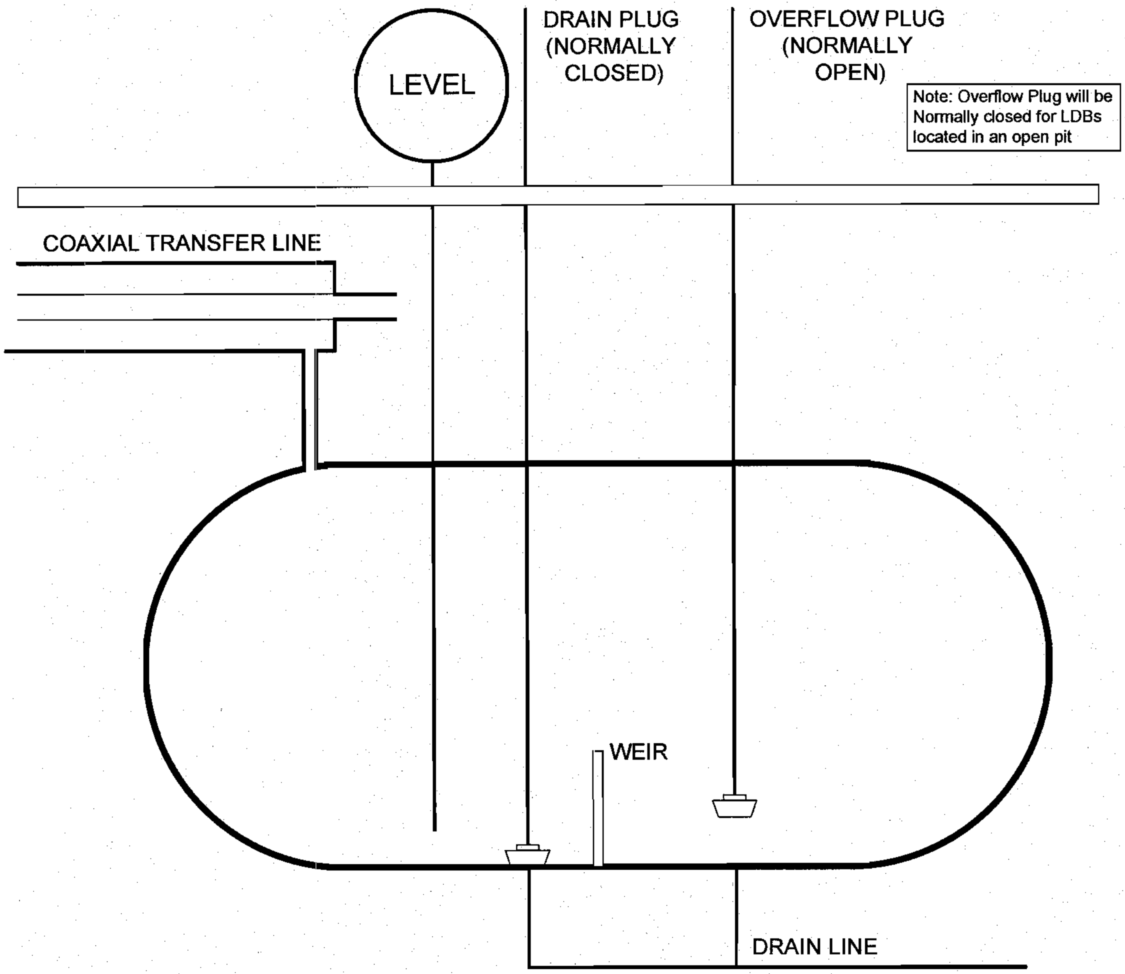

Figure 2 Typical Radar Level Measurement for Sumps in C5 Area

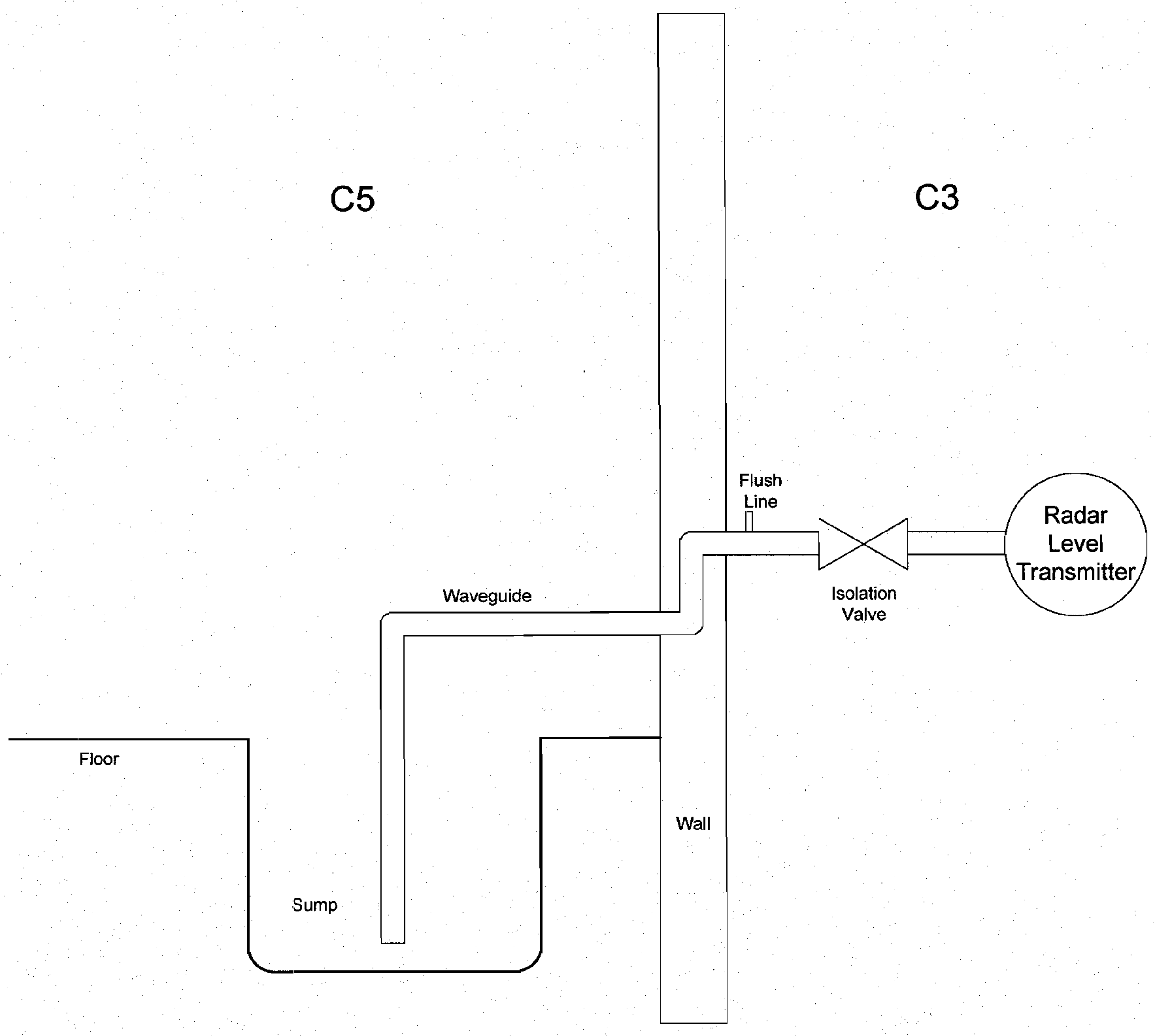

Figure 3 Typical Bubbler Level Measurement

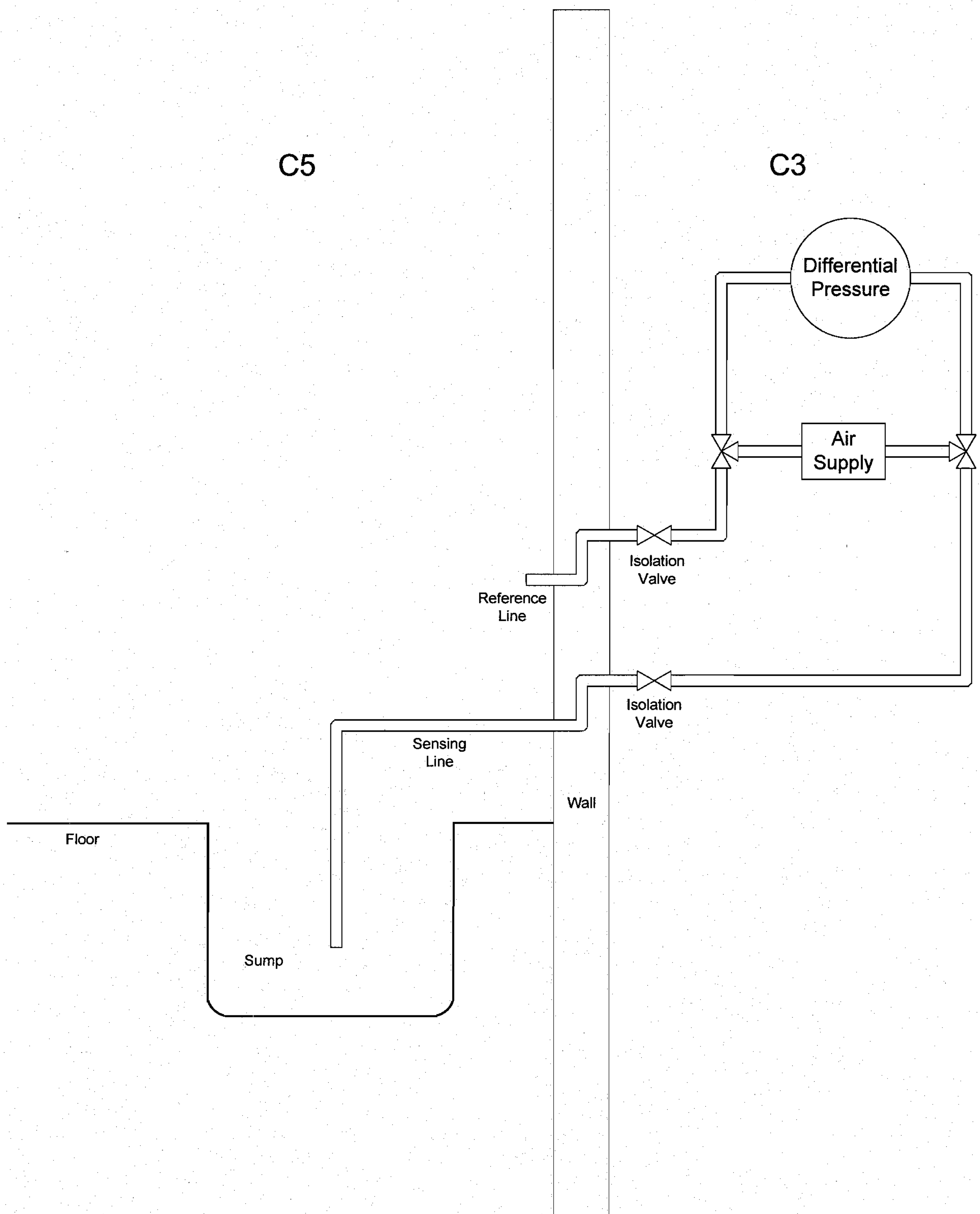

Figure 4 Typical Thermal Dispersion Level Measurement

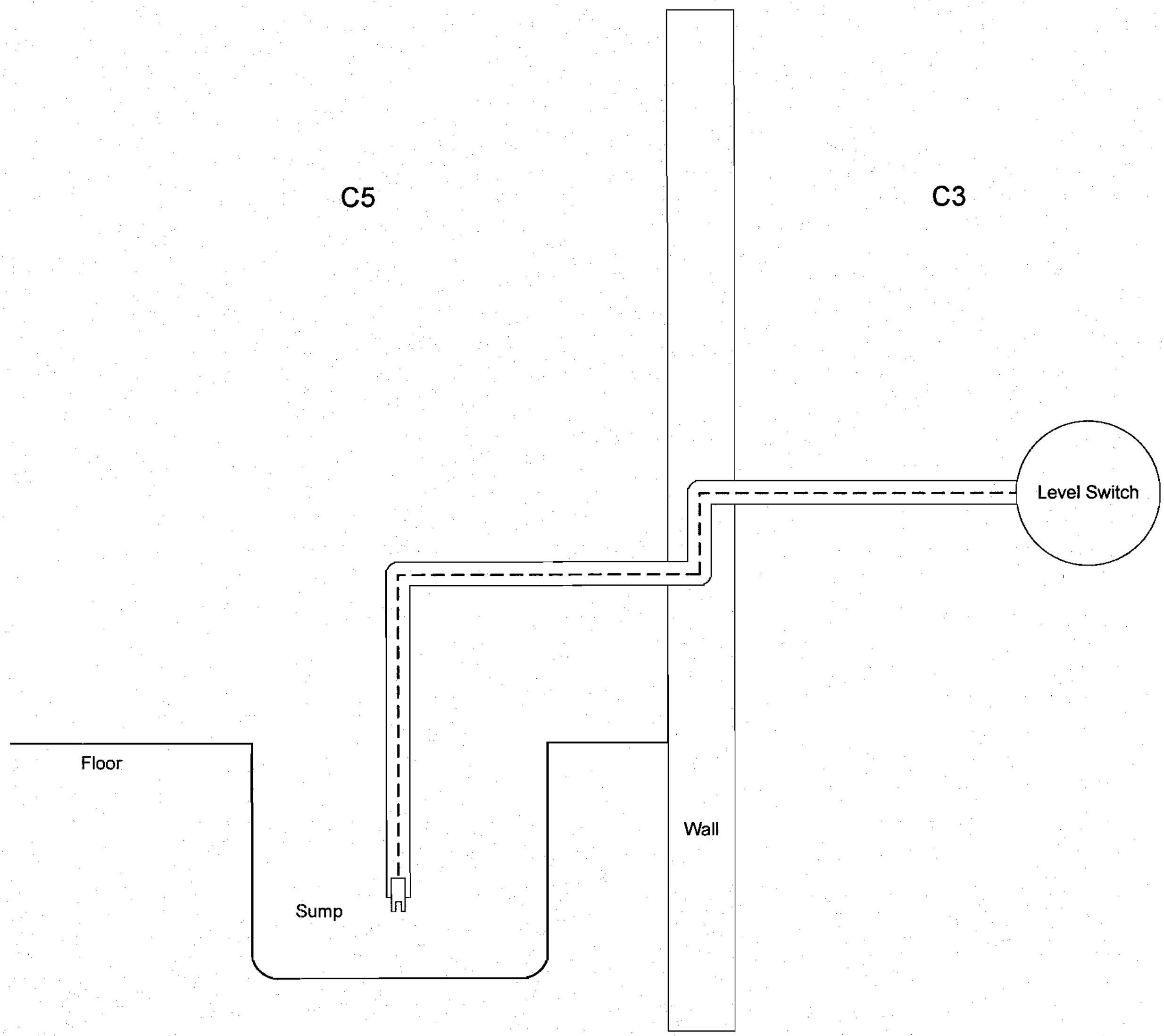

Figure 5 Ultrasonic Gap Level Measurement

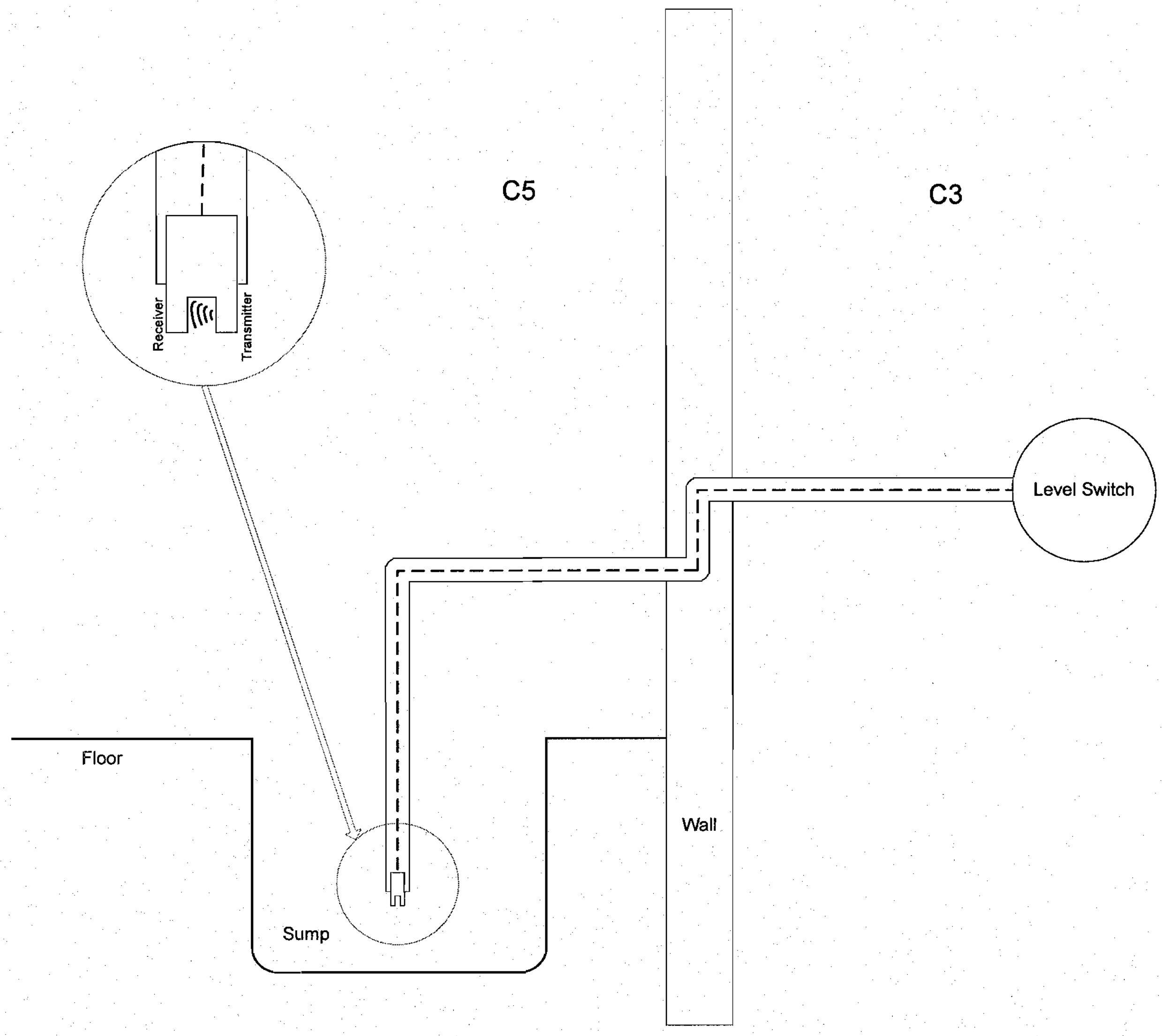

Figure 6 **Typical Conductivity Cable Level Measurement for Pipe and Equipment Monitoring**