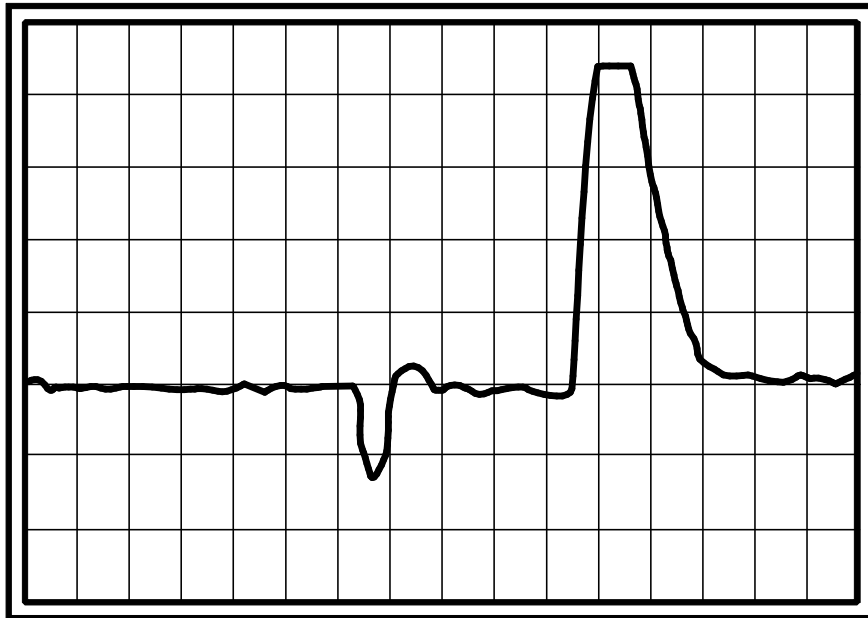


PAL-AT[®]

INSTALLATION MANUAL

MODELS AT30C, AT75C & AT30K



Notice

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Caution --This manual may not be up-to-date.

Please check the PermAlert website, www.permalert.com, for the latest revision of this manual.

The manual is typically revised at least once a year. The revision date is on the back cover.

Contact techsupport@permalert.com for technical assistance with the PAL-AT system.

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Safety Information

Please Read This Installation Manual

Please take the time to read this installation manual carefully. It will help you set up and operate your system properly. **Failure to follow these instructions may impair the safety of the equipment.** Please save this installation manual for future reference.

For your safety

Caution: *To reduce the risk of fire or electric shock, do not expose the PAL-AT to rain or moisture.*

CAUTION: TO REDUCE THE RISK OF ELECTRIC SHOCK,
TURN OFF POWER BEFORE OPENING ENCLOSURE DOOR.
REFER ALL SERVICING TO QUALIFIED PERSONNEL



This symbol alerts the user to the presence of uninsulated, dangerous voltage within the system enclosure that may be of sufficient magnitude to constitute a risk of electric shock.



This symbol alerts the user to the presence of important operating and maintenance instructions in this manual.

Approvals and Certifications



Regulatory Compliance Statements

FCC Class A Notice

This device complies with part 15 of the FCC Rules. Operation is subject to the following two conditions.

1. This device may not cause harmful interference, and
2. This device must accept any interference received, including interference that may cause undesired operation

NOTE: This equipment has been tested and found to comply with the limits for a Class A digital device, pursuant to Part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference when the equipment is operated in a commercial environment. This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with this instruction manual, may cause harmful interference to radio communications.

Operation of this equipment in a residential area is likely to cause harmful interference in which case the user will be required to correct the interference at his own expense.

Changes or modifications not expressly approved by the party responsible for compliance could void the user's authority to operate the equipment.

The party responsible for product compliance:

Perma-Pipe, Inc.
6410 W. Howard St.
Niles, IL 60714

1 Introduction

1.1 General Description

This PAL-AT® Installation Manual is intended for use as a general installation guide for PAL-AT alarm/locator panels, sensor cable, cable connectors, and probes. Users (installers) should independently evaluate the suitability of this information and PermAlert's products for their application and specific installation. If you receive a PermAlert product not described in this manual, contact PermAlert for the appropriate instructions. PermAlert is a division of Perma-Pipe, Inc. Refer to the PermAlert website, permalert.com, for the latest revision of manuals and product data sheets.

1.2 Applications

The PAL-AT system consists of an electronic microprocessor-based alarm/locator panel that monitors sensor cables and/or probes. The sensor cable may be installed in many applications including: secondary contained piping; directly in the ground adjacent to fuel pipes or tanks; computer room subfloors; cleanroom subfloors, or any area where liquids need to be detected. There are several PAL-AT models available including:

AT30C: Monitors 1 cable up to 3,000 ft [900 m].

AT75C: Monitors 1 cable up to 7,500 ft [2300 m].

AT30K: Monitors 4 cables each up to 7,500 ft [2300 m].

Applications monitoring cables in hazardous locations must use a Zener Barrier Panel (see section 3).

1.3 Receiving and Handling Precautions

The following general precautions should be observed:

1. **Do not use substitute materials or short cut recommended procedures.** Understanding and following this guide is essential to avoid installation problems.
2. Collect the needed quantities of all materials well in advance of scheduled work.
3. Check the packing list against received items. **Report immediately any shortages or damaged materials to the delivering carrier.**
4. All cable must be tested immediately upon receipt following the cable test procedures contained in this manual. Report immediately to PermAlert any cables that fail the tests. Failure to report within ten workdays of receipt of goods shall waive the purchaser's right to file a warranty claim.
5. **The recommended minimum bend radius for all sensor and jumper cables is 1.5" [38mm].**
6. Care must be taken to store all PAL-AT components in a dry and protected area at all times. Electronic alarm/locator panels and sensor cable should be wrapped and sealed with plastic.
7. System drawings, provided by the designer, should indicate the extent, general location, and arrangement of leak detection equipment, cable, and probes. The contractor (installer) should become familiar with all details of the installation before proceeding.
8. Electrical work should be performed by a qualified electrician.

1.4 Materials and Equipment Normally Supplied by PermAlert

Each system may include the following items as quoted:

1. Leak detection/location alarm panel
2. Leak sensor cable
3. Jumper cable
4. Cable connector assemblies
5. Adhesive backed cable mounts (CMA) furnished for attachment of sensor cable to flat surfaces
6. Probe assembly, including a PT10 Probe Integrator installed in a NEMA 4X [IP66] junction box with 60' of jumper cable and one cable connector assembly
7. Watertight junction boxes conforming to NEMA 4X [IP66].

Maximum No. of Cable Connectors in Enclosure	Enclosure Dimensions
1	6" x 6" x 4" [150 mm x 150 mm x 100 mm]
2	8" x 6" x 4" [200 mm x 150 mm x 100 mm]
4	10" x 8" x 4" [250 mm x 200 mm x 100 mm]

8. Watertight cord grips
9. Shrink tubing for cable connectors
10. Non-corrosive RTV adhesive/sealant for cable connectors

1.5 Materials and Equipment Normally Supplied by Installing Contractor

Each system may require the installing contractor to supply the following items:

1. Pull rope, 1/8" [3 mm] diameter, 7 strands, steel wire rope aircraft cable. For installation of cable in fiberglass or other plastic piping systems, use plastic coated (non-vinyl) wire rope. Provide pull rope in quantities equal to 120% of system length. (Included with Perma-Pipe piping systems)
2. Cable spool rack or stand
3. PVC electrical tape
4. Miscellaneous pipe nipples, unions, and fittings, as required to provide watertight jumper cable connections to sensor cable.
5. 1" rigid or liquid-tight flexible electrical conduit, as required, for installation of jumper cable within manholes, pits, and buildings. Use 1" conduit hub, OZ Gedney CH-100, or equal, connection to junction boxes.
6. Electrical conduit, junction boxes, and wiring, as required.
7. Ohmmeter for testing jumper cables and sensor cables.
8. 1000-volt megger for testing ATP sensor cable.
9. Hole saw or knockout punch.
10. Construction adhesive mastic for attachment of cable mounts to unsealed concrete surfaces
11. Hot air gun for shrink tube application on cable connector assemblies

2 PAL-AT Alarm/Locator Panel

2.1 Alarm/Locator Panel Installation

The PAL-AT panel is designed to be permanently mounted indoors in a dry area. The enclosure is rated Type 12 [IP52]. It must not be located in direct sunlight to prevent excessive heat buildup. **In all installations, the ambient temperature surrounding the PAL-AT panel must be within the limits below.** The equipment is designed to be safe in the following range of environmental conditions:

- a) Indoor use;
- b) Altitude up to 6,560 ft [2000 m];
- c) Temperature -4°F [-20°C] to 122°F [50°C];
- d) Maximum relative humidity 95%;
- e) Pollution degree 2.

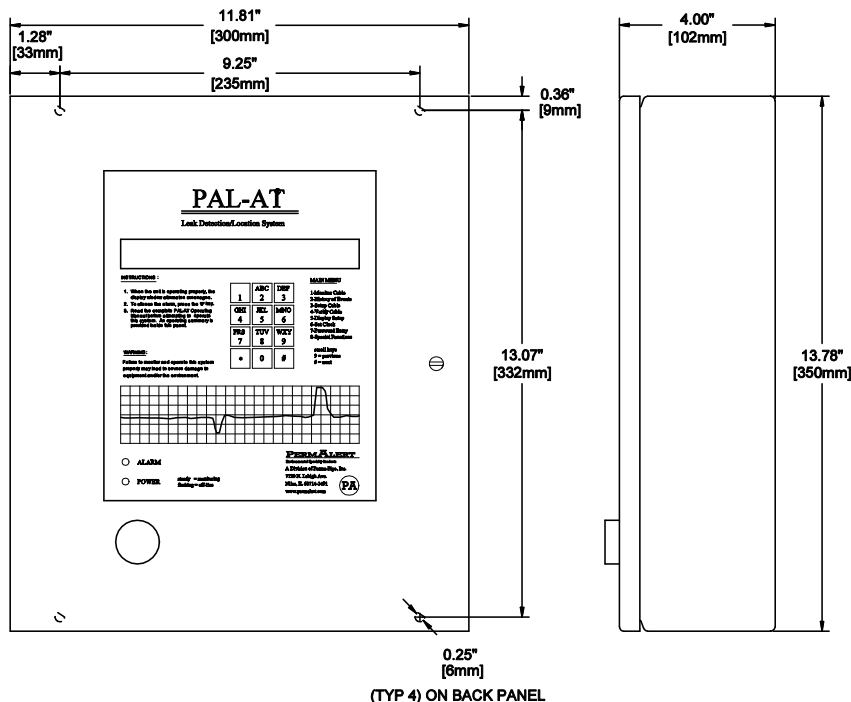


Warning: Do not mount the PAL-AT panel in a hazardous location. The panel must be in an ordinary location even though sensor cables may be located in hazardous locations. Refer to the Zener Barrier Panel section of this manual.

Mount the PAL-AT panel securely to a wall, using ¼" [M6] hardware in the 4 holes on the back of the panel (see figure 2-1). If it is mounted to a typical ½" plasterboard wall, use ¼" x 1 ½" [M6 x 40mm] lag screws to secure it to the studs (nominal 2" x 4" [50mm x 100mm]). The panel can also be mounted to steel mounting channel struts using ¼" [M6] machine screws.

The PAL-AT panel is connected to the sensor cable using jumper cable (Type JMP-U, JMP-UD or JPP). An exception to this requirement is ATP cable that uses 50' [15 m] of ATP for jumper (see section 9). **At least 50' [15 m] of jumper cable (65' [20 m] if JPP) must be connected between the panel and the connection to the sensor cable.**

The jumper cable must be run in a separate conduit from the power supply cable. All conduit fittings must be appropriately rated and installed properly to maintain the rating of the enclosure. All electrical connections must comply with local codes. **Remove the system board from the white back panel (six #6-32 screws) before drilling holes in the enclosure for conduit openings to prevent damage and contamination from metal shavings.**



**Models AT30C, AT75C and AT30K
Mounting Dimensions**

Figure 2-1

2.2 Terminals

The terminals on the PAL-AT system board use a quick-connect design that provides an easy, fast and robust connection. A flat blade screwdriver, 1/8" [3.5 mm], is used to press down on the terminal lever and open the terminal for easy wire insertion. Release the lever, and the wire is tightly clamped. **The acceptable wire size for connection to any terminal, including the mains, is 28 - 12 AWG [0.08-2.5 mm²].** The terminals can accommodate solid or stranded wires. **If ferrules are used with stranded wire, the maximum wire size is 14 AWG [1.5 mm²].** Refer to the detail located at the upper right side of figures 2-2 and 2.3. **Caution: The lever only travels 1/8" [3.5 mm] to open the terminal completely, and only requires 5 - 8 lbs [2-4 kg] force. Do not exceed these limits or the terminal will be damaged.**

2.3 Power Connection

The PAL-AT must be permanently wired to instrument-quality power using appropriate certified conduit, fittings, and wiring. Refer to figures 2-2 and 2-3 wiring diagrams for details. The PAL-AT contains a universal power supply. The power requirement is 110-240 VAC, 50 / 60 Hz, 0.3 A / 50 VA.

A suitable external over-current protection device, such as a fuse or circuit breaker (15 A), and disconnect device is recommended. The over-current protection and disconnect devices shall be installed on all ungrounded conductors, i.e. the terminal marked hot (L) (and neutral (N) terminal if ungrounded for 240 VAC). The disconnect device shall be located near the equipment and marked with appropriate ON (I) OFF (O) markings as specified by local codes. The ground conductor shall have green with a yellow stripe insulation and be connected to the grounding connection on the upper right corner of the back panel as shown. Installation should be performed by qualified personal in accordance with local codes and procedures.

The PAL-AT can also be powered by a 24 VDC, 1 A / 24 VA, over-current protected power source at terminal T5. Fuse F1 on the PAL-AT system board protects the 24 VDC input. It is a 2A, 250 V, time-delay, 5 x 15 mm fuse.



Caution - Before accessing the PAL-AT panel, the panel must be disconnected from the power source and isolated from any hazardous voltage present in the panel, e.g. relay wiring.

Three internal switches on the system board control the power source utilized by the panel. These switches are intended for use by service personnel. Set the AC Power Switch (SW3) and the 24 VDC Power Switch (SW1) in the down, or "OFF" position. Next, set the Input Power Select Switch (SW2) to either VAC or VDC depending on the desired power source. The panel is controlled by SW3 for AC power or SW1 for DC power.

2.4 Audible Alarm Wiring

An internal 90-dBA pulse horn is supplied. An optional chime alarm is available. The wiring for the horn is a 2-wire cable connected to terminal strip T6. The red wire must be connected between the "+" terminal on the horn and the "+" T6 terminal. The black wire must be connected between the "-" terminal on the horn and the "-" T6 terminal. The terminal provides 24 VDC @ 10 mA.

2.5 Control Relays

PAL-AT has 3 to 6 SPDT output relays, depending on the model, rated for 250 VAC, 10 A. They are labeled "Fault Alarm", "Common Alarm" and "Cable x", where x=1 to 4 for the appropriate cable number (see figures 2-2 and 2-3). The relay contacts are labeled in their unpowered or "on-the-shelf" condition.

The fault relay energizes when the panel is powered and monitors for a power fault.

The common alarm relay switches state in response to any fault condition. The # key can be pressed to reset the common alarm relay to its normal state and deactivate the internal audible alarm for up to 96 hours. The default reset time is 12 hours.

The cable relay(s) will activate when a fault is detected and will reset when the fault returns to normal or the alarm queue is cleared. The default setting is to activate for all alarms, but it is firmware selectable to activate in response to only leak and probe active alarms.

Control devices or auxiliary equipment should be connected to the cable relay(s) so they will not be reactivated when the alarm is silenced. PAL-AT is shipped with the common alarm and cable

relays configured to operate in a normally de-energized mode, so they energize when the panel is in the alarm state (see the *PAL-AT Operating Manual* for changing relay configuration).

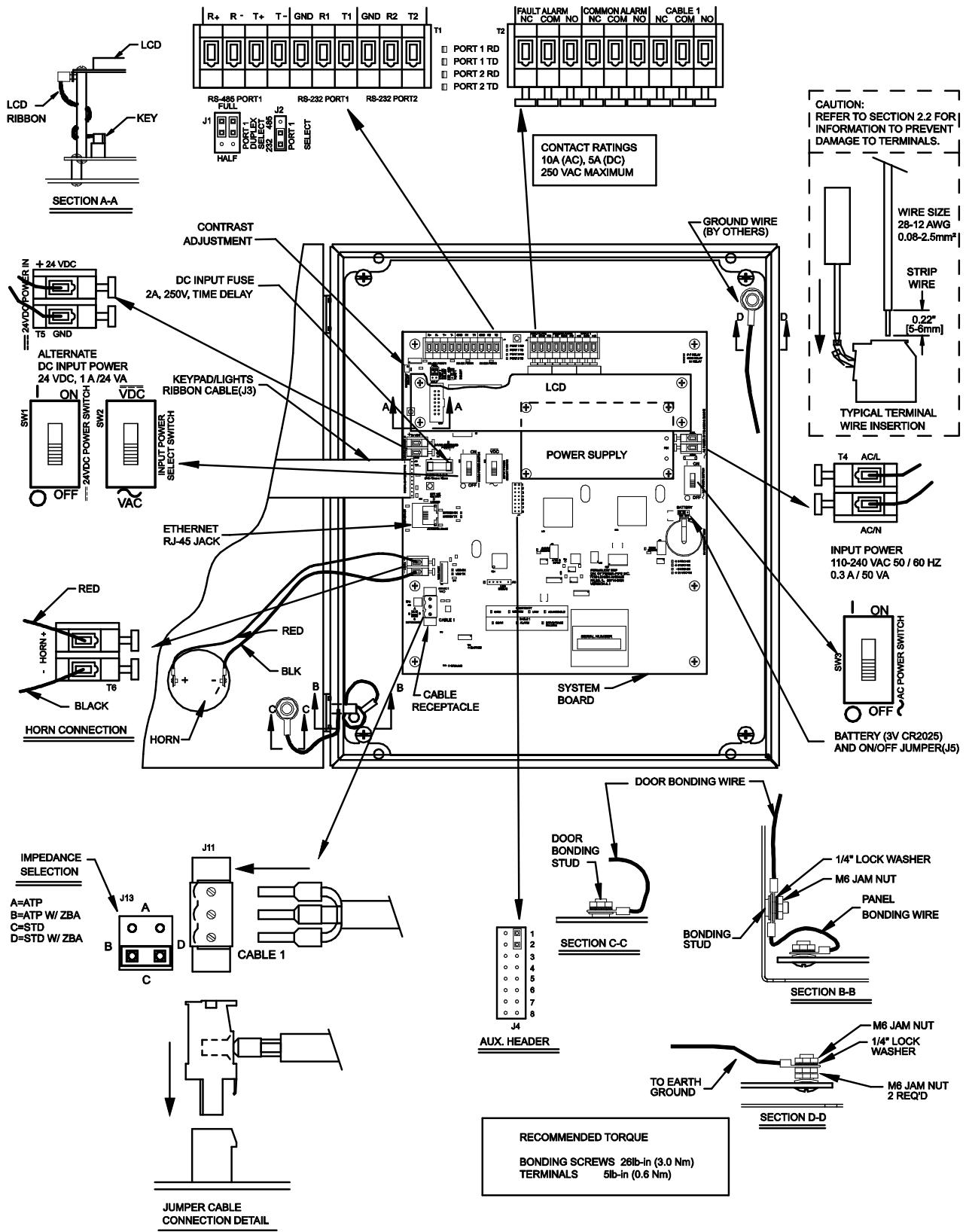


Figure 2-2
Wiring Diagram for PAL-AT Models AT30C & AT75C

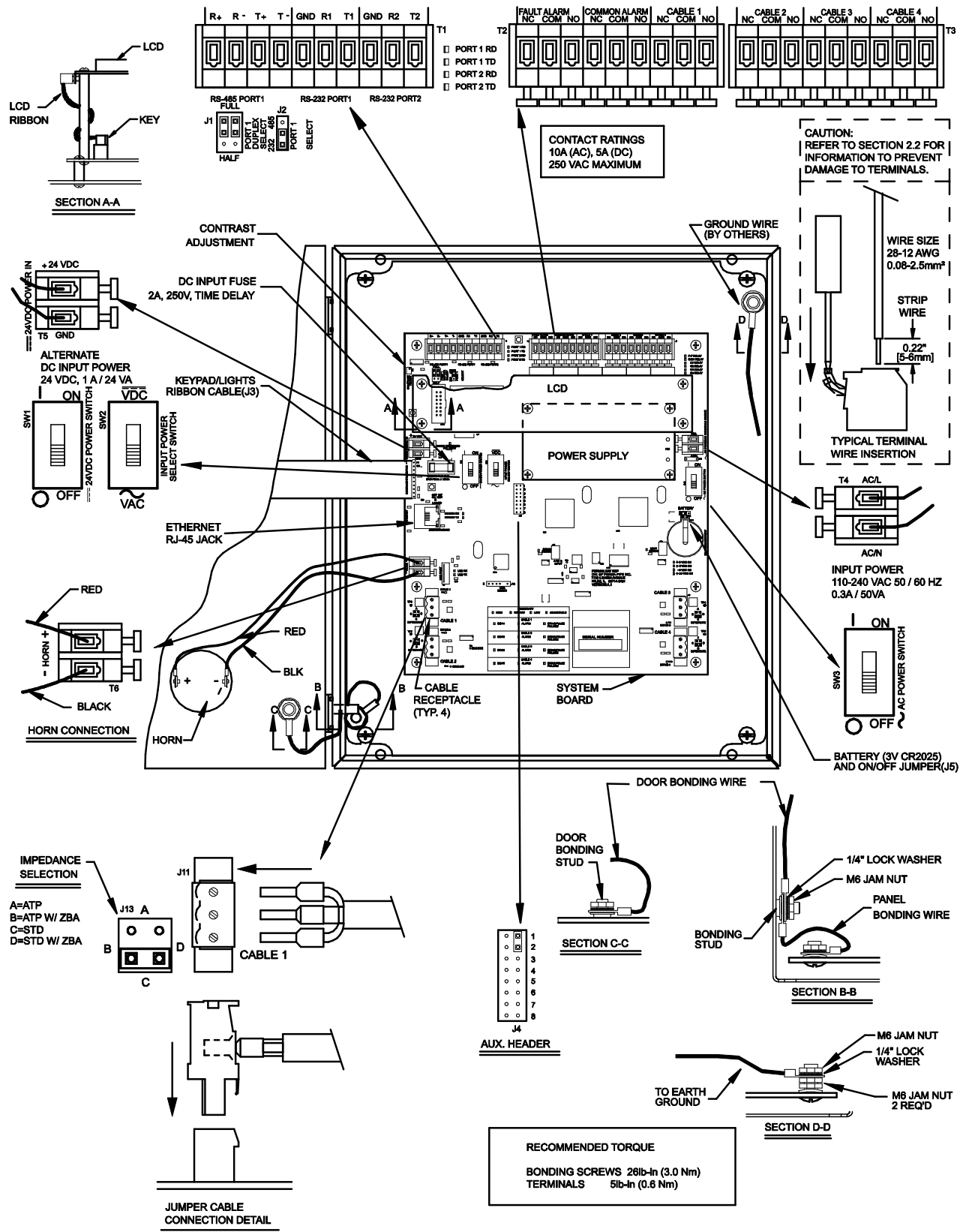


Figure 2-3
Wiring Diagram for PAL-AT Model AT30K

2.6 Communications

PAL-AT is provided with several options for communication. The options include:

- Port 1 – RS-485/RS-232
- Port 2 – RS-232
- Ethernet - RJ-45 connector

Refer to the *PAL-AT Operating Manual* for complete operating details and firmware configuration.

2.6.1 Port 1 - RS-485/RS-232

Port 1 can be configured for RS-485 or RS-232 (refer to figures 2-2 and 2-3). To configure it for RS-485, jumper J2 should be placed in the top position. Then the two jumpers at J1 can be set to select either full (top positions) or half-duplex (bottom positions).

Full duplex is available using two twisted-pairs connected to T1 terminals R+, R-, T+ and T-.

Half duplex, or 2-wire RS-485, requires a jumper wire connecting terminal R+ to T+ and a jumper from R- to T-. Each PAL-AT is a full load for the RS-485 network. A crimp ferrule is recommended to connect each incoming RS-485 lead to the corresponding jumper wire to insure a solid connection of the two wires in the T1 terminals.



All RS-485 cables in the network should be properly terminated as per EIA RS-485 recommendations. Typically the network is a daisy-chain configuration and two 120 ohm termination resistors are installed, one at each end of the network. Shields of the network cables should be connected together and grounded at only one point.

Port 1 can be configured for RS-232 by moving J2 to the bottom position. Then a 3-conductor cable should be connected to T1 terminals GND, R1 (receive) and T1 (transmit). The baud rate is configured via the PAL-AT firmware.

2.6.2 Port 2 - RS-232

RS-232 communications through port 2 requires a 3-conductor cable connected to T1 terminals GND, R2 (receive) and T2 (transmit). The baud rate is configured via the PAL-AT firmware.

2.6.3 Ethernet

An Ethernet RJ-45 jack provides a TCP connection to the PAL-AT. There are three ports available to handle different protocols: port 1024 for ASCII data (PALCOM), port 502 for Modbus TCP, and port 1050 for Modbus RTU over TCP.

An optional BACnet gateway is also available. Refer to Modbus to BACnet Converter Instructions (DOCID: PPPA-PRC-CSV-006) for more information.

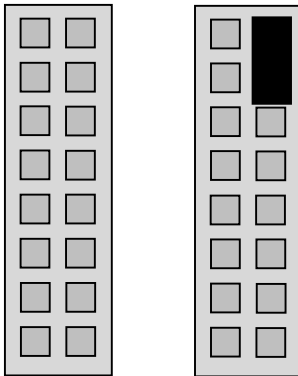
Refer to the *PAL-AT Operating Manual* for complete operating details and firmware configuration.

2.6.4 Ethernet Auto-Negotiate Selection

By default, the PAL-AT is shipped with the Ethernet port permanently set to 100Mb / Full duplex. Optionally, the port can be set to auto negotiate speed and duplex when required. This is most often required when hard setting the switch port isn't possible to allow 100Mb / full duplex, or when connecting to a network that otherwise requires auto negotiation (i.e. Gigabit networks).

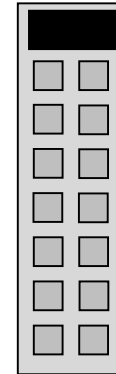
Ethernet auto negotiation is set through the placement of a jumper on the Auxiliary Header "J4". The header is located to the lower left of the power supply. Refer to Figure 2.3 for the exact location.

Fixed 100Mb full duplex permanently set (Legacy)



No Jumper or jumper not in active position (across right pins or on 1 pin).
Default as shipped.

Auto Negotiate



Jumper active in position 1

NOTE: System must be power cycled after changing the jumper position.

2.7 Replaceable Parts



Caution - Before accessing the PAL-AT panel, the panel must be disconnected from the power source and isolated from any hazardous voltage present in the panel, e.g. relay wiring.

2.7.1 Battery

Battery BT1 on the PAL-AT system board maintains the clock settings when the panel is off. Jumper J5, located above the battery, must be set "On" (left position) to enable the battery. The battery is a 3 V lithium type.



Replace Battery With Energizer CR2025 Only. Use of Another Battery May Present A Risk of Fire or Explosion.

Caution, Battery May Explode if Mistreated. Do Not Recharge, Disassemble or Dispose Of in Fire.

It can be obtained locally or through PermAlert. It is replaceable by gently lifting the retaining clip to remove the old battery and sliding in the new one. Be careful to install the battery correctly. The lettering on the battery (+) should be facing out.

2.7.2 24 VDC Fuse

In addition to a user supplied external overcurrent protection device, fuse F1 on the PAL-AT system board protects the 24 VDC input. It is a 2 A, 250 V, time-delay, 5 x 15 mm fuse. It can be obtained locally or through PermAlert.

2.8 Contrast Adjustment

The contrast of the LCD can be adjusted by turning the contrast adjustment screw on the system board (see figures 2-2 and 2-3). This may be necessary to get the best viewing angle, depending on the

mounting height of the PAL-AT panel.

2.9 Impedance Jumper Setting

Refer to figures 2-2 and 2-3 for positioning the impedance jumper. The 2-pin jumper is placed in position A, B, C, or D according to the type of cable and whether a Zener Barrier Assembly (for hazardous locations) is connected to the selected cable. The position should be:

<u>Jumper Position</u>	<u>Cable Type</u>	<u>Zener Barrier Ass'y Installed</u>
A	ATP only	No
B	ATP only	N/A
C	All others	No
D	All others	Yes

2.10 UL

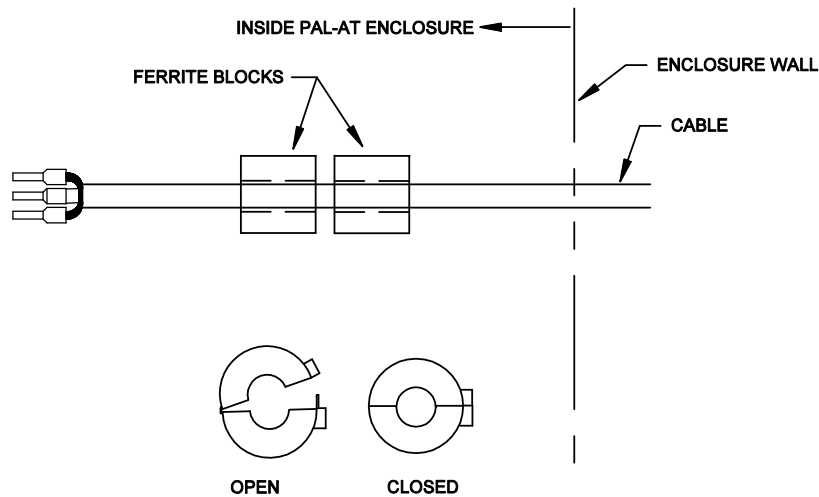
PAL-AT is listed by Underwriters Laboratories, Inc. for installation in ordinary locations. The optional Zener Barrier Panel must be installed if any leak detection circuits are located in hazardous locations.



CAUTION - The maximum operating voltage allowed in the PAL-AT panel is 250 VAC. In addition, the voltage on any wires to the control relays must be limited to 250 VAC.

2.11 FCC and CE Compliance Requirements

Each PAL-AT system is supplied with several "ferrite blocks" (PermAlert part # 8058207) to comply with FCC and CE regulations for a Class A digital device. The sensor cables, jumper cables, and all communications wires must pass through two blocks before exiting the enclosure (see figure 2-4). All relay wires and power wires must pass through one block.



NOTE: JUMPER CABLES AND COMMUNICATION CABLES MUST PASS THROUGH 2 FERRITE BLOCKS.
RELAY WIRES AND POWER WIRES MUST PASS THROUGH 1 FERRITE BLOCK.
A FERRITE BLOCK CAN HAVE MORE THAN 1 WIRE IN IT IF THERE IS SUFFICIENT SPACE.

Figure 2-4
Ferrite Block Assembly

3 Zener Barrier Panel

3.1 Introduction

The optional Zener Barrier Panel (ZBP) is available for connection to PAL-AT when leak detection cables and probes are installed in hazardous locations. It provides intrinsically safe output circuits for use in Class I, Division 1 Groups C and D hazardous locations (Zone 0, Group IIB) when used with PAL-AT sensor cables, jumper cables, and probes, installed in accordance with the instructions in this manual. **Refer to Appendix A, Special Instructions, for intrinsic safety requirements.**

The ZBP also functions as a surge suppressor and reduces the chance of damage to the internal Zener Barrier Assemblies (ZBA) and PAL-AT from external voltage spikes, e.g. nearby lightning strikes.

3.2 Panel Installation

The ZBP is designed to be permanently mounted indoors in a dry, non-hazardous location. The enclosure is rated Type 4, 12 [IP66] (see figures 3-1, 3-2, and 3.3). The enclosure must not be located in direct sunlight to prevent excessive heat buildup. **In all installations, the ambient temperature surrounding the panel must not be less than -4°F [-20°C] and not exceed 140°F [60°C].** Relative humidity must be less than 95% (non-condensing).

The ZBP must be located adjacent to the PAL-AT panel. **Each Zener Barrier Assembly (ZBA) in the panel has a 5 ft [1.5 m] cable connected to the cable plug in the PAL-AT. The cable must be run in conduit between the two panels.**

The jumper cable from the ZBP to the sensing cable in the hazardous location must be routed in conduit. All conduit fittings must be appropriately rated and installed properly to maintain the rating of the enclosures. All electrical connections must comply with local codes. Seal-offs may be required to prevent vapors from traveling into the ZBP.

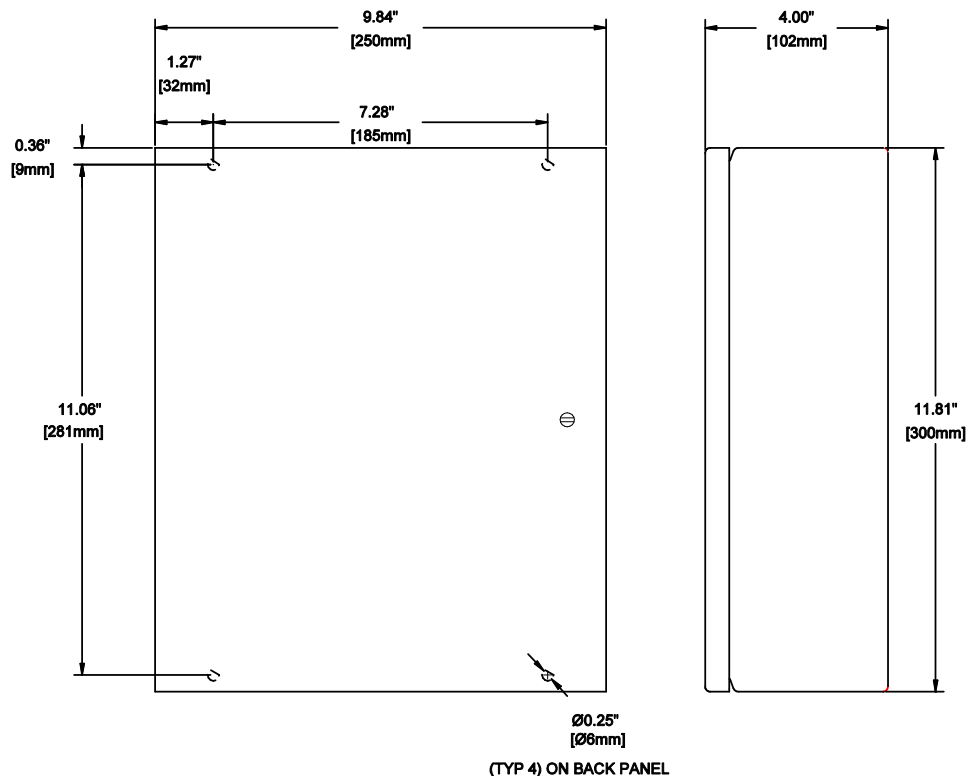


Figure 3-1
Zener Panel Mounting

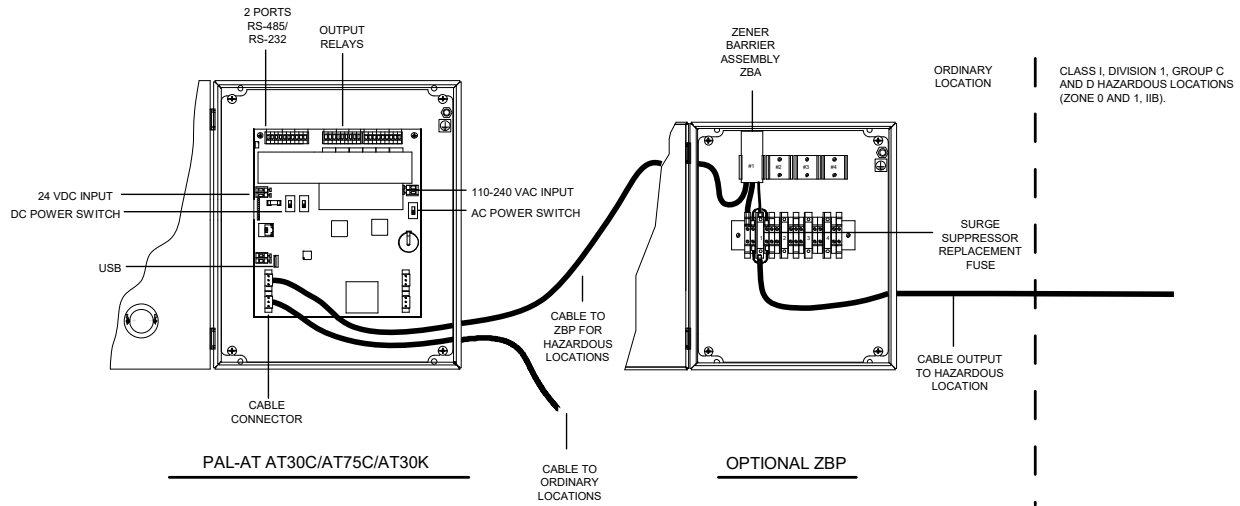


Figure 3-2
PAL-AT and Zener Barrier Panel

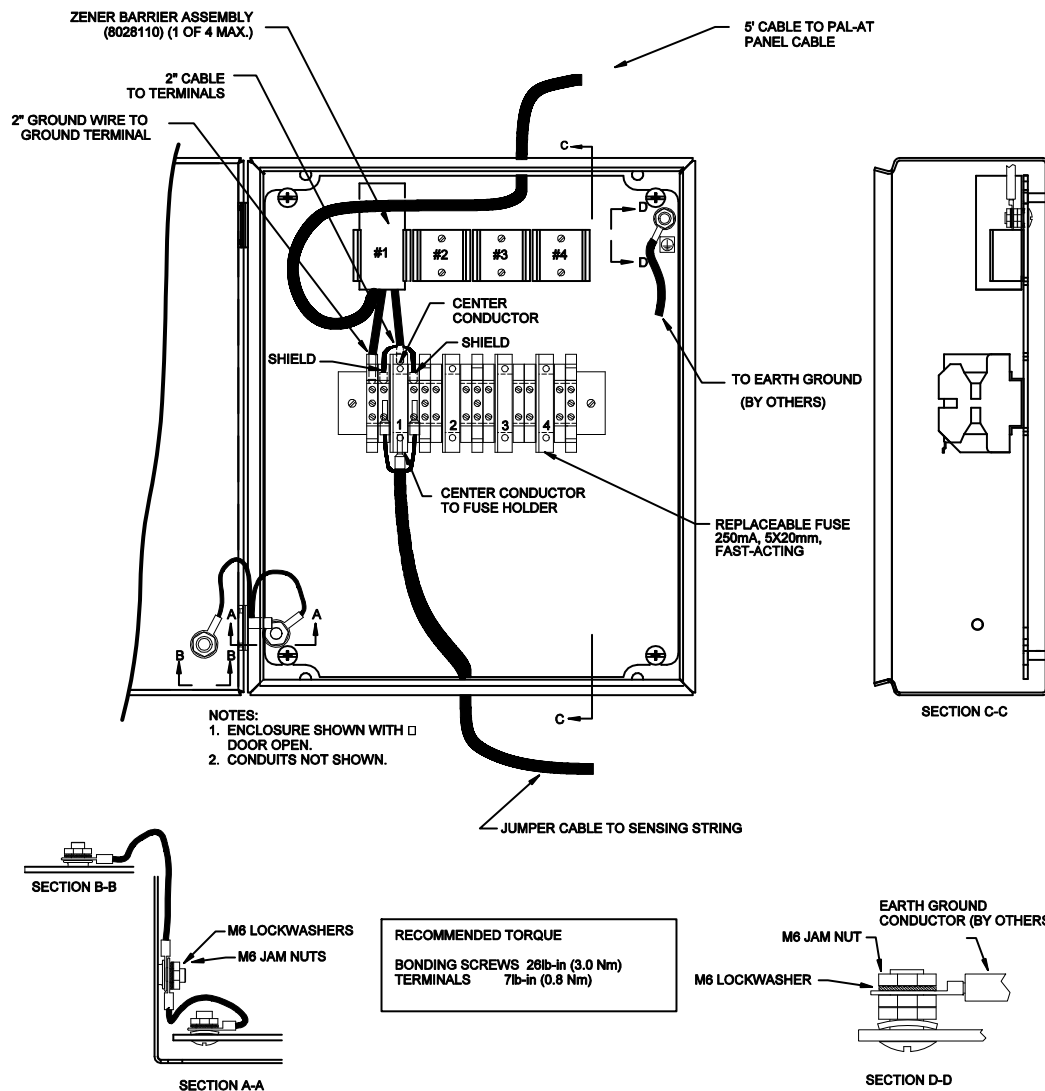


Figure 3-3
Zener Barrier Panel (ZBP) Wiring

3.3 Panel Wiring

The standard Zener Barrier Panel (ZBP) includes one zener barrier assembly (ZBA) and has provisions to install three additional ZBA's. Each ZBA has a 2" [50 mm] coaxial cable lead, a 5' [1.5 m] coaxial lead and a 2" [50 mm] ground wire.

The 5' [2 m] cable should be routed through conduit and connected to the appropriate cable plug in the PAL-AT panel. The jumper cable to the PAL-AT sensing string should be connected to the fuse holder and adjacent terminal blocks for the appropriate cable number. The jumper cable should have a ferrule on the center conductor and two ferrules on the braid. Refer to section 8, Cable Connectors, for details.

A customer supplied earth ground wire, minimum 12 AWG [4 mm²], must be connected between the ground connection on the upper right corner of the white back plate of the enclosure and the ground bus of the power distribution panel.

3.4 Zener Barrier Assembly (ZBA) Installation

Refer to figure 3-3 to install a ZBA.

1. If an existing ZBA is to be replaced, loosen the four screws on the terminal strip for the ground wire, coaxial cable center conductor, and two coaxial cable braid wire ferrules. Lift the ZBA out of the mounting clip. Remove the end of the 5 ft. long cable from the connector in the PAL-AT panel.
2. Position and rotate the new ZBA so the 2" ground wire aligns with the appropriate ground terminal (green/yellow terminal). Note the ground terminal for barrier #4 is on the opposite side of the fuse holder as the other barriers. Loosely insert the ground wire, the coaxial center conductor ferrule and two braid wire ferrules into the ground terminal, fuse holder and adjacent terminals. The ground wire ferrule is a snug fit in the terminal and may have to be rotated slightly to insert fully.
3. Press and hold the ground wire fully inserted into the ground terminal, while tightening the terminal screw. Next, press and hold in place the coaxial center conductor ferrule into the fuse terminal and tighten the terminal screw. Similarly, press, hold and tighten each of the braid wire ferrules. Snap the zener barrier assembly into the plastic holder. The 5' [1.5 m] cable should be routed through conduit and connected to the appropriate cable plug in the PAL-AT panel.

3.5 Fuse Protection

Each Zener Barrier Assembly is protected from external voltage surges by a replaceable fuse in the terminal strip fuse holder. The 5 x 20 mm fuse is rated 250 mA, 250 V, fast-acting (Littelfuse 0217.250 or equal). A replacement may be purchased from PermAlert (part # 8067989) or obtained locally.

3.6 Allowable Cables and Probes

Refer to Appendix A – Special Instructions for the PAL-AT control drawing and additional intrinsic safety requirements for hazardous areas. The following cables, probes, and probe integrators supplied by PermAlert comply with the allowable electrical characteristics:

<u>Part No.</u>	<u>Cable Type</u>	<u>Part Number</u>	<u>Probe Type</u>	<u>Part Number</u>	<u>Probe Type</u>
8017705	AGW-Gold	8027888	PHLR-S	8027920	PSTV-L
8017700	AGT-Gold	8027889	PHLR-L	8027633	PTHL-S
8017640	TFH-Gold	8027911	PHLR-P-S	8027970	PTHL-L
8017635	TFH	8027912	PHLR-P-L	8027629	PT10-SC
8017715	JMP-U	8027623	PFS-S	8027932	PT10-SO
8017718	JMP-UD	8027910	PFS-L	8027930	PT10-LC
8017685	JPP	8027624	PSTV-S	8027934	PT10-LO



Note: A PWS probe or a probe integrator connected to a customer supplied probe having an exposed conductive surface, may not be connected to a ZBA.

4 Jumper Cable and Junction Box Installation

4.1 Jumper Cable

1. Jumper cable (types JMP-U, JMP-UD, or JPP) is used to connect sensor cable segments and probes in series to form the sensing circuit (sensing string). Jumper cable is not affected by occasional contact with water and can be installed in building and vaults. In underground locations and areas where damage may occur to the jumper cable, electrical conduit should be used to provide protection. In wet environments or areas subject to flooding, cable connectors on jumper cable should be located in watertight electrical junction boxes (NEMA 4 or 4X) [IP66].
2. At least 50' [15 m] of jumper cable (65' [20 m] for type JPP) must be installed from the PAL-AT panel or Zener Barrier Panel to the first section of sensor cable or probe. An exception is connecting to ATP cable (see section 10).
3. Table 4-1 lists the length of jumper installed at the very end of a sensing string. A cable connector must be installed to terminate the end of the last jumper cable section and a threaded plastic cap is supplied to cover the connector.
4. Refer to section 9, table 9-1 for additional jumper cable required in a probe section.
5. Where possible, jumper cable connections to sensor cable should be made within the monitored area. PermAlert recommends the use of OZ Gedney, or equal, cord grips installed as shown in figure 4-1. Cord grips must clamp only jumper cable or TFH cable. The plastic outer braid on TFH cable must be pulled back so the cord grip is located on the smooth outer jacket.
6. Check the cable/connector assembly with an ohmmeter in accordance with the cable testing procedures contained in this manual.
7. The recommended minimum bend radius for all jumper cables is 1.5" [38mm].

Table 4-1
End of System Jumper Cable Length

System Length ft / [m]	JMP-U/UD End Jumper Length ft / [m]	JPP End Jumper Length ft / [(m]
0-2500 / [0-750]	30 / [9]	40 / [12]
2500-5000 / [750-1500]	50 / [15]	65 / [20]
5000-7500 / [1500-2300]	100 / [30]	125 / [40]

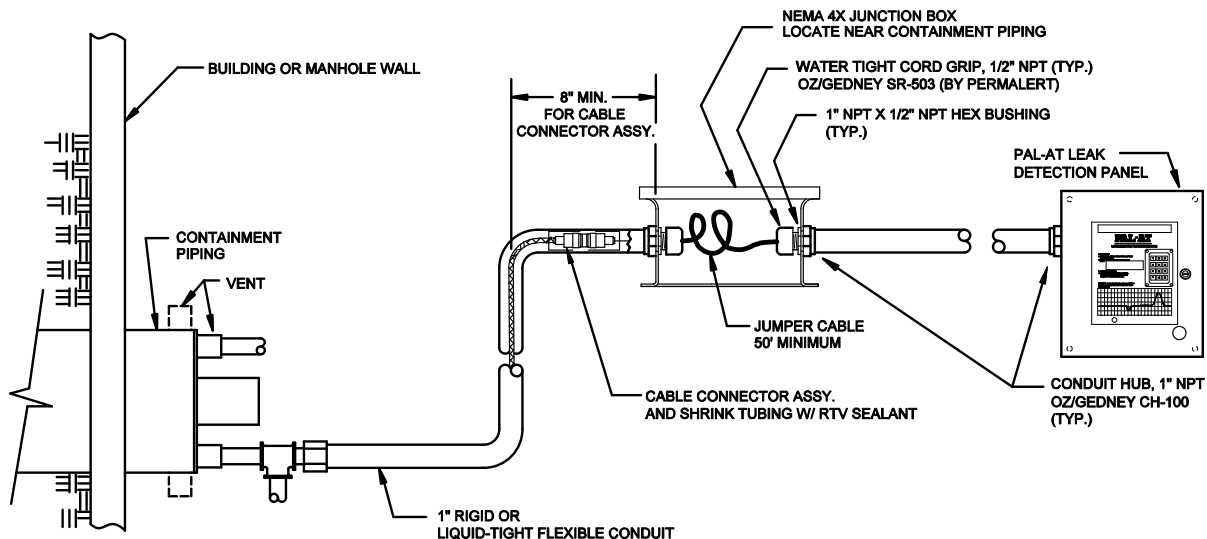


Figure 4-1
Typical Cable Connection in Monitored Areas with Junction Boxes

4.2 Calibration Points

1. During the initial setup and calibration of the PAL-AT system, connectors at selected locations (calibration points) are temporarily disconnected. **Therefore, it is imperative to have accessibility to connectors at calibration points at all times until the system is brought on-line.**
2. Reported fault location accuracy of the first leak is dependent upon the use of and distance between calibration points. Calibration points are required at changes of cable types unless connected to short lengths of jumper cable (15' [5 m] or less). Additional calibration intervals of 500' [150 m] or less will result in location accuracy of within +/- 6' [2 m]. Systems installed with calibration intervals exceeding 500' [150 m] will have a location accuracy of less than +/- 1% of the cable length from the previous calibration point.

4.3 Junction Boxes

There are two series of junction boxes supplied by PermAlert. The standard, polyester box has a maximum temperature rating of 150°F [65°C]. A fiberglass box is available for temperatures to 300°F [150°C].

1. Locate and install all junction boxes before installing any cable. Locate junction boxes as indicated on system drawings or as required. These locations include calibration points, the start and end of cable runs, manholes, probes, etc. Care must be taken to prevent water from contaminating these areas.
2. Securely mount the junction boxes to a vertical wall. In manholes or pits that might collect and hold water, mount junction boxes as high as possible. Use NEMA 4X [IP66] junction boxes at all locations.
3. Use a hole saw to cut the junction box as needed for conduit.
4. When jumper cable is installed in electrical conduit, use watertight conduit hubs and cord grips at junction boxes. Discard the male bushing supplied with the hub and use the cord grip supplied in its place. Depending upon the specific products used, a lock nut may be required on the cord grip's threads to pull the hub tight to the wall of the junction box.

Caution: Always keep junction boxes and electrical conduits capped to prevent water from entering.

5 Cable Installation in Secondary Contained Piping

5.1 General

In secondary contained pipe applications, the sensor cable is installed in the bottom (6 o'clock position) of the air space between the product pipe(s) and secondary containment (outer casing or conduit). The leak detection cable is a sensitive sensor, capable of detecting small amounts of liquid. **Therefore, every effort must be made to keep the cable dry and prevent water from entering the air space. In addition, long-term accumulations of water, corrosive liquids, or hydrocarbon liquids in the containment pipe may degrade the containment or the leak detection system components.** The piping system must remain sealed during installation to prevent moisture entering the system. The installing contractor must install caps on the open ends of pipe installed in a trench to prevent liquids from entering the conduit or containment pipe.



Caution: A heated system using mineral wool or fiberglass insulation should be carefully monitored during startup. If the insulation is wet (even from atmospheric moisture) prior to startup, the water may combine with the ammonium sulfate binders in the insulation and release ammonia when the pipe is heated. The ammonia is detrimental to the leak detection cable and may be detrimental to the piping system if left uncorrected.

If the system becomes wet, it must be completely dried. Drying methods can consist of pulling a vacuum on the interstitial space, using compressors with desiccant dryers, or other methods. Obtain guidance from your piping supplier on proper techniques to be used with your system.

This section is intended to cover installation methods typically employed with any fabricated secondary contained pipe systems. Typically, these manufactured products are custom fabricated with product pipes positioned by specially designed supports within the secondary containment. **All pipe supports and changes in direction must have guides constructed out of stainless steel, minimum 3/4" [20 mm] ID tubing, with flared ends. Plastic supports must be avoided when the carrier pipe is metal. Consult with the piping system manufacturer before installation to ensure provisions are being made for the cable installation.** Because the sensor cable installation is dependent upon the design provisions employed by the pipe manufacturer, it is recommended the secondary pipe manufacturer supply the leak detection/location products. This sole source responsibility will greatly facilitate proper installation with lower cost.

The following charts are general references for installing a sensor cable into field-constructed secondary contained pipe system built with piping components. Typically, these systems are constructed using standard lengths of pipe and fittings for the product and secondary containment structures. Components of the piping system should be designed, manufactured, and installed to facilitate sensor cable installation. Because the sensor cable is placed on the bottom of the air space, there must be a continuous unobstructed passage for the cable(s) being pulled into the system. **PermAlert recommends a 1" [25 mm] air space. Pipe support design and alignment is critical. Pipe supports and other surfaces the cable contacts during "pulling" operations must be smooth to prevent snagging or damaging the cable.**

Field joint designs and procedures employed in the installation of the piping system must prevent damage to the pull rope and/or sensor cable.

Pull ropes must be installed as the pipe system is assembled together to facilitate the installation. Special stainless steel 3/4" [20 mm] ID guide tubes must be installed in the air space of the containment straight, elbows, tees and wyes (lateral) at the factory. Pull points must be designed and provided at specific locations to facilitate the installation of the pull cable and leak detection cable. **The recommended minimum bend radius for all sensor and jumper cables is 1.5" [38mm].**

Polypropylene / Polyethylene Piping SDR Sizes

Pipe Size (in) [mm]	Casing Size (in) [mm]	SDR11/SDR11	SDR11/SDR32.5
1.5 [40]	4 [100]	OK	OK
2 [50]	6 [150]	OK	OK
3 [80]	6 [150]	OK	OK
4 [100]	8 [200]	OK	OK
6 [150]	10 [250]	OK	OK
8 [200]	12 [300]	OK	OK
10 [250]	14 [350]	NO	OK
12 [300]	16 [400]	N/A	OK
14 [350]	18 [450]	N/A	OK
16 [400]	20 [500]	N/A	OK

Leak Detection Sizing Chart For Standard Weight Steel and Fiberglass Pipe (w/o insulation, 10 gauge steel or fiberglass containment)

Pipe Size (in) [mm]	Casing Size (in) [mm]
2 [50]	6 [150]
3 [80]	6 [150]
4 [100]	8 [200]
6 [150]	10 [250]
8 [200]	12 [300]
10 [250]	14 [350]
12 [300]	16 [400]

Note:

1. Not all pipe types or sizes are shown in the above charts. For different systems, contact PermAlert.
2. Chart is based on smooth pulling surfaces and installation of guide tubes.
3. Multi pipe system will require factory sizing.

5.2 Pull Points

1. Sensor cable must be “pulled” into the monitored areas using a continuous pull rope free of splices between pull points. Surfaces the cable contacts during “pulling” operations must be smooth to prevent snagging or damaging the cable.
2. Generally, pull points can be located at 500' [150 m] intervals for straight runs. Each 90° fitting on the run reduces the interval by 150' [50 m]. For example, a run of 50' [15 m] with three elbows is allowable ($500' - (3 \times 150') = 50'$).
3. Pull point designs should be selected not only based on accessibility during installation, but potential future cable replacement. When future cable replacement is a consideration, it is recommended underground installations have watertight junction boxes or secondary contained access points installed at grade or in vaults (see figure 5-1).



Caution: Pulling points often become calibration locations. When this occurs, accessibility to the cable connectors is necessary during the initial commissioning of the PAL-AT and the system's setup procedures.

4. **Pull ports may also be used for periodic testing.** If so, a short length of sensor cable (minimum 5' - AGW-Gold, 15' - TFH/TFH-Gold) with connectors should be installed in the pull port during the initial setup. It is used as a test piece and can be replaced if needed after testing without setting up the cable string again.

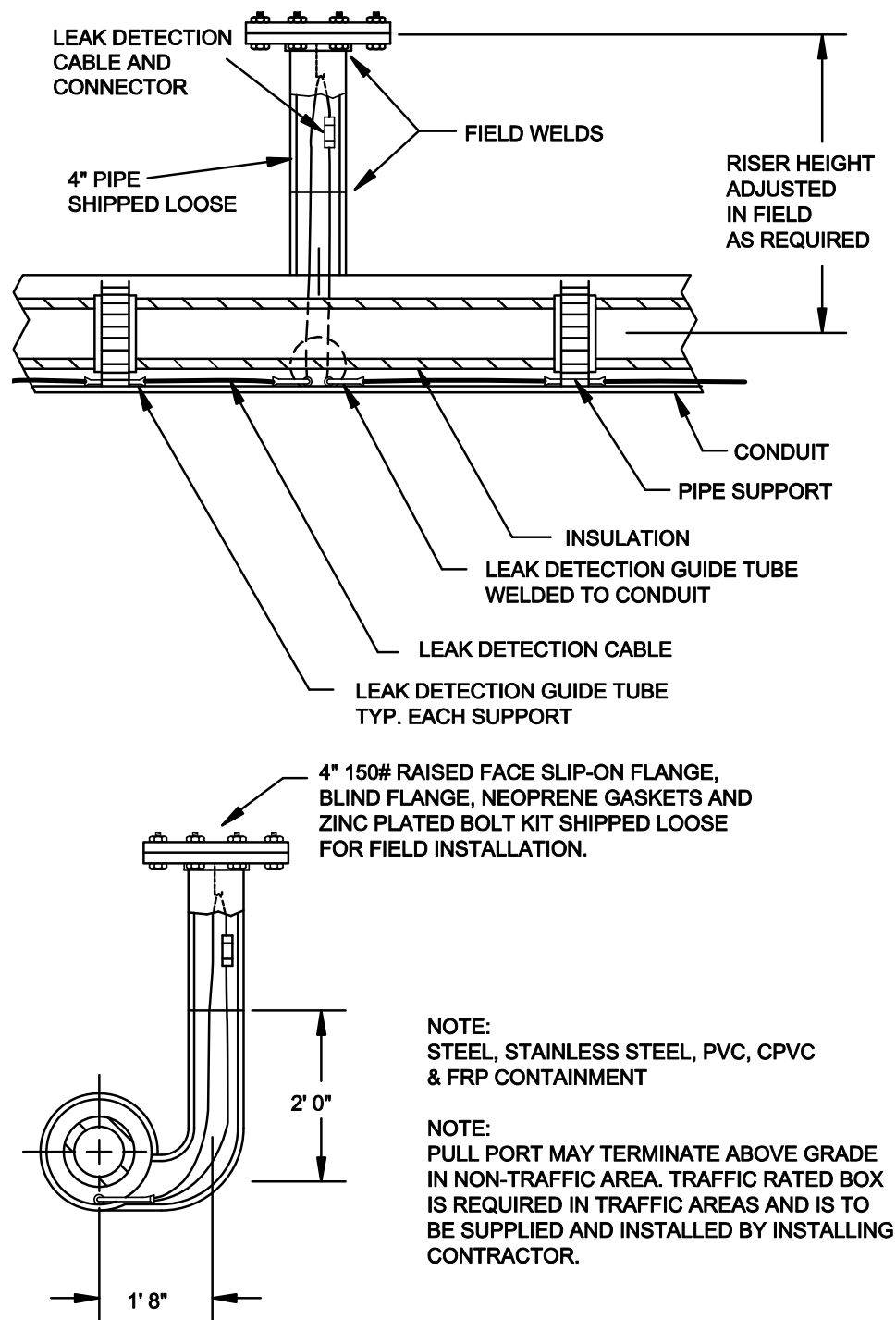


Figure 5-1
Detail of Pulling Point

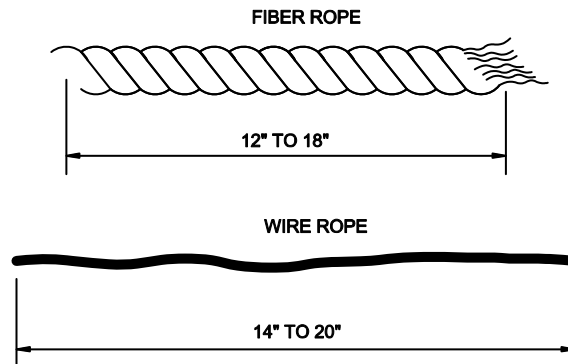
5.3 Cable Splices

Continuous pull rope and sensor cable are "pulled" into the secondary containment during certain stages of installation. Several splices are used to provide secure attachments to pull ropes and cable during this procedure. The following methods are recommended for splicing.

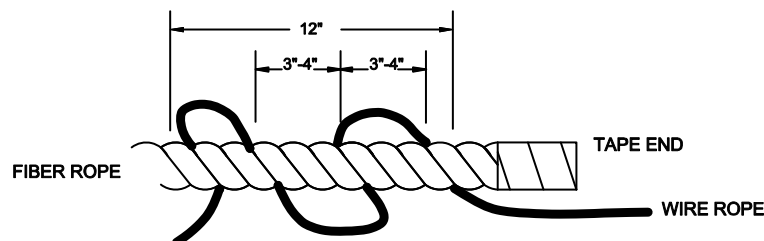
Note: When using tape to seal the splices, use only PVC electrical tape. PVC tape minimizes drag on the cable and reduces snags.

5.3.1 Factory Installed Fiber Pull Rope to Continuous Pull Wire Rope Splice

Step A Extend 12" to 18" [300 mm to 450 mm] of fiber rope and 14" to 20" [350 mm to 500 mm] of wire rope.



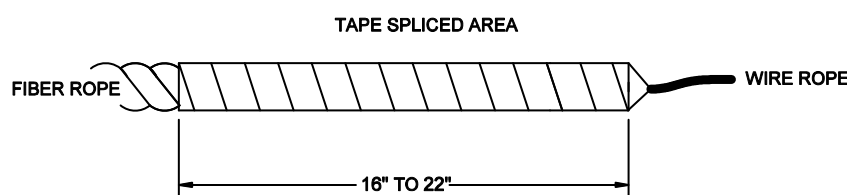
Step B Wrap a small amount of electrical tape around the fiber rope's end to prevent unraveling. Using a small pointed object (such as a nail), slightly separate the fiber rope braid and weave the wire rope into each opening of the braid as you go.



Step C Pull the wire rope tight, as it is woven into the braid.

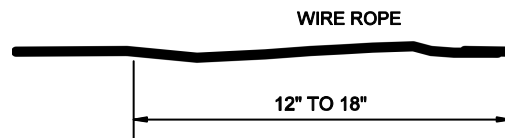


Step D Using electrical tape, wrap the entire length of the splice area. The tape should extend approximately 2" [50 mm] over each end of the splice.



5.3.2 Wire Rope to Wire Rope Splice

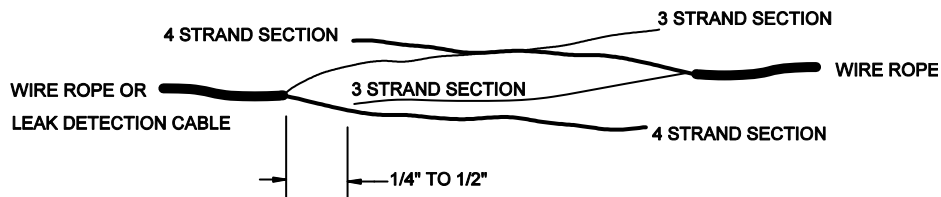
Step A Extend 12" to 18" [300 mm to 450 mm] of each wire rope end for the splice.



Step B Unravel each of the 12" to 18" ends into a 3-strand and a 4-strand section (approximately 50% in each), keeping the adjacent strands together.



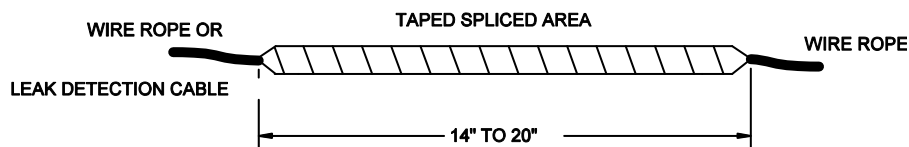
Step C Starting approximately 1/4" to 1/2" [6 mm to 12 mm] from the start of the wire rope's split, intertwine a section from each of the two ropes.



Step D Line up the two remaining sections and intertwine them together in a similar manner. In order to minimize the size of the splice, make sure the starting points for each intertwining operation line up with each other.



Step E Starting at approximately 1" [25 mm] from the beginning of the splice, wrap electrical tape around the splice until the entire splice, plus 1" on each end, is covered. Normally only one wrap is needed. Make sure both ends of the tape wrap are tapered and smooth in case the pull direction must be reversed.



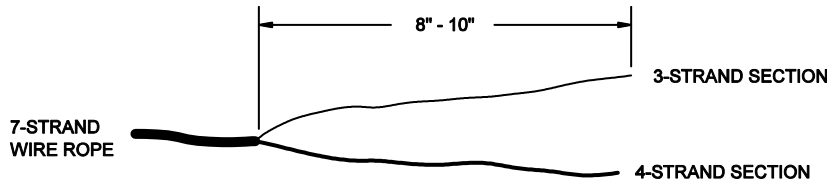
5.3.3 Wire Rope to Wire Rope Splice (alternate)

Note: Use this splice when splicing two different size wire ropes together

Step A Extend 8"-10" [200 mm to 250 mm] of each wire rope to be spliced.



Step B Unravel each of the 8"-10" sections (to approximately the same length) into two sections to form a Y with three adjacent spiral strands on one side, three adjacent spiral strands with center strand on the other.



Step C Taking one end of the first cable, fold over the 4-strand section of the Y to form a loop. Join the 3-strand section to the 4-strand section. Wrap the 3-strand section around the 4-strand section so the strands appear as in the original undisturbed cable.



Step D Take the second cable Y end and place the 4-strand end through the eye of the first cable loop.



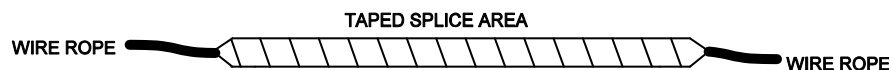
Step E Repeat steps A through C.



Step F Using a pair of pliers, crimp the ends of the loops.



Step G Spiral wrap the splice tightly, using electrical tape.



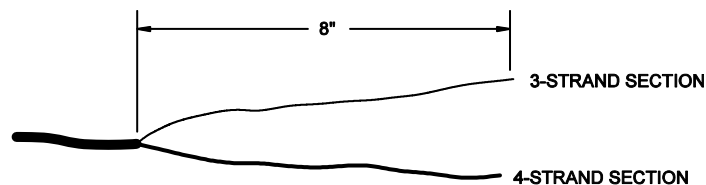
5.3.4 Wire Rope to Leak Detection Cables

The following steps apply in general to all sensor and jumper cables. However, there may be slight variations to the steps presented depending on the cable selected. For example, the jumper cables have an outer jacket but no plastic overbraid, while the TFH cable has both a jacket and an overbraid.

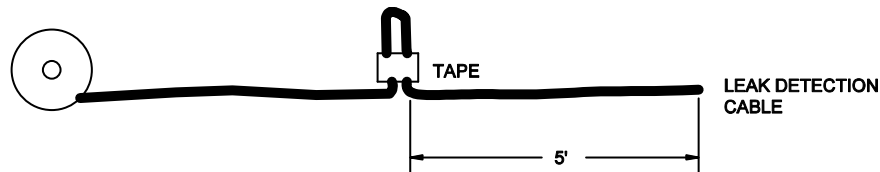
Step A Extend the 7-strand 1/8" [3 mm] wire rope for splicing. Cut the end so all strands are even.



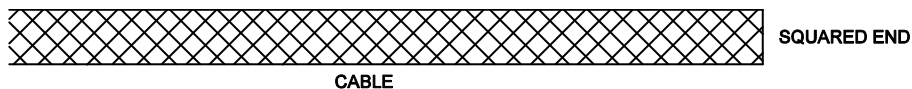
Step B Unravel 8" [200 mm] of the wire rope into two sections to form a "Y" with three adjacent spiral strands on one side and four strands on the other side.



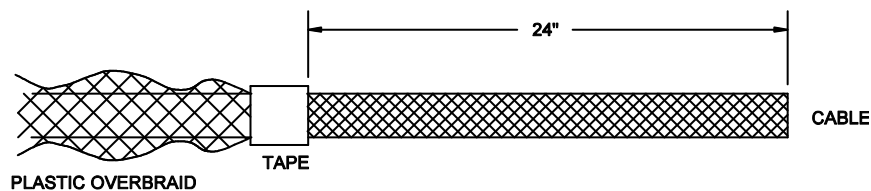
Step C Extend approximately 5' [1.5 m] of cable for the splice. Form a small loop in the shape of a "U" 5' from the end of the cable and tape it in place tightly. Do not kink the cable when forming the "U" (Skip this step with jumper cables.)



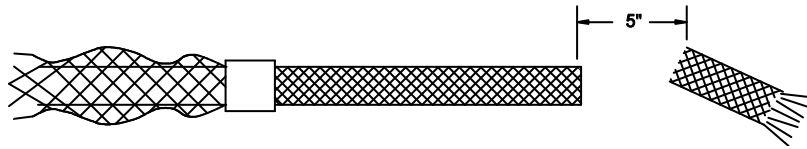
Step D Cut the end of the cable so the plastic overbraid, jacket, metallic braid, center conductor insulation, and center conductor are flush at the end of the cable.



Step E Slide the plastic overbraid back over the sensor cable at least 24" [600 mm] and tape in place tightly.

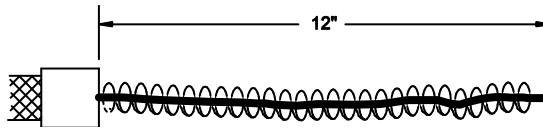


Step F Cut 5" [125 mm] off the exposed end of the sensing cable.

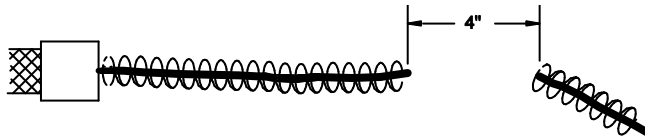


Step G Cut off 15"-18" [380 mm to 450 mm] of the outer jacket and tightly tape the edge of the outer jacket to the metallic braid. (This applies to only TFH and jumper cables.)

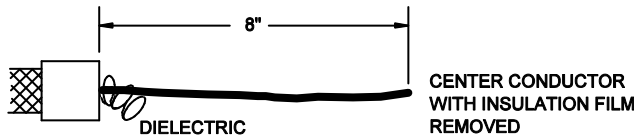
Step H Slide 12" [300 mm] of the metal braid back towards the taped jacket. Tape the metallic braid in place.



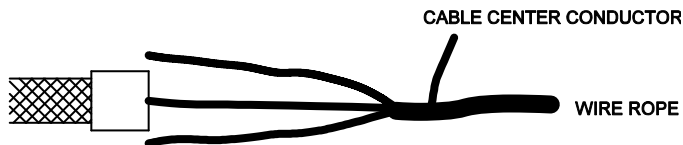
Step I Cut 4" [100 mm] off the end of the center conductor and conductor insulation.



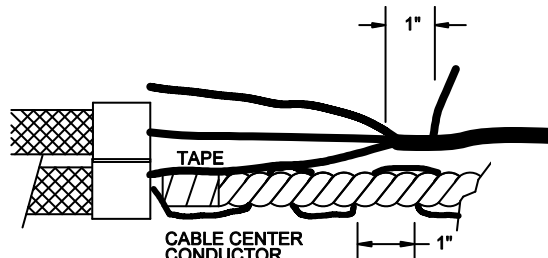
Step J Carefully remove 6"-8" [150 mm to 200 mm] of the dielectric spacer material and conductor insulation from the center conductor. Do not cut the center conductor strands when removing the thin film of insulation. Securely tape the end of the dielectric spacer to the center conductor.



Step K Insert 1" [25 mm] of the cable's center conductor into the throat of the wire rope.



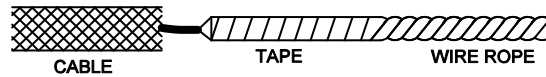
Step L Carefully braid 1" of the 3 and 4-strand sections of the wire rope.



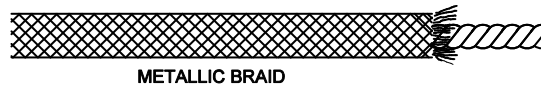
Step M Insert the center conductor of the cable into the next section of the Y throat of the wire rope. Continue to wrap and insert until approximately 5"-7" [125 mm to 175 mm] of the cable center

conductor is woven into the wire rope. Tape the end of the wire rope with electrical tape. Cut off excess wire rope at the end of the splice if necessary.

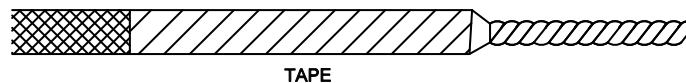
Step N Spirally tape the entire spliced wire rope/center conductor area tightly from front to end.



Step O Carefully slide the metallic braid over the woven splice area making sure the braid extends over the splice as much as possible, and is tight.



Step P Tightly tape the metallic braid in place, from the left end. Extend the tape just past the woven splice area. (Include 2"-3" [50 mm to 75 mm] of the white jacket if applicable.)



Step Q Carefully slide the plastic overbraid over the cable splice. Extend the plastic overbraid over the splice area as far as possible.



Step R Tightly tape the plastic overbraid in place, spirally, from the front end. Extend the tape just past the spliced area. The finished splice should be tapered in appearance.



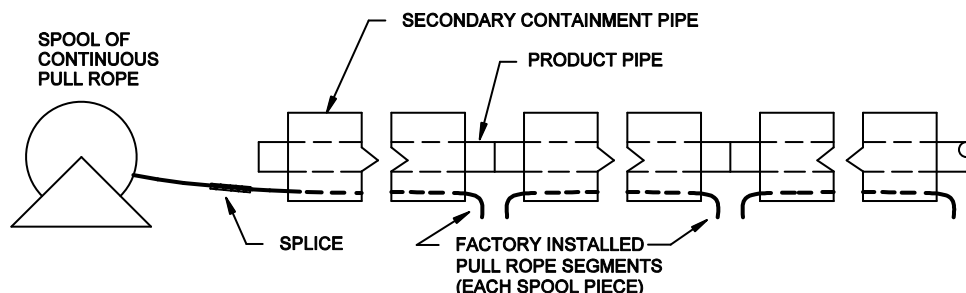
5.4 Installation of the Continuous Pull Rope

1. PermAlert recommends the installation of a continuous pull rope, free of splices between properly located and accessible pull points.
2. All sections of factory-prefabricated piping should be supplied with a factory-installed pull rope. The factory-installed ropes shall be used to pull the continuous pull rope into the air space before the secondary containment field joint closures are completed. Make sure the factory installed pull rope moves freely in each section of conduit when laying the pipe in the trench.
3. Pulling the continuous pull rope into the air space of the secondary containment requires careful planning on the installer's part. Care must be taken during the installation of the pipe system to proceed in a manner to maintain accessibility to the factory installed pull rope.
4. The installation of the continuous pull rope and the pipe system must proceed simultaneously. Working ahead on closing the pipe system joints may prevent the successful installation of the pull rope, necessitating the reopening of a joint(s). **Avoid allowing water, mud or other debris from entering the air space.** This can prevent successful cable pulling and a functional system.

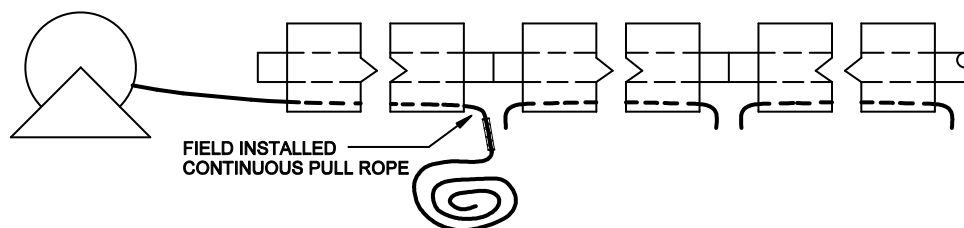
5. **Caution** all workers involved in the pipe installation that the factory installed pull rope should never be “temporarily” removed with the expectation it can be replaced later. Losing the end of the pull rope and allowing it to fall back inside the secondary containment must be avoided. Special care must be taken at risers where the weight of the rope, in the vertical section of the pipe, tends to pull the rope into the secondary containment.



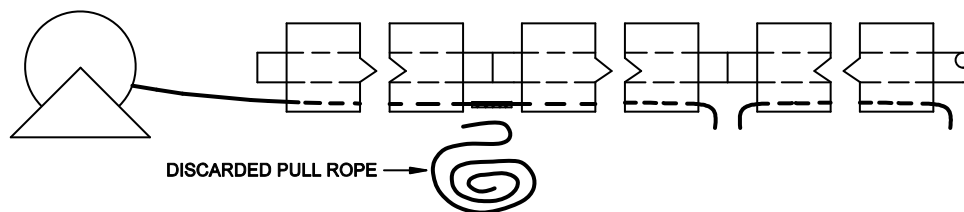
Step A Splice the continuous pull rope to the factory installed pull rope. Follow splicing procedures contained in the “Cable Splices” section.



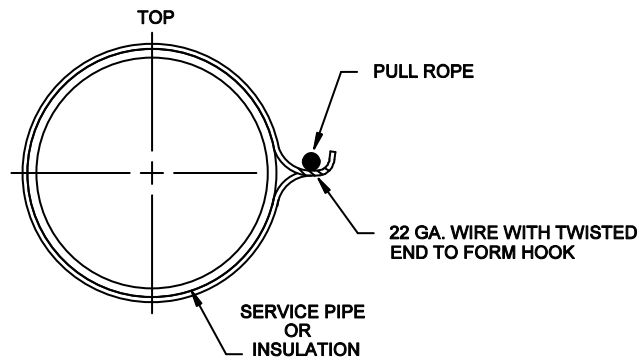
Step B Go to the first uncompleted secondary containment field joint and pull the continuous pull rope into the first section of piping until the splice exits the field joint.



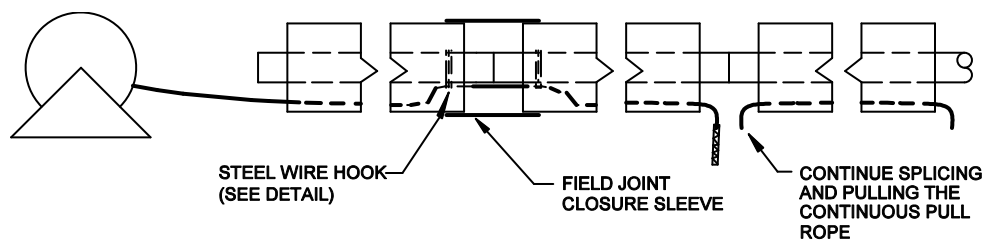
Step C Break the splice on the factory installed pull rope and discard the pull rope. Splice the continuous pull rope to the next section of factory pull rope, and pull the continuous pull rope into the next pipe



Step D Return to the first field joint. If the product pipes are insulated, apply insulation material. To prevent the continuous pull rope from being damaged during joining of the secondary containment, it must be held off the bottom of the containment. Attach the pull rope temporarily to the carrier pipe (insulation) by looping a piece of 22 gauge steel wire around the carrier pipe (insulation) and twisting the ends together to form a hook around the pull rope.



Step E The secondary containment field joint can now be made. After closing the field joint of the secondary containment, restrain the continuous pull rope at the spool end, and pull on the rope at the open field joint in order to pull the rope off the wire hook.



Step F Pull the continuous pull rope from the previously sealed joint to the next open field joint.

Step G Repeat the sequence of splicing, pulling and closing the field joints of the secondary containment until the continuous pull rope has been pulled through the entire piping run. Each time after completing 3 or 4 field closures, move the continuous pull rope back and forth in the containment to insure the pull rope moves freely.

5.5 Installing Sensor and Jumper Cables

1. After all other work is completed and the area is free and clear of all activities that can cause damage, the sensor cable should be installed. **Care must be taken during installation of sensor cable to avoid contact with potential contaminants such as water puddles or oil.**
2. PermAlert recommends installing the sensor cable before backfilling of underground secondary contained pipe systems.
3. **Keep the cable dry and clean.** Tent the spool area and do not install the sensor cable during a rainstorm.
4. Slowly play out the cable by hand rotating the spool. Never attempt pulling loose coils of cable off the end of the spool. When loose coils are pulled taut, kinks may form that could prevent bringing the system on-line.
5. **Always be careful to prevent the cable from falling into the secondary containment.** Be particularly careful at risers, where the weight of the cable in the vertical section of pipe tends to pull back the cable.
6. The bottom of a secondary containment that penetrates into a vault or building should be fitted with a minimum 1" [25 mm] threaded pipe coupling or similar fitting. This fitting will be located where the sensor cable enters (exits) the secondary contained piping system.
7. Check that the air spaces of secondary containment, at termination points of the piping system, are dry. Drain plugs in the containment should be provided for this purpose. If water is found, dry the system completely before attempting installation of the sensor cable.
8. Place the spool of sensor cable at the high end of the run. At this time, do not route the pull rope or

cable through the junction box and conduit.

9. Splice the sensor cable to the continuous pull rope using the method described in section 4.3, "Cable Splices".
10. At least two workers are required to pull sensor cable. Work should proceed continuously from pull point to pull point. At the lowest elevation between two pull points, one person should slowly pull on the pull rope. At the higher elevation pull point, the second person should carefully play out the cable while pushing it into the interstitial air space. This push/pull action significantly reduces the pulling force required to install the cable. If a problem does arise, the workers must be able to signal each other quickly. Walkie-talkies are recommended so communication can occur to prevent cable damage.
11. **The pulling force should never exceed 50 lb [23 kg].** If a snag is encountered, carefully work the cable back and forth in an attempt to clear the cable. If the snag cannot be cleared, contact PermAlert's Field Service Department for assistance.
12. Where electrical conduit and junction boxes are required, use watertight NEMA 4X [IP66] boxes and mount per the instructions contained in this guide. Temporarily pull enough sensor cable out of the secondary containment and into the junction box (approximately 2' [600 mm]) to allow installation of cable connectors (see figure 5-2). **Make sure the bushings and cord grips are slipped on the jumper cable before installing the cable connectors.** Attach the cable connectors, test them, and push the assemblies into the electrical conduits. Thread and tighten the cord grips making a watertight seal against the jumper cable. The conduit termination points must be sealed. **Do not leave conduit termination points open, or moisture may enter and wet the sensor cable.**
13. **The ends of all cables should be kept dry during installation. If the cable ends are submerged in water, capillary action will wick water into the center conductor. This could cause corrosion and shorten the life of the cable.**
14. **If TFH cable is installed, the ends of the cable must be immediately sealed with the shrink tube caps supplied by PermAlert to prevent water from entering the cable under the jacket.** Make sure the polyester overbraid is not under the shrink cap to insure a good seal. **If water is allowed to enter the ends of TFH cable, it must be replaced.**

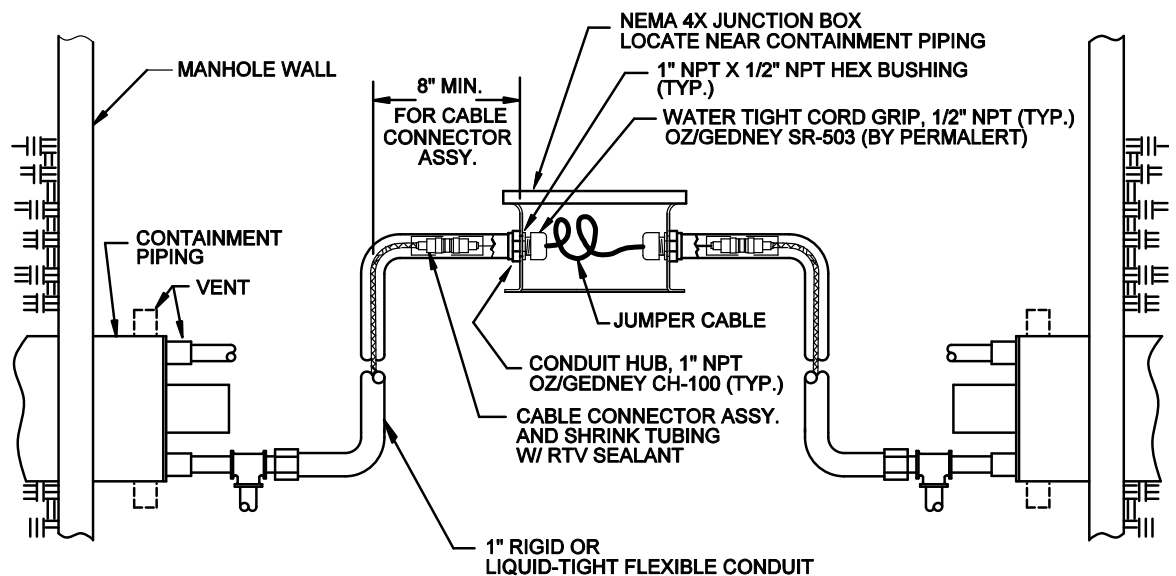


Figure 5-2
Cable Connections with Electrical Conduit and Junction Boxes

15. In contained pipe systems where branch runs and main runs are monitored, jumper cable can be used to return to the main from the branch. For these installations, PermAlert can furnish a cable routing

drawing showing locations requiring the installation of sensor cable and jumper. Depending on the design of the secondary contained system and the free unobstructed air space available, both cables (sensor and jumper) may be installed in the secondary containment air space. This will require simultaneously pulling both cables, and most likely will reduce the length of cables that can be pulled at one time. When 2 cables are installed in the same air space, both cables must be pulled out of the secondary containment through the threaded coupling and finally connected together with a cable connector in either: (1) a watertight capped pipe chamber connected to the threaded coupling, as shown in figure 5-3 or (2) a NEMA 4X [IP66] junction box. This type of termination should also be accessible to allow for future maintenance. As an alternative to pulling both cables into the air space of the secondary containment, jumper cable can be routed in electrical conduit. If connectors must be used, it is recommended they be installed in accessible watertight NEMA 4X [IP66] junction boxes located at grade.

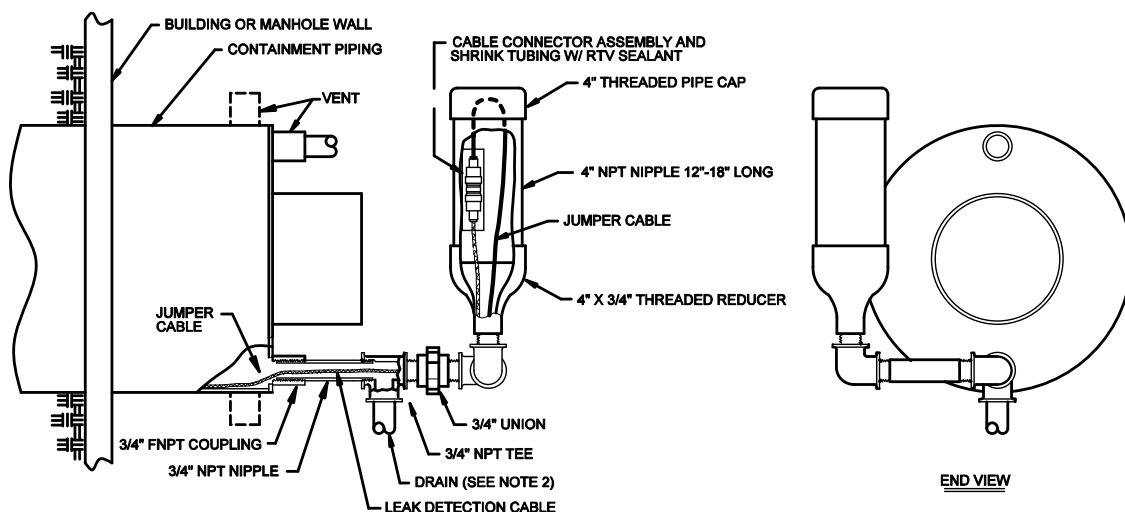


Figure 5-3
Branch Line Routing of Jumper Cable

16. At least 50' [15 m] of jumper cable must be installed from the PAL-AT panel before connection to sensor cable. Refer to table 1 (see section 3) for jumper installed at the very end of a sensing string in an enclosure (see figure 5-4). A cable connector must be attached to terminate the end of the jumper cable. Install the red plastic cap supplied with the PAL-AT, over the connector to keep it clean. The termination of the sensing string should be accessible for future maintenance.

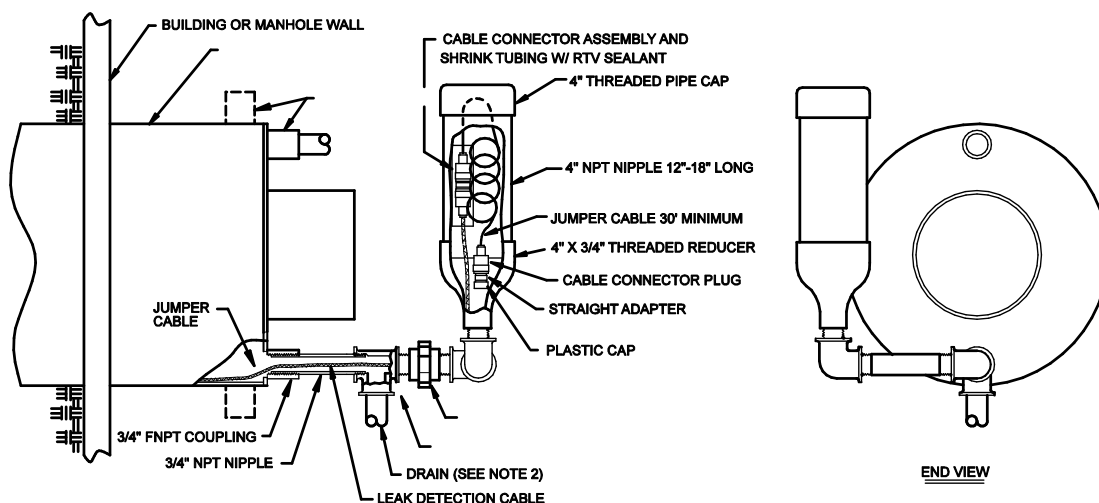


Figure 5-4
Termination of Sensing String

5.6 Air Testing

1. Air testing of the secondary containment must be performed before backfilling.
2. All sensor cable termination chambers (see figures 5-3 and 5-4) must be completely installed before applying the air test. Also, cap any open vents or drains. Be careful to prevent the pull rope or sensor cable from being blown back into the secondary containment.
3. Assemble required piping for air test and follow test procedure provided by the secondary containment piping manufacturer's installation guide.

CAUTION: THE COMPRESSED AIR SUPPLY MUST BE FREE OF WATER AND OIL.

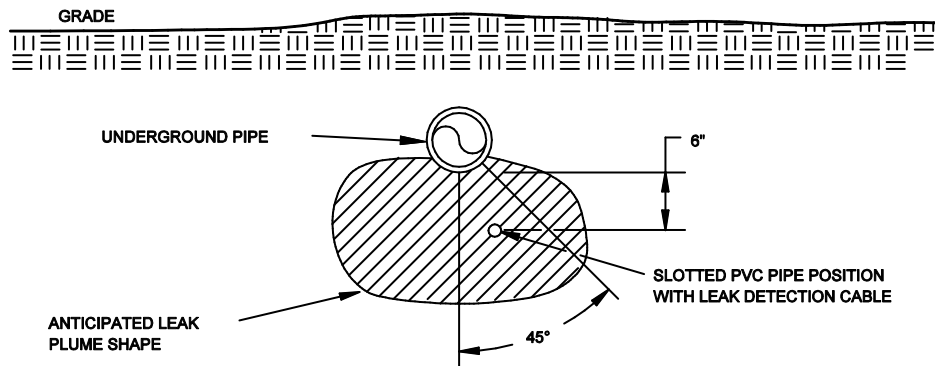
4. After the air test has been completed, remove test piping and cap test ports on the secondary containment.

6 Installation of Direct Buried Sensor Cable

6.1 General

The following instructions and precautions are very important for the successful installation and operation of the PAL-AT system with direct buried sensor cable. These instructions do not cover every possible situation, but are intended as guidelines for the majority of applications. Remember, the sensor cable is a sensitive electrical cable and should not be crushed, stretched, kinked, cut or damaged. If you have any questions regarding the installation of the direct buried cables, contact PermAlert. Failure to follow these instructions may result in damage to the cables or its jacket and prevent or limit operation of the PAL-AT system.

1. TFH and TFH-Gold cables are constructed of materials that detect hydrocarbon liquids, but ignore the presence of water. TFH cable has an outer jacket to protect the nickel-plated, copper braid wire. TFH-Gold cable does not have an outer jacket, but uses polymer-coated braid wire that is corrosion resistant.
2. These unique sensor cables can be installed in wet soil environments while monitoring for the leakage of hydrocarbon liquids. This feature permits direct burial of TFH/TFH-Gold, in 1½" or 2" "screened" or slotted PVC pipe, for the monitoring of underground single wall piping and tanks. The maximum burial depth of TFH/TFH-Gold cables is 20' [6 m]. This limitation is due to the fact the cable materials repel water to a maximum pressure of 8.7 psi [0.6 bar]. If the cable jacket (TFH) or cable core (TFH-Gold) is damaged, water may enter the cable and prevent or limit the operation of the PAL-AT system.
3. The location of the slotted pipe and hydrocarbon detection cable is determined by several variables. These variables include soil type, backfill material, product in the pipeline, water table, pipeline pressure and leak rate. Another consideration is if the installation is new or a retrofit of an existing pipeline.
4. It is recommended to slide a fabric sleeve or sock liner over the slotted PVC pipe to minimize soil entering and possibly blocking the pipe after an extended time. A 3" sleeve is typically available in home improvement stores and other sizes are available at industrial sources.
5. The sensor cables must be located where the hydrocarbon liquids will collect and allow detection. For some applications, the use of a closed synthetic liner, installed in the pipe trench, may be considered to facilitate the collection of hydrocarbon liquid for detection and reduce soil contamination. Normally one cable located in a slotted pipe adjacent to an underground pipe will provide satisfactory results. The slotted pipe may be located under the service pipe for a new installation. If the system is installed with an existing pipeline, the slotted pipe can be installed a few inches to the side of the pipeline to minimize the excavation cost.



6. If buried TFH/TFH-Gold is submerged in water and the water freezes, the resulting compression of the cable may be detected as a leak and cause an alarm. This effect should be considered when determining the placement of the cable to reduce false alarms. It does not damage the cable.
7. **The recommended minimum bend radius for all sensor and jumper cables is 1.5" [38mm].**

8. If a synthetic liner is not installed under the slotted pipe, a compacted clay/silt base layer should be used under the pipe to minimize the vertical migration of a leak. The slotted pipe should be covered with backfill material of sand or soil.
9. It is recommended to have 12" [300 mm] inches of backfill installed and compacted with hand tampers above the slotted pipe before mechanical compactors are used, to prevent crushing the pipe.
10. During the storage and installation of TFH cable, the ends of the cable must be protected to keep water from entering. The cable is shipped with shrink tube caps on the ends. Additional caps are supplied with TFH connectors to be installed on the cable temporarily until the connectors are installed. The caps should be installed over the jacket, but under the outer plastic overbraid of the cable. The cable ends should not be immersed in water at any time, even with the shrink caps installed. After the connectors are installed, if there is any possibility of water contacting the connectors, they should be sealed with non-corrosive RTV and shrink tubing immediately. If the connector needs to be reopened later for calibration, slit open the outer shrink tubing. Replace it with a new shrink tube immediately after calibration. Shrink tube caps are not required for TFH-Gold.
11. The sensor cable must be protected from damage when it is in the trench before backfilling. The cable must be protected when pipes are being welded or other work is occurring nearby. The cable should not be stepped on.
12. All connectors of sensor cable must be located in junction boxes at or above grade. A vertical riser of PVC conduit or other material suitable for the project must be installed to provide protection to the cable through the backfill and into the junction box (see figure 6-1). Follow the instructions for installing cable connectors using shrink tubing and RTV sealant to insure a watertight assembly.



CAUTION: It is extremely important to prevent damage to the TFH cable jacket. A damaged cable must be replaced.

6.2 Installing the Sensor Cable

1. After all other work is completed and the area is free and clear of all activities that can cause damage, the sensor cable should be installed.



Care must be taken during installation of sensor cable to avoid contact with potential contaminants such as oil, hydrocarbon liquid, soap or other material that may contain surfactants. Contamination by any of these liquids will destroy the water repellency of the cable and it will need to be replaced.

2. When the construction schedule allows, the PAL-AT panel should be permanently mounted and connected with electrical power before installing jumper or sensor cable. This will allow the system's setup and calibration procedures to proceed efficiently. For additional information on calibration points, refer to the *PAL-AT Operating Manual*.
3. Slowly play out the cable by hand rotating the spool. Never pull loose coils of cable off the end of the spool. When loose coils are pulled taut, kinks form in the cable that could prevent bringing the system on-line. Protect open ends of the cable from damage, contaminants and moisture.
4. Starting from the panel, connect a minimum of 50' [15 m] of jumper cable before connecting the sensor cable. Route the sensor cable as shown on the contract drawings. Refer to table 1 (see section 3) for amount of jumper cable to be connected to the end of the sensing string.
5. Make sure all TFH cable ends are sealed with shrink tubing after installation.

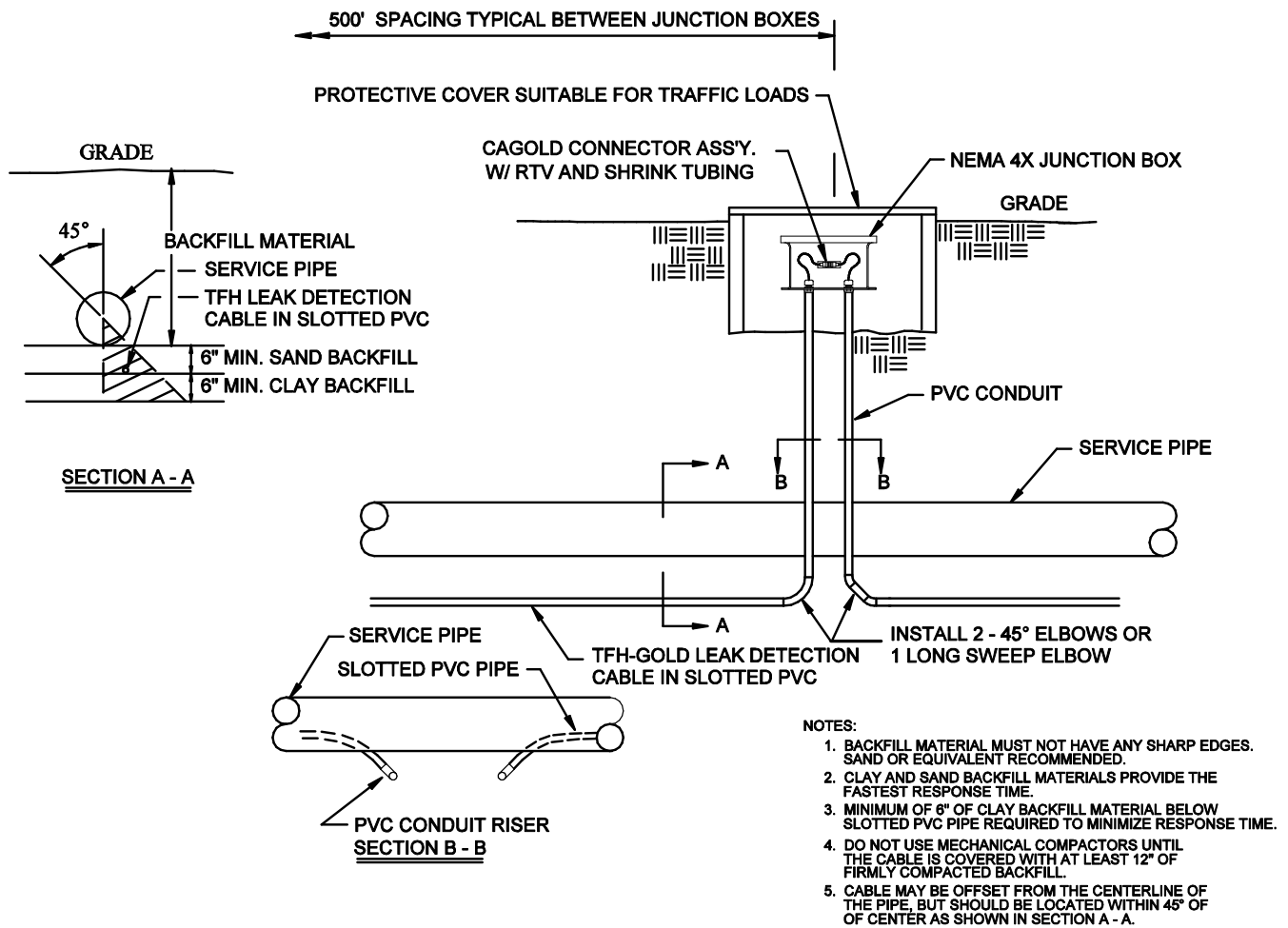


Figure 6-1
Direct Buried TFH/TFH-Gold Hydrocarbon Sensor Cables

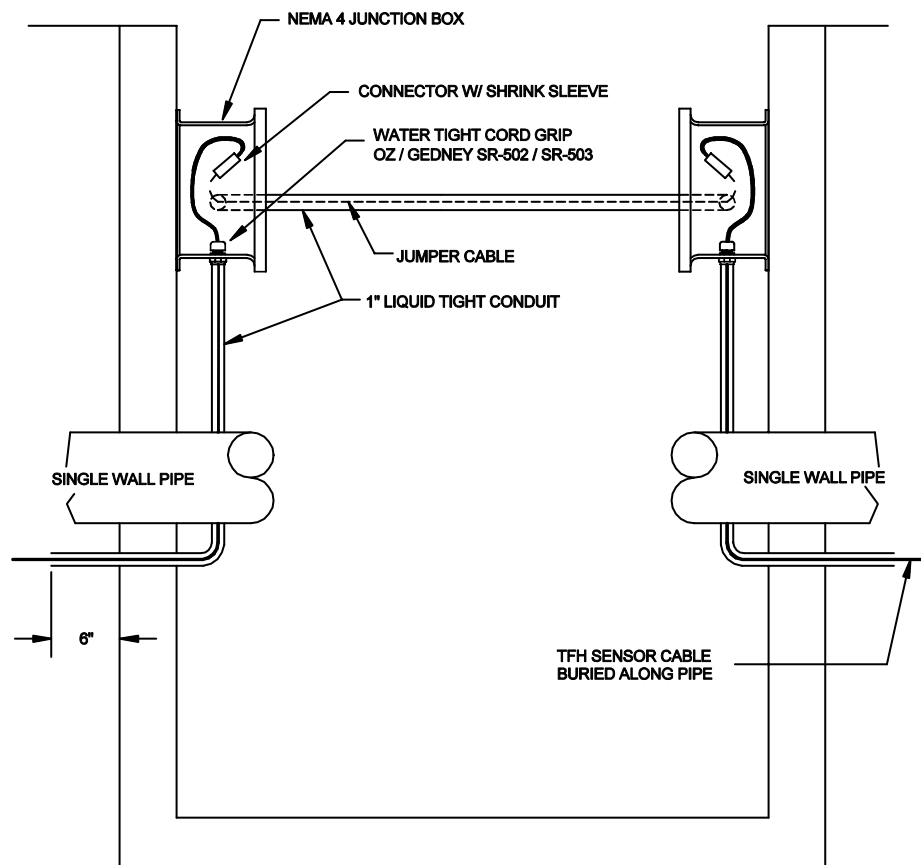


Figure 6-2
Hydrant Valve Pit / Manhole Penetration
Direct Buried Cable

6.3 Above Ground Storage Tanks

Above ground storage tanks can be monitored for leaks by installing TFH/TFH-Gold sensor cable in slotted PVC pipe under the bottom of the tank or around the perimeter. Figures 6-3 and 6-4 show two such applications. For specific applications, contact PermAlert for assistance.

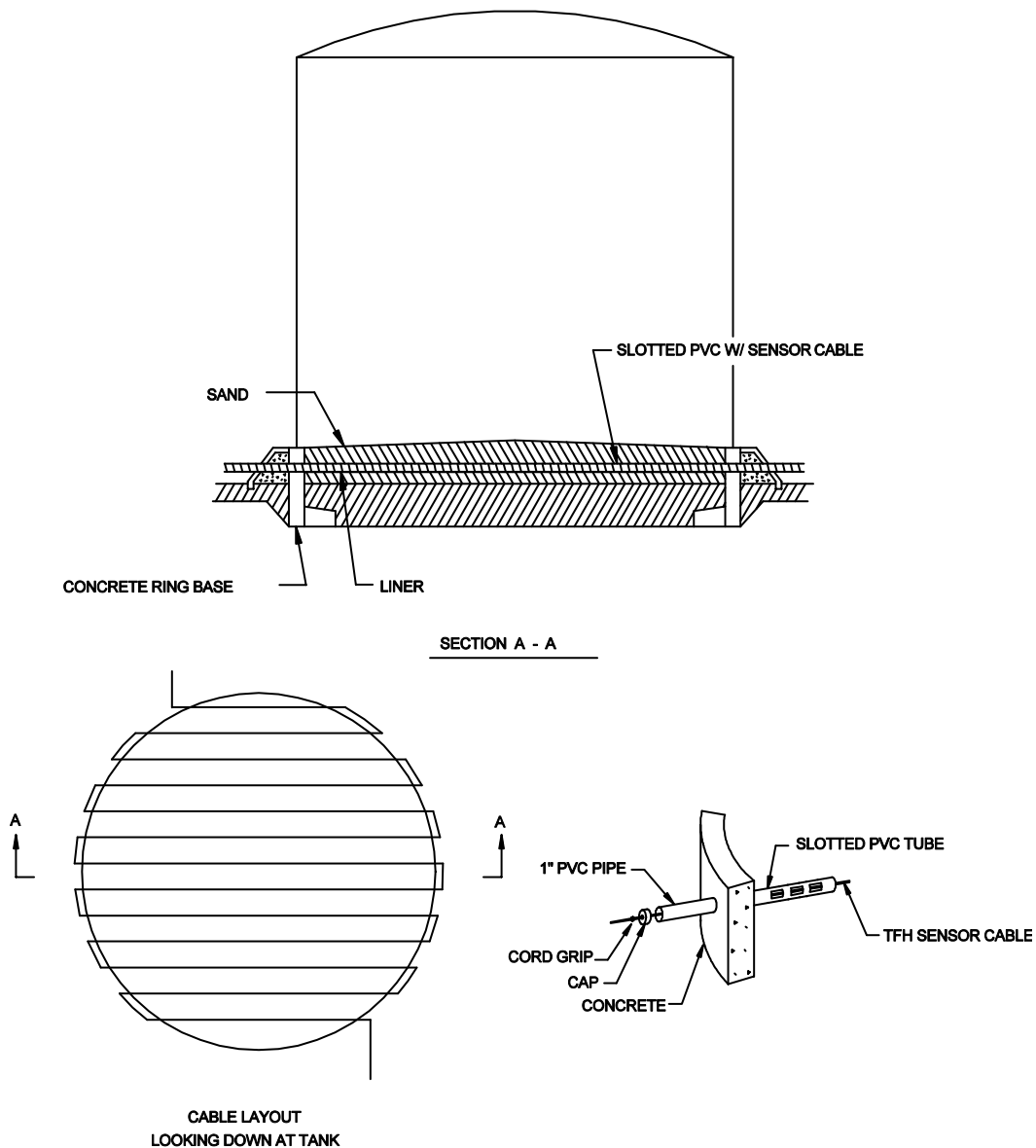


Figure 6-3
Double Bottom Above Ground Storage Tank

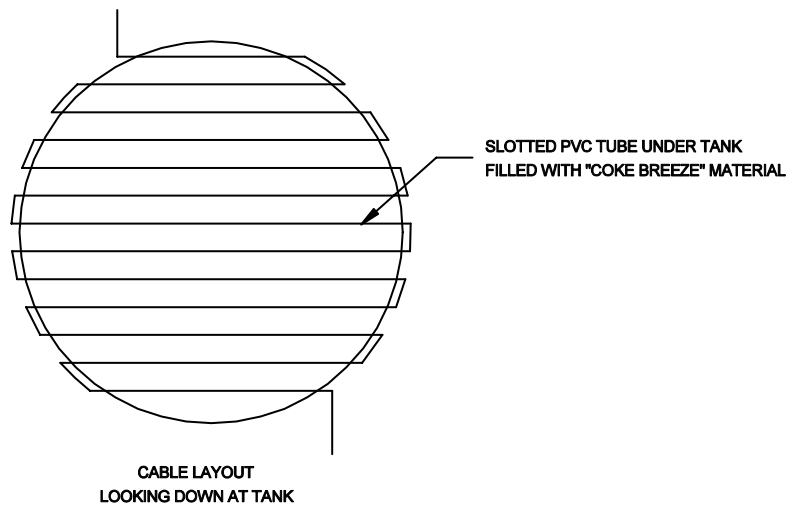
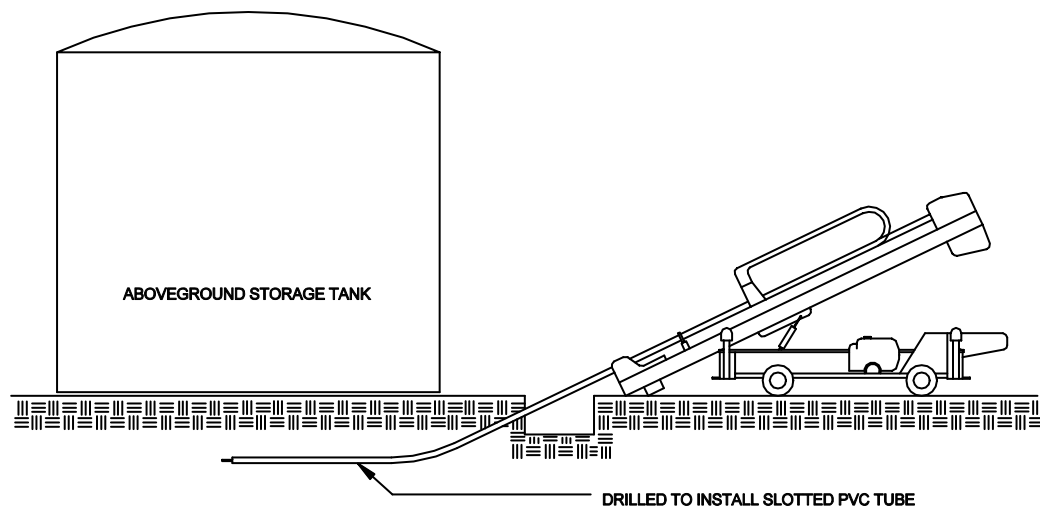


Figure 6-4
Above Ground Storage Tank Horizontal Drilling

7 Cable Installation for Raised Floor and Ceilings

7.1 General

The PAL-AT sensor cables can be installed in ceilings above drop ceilings or on subfloors below raised flooring to detect water, hydrocarbons, or chemical liquids. AGT-Gold responds quickly to thin films of liquid. AGW-Gold allows a small accumulation before detecting a leak and dries quickly after removal of the liquid. AGW-Gold was tested and passed UL910 for Plenum applications. AGW-Gold is the preferred selection unless the application requires wicking of the liquid for detection of small liquid leakage.

The AGT-Gold sensor cable has a polypropylene yarn dielectric and is designed to absorb liquids readily and detect leaks quickly. It also absorbs moisture from the air if the air is saturated or near saturation. PermAlert recommends a maximum of 80% relative humidity, keeping in mind the relative humidity will increase if the temperature of the air or a surface in the airflow decreases. In subfloor applications, care must be taken to make sure the cable is not located directly in the airflow where localized higher humidity or saturated air is present.

If the humidity level cannot be controlled and intermittent high humidity conditions exist, then the best option is to use the quick-drying AGW-Gold cable in place of the wicking AGT-Gold cable.

7.2 Install the Sensor Cable

1. After all other work is completed and the area is free and clear of all activities that can cause damage, the sensor cable should be installed. Care must be taken during installation of the sensor cable to avoid contact with potential contaminants, such as water puddles or oil.
2. When the construction schedule allows, the PAL-AT panel should be permanently mounted and connected with electrical power before installing jumper or sensor cable. This will allow the system's setup and calibration procedures to proceed efficiently. For additional information on calibration points, refer to the *PAL-AT Operating Manual*.
3. Slowly play out the cable by hand rotating the spool. Never pull loose coils of cable off the end of the spool. When loose coils are pulled taut, kinks form in the cable that could prevent bringing the system on-line. **Keep the cable dry and clean.**
4. Starting from the PAL-AT panel, connect a minimum of 50' [15 m] of JMP-UD jumper cable (65' [20 m] for type JPP) before connecting the sensor cable. Route the sensor cable as shown on the contract drawings. Most designs require the sensor cable to be installed in a serpentine pattern of 4' [1.2 m] centers. Normally, this method gives satisfactory protection and does not require the cable to be repositioned when equipment is moved later. Typically, centers of 6' to 12' [2 m to 4 m] can be used if the facility has low risk (see figure 7-1).
5. If the serpentine pattern cannot be adapted to the installation, an alternative is to isolate the potential leakage areas. Typically, this means running the sensor cable around the perimeter of the room and placing a run of cable under or near any water lines or drains in the room's interior. The sensor cable should be routed around air conditioning units and chillers so an overflow from a plugged condensate tray must pass the sensor cable before it can reach power or data cables.
6. The sensor cable should not be routed directly in the airflow from an air-handling unit, especially if a humidifier is being used. In this case, the unit may send out drops of water that can collect in the cable and give an alarm for a minor puddle.

This is more critical with AGT-Gold cable. The wicking nature of the cable will absorb the fine spray from the humidifier and cause an alarm. Typically, the cables are 3' to 5' from the perimeter of the air units.
7. Refer to table 1 (see section 3) for amount of jumper cable to be connected to the end of the sensing string.
8. Cables are attached to the subfloors and ceilings with fasteners (cable mounts). Normally, cable mounts are spaced on 8' [2.5 m] intervals along the sensor and jumper cable length. Additional cable mounts are located adjacent to all changes in direction of the sensor cable.

9. Cable mounts (CMA) ordered from PermAlert are adhesive backed. When installations require mounting to unsealed concrete surfaces, it is recommended construction mastic be used. Care must be taken to ensure the mastic does not touch the sensor cable. This material can be purchased from most supply houses. Inspect subfloor (or ceiling) surfaces to be sure it is clean and dry before beginning installation. Cable tags (CTA) are typically installed on 50' [15 m] intervals for location purposes.
10. In high traffic areas, cable shields should be used to protect the cable from damage.
11. Service loops (slack cable) should be positioned at connector locations.
12. If the cable is going to be installed in a location that will have limited or challenging access, it is recommended test ports be installed in a serviceable location for calibration and functional testing. See section 7.4 for further details.

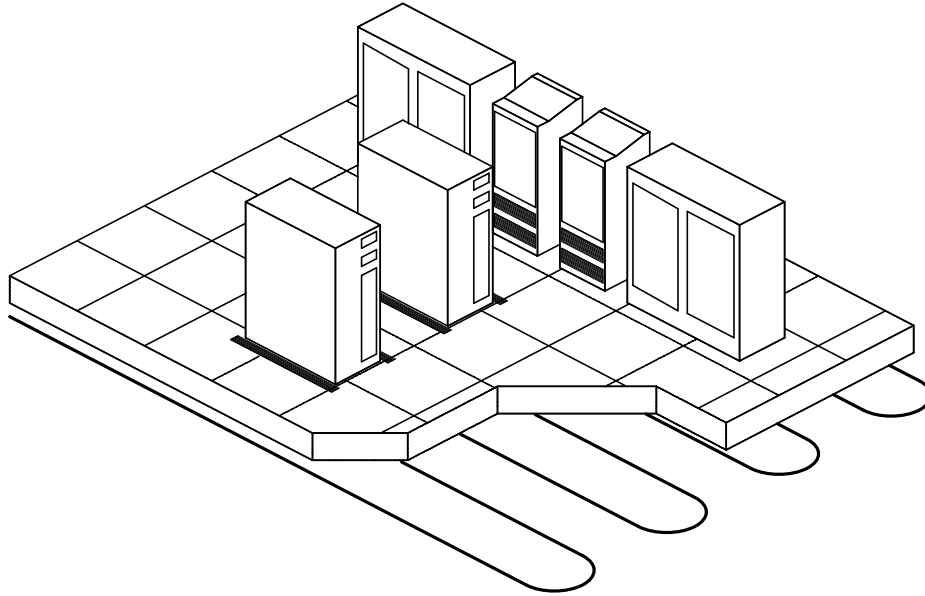


Figure 7-1
Computer Room Floor

7.3 Locator Chart

A graphic display map drawn to scale shall be prepared by the contractor (installer) after completion of installation from "as built" drawings. The map shall indicate, in relation to the raised floor grid, the location of the cable, connectors, and landmarks (such as equipment, walls, and drains). Cable distance readings shall be marked off in 100' [30 m] (or other suitable) increments, beginning at the monitoring panel, to facilitate physically locating a leak detected by the system. The locator chart should be placed in a plastic frame suitable for permanent mounting adjacent to the PAL-AT panel.

7.4 Calibration and end of run Access Points

In the event the cable will be inaccessible or in a location where access will be limited or challenging, it is recommended that calibration points be added. Calibration points should be brought to an easily serviceable location every 500 feet or at the end of serpentine runs along a wall where the cable returns in the opposite direction. To create a calibration point, jumper cable is run to an accessible junction box to a 10' length of sensor before returning to jumper cable back to the main cable run. The 10' sensor cable can be used as a calibration and testing point to validate cable lengths and functionality when the main cable cannot be accessed. At minimum, it is recommended that the end of the cable run be installed in an accessible location to give a validation point for cable length.

8 Cable Connectors

8.1 General

This section outlines: (1) the installation procedures for several types of connectors; (2) the application of shrink tubing; and (3) the electrical testing of connectors and cable. **All connectors are crimp style and soldering is not required.**

Instructional videos for Cable Connector Installations are available at the PermAlert web site, www.permalert.com.



WARNING For Hazardous Locations – Some cable connectors are located in NEMA 4X [IP66] junction boxes that are made of plastic and as such, present a possible electrostatic hazard. They are not intended to be cleaned, but if they are, a damp cloth should be used.

8.2 Cable Connector Installation

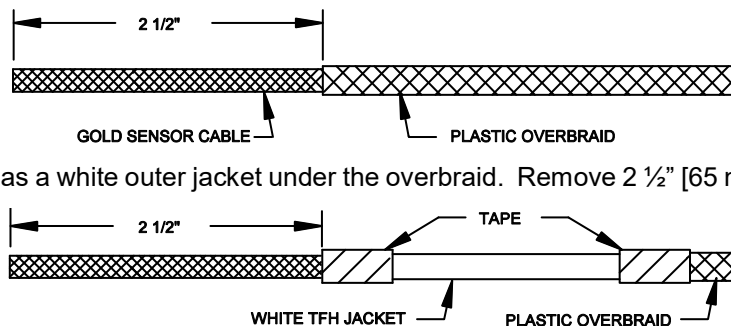
1. Cable connectors must be installed at changes of cable types, pull points, junction boxes, calibration points, and at the termination of the sensing string.
2. All the PAL-AT cables, except ATP, are coaxial construction consisting of an insulated center conductor and a braid shield. Jumper cables and TFH sensor cable have a polymer jacket over the braid. All coaxial sensor cables also have a polymer overbraid surrounding the cable.
3. **Crimp style connectors are required for all sensor cables and all jumper cables.**
4. **TFH sensor cable ends must be kept dry and encapsulated in shrink tubing until the connectors are installed. Connectors that become calibration points during the commissioning of the system should not be installed prior to commissioning, if they cannot be kept dry. Install the shrink tube caps, included with the connectors, on the end of the cables temporarily.**

8.2.1 CAGOLD and CATFH Connectors for Sensor Cables AGW-Gold, AGT-Gold, TFH-Gold and TFH

The CAGOLD connector assembly for AGW-Gold, AGT-Gold and TFH-Gold consists of two crimp style UHF plugs, two #14 AWG wire ferrules, one UHF straight adapter, and one piece of shrink tubing. The CATFH assembly for TFH includes the same connectors and 3 pieces of shrink tubing. Steps A thru I must be followed to install a connector.

Step A Measure and cut the required length of cable.

Step B Carefully cut and remove 2 1/2" [65 mm] of the plastic overbraid. It may be helpful to slide the remaining overbraid back several inches and use electrical tape to hold it in place out of the way.



TFH cable has a white outer jacket under the overbraid. Remove 2 1/2" [65 mm] of the white jacket.

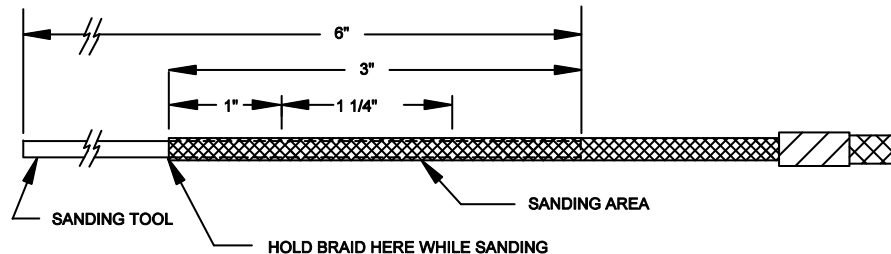
Step C Skip this step for TFH cable. A sanding tool (included with the purchase of a crimp tool) is inserted into the cable. The tool is a 6" [150 mm] length of stainless steel tubing.

For AGW-Gold, insert the center conductor and two plastic spiral spacers into the end of the tool. Then slowly rotate the tool counterclockwise and gently push the tool 3" [75 mm] into the cable underneath the braid wire.

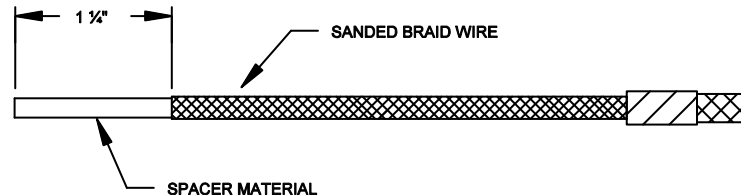
For TFH-Gold, insert the center conductor and the white core into the end of the tool. Then slowly rotate the tool and gently push the tool 3" [75 mm] into the cable underneath the braid wire.

For AGT-Gold, slide the braid wire back 2" [50 mm] and remove 1 7/8" [47 mm] of the yarn spacer. Then insert the sanding tool 3" [75 mm] over the center conductor and slide the braid wire back over the tool.

For all three cables, hold the end of the braid in place against the sanding tool while you sand the 1 1/4" [32 mm] area as shown below. Rotate the cable slightly and repeat the sanding process until the entire circumference of the 1 1/4" section has been sanded. The gold-colored plastic coating on the braid strands does not have to be removed completely. However, the outer surface of the braid strands should have bare copper exposed around the entire circumference of the cable.



Step D Carefully cut and remove approximately 1 1/4" [32 mm] of braid (this should remove all the unsanded braid wire). Tap the cable gently on a hard surface to knock off loose strand ends, clippings and any debris.

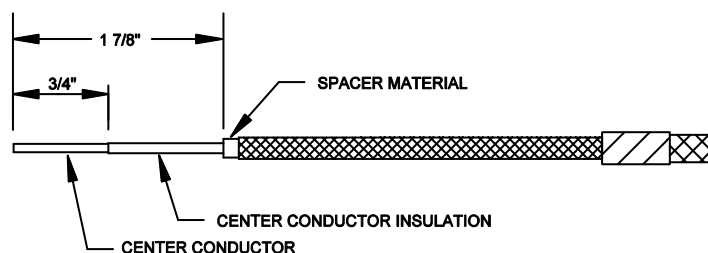


Step E For AGW-Gold and TFH cables, slide the braid back an additional 3/4" [19 mm] then remove 1 7/8" [47 mm] of spacer material (plastic spiral on AGW-Gold and white core on TFH).

Or

For TFH-Gold cable, the white core needs to be "thinned" for 1 7/8" [47 mm] to reduce the diameter of the white core slightly so it fits into the connector body. This requires a wire stripper tool set for #10 AWG. First, make sure the center conductor is straight so the thin film of insulation on the conductor is not nicked. Starting 1/2" from the end, strip the wire using the #10 setting. This does not remove the white core, but stretches it and makes it smaller in diameter. Continue this process, moving in 1/2" increments from the end. Each time apply the tool and strip to the end of the cable, until the insulation over the last 1 7/8" of the conductor is thinned. Cut off the white material that was stretched past the end of the center conductor. Next, using a #14 AWG wire stripper, strip 3/4" of the white core from the center conductor.

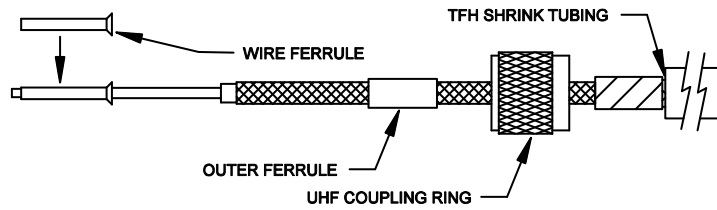
For all cables, remove 3/4" of the thin film of insulation from the center conductor.



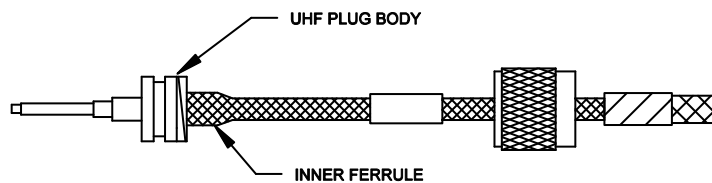
Step F For TFH cable only, slide one 4" [100 mm] piece of heavy wall shrink tubing over the end of the cable, and position it over the overbraid.

For all cables, slide the UHF plug coupling ring onto the cable. Then slide the outer crimp ferrule onto the cable.

A $\frac{3}{4}$ " [19 mm] long, #14 AWG [1.5 mm²] wire ferrule should be installed on the center conductor. If the wire ferrule is slightly crushed, the conductor will not slide in easily. If this happens, push the ferrule onto a piece of solid #14 AWG copper wire (or standard 3d finish nail) to straighten the ferrule. Slide the ferrule over the conductor until it stops at the center conductor insulation. Make sure all the strands go through the ferrule and extend out of the end.

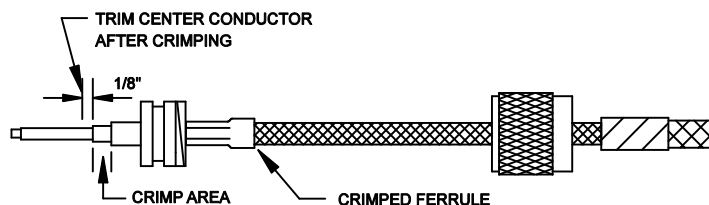


Step G Slide the UHF plug body over the cable center conductor. Be sure all the strands of the center conductor or the wire ferrule slide completely through the center contact of the plug. At the same time, slide the braid over the inner ferrule to the UHF plug body.

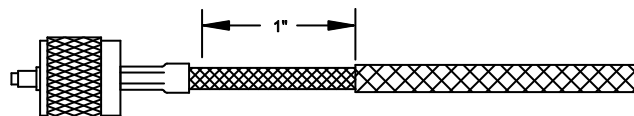


Step H Slide the outer ferrule over the braid and up against the UHF plug body. Make sure the braid extends slightly past the end of the outer ferrule against the UHF plug body. **Caution: Once the crimp tool (PermaAlert Part No. 8068301) starts to close, it must be closed completely before it will open again.** Position the crimp tool (0.255" die) carefully around the outer ferrule and crimp it.

Crimp the end of the center contact as shown using a 0.100" die. Leave a $\frac{1}{8}$ " [3 mm] gap from the end of the plug and trim the excess center conductor and ferrule.



Step I Slide the plastic overbraid as close to the UHF plug body as possible to remove any slack. Trim it so there is approximately a 1" [25 mm] gap between the end of the overbraid and the end of the ferrule.



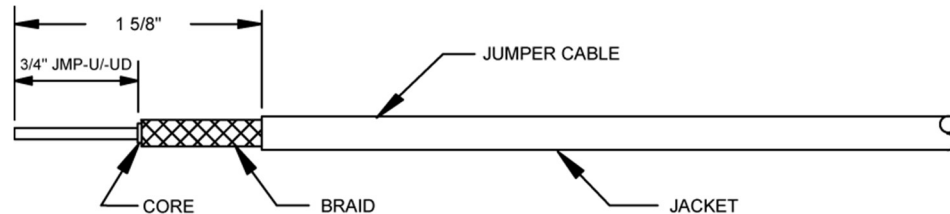
Test all connections as described in the "Cable and Connector Testing Procedures" section. Each end of the cable in the stage shown above will be fastened together by using one UHF straight adapter. All cable connectors should be encapsulated with non-corrosive RTV sealant and shrink tubing.

8.2.2 CAJMP Connectors for Jumper Cables JMP-U/-UD

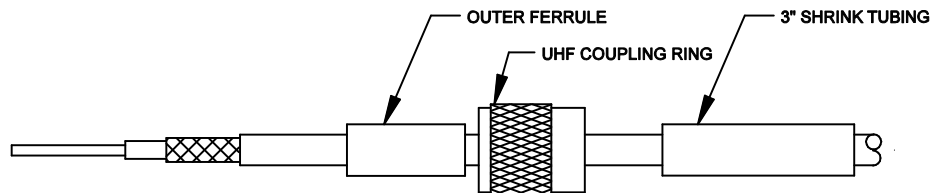
The CAJMP connector assembly for JMP-U/-UD jumper cables consists of two crimp style UHF plugs and one UHF straight adapter. It also includes 2 pieces of shrink tubing and spiral cable wrap. Steps A thru H must be followed to install a connector.

Step A Measure and cut the required length of cable.

Step B Carefully cut and remove 1 5/8" [41 mm] of the outer jacket, 3/4" [19 mm] of the braid and 3/4" [19 mm] of the plastic dielectric core. JMP-U has a sticky water-blocking material on the braid. To make handling it easier, keep your fingers and tools damp with water.



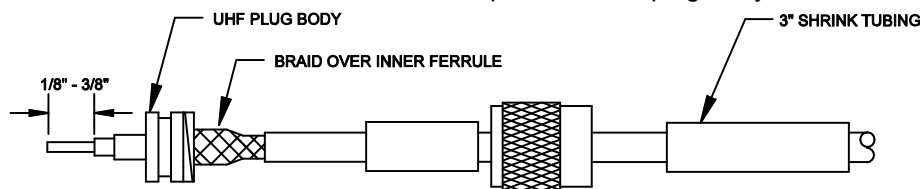
Step C Slide the 3" [75 mm] piece of shrink tubing onto the cable. Next, slide the UHF coupling ring and the outer ferrule onto the cable.



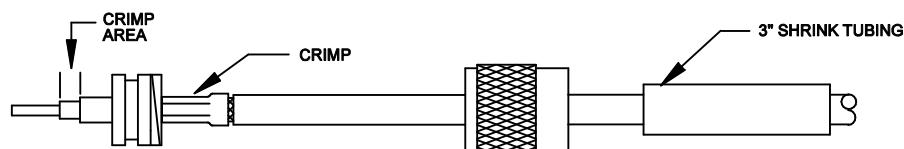
Step D Slide the UHF plug body over the cable center conductor. Be sure all the strands of the center conductor slide completely through the center contact of the plug. At the same time, the plastic core should fit inside the inner ferrule of the plug body and the braid should go over the outside of the inner ferrule. When the cable is inserted properly, 1/8" [3 mm] to 3/8" [9 mm] of the center conductor will extend past the end of the UHF plug body and **the plastic core will be tight against the plug body inside the inner ferrule.**

Note: Before installing JMP-U/-UD, flair the braid wire I.D. slightly with a small 1/8" [3 mm] slotted screwdriver so the braid will slide over the inner ferrule. **Be careful to keep the wire braided, i.e. two strands thick, over the inner ferrule, to have the correct thickness for a good crimp.**

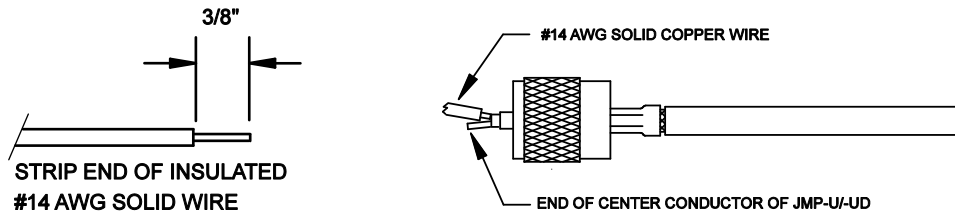
Step E Slide the outer ferrule over the braid and up to the UHF plug body. Make sure the braid extends



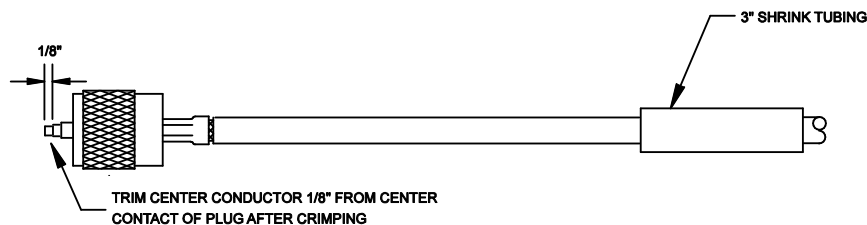
slightly past the end of the outer ferrule against the UHF plug body. **The center conductor should extend at least 1/8" [3 mm] past the end of the connector. Caution: Once the crimp tool (PermAlert Part No. 8068300) starts to close, it must be closed completely before it can be opened again.** Position the crimp tool 0.429" die carefully around the outer ferrule and crimp it.



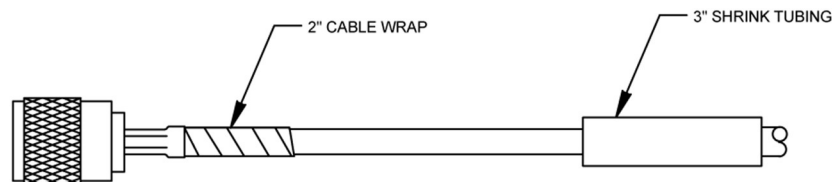
The procedure for crimping the center conductor requires a short length of #14 AWG solid copper wire to fill the center contact of the connector. Strip 3/8" of insulation from the wire. Bend the end of the strands of the center conductor slightly to the side. Next, carefully slide the bare #14 AWG wire all the way into the center contact as shown. The #14 wire should be inserted next to the JMP-U conductor and not into the strands of the conductor. Be careful so the strands of JMP-U do not slide into the connector with the #14 wire. Crimp the center contact as shown using a 0.100" die.



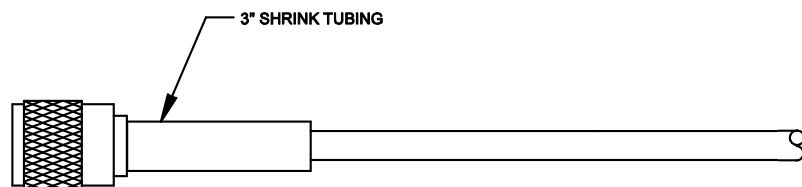
Step F Trim any center conductor (and #14 AWG wire, if applicable) extending out of the center contact of the plug. Thread the UHF coupling ring onto the UHF plug body.



Step G Place a 2" piece of plastic cable wrap around the cable jacket and slide it under the uncrimped end of the outer ferrule as far as possible.



Step H Slide the 3" [75 mm] piece of shrink tubing over the crimped outer ferrule until it completely covers the ferrule. Make sure the shrink tubing does not slide onto the plug body. Heat the shrink tubing with a heat gun until it has fully shrunk and adhesive oozes out the end. Let the assembly cool before handling.

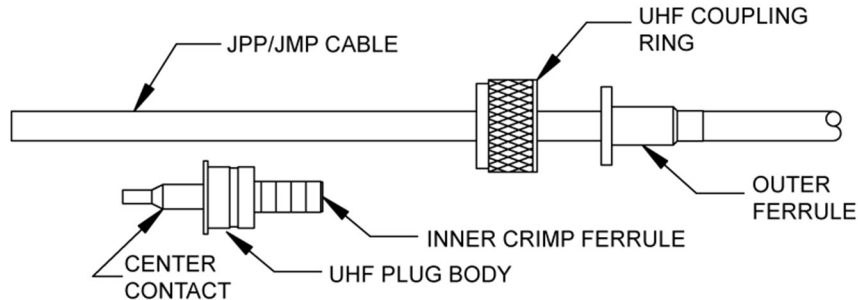


Test all connections as described in the "Cable and Connector Testing Procedures" section. Each end of the cable in the stage shown above will be fastened together by using one UHF straight adapter. All cable connectors should be encapsulated with non-corrosive RTV sealant and shrink tubing.

8.2.3 CAJPP Connectors for Jumper Cables JPP and JMP

The CAJPP connector assembly for JPP and JMP jumper cables consists of two crimp style UHF plugs and one UHF straight adapter. Steps A thru F must be followed to install a connector. It is recommended to use Ideal Stripmaster® Model 45-091 or 45-092 wire strippers, or equal, for stripping the wires. Use the die openings for stranded wire for the wire size specified in the steps below.

Step A Measure and cut the required length of cable. The connector components are shown below.

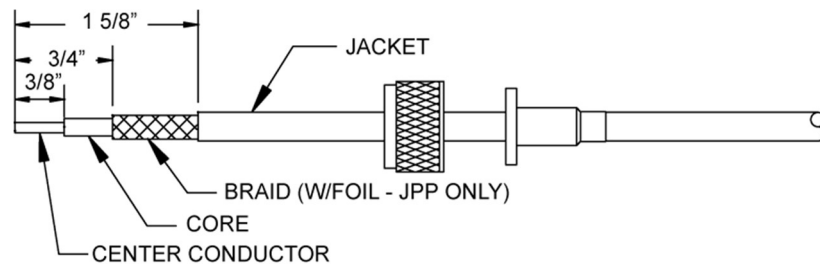


Step B Carefully mark the cable jacket at 3/8", 3/4" and 1 5/8" from the end.

At the 3/8" mark, strip the wire with the 14 AWG stripping hole. You may need to repeat the strip with the 16 AWG stripping hole to remove all the core insulation.

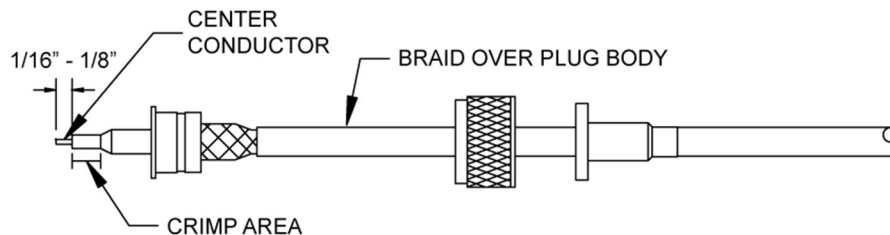
At the 3/4" mark, strip the wire with the 12 AWG stripping hole to remove the braid.

At the 1 5/8" mark, strip the wire with the 10 AWG stripping hole to remove the jacket.

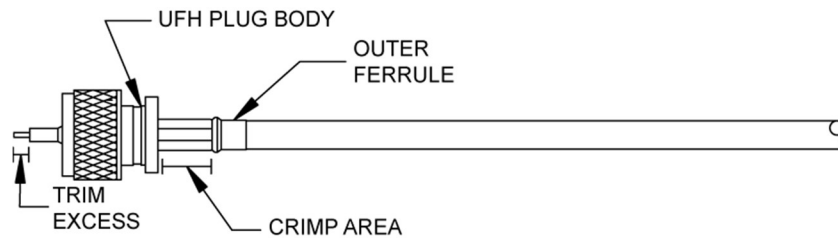


Step C JPP only - JPP has foil wrapped under the braid and bonded to the core insulation. Slide the braid back to the jacket to expose the foil. Use long nose pliers with serrated grip surfaces and gently squeeze the foil near the end of the core. Gently rotate the pliers back and forth 10° - 30° several times until the foil breaks free from the core. Unwrap the foil and remove it. This step may need to be repeated to remove all the foil under the exposed braid.

Step D Slide the UHF plug body over the cable center conductor. Be sure all the strands of the center conductor slide completely through the center contact of the plug. At the same time, the plastic core should fit inside the large section of the center contact and the braid should go over the outside of the inner ferrule. When the cable is inserted properly, 1/16" [1.5 mm] to 1/8" [6 mm] of the center conductor will extend past the end of the UHF plug body and the plastic core will be inside the center contact. **Caution: Once the crimp tool (PermAlert Part No. 8068300) starts to close, it must be closed completely before it can be opened again.** Crimp the center contact in the crimp area using a 0.068" die.



Step E Slide the UHF coupling ring onto the plug. Slide the outer ferrule (and the remaining foil, if any, for JPP cable) over the braid and up to the UHF plug body. Make sure the braid extends slightly past the end of the outer ferrule against the UHF plug body. Position the crimp tool 0.255" die carefully around the outer ferrule. Hold the outer ferrule tight against the plug body and crimp it. The UHF coupling ring is now captive and cannot be removed from the plug body.



Step F Trim any center conductor extending out of the center contact of the plug.

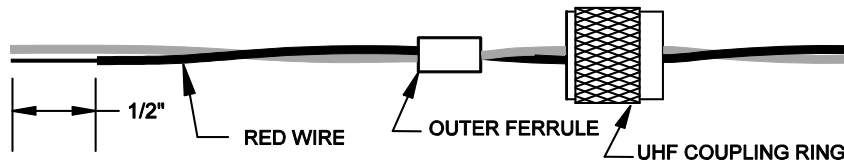
Test all connections as described in the "Cable and Connector Testing Procedures" section. Each end of the cable in the stage shown above will be fastened together by using one UHF straight adapter. All cable connectors should be encapsulated with non-corrosive RTV sealant and shrink tubing.

8.2.4 CAGOLD Connector for ATP Cable

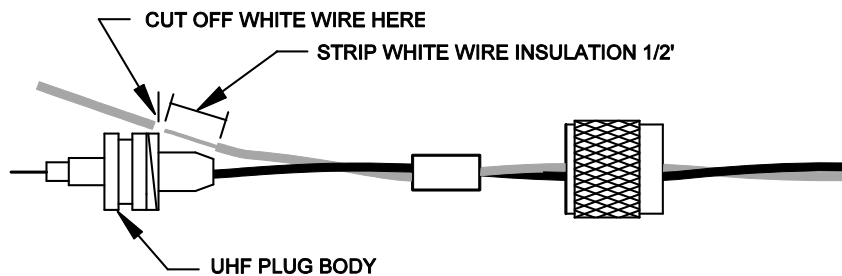
The CAGOLD cable connector can be used at a calibration point to make it reusable, instead of the standard permanent crimp connector. Steps A thru G must be followed to install a connector.

Step A Make sure the red and white wires are twisted with an approximate 2"-3" [50mm-75mm] pitch and then cut off excess ATP cable. Slide the UHF coupling ring onto the cable, followed by the outer ferrule.

Step B Remove 1/2" [12 mm] of the insulation on the red wire.



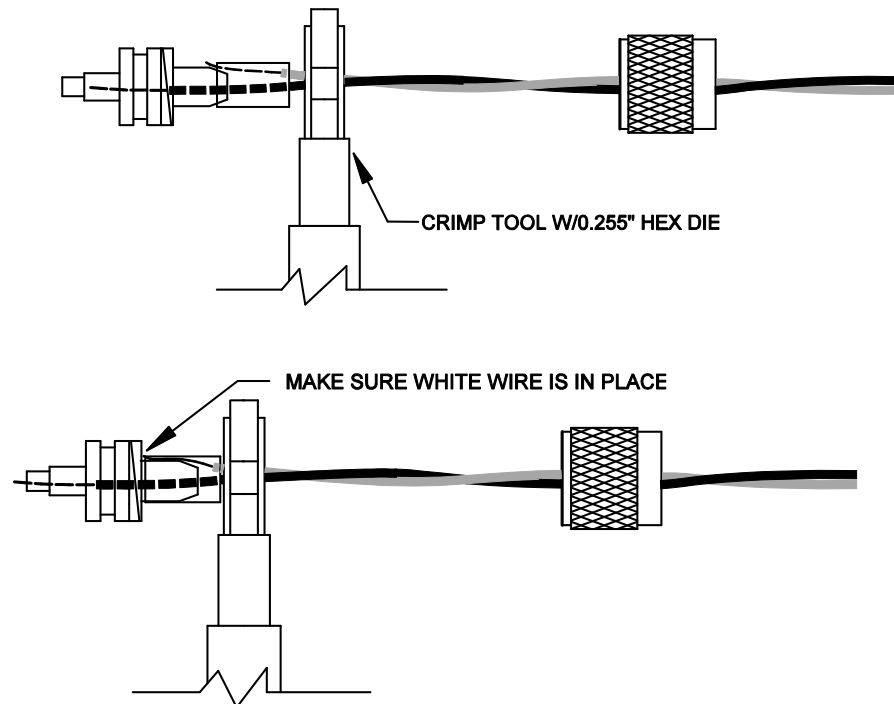
Step C As a measuring guide, slide the plug body onto the red wire until it stops against the wire insulation. The wire should extend out of the center contact. Cut the white wire even with the shoulder of the plug body. Remove the plug body and strip 1/2" [12 mm] of the insulation from the white wire.



Step D Slide the plug body on the red wire again until the white wire is just past the tapered end of the inner ferrule. Then slide the outer ferrule over the end of the inner ferrule and the white wire until it is a snug fit.

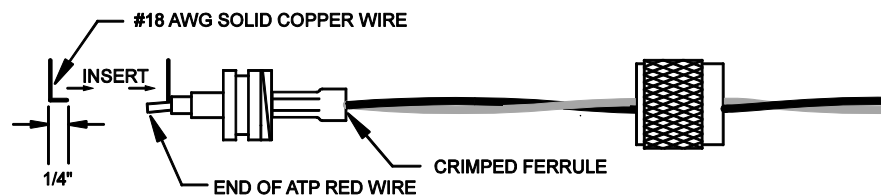


Step E Next, take the crimp tool and clamp the 0.255" die around the twisted wires behind the outer ferrule. Be careful not to pinch the wires. They should slide freely through the die. Then push the plug body toward the crimp tool to force the outer ferrule and white wire to slide over the inner ferrule until they are tight against the plug shoulder as shown in the second view.

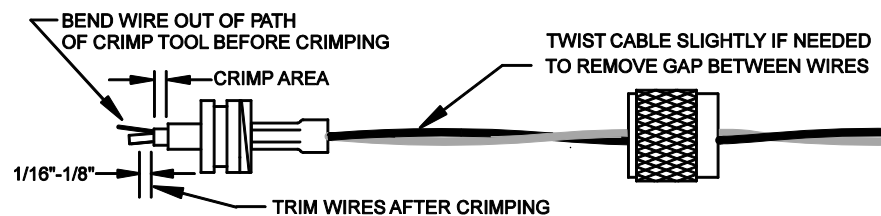


Step F Use the 0.255" hex die and crimp the outer ferrule.

Step G Bend a short length of #18 AWG [0.75 mm²] solid copper wire to a ¼" [6mm] long right angle and insert it into the center contact next to the ATP conductor. Insert it as far as the bend.



Straighten the copper wire so it does not interfere with the crimp tool closing. Crimp the center contact using the crimp tool 0.100" die. Trim excess wire as shown. Slide the coupling ring to the plug body and thread it onto the body. If there are any gaps between the red and white wires, twist the connector slightly to remove them.



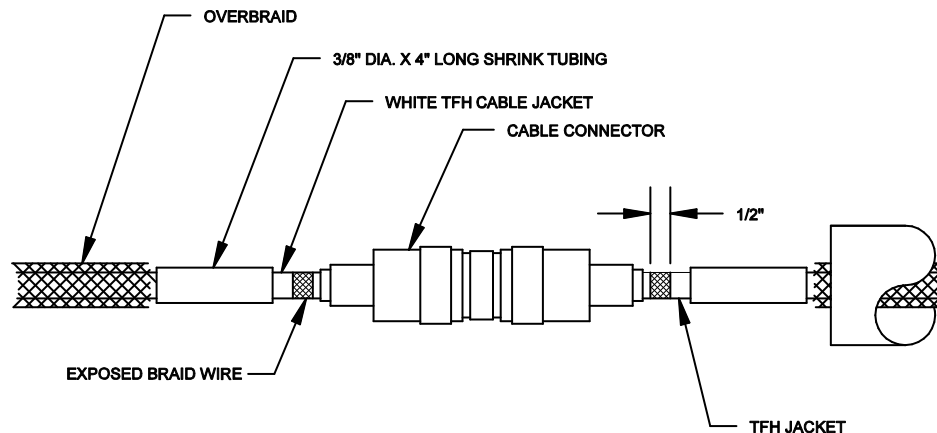
8.3 Shrink Tubing

All cable connectors installed in inaccessible locations or locations subject to frequent leaks or corrosive environments must be encapsulated with shrink tubing. This applies to sensor cables and jumper cables. Connectors used for calibration points should not be sealed until the system has been brought online unless they may be exposed to water before start-up.

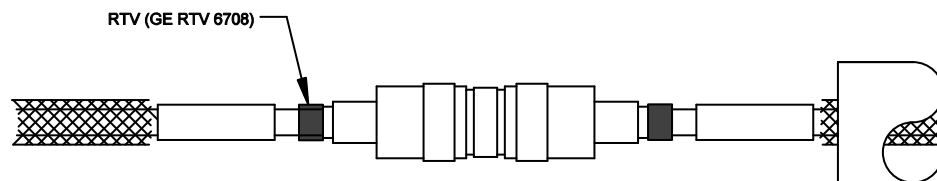
8.3.1 Cable Type TFH

1. The TFH cable connector assemblies must be encapsulated in watertight shrink tubing. Test connectors according to the "Cable and Connector Testing Procedures" before heating the shrink tubing. Connectors used for calibration points must be kept dry until the system has been commissioned. After commissioning, the shrink tubing should be installed. If water is allowed to enter the end of the cable and get under the jacket, the cable must be replaced.
2. Install the shrink tubing in accordance with the following steps:

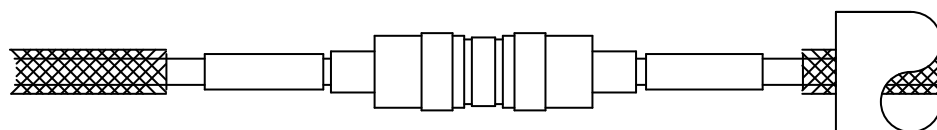
Step A Slide the overbraid and cable jacket back from the reducing adapter, to expose ½" [12 mm] of braid wire. Smooth the excess cable jacket away from the connector, so there is at least 5" [125 mm] of smooth surface adjacent to the connector. If the sensor cable is being connected to a jumper cable, skip steps A and B for jumper cable.



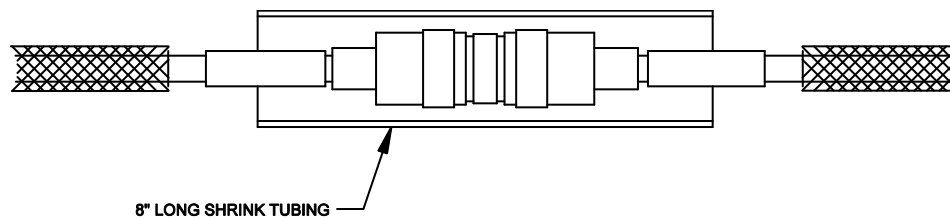
Step B Place a 1/4" [6 mm] bead of non-corrosive RTV sealant around the cable on the exposed braid wire.



Step C Slide the 4" [100 mm] long shrink tubing to the reducing adapter, if the CASTD connector is used. Make sure there are no wrinkles in the cable jacket. Make sure the shrink tubing does not overlap the reducing adapter. Slide the shrink tubing over the outer crimp ferrule to the back of the connector body if the CAGOLD crimp style connector is used. Heat the shrink tubing with a heat gun until it has fully shrunk and adhesive oozes out the end. Do not disturb the assembly until the shrink tubing has cooled (approximately 5-10 minutes).



Step D After both cable ends have been sealed with the 4" [100 mm] shrink tubing, recheck that the connectors are tightened securely. Test the connector according to the "Cable and Connector Testing Procedures". Then slide and center the 8" [200 mm] shrink tubing over the connector and heat it until it is fully shrunk and adhesive oozes out the ends.

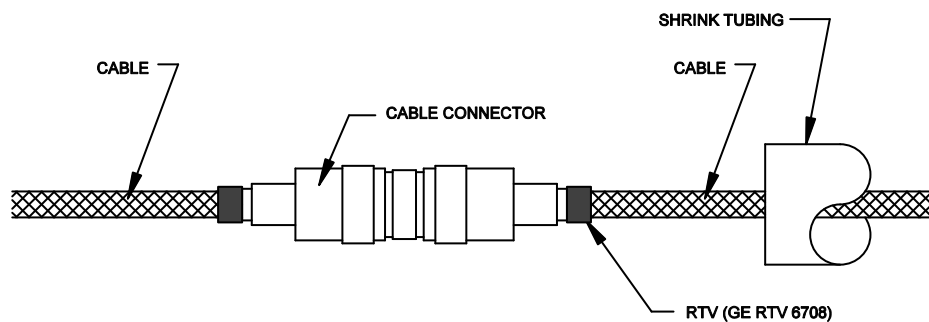


Step E Slide the overbraid to the connector and tape in place with electrical tape.

8.3.2 Cable Types AGW-Gold, AGT-Gold and TFH-Gold

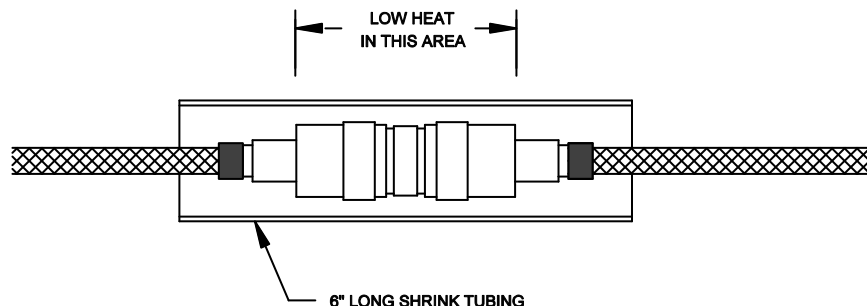
Step A Install connectors and test them following the "Cable and Connector Testing Procedures" in this manual.

Step B Slide a 6" [150 mm] piece of shrink tubing on the cable and tighten the connector assembly securely.



Apply a minimum ¼" [6 mm] bead of **noncorrosive type RTV** completely around the cable next to the end of each of the connectors.

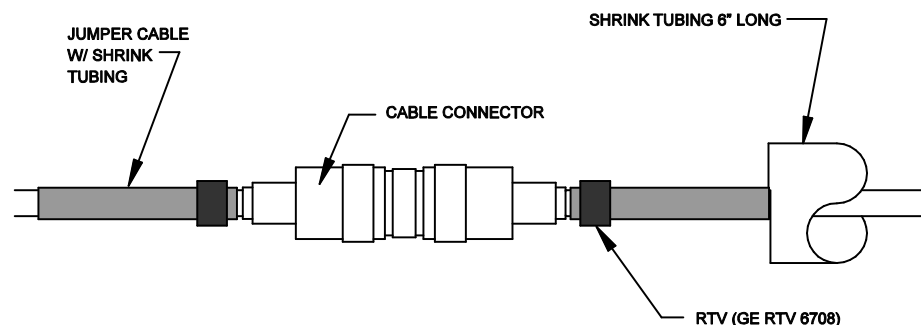
Step C Center the shrink tubing over the connector. Carefully heat the tubing, slightly, over the center of the connector. **Caution: If the shrink tubing is overheated in the center area, it may tear as it tries to shrink to the size of the cable. Next heat the remainder of the tubing. Do not heat the tubing any longer than required to shrink the tubing around the cable.**



8.3.3 Cable Types JMP-U/-UD, JPP and JMP

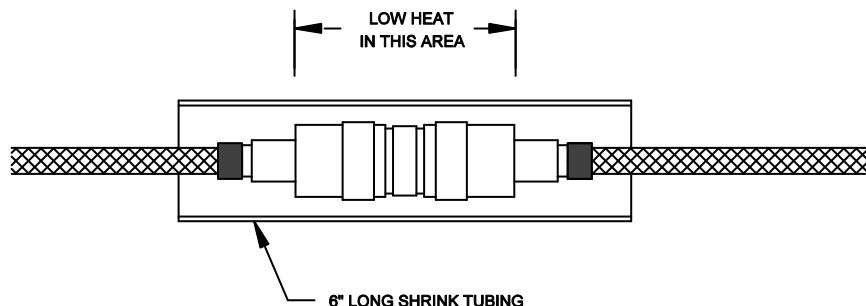
Step A Install connectors and test them following the "Cable and Connector Testing Procedures" in this manual.

Step B Slide a 6" [150 mm] piece of shrink tubing on the cable and tighten the connector assembly securely.



Apply a minimum 1/4" [6 mm] bead of **noncorrosive type RTV** completely around the cable on the installed shrink tubing next to the end of each of the connectors.

Step C Center the 6" long shrink tubing over the connector. Carefully heat the tubing, slightly, over the center of the connector. **Caution: If the shrink tubing is overheated in the center area, it may tear as it tries to shrink to the size of the cable. Next heat the remainder of the tubing. Do not heat the tubing any longer than required to shrink the tubing around the cable.**



8.4 Cable and Connector Testing Procedures

8.4.1 General

The following tests should be performed on each length of cable after both connectors are installed. Figure 8-1 illustrates the tests. Any overbraid or outer jacket is not shown.

8.4.2 Continuity Test

The continuity test checks for broken cable, open connectors, and poor connections.

1. Connect a short jumper wire with alligator clips between the UHF connector's center contact and the body of the connector at one end of the cable, as shown in figure 8-1. **Note: Do not clip onto the threaded coupling ring because the ring is not tightly secured, resulting in intermittent readings.**
2. Connect the ohmmeter's test leads to the connector's center contact and connector body on the other end of the cable.
3. The ohmmeter reading should be less than 10 ohms/1000' [10 ohms/300 m] of cable. If it is not, check the jumper wire, test lead connections, and repeat the test. If the problem persists, contact the PermAlert Field Service Department for assistance.

8.4.3 Alternative System Test

1. Connect the entire cable string to the PAL-AT panel.
2. Make sure the panel is turned off. Set the impedance jumper for the cable under test – position C (w/o ZBA) or D (w/ZBA). If applicable, make sure the replaceable fuse in the ZBP is good.
3. Measure the resistance at the far end of the cable string. Connect one test lead to the center contact of the last connector and the other lead to the connector body. The resistance should be less than 60 ohms + 10 ohms/1000' [75 ohms/300 m] of cable string.
4. If intermittent connections are suspected, gently flex the connectors while the meter is monitored.

8.4.4 Insulation Test

The insulation test checks for a short between the center conductor and outer braid.

1. Remove the jumper wire used in the continuity test, as shown in figure 8-1 and connect one ohmmeter test lead to the connector's center contact and the other lead to the connector body.
2. A good cable will give a full-scale reading (at least 10 megohms). Test readings below full scale indicate damaged cable or an improperly installed connector. If you cannot resolve the problem, contact PermAlert's Field Service Department for assistance.

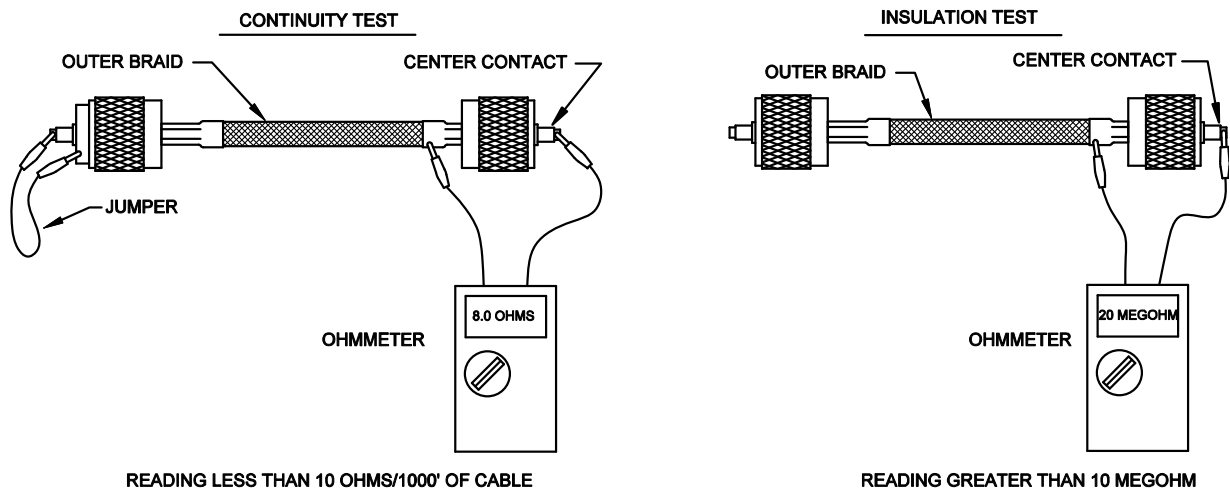


Figure 8-1
Cable Test Procedures

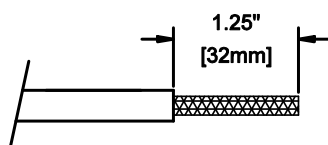
8.5 Cable Connections to Panels

8.5.1 General

The ends of the jumper cables connected to the PAL-AT panel or Zener Barrier Panel need to be terminated with wire ferrules. The ferrules provide a positive connection and prevent stray strands of the wires from shorting to adjacent terminals.

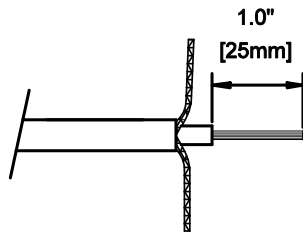
8.5.2 Ferrule Installation in PAL-AT Panel

Step A Remove 1.25" [32 mm] of cable jacket



Step B Separate the braid wire into two equal groups. It is easier to unbraid the wire if it is done in 1/4" long increments. It is helpful when working with JMP-U cable to keep tools and fingers damp when

touching the sticky, water-blocking material. Twist each group into a small wire. Remove 1.0" [25 mm] of insulation from the center wire.

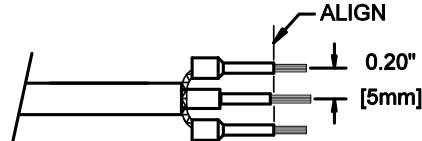


Step C JMP-U/-UD Cable

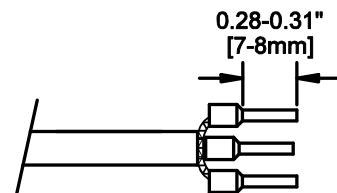
Slide a 14 AWG [2.5 mm²] uninsulated ferrule onto the center wire until it is tight against the center insulation. Crimp the ferrule using a 2.5 mm² die. Then crimp it again with a 1.5 mm die. Slide a 16 AWG [1.5 mm²] insulated ferrule over each group of braid wire twisted strands. Spread the ferrules apart to fit into the connector as shown. Align the ferrule ends as shown while minimizing slack in the braid wire. Crimp the ferrules using a 1.0 mm crimp die.

JMP (from ZBA) or JPP Cable

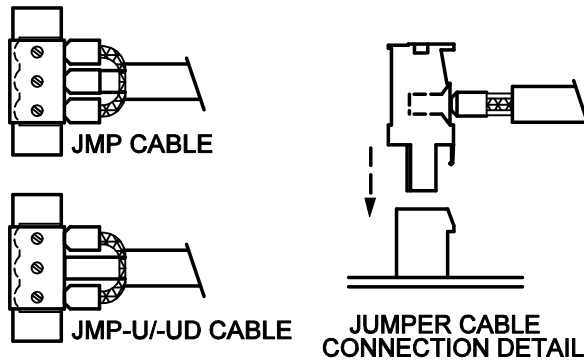
Slide an 18 AWG (1.0mm²) insulated ferrule onto the center wire until the ferrule insulation is completely over the wire insulation. Crimp the ferrule using a 0.50 mm crimp die. Slide an 18 AWG (1.0mm²) insulated ferrule over each group of braid wire twisted strands. Spread the ferrules apart to fit into the connector as shown. Align the ferrule ends as shown while minimizing slack in the braid wire. Crimp the ferrules using a 0.50 mm crimp die.



Step D Trim excess wire from the end of the ferrules.

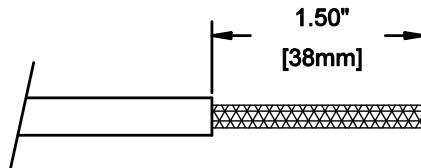


Step E The cable ferrules should be inserted into the cable plug and tightened as shown. **Before connecting the cable, route the excess cable in the enclosure so there will not be excessive strain or twisting at the terminals.** Insert the plug into the appropriate receptacle as shown. The center conductor ferrule should be in the center terminal of the plug and the two braid ferrules in the outer terminals. When removing the cable, grip the plug and pull it straight out of the receptacle. **Note the plug and receptacle are polarized so they can only be connected one way.**

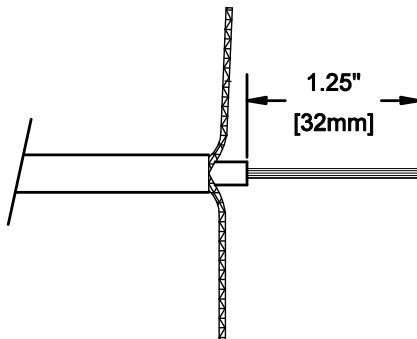


8.5.3 Ferrule Installation in Zener Barrier Panel

Step A Remove 1.5" [38 mm] of cable jacket.



Step B Separate the braid wire into two equal groups. Twist each group into a small wire. Remove 1.25" [32 mm] of insulation from the center wire.

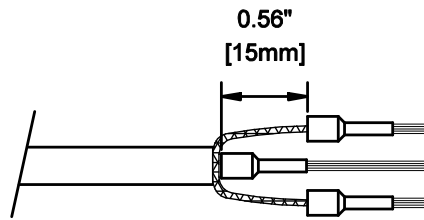


Step C JMP-U/-UD Cable

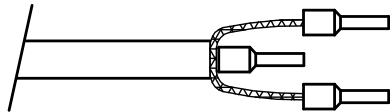
Slide a 14 AWG [2.5 mm²] uninsulated ferrule onto the center wire until it is tight against the center insulation. Crimp the ferrule using a 2.5 mm² die. Then crimp it again with a 1.5 mm die. Slide a 16 AWG [1.5 mm²] insulated ferrule over each group of braid wire twisted strands. Align the ferrule ends as shown while minimizing slack in the braid wire. Crimp the ferrules using a 1.0 mm crimp die.

JPP Cable

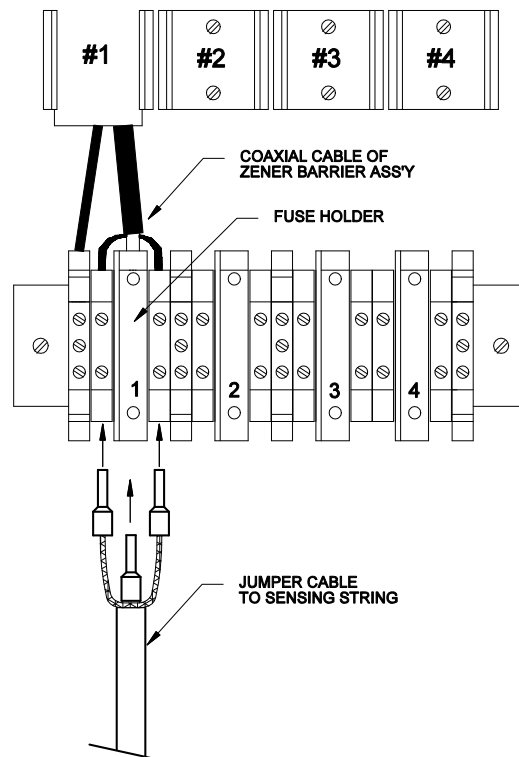
Slide an 18 AWG (1.0mm²) insulated ferrule onto the center wire until the ferrule insulation is completely over the wire insulation. Crimp the ferrule using a 0.50 mm crimp die. Slide an 18 AWG (1.0mm²) insulated ferrule over each group of braid wire twisted strands. Align the ferrule ends as shown while minimizing slack in the braid wire. Crimp the ferrules using a 0.50 mm crimp die.



Step D Trim excess wire from the end of the ferrules.

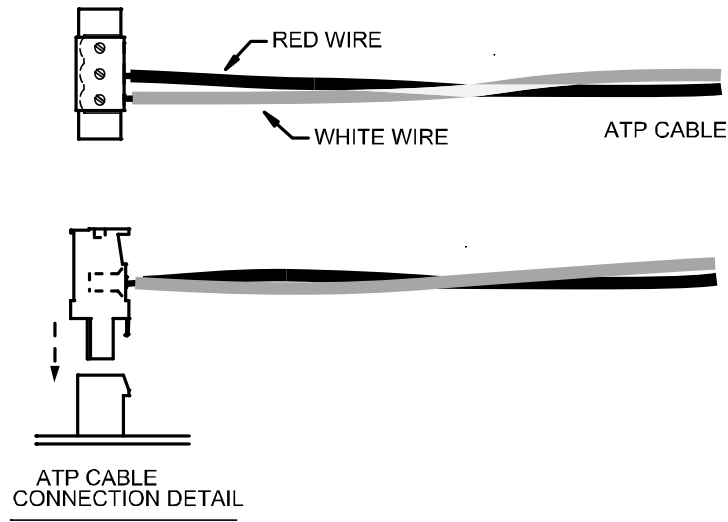


Step E **Before connecting the cable, route the excess cable in the enclosure so there will not be excessive strain or twisting at the terminals.** Insert the center wire into the fuse holder terminal and tighten the screw. Then insert one of the braid ferrules in the adjacent braid terminal and fasten it. Repeat with the remaining braid ferrule. If the ferrules were installed properly, there should be very little slack braid wire.



8.5.4 ATP Cable Connection at PAL-AT

The ATP cable uses two of the three cable plug terminals as shown below. Strip 3/8" [10mm] of insulation from the end of the red and white wires. Insert the red wire into the center terminal and the white wire into either of the side terminals of the cable plug and tighten as shown. **Before connecting the plug, route the excess cable in the enclosure so there will not be excessive strain or twisting at the terminals.** Insert the plug into the appropriate receptacle as shown. When removing the cable, grip the plug and pull it straight out of the receptacle. **Note the plug and receptacle are polarized so they can only be connected one way.**



9 Probes

9.1 UL Requirements

All PermAlert probes are approved for installation in ordinary, or unclassified, locations. All PermAlert probes, **except the PWS water probe**, are also approved for installation in hazardous locations (see figures 3-2 and 3-3) when the sensing string is connected to a Zener Barrier Panel and Zener Barrier Assembly.

9.2 Probe Integrator Selection

All probe integrators have a red or blue band(s) of shrink tubing on the probe lead cable. A probe integrator with a red band(s) is used with PHLR, PSTV, PFS and PTHL probe or a normally closed switch. A probe integrator with a blue band(s) is used with the PWS probe or a normally open switch.

The number of bands on the probe integrator indicates where it can be used in the sensing string. One band (-S model) indicates the probe integrator must be connected to the system in the first 5,000' [1500 m] of sensing string. Two bands (-L model) indicate the probe integrator must be connected to the sensing string beyond 5,000' [1500 m] (Contact factory for specific requirements).

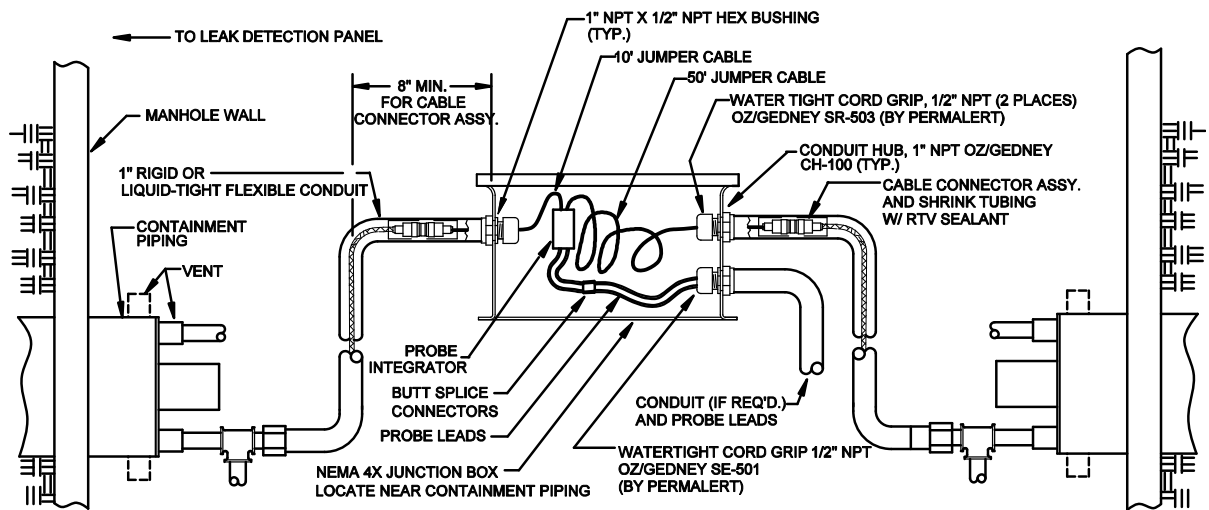
9.3 Probe Installation

1. All PAL-AT probes are furnished with a probe integrator and 60' [18 m] of JMP-U jumper cable in a NEMA 4X [IP66] junction box. The probe integrator allows the attachment of probes to the PAL-AT monitoring system. The standard 10" x 8" x 4" [250 mm x 200 mm x 100 mm] junction box can house one integrator. A 12" x 10" x 4" [300 mm x 250 mm x 100 mm] junction box is recommended if 2 probe integrators are located in one box.
2. The maximum temperature for a probe integrator is 180°F [80°C] in ordinary locations. **If a probe integrator is connected to a ZBA in a hazardous location, the maximum temperature is 140°F [60°C].**
3. The standard polyester probe junction box is rated for 150°F [65°C]. An optional high- temperature fiberglass box is also available. Make sure the enclosure is appropriate for the ambient temperature.
4. Some probe components (epoxy, shrink tubing, etc.) are resistant to many hydrocarbons and chemicals. However, the probes should be cleaned promptly after a leak event. **If left exposed to hydrocarbon liquids or chemicals for extended periods, the probes may require replacement.**
5. Mount the probe integrator junction box at a location close to the point being monitored. PermAlert supplies probes with 20' [6 m] of twin lead cable. Uncoil the twin lead cable. **Do not splice on additional wire to lengthen the leads.** If the probe integrator is located in a manhole or pit, which may collect and hold water, mount the junction box as high as possible.
6. Figures 9-1 and 9-2 show the recommended installation procedures. Figures 9-3 thru 9-7 show typical probe installations. Install the probe and use electrical conduit and/or watertight cord grips, as necessary, to prevent water entry where the probe twin lead penetrates the monitored area. If the probe lead length is longer than 5' [1.5 m] and the probe is installed in the first 800' [245 m] of a system, plastic conduit should be used instead of metal conduit. The cord grip (part # 8057950) with the oval opening in the bushing is used with the twin lead cable. The cord grip (part # 8057954) with the round hole is for the jumper cable.
7. Once a probe is installed, the twin lead should be routed to the junction box containing the probe integrator. **Trim the excess length of the probe twin lead before splicing it to the probe integrator.** Splice the leads to the integrator by using the crimp connectors supplied with the probe. Heat the splice with a heat gun to seal the adhesive-lined shrink tubing on the connector.
8. Use all 60' [18 m] of jumper cable furnished with the probe integrator. **If the jumper cable leads are too long, do not shorten,** but loosen the watertight cord grips and coil the excess jumper cable within the probe junction box. One jumper cable length is shorter than the other is. Connect the shorter end (10') [2.5 m] to the cable segment closest to the PAL-T panel. The longer end of jumper cable (50') [15 m] should be routed to the connection point for the continuation of the sensing string.
9. Additional jumper cable may be required to be added to the end of a probe installed beyond 3000' [900 m] on the cable string (see table 9-1).

10. If the probe is the end of the sensing string, refer to table 4-1 (section 4) for the required length of jumper cable needed to be added to the end of the probe.
11. Additional jumper cable may be connected on either side of the probe integrator to facilitate connection of remote sensing string components.
12. Refer to the "Cable Connector Installation" section of this manual and install a connector on each length of jumper cable. Test all connectors using the "Cable and Connector Testing Procedures".
13. Cable connections to jumper cable from the probe integrators will become calibration points and must be accessible during system start-up.
14. The maximum number of probes per cable string is 10. A maximum of three probes installed past 5000' [1500 m] is allowed (Contact factory).

Table 9-1
Additional Jumper Cable after Probe

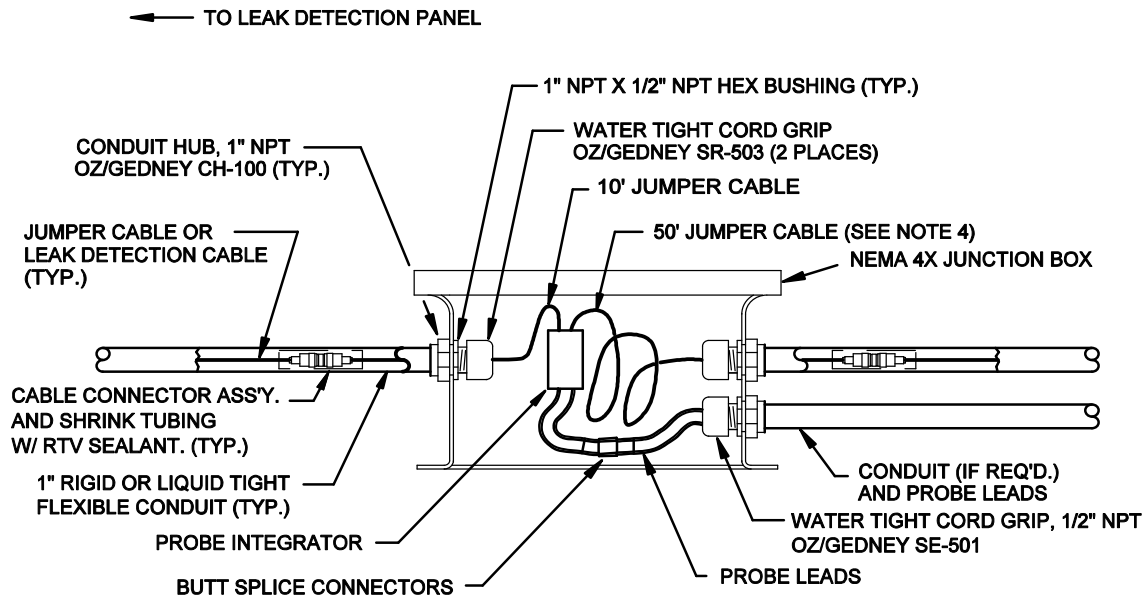
Probe Location on Sensing String ft / [m]	Additional JMP-U/-UD At End of Probe ft / [m]			Additional JPP At End of Probe ft / [m]		
	Twin Lead Length			Twin Lead Length		
	20 / [6]	15 / [4.5]	10 / [3]	20 / [6]	15 / [4.5]	10 / [3]
0-3000 / [0-900]	0 / [0]	0 / [0]	0 / [0]	0 / [0]	0 / [0]	0 / [0]
3001-4000 / [900-1200]	20 / [6]	0 / [0]	0 / [0]	25 / [8]	0 / [0]	0 / [0]
4001-5000 / [1200-1500]	60 / [18]	25 / [8]	20 / [6]	80 / [25]	35 / [11]	25 / [8]
Over 5000 / [over 1500]	Contact Factory					



NOTES:

1. WATERTIGHT CORD GRIPS, CONDUIT HUBS AND CONDUIT ARE RECOMMENDED
2. THE 10' AND 50' JUMPER CABLE CONNECTED TO THE PROBE INTEGRATOR MUST NOT BE SHORTENED. COIL EXCESS WITHIN NEMA 4X JUNCTION BOX.
3. 50' LENGTH OF JUMPER CABLE ATTACHED TO THE PROBE INTEGRATOR MUST BE DOWNSTREAM OF THE PROBE INTEGRATOR AWAY FROM THE PAL-AT PANEL
4. CONDUIT SHOULD BE USED TO PROTECT THE PROBE LEADS IN APPLICATIONS WHERE DAMAGE MAY OCCURE
5. MARK UNPROTECTED PROBE LEADS WITH CABLE TAG, PART NUMBER 8057661.
6. ALLOW SLACK ON SENSOR CABLES TO INSTALL CONNECTORS.

Figure 9-1
Typical Probe Connection in Monitored Areas



NOTES:

1. ALLOW SLACK IN LEAK DETECTION CABLE TO INSTALL AND SERVICE CONNECTOR
2. PIPE AND CONDUIT FITTINGS SUPPLIED BY INSTALLER.
3. THE 10' AND 50' JUMPER CABLE CONNECTED TO THE PROBE INTEGRATOR MUST NOT BE SHORTENED. COIL EXCESS WITHIN NEMA 4X JUNCTION BOX.
4. 50' LENGTH OF JUMPER CABLE ATTACHED TO THE PROBE INTEGRATOR MUST BE DOWNSTREAM OF THE PROBE INTEGRATOR AWAY FROM THE PAL-AT PANEL
5. CONDUIT SHOULD BE USED TO PROTECT THE PROBE LEADS IN APPLICATIONS WHERE DAMAGE MAY OCCURE
6. MARK UNPROTECTED PROBE LEADS WITH CABLE TAG, PART NUMBER 8057661.

Figure 9-2
Typical Conduit Connection Detail

9.4 PHLR Hydrocarbon Probe

The PHLR series is a reusable hydrocarbon probe that detects hydrocarbon liquids in sumps, interstitial spaces of pipes and any other areas where hydrocarbon liquids can accumulate to a depth of 1/4" [6 mm]. The probe is designed to detect fuels (gasoline, diesel fuel, jet fuel, crude oil, etc.) and many hydrocarbon solvents. The probe is reusable by cleaning or replacing the sensor elements. There are two models of the PHLR probe available:

- The standard PHLR is designed for non-pressurized locations such as sumps, manholes, and non-pressurized containments. The PHLR can be installed in any orientation – vertical or horizontal.
- The PHLR-P is designed for pressurized containment applications. This model is ideal for typical sealed, containment piping systems that are maintained under pressure with a nitrogen or air blanket. The PHLR-P should be installed in a vertical orientation. **The PHLR-P has vent holes that must not be submerged in a liquid before the containment is pressurized** (see figure 9-4).

An extension to the probe housing can easily be added with standard 3/4" Schedule 40 PVC pipe to accommodate installation requirements.

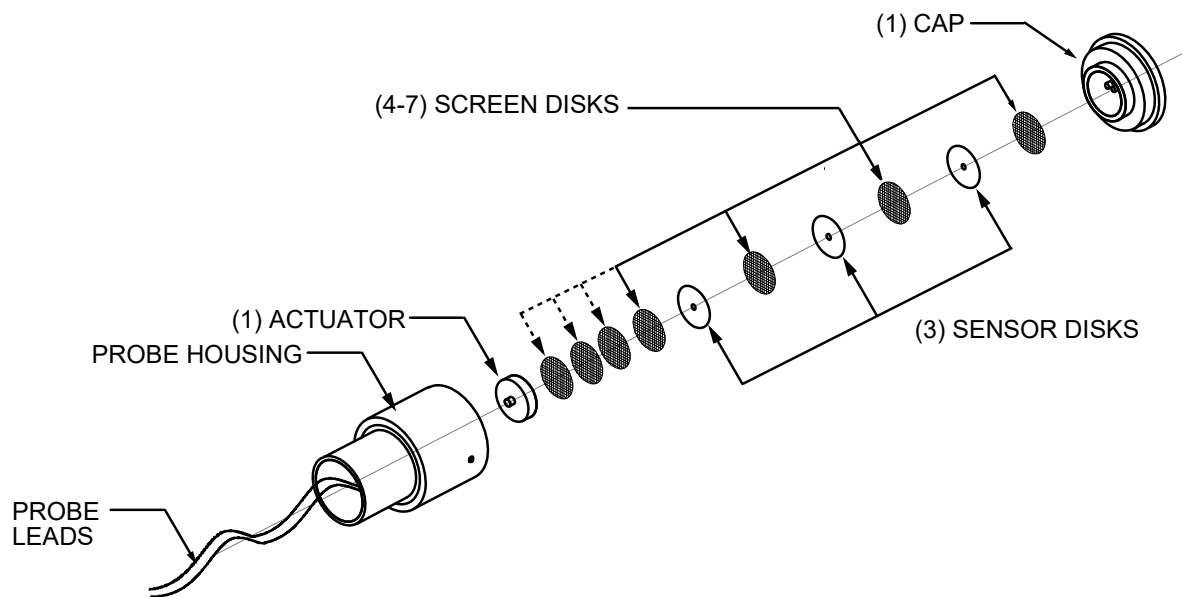


Figure 9-3
PHLR Sensor Package

9.4.1 Cleaning Sensor Elements Procedure

The replacement sensor package consists of 10 disks: seven screen disks and three sensor disks as shown in figure 9-3. The replacement package includes all removable parts: probe cap, sensor elements, and actuator. Replacement sensor elements can also be purchased separately.

The following procedure is a general guideline to follow to clean the probe and sensor elements after exposure to hydrocarbon liquids.



Caution: It is the user's responsibility to determine safety precautions and the suitability of exposing personnel to the hydrocarbon liquid on the probes and various cleaning solvents suggested.

The sensor disks swell after exposure to fuels and solvents. The swelling forces the actuator to move and operate a low-force sealed switch. Volatile hydrocarbon liquids, such as gasoline, will eventually evaporate resulting in the sensor disks returning to their original size. This allows the switch to return to the normal position. A faster resetting process is to disassemble the probe to speed the evaporation of the liquid. Other liquids, such as diesel fuel and jet fuel that do not evaporate, must be flushed with a solvent to remove the contamination. Disassemble and clean the probe as follows:

1. Remove excess hydrocarbon contamination from the exterior of the probe.
2. Hold the switch in a vertical position with the cap downward and unscrew the cap. Do this over a table so the small parts are not lost if they are dropped. **Be very careful not to lose the sensor disks.** They are very similar to contact lenses in size and texture.
3. Place the actuator, screens, cap, and sensor disks into a small container of solvent. Coleman Camp Fuel, which is naphtha, works well and evaporates very quickly. Other solvents that evaporate quickly and completely are also suitable.
4. Soak the components for a minute or two and then remove them.
5. Let the solvent evaporate until the disks return to the original diameter and fit into the cap easily. If the sensor disks do not slip easily into the circular holder in the cap, repeat the cleaning process. The disks should be about 0.5" [12 mm] diameter when dry.

6. Reassemble the switch. Carefully alternate the screens and three sensor disks in the cap as shown in figure 9-3. If there are more than 4 screens, place the extra screens on top. Place the actuator on top of the top screen. The actuator has a small point in the center of one side that must face the probe housing as shown. Hold the probe housing vertically and screw the cap finger-tight into the bottom of the housing.
7. If response time is over 5 minutes for diesel fuel at room temperature, insert the optional fifth screen next to the actuator. Make sure the extra screen does not activate the probe when it is tightened. If so, remove the extra screen. The extra screen accommodates manufacturing tolerances and reduces the amount of swelling of the sensor disks required before the probe activates.

9.4.2 Testing the Probe

The assembled probe can be easily tested with an ohmmeter and a small paperclip.

1. Connect the ohmmeter leads to the probe leads.
2. The reading should be very low, typically under two ohms.
3. Insert the paper clip into one of the five holes in the center of the cap and press gently (1-2 oz of force [25 g to 50 g]) into the switch.
4. The ohmmeter should read an open circuit or 0.L.
5. Remove the paper clip and the meter should return to the original low reading.
6. Disconnect the ohmmeter.

9.4.3 Troubleshooting

If the test results are not as expected, the following checks should help determine the problem.

- If the original reading is greater than 2 ohms or open, or 0.L, then
 - Check the sensor disks and screens are installed correctly. They must be flat, not folded over.
 - Verify the diameter has returned to the original size. Clean again if needed.
 - Recalibrate the probe as described below.
- If the ohmmeter reading is not an open circuit, 0.L, when the paperclip is inserted, then
 - Check the meter leads or probe wires are not shorted together.
 - Disassemble the probe and make sure the actuator point is oriented properly to press into the center of the switch in the probe housing.
 - Recalibrate the probe as described below.

9.4.4 Calibrating the Probe

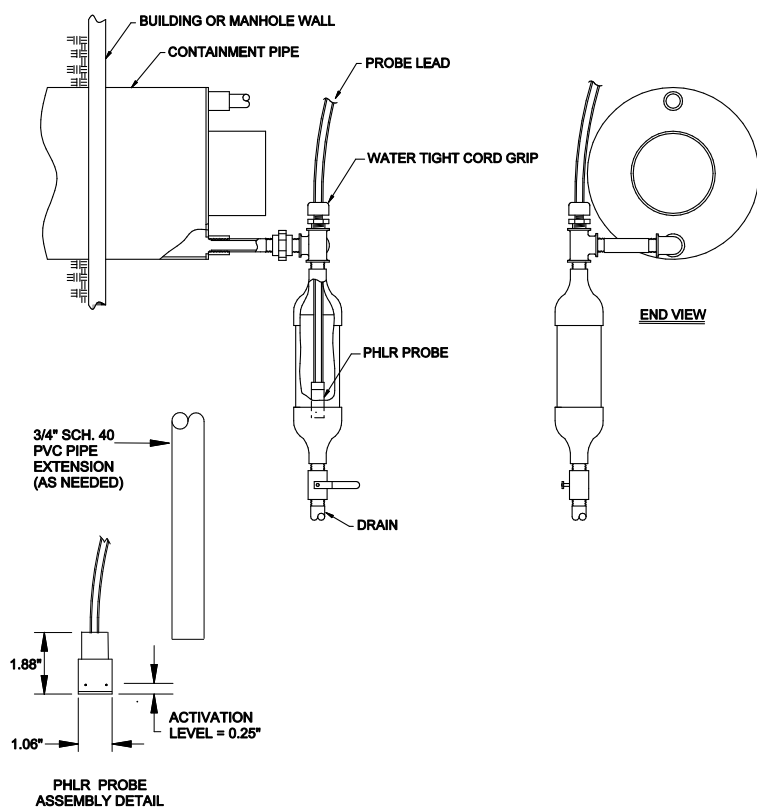
If the sensor elements are replaced, it is necessary to use the correct number of screen elements for optimum sensitivity (see figure 9-3). The number of screens required varies due to manufacturing tolerances of the probe. A multimeter is required.

1. Set the multimeter to the ohms function, auto-ranging scale, and connect to the probe leads.
2. Assemble the probe with seven screens and three elements as shown. Tighten the cap finger tight.
3. If the meter reading is less than 2 ohms, the probe fails the calibration. Make sure there are no extra screen or sensor disks installed.
4. If the reading is 0.L, remove a screen (shown by the dashed arrows in figure 9-3). If the reading is less than 2 ohms, the calibration is complete.
5. If more than four screens are installed repeat step 4.
6. If the reading is 0.L with four screens, the probe fails the calibration. Make sure there are three sensor disks and at least four screen disks installed.

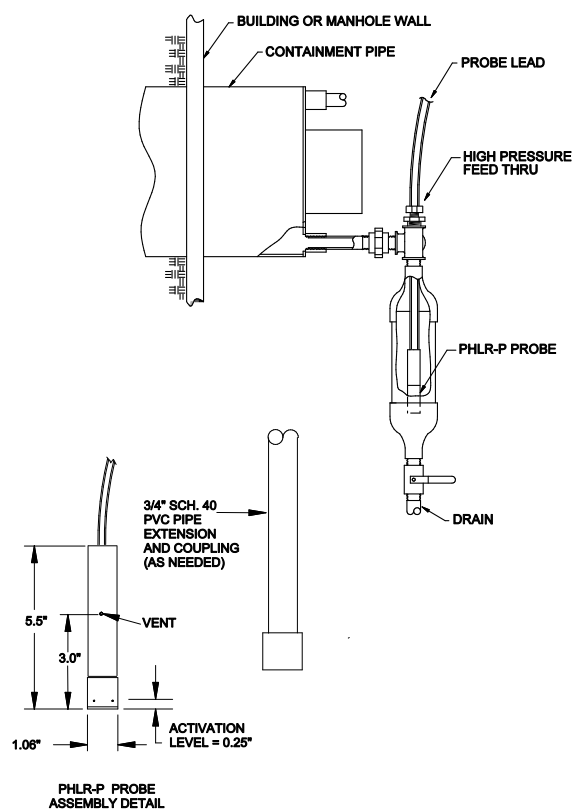
If the reading in step 4 is not less than 2 ohms, hold the probe in a vertical orientation and gently tap the housing. The switch resistance should be less than 2 ohms in the normal dry state.

9.5 Typical Installations

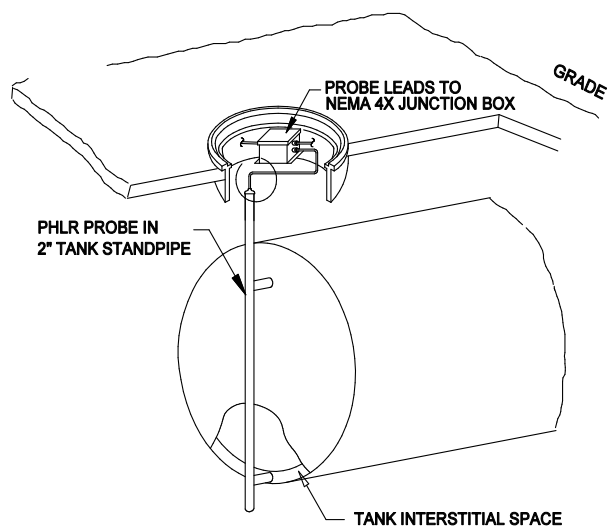
Contained Pipe



Pressurized Contained Pipe



Double-Wall Tanks



Contained Area

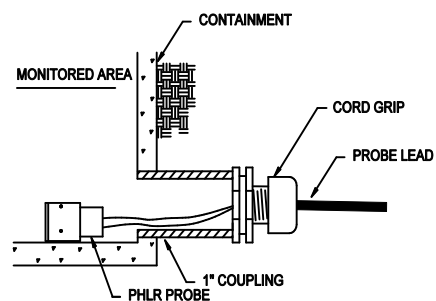
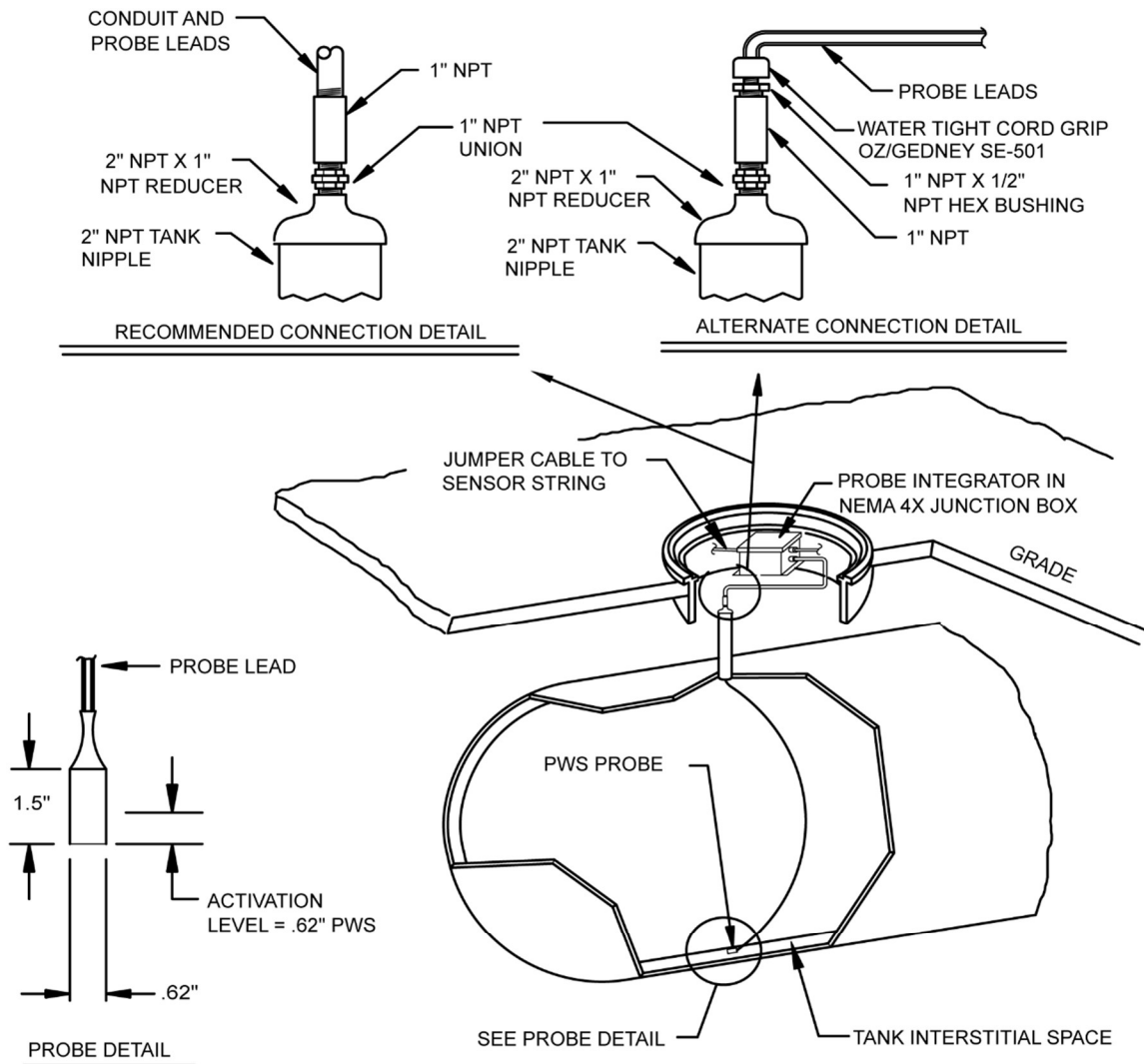


Figure 9-4
Typical PHLR and PHLR-P Probe Installations



NOTES:

1. LENGTH OF PROBE LEAD IS 20 FEET MAX.

Figure 9-5
Typical PWS Probe Installation

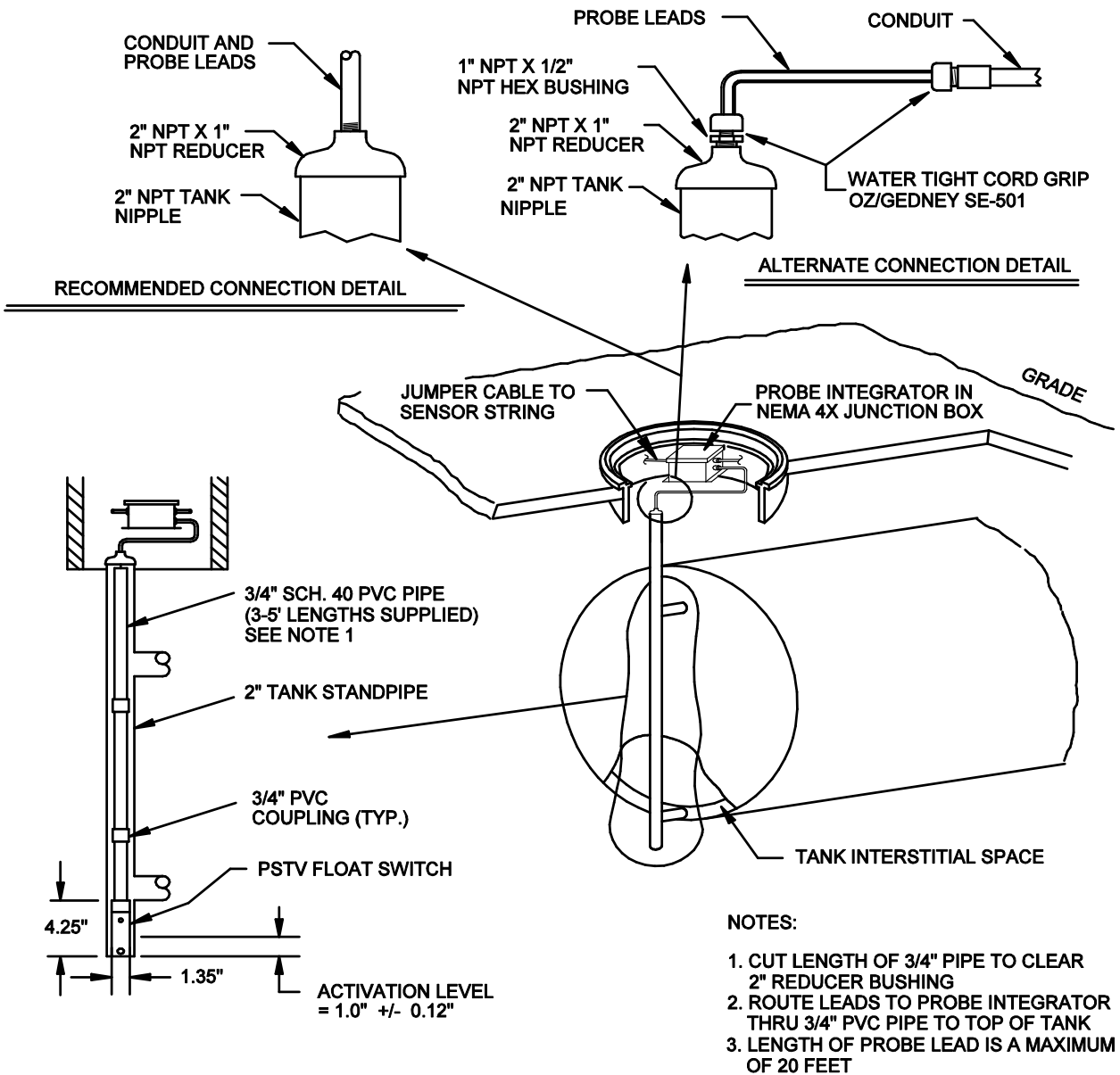


Figure 9-6
Typical PSTV Tank Float Switch Installation

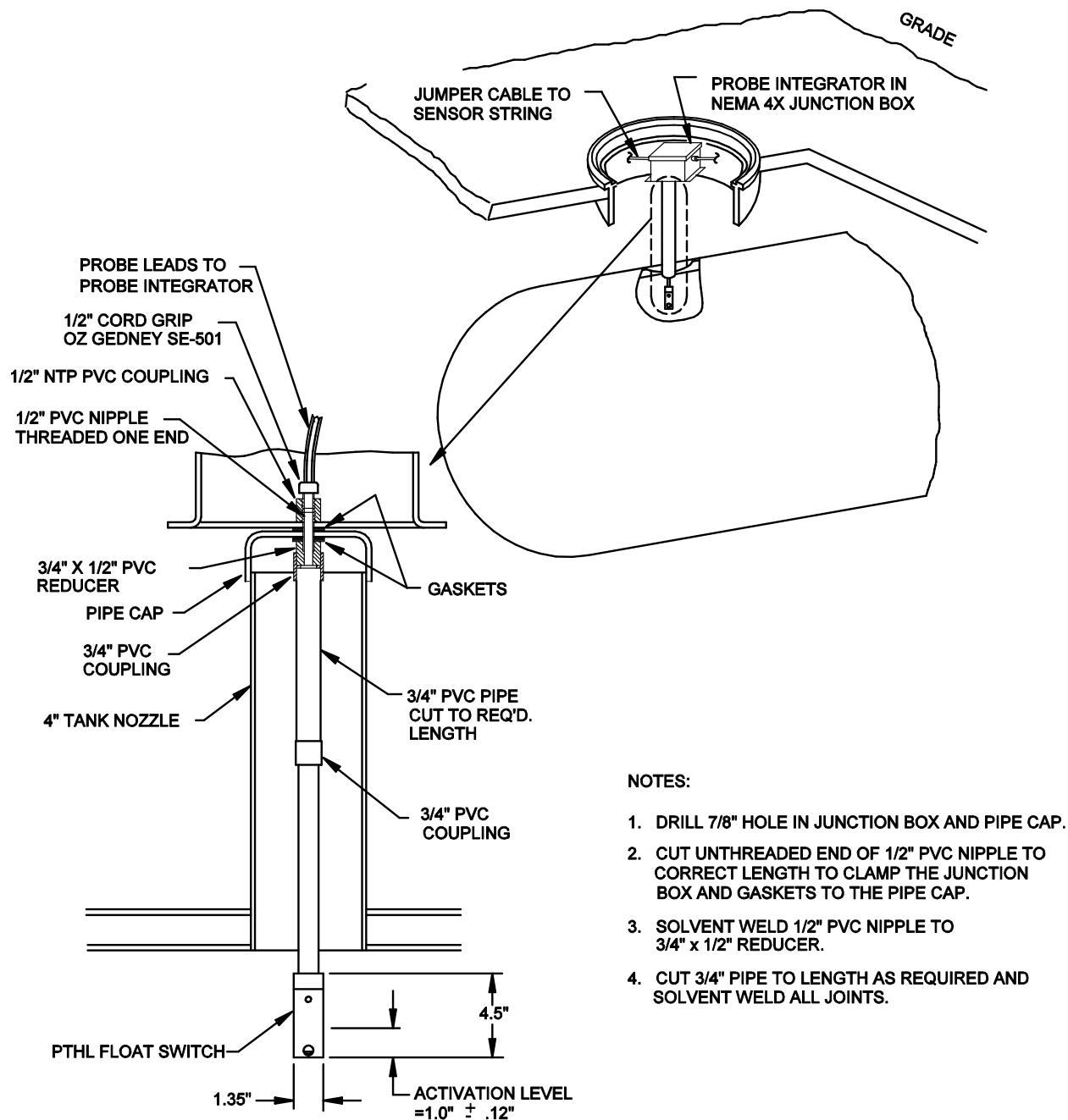


Figure 9-7
Typical PTHL Installation

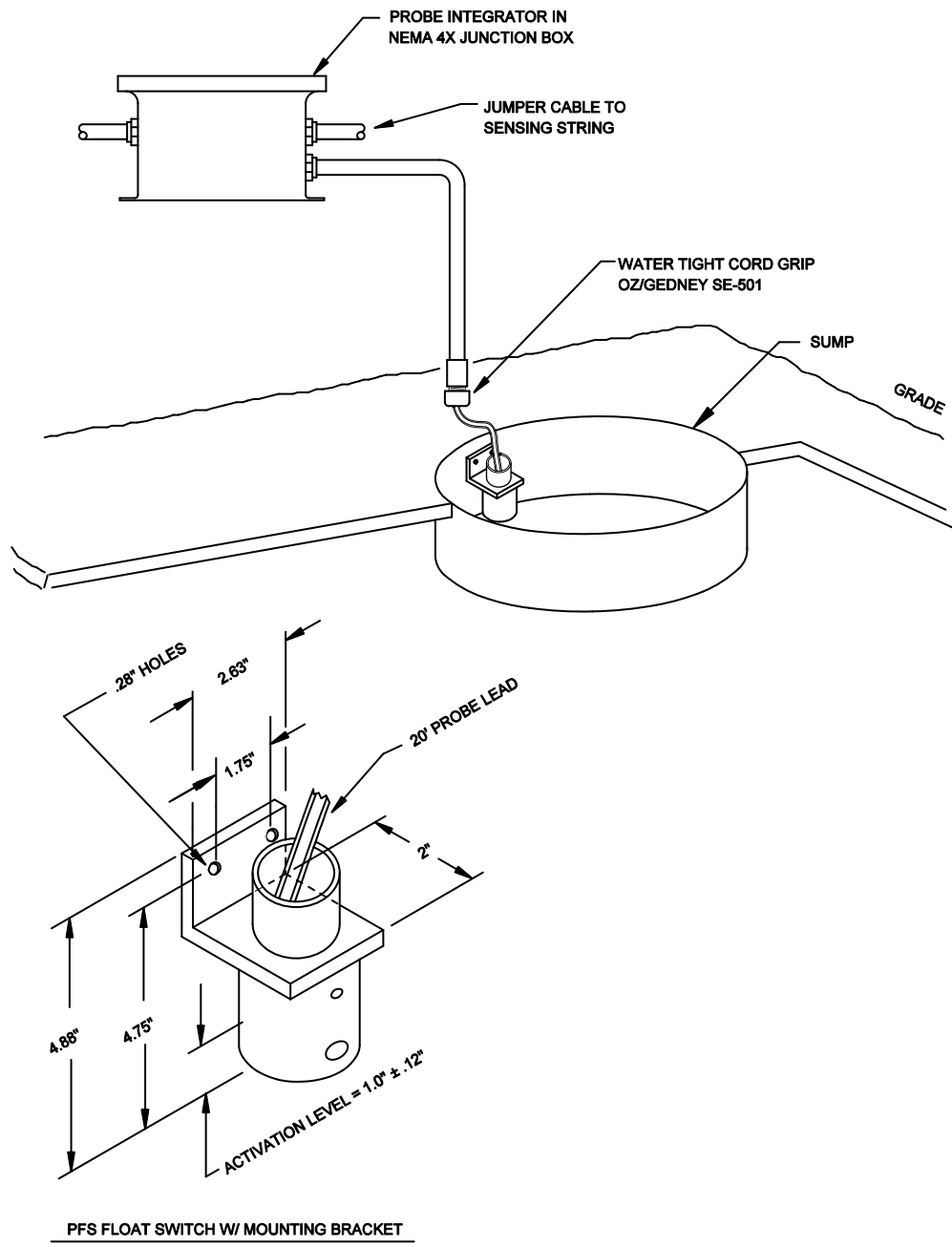


Figure 9-8
Typical PFS Installation

9.6 Probe Tests

Figure 9-9 shows a typical probe integrator test setup. There are four test procedures based on the type of integrator used. The red lead of an ohmmeter should be connected to the center pin of either of the connectors (point A). The black lead should be connected to the connector housing (point B). The ohmmeter should be set to resistance. Follow the test procedure in figure 9-10 to test the probe integrator and probes.

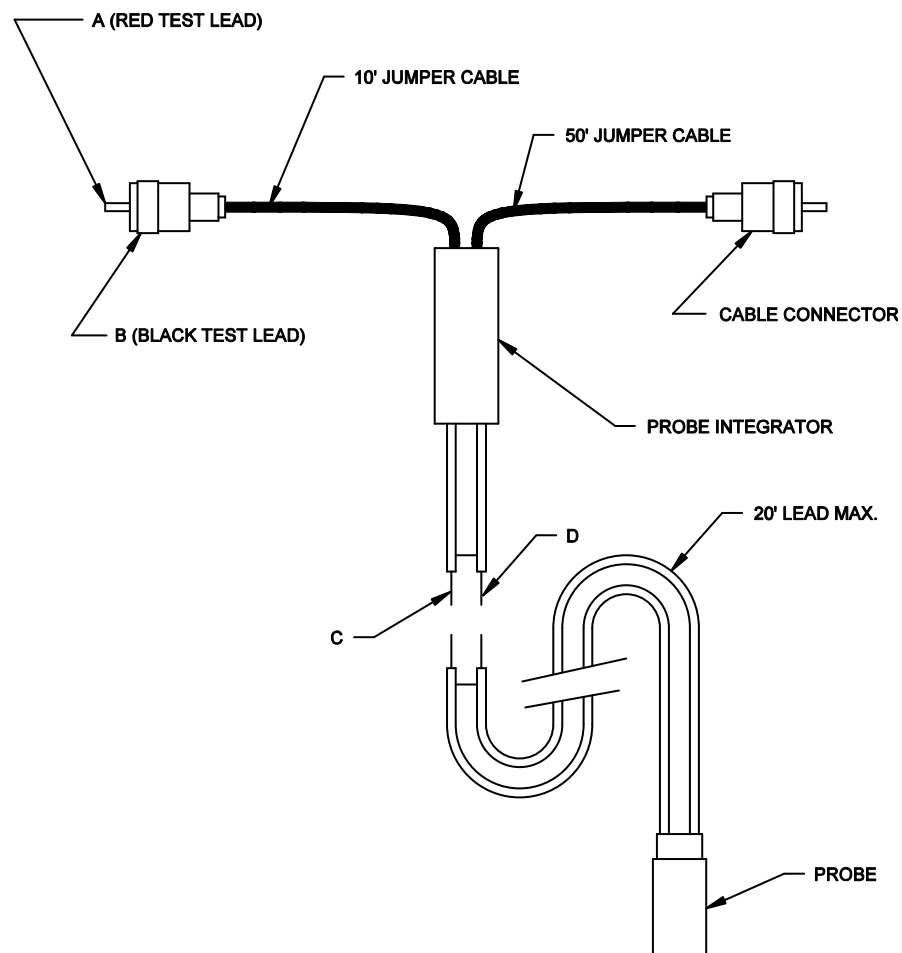


Figure 9-9
Probe Integrator Test Setup

PROBE INTEGRATOR TESTS

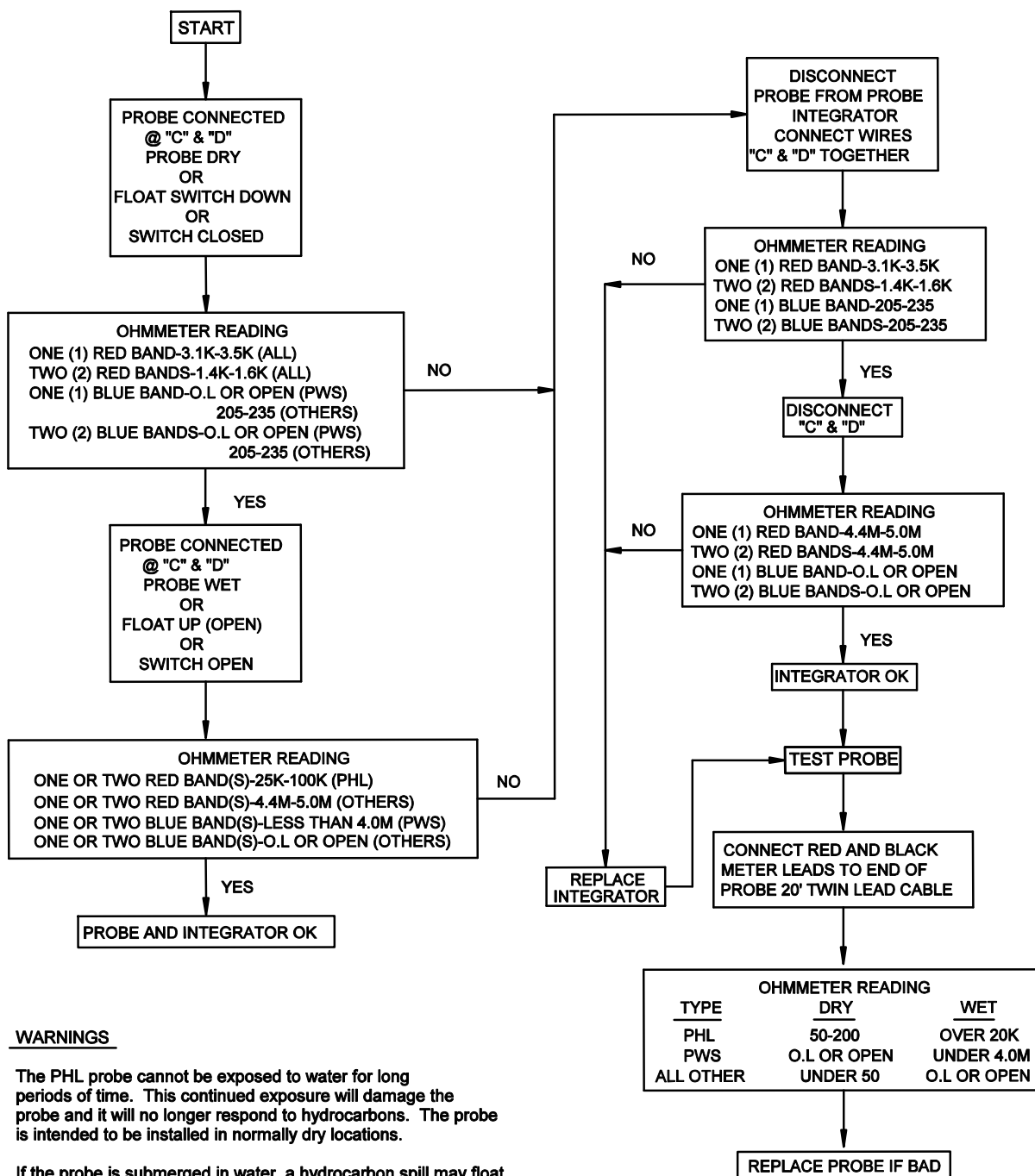


Figure 9-10
Probe Integrator Test

10 ATP Cable in Polyurethane Foam Insulation

10.1 General

This section outlines installation procedures for ATP twisted pair leak detection cable. The cable has two insulated solid copper wires, one red and the other white. It is installed at the factory in polyurethane foam insulation.

The cable is typically installed at the 12 o'clock position in the foam insulation for straight runs. It may be in other orientations for fittings and returns from branch runs, so check the drawing layout for specific job information. **It is very important that the ATP cable be installed straight across each field joint. The pipe should be rotated so the location where the ATP cable exits the polyurethane foam in adjacent pipe sections line up to each other. The exit location is stenciled "ATP" on the pipe jacket.**

10.2 Pipe Installation Precautions

Extra cable extends past each end of the pipe and is coiled around the pipe to protect it during shipping. **The extra cable must be protected from damage and must be moved away from the pipe before welding the pipe. Repeated bending of the cable can also damage it.**

There are several techniques to protect the ATP cable during the pipe welding/brazing process, depending on the pipe dimensions and material. The cable can be exposed to temperatures of 300°F [150°C] for a short time. A wet rag next to the cable can reduce the temperature sufficiently in some cases. **If the ATP cable is within 6" from the weld, additional precautions must be taken.** There are heat block insulator paste products available that can be placed on the pipe between the heat source and the cable. Typically, the process involves applying a thick layer of insulator paste around the pipe and then removing it after the welding operation (per manufacturer's instructions).

10.3 System Configuration

A PAL-AT Leak Detection and Location System can monitor 1 to 4 cables, or sensing strings, depending on the model. **A sensing string used to monitor ATP must only monitor ATP. No jumper cable, probes or other types of sensor cables can be connected to the string.**

An ATP cable string has at least 50' [15 m] of ATP connected to the panel that replaces the standard jumper cable. The ATP "jumper" cable connects directly to the ATP cable in the pipe foam insulation at the start of the pipeline. Watertight electrical conduit should be used to protect the cable and keep it dry. **The watertight requirement for conduit is critical to prevent false alarms.**

10.4 Calibration Points

During the initial setup and calibration of the PAL-AT system, connectors at selected locations, called calibration points, are temporarily disconnected. **Therefore, it is imperative to have accessibility to connectors at calibration points at all times until the system is brought on-line.** The cable at these locations can be prepared for permanent crimp connectors, but the connectors should not be crimped until the calibration process is completed for each section. A reusable connector (CAGOLD) can be installed at these points to allow multiple making/breaking the connection if needed (see section 8.2.4).

10.5 ATP Cable and Connector Testing Procedures

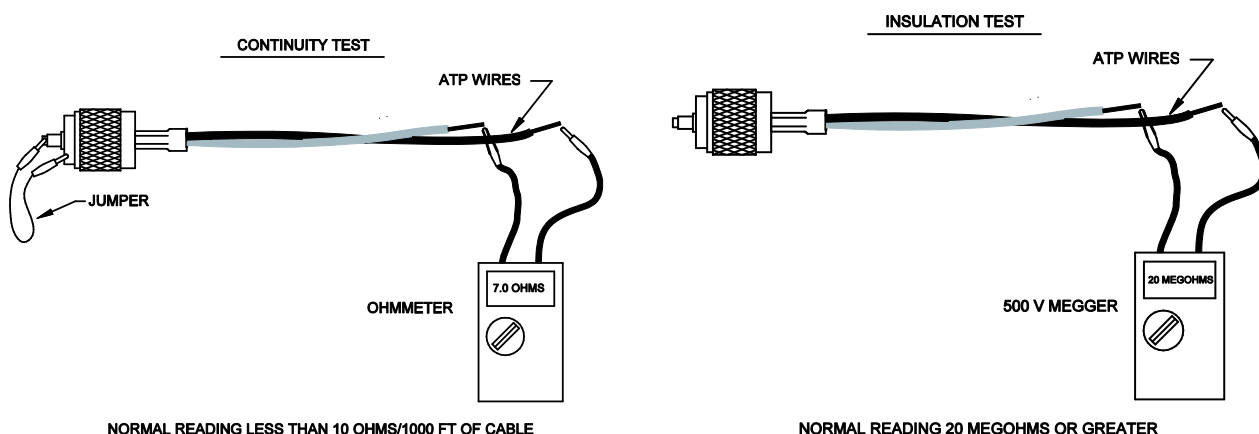
The following "Continuity Test" and "Insulation Test with Wet Cloth" should be performed after each pair of crimp connectors is installed at a field joint, prior to installing the polyurethane foam. In addition, the continuity test and standard insulation test should be performed again, prior to backfilling the pipe. When performing connector tests, if a CAGOLD connector is used, the center pin of the UHF connector is connected to the red wire and the connector housing is connected to the white wire.

A 9-volt digital multimeter, e.g. a Fluke Model 75, can be used for the continuity test and a 500-volt megger must be used for the insulation test.

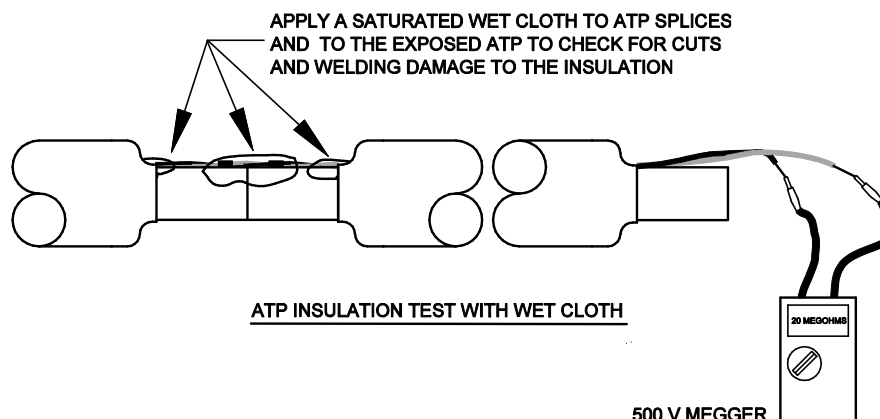
10.5.1 Continuity Test

The continuity test checks for broken cable, open connectors and poor connections. The test can be performed on the entire ATP sensor string or a partial section.

1. At the start of the pipe (or at the connector in the panel) temporarily connect the red and white wires together. A short jumper wire with alligator clips or wire nut can be used. If a UHF connector is installed, connect the jumper between the UHF connector's center contact and the body of the connector, as shown. **Note: Do not clip onto the threaded coupling ring because it is not tightly secured and will give intermittent readings**
2. Connect the ohmmeter's test leads to the red and white wires on the other end of the cable.
3. The ohmmeter reading should be less than 6 ohms/1000 ft [20 ohms/1000 m] of cable. If it is not, check the jumper wire, test lead connections and repeat the test. If the problem still persists, check the last connector installed and correct the problem.



ATP Cable Test Procedures



ATP Wet Cloth Test Procedure

10.5.2 Insulation Test

This insulation test checks for a short between the red and white wires or from either wire to the pipe. The test can be performed on the entire ATP sensor string or a partial section.



The ATP cable must be disconnected from the PAL-AT panel when conducting the insulation tests or damage to the equipment will result. A 500-volt megger is used to measure the resistance between the wires and the carrier pipe.

1. If the jumper wire used in the continuity test is still installed, remove it.
2. Perform this test at the unconnected end of the length of ATP.

3. Connect one of the megger test leads to the red wire and the other lead to the pipe. The reading should be “open” or greater than 20 megohms.
4. Check the white wire in a similar manner.
5. Connect one of the megger test leads to the red wire and the other lead to the white wire. The reading should be “open” or greater than 20 megohms.
6. A good cable will have a reading of at least 20 megohms. If any reading is less than 20 megohms, check the last connection for a short and repair the problem. The wire insulation may be damaged or adhesive lined shrink tubing was not installed over a splice and the condition must be corrected.

10.5.3 Insulation Test with Wet Cloth

This insulation test checks for a short between the red and white wires or from either wire to the pipe. This test should be performed when the ATP splice connections are completed at each field joint, before the field joint insulation and jacket are installed.



The ATP cable must be disconnected from the PAL-AT panel when conducting the insulation tests or damage to the equipment will result. A 500-volt megger is used to measure the resistance between the wires and the carrier pipe. Make sure no one is touching the wet cloth when the megger test is conducted.

7. If the jumper wire used in the continuity test is still installed, remove it.
8. Perform this test at the unconnected end of the length of ATP just added to the sensor string.
9. Place a saturated cloth on the splices and exposed ATP cable at the field joint. The water will enter any damaged wire insulation and cause a low megger reading.
10. Connect one of the megger test leads to the red wire and the other lead to the pipe. The reading should be “open” or greater than 20 megohms.
11. Check the white wire in a similar manner.
12. Connect one of the megger test leads to the red wire and the other lead to the white wire. The reading should be “open” or greater than 20 megohms.
13. A good cable will have a reading of at least 20 megohms. If any reading is less than 20 megohms, check the last connection for a short and repair the problem. The wire insulation may be damaged or adhesive lined shrink tubing was not installed over a splice and the condition must be corrected.
14. Remove the wet cloth and dry the pipe before insulating the field joint.

10.6 Start of Run

The initial length of ATP cable from the PAL-AT panel is connected to the ATP cable at the start of the pipe run as shown in figure 10-1.

The ATP cable should be connected to the cable plug in the PAL-AT panel as follows:

Before connecting the cable to the plug, route the excess cable in the enclosure so there will not be excessive strain or twisting at the terminals. Connect the ATP red wire to the center terminal of the cable plug. The white wire should be connected to either of the side terminals of the plug. Insert the plug into the appropriate receptacle as shown. When removing the cable, grip the plug and pull it straight out of the receptacle. **Note the plug and receptacle are polarized so they can only be connected one way.**

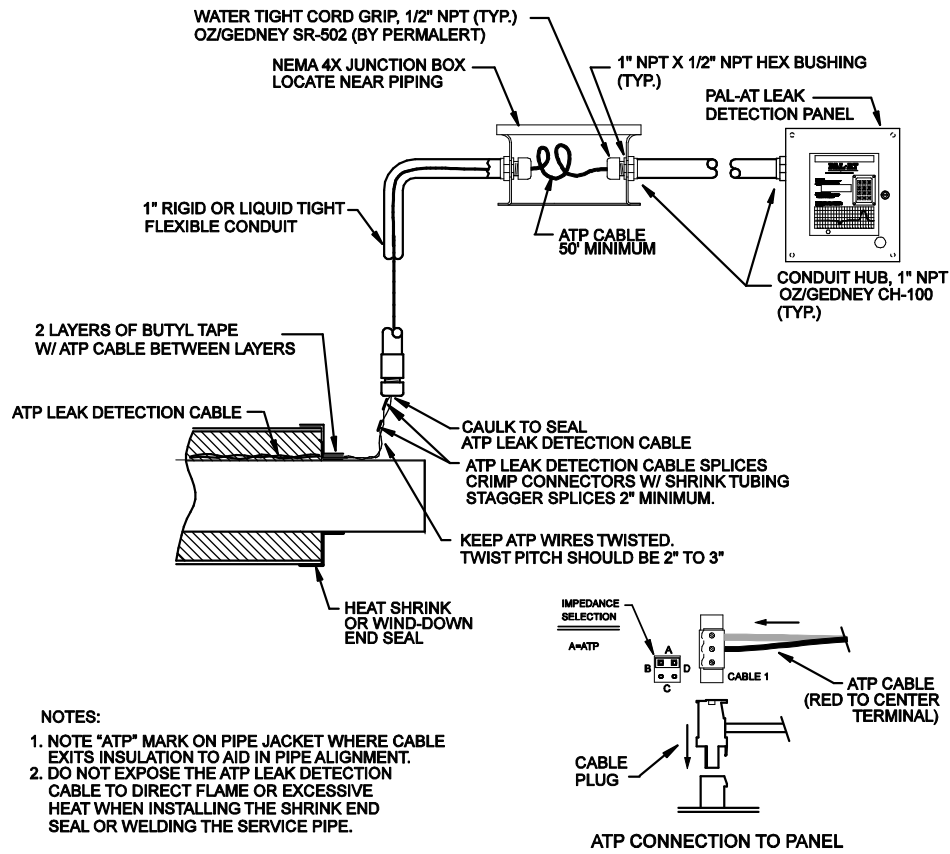


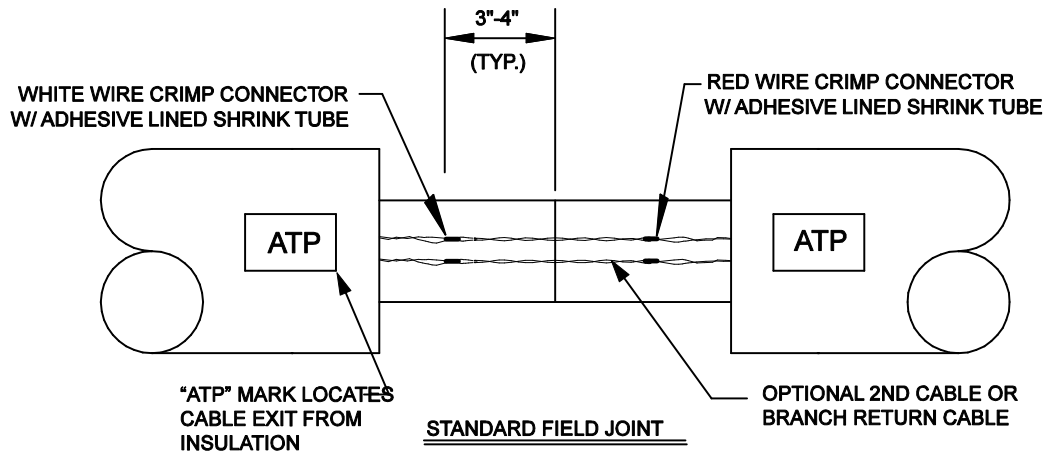
Figure 10-1
ATP Cable Connection - Start of Run

10.7 ATP Cable Splices

The ATP cable is spliced at field joints with crimp connectors using the following steps (see figure 10-2).

1. The red wires should be spliced on one side of the pipe joint and the white wires on the other side, each splice approximately 3"- 4" [75 mm -100 mm] from the end of the pipe.
2. If the ATP cable from the first pipe is not directly in line with the cable from the second pipe, the cable should be routed in as direct a line as possible between the two splice points (refer to Branch Return design in figure 10-2).
3. Cut the red wire from one pipe so the end is centered over the first splice location. Cut the other red wire so the wires meet. Minimize excess slack in the wire.
4. Strip 5/16"-3/8" [7 mm - 9 mm] of insulation from the ends of the red wires. The wire size is 1.5 mm² (metric size). If the correct stripping tool, Model T60/124, part number 8068309, is not available, use a tool for #14 AWG. Do not use a smaller die or uncalibrated hand tool, such as wire cutters, that may damage the conductor.
5. **Slide a 1½" [38 mm] long piece of adhesive lined shrink tubing on the wire before crimping the connector.**
6. The crimp tool, Model T60/125, part number 8068308, is ratcheted so the crimp must be completed once it is started. The crimp connector has an indentation (wire stop) in the center. **Two crimps are required, one on each half of the connector. The model T60/125 crimp tool must be used.**
7. Insert one red wire into the connector and place the connector in the T60/125 tool so the die is centered over the half of the connector with the wire. Make sure the wire is fully inserted into the connector until it hits the stop, and then crimp the connector.
8. Repeat step 7 with the other red wire.

9. Try to pull the splice apart with 10-25 lb [4.5-11 kg] force to ensure the wires were correctly seated in the connector.
10. Repeat steps 3-9 for the white wire. The red and white wires must be twisted with a 2" – 3" [50-75 mm] pitch throughout the splice area before crimping the second connector.
11. Slide the 2 pieces of shrink tubing over the splices and shrink the tubing. There should be no copper wire exposed after the tubing shrinks. If so, the connector should be replaced.
12. **There should not be gaps between the red and white twisted wires.** If they are not in contact with each other, twist the wires slightly to eliminate any gap.
13. Test each wire for continuity and insulation as described above.



NOTES:

1. NOTE "ATP" MARK ON PIPE JACKET WHERE CABLE EXITS INSULATION TO AID IN PIPE ALIGNMENT.
2. DO NOT EXPOSE THE ATP LEAK DETECTION CABLE TO DIRECT FLAME OR EXCESSIVE HEAT WHEN INSTALLING THE SHRINK END SEAL OR WELDING THE SERVICE PIPE.
3. KEEP ATP LEAK DETECTION CABLE WIRES TWISTED. TWIST PITCH 2" TO 3" IN FIELD JOINT AREA.
4. ONLY USE THE CRIMP CONNECTORS AND CRIMP TOOL SUPPLIED BY PERMALERT.

Figure 10-2
ATP Connection Details

10.8 ATP Cable at Tee Connections

Two lengths of ATP cable are used on branch lines and tees (see figures 10-2 and 10-3). Both cables are typically at the 12 o'clock, position separated 2" - 3" apart. The ATP cable from the preceding section before a tee is connected to the ATP cable using the procedure described above. At the end of the branch, the two cables are spliced together as shown.

The return length of ATP cable from the end of the branch is spliced at the tee to the appropriate ATP cable as shown below using the standard procedure.

An optional second ATP cable may be supplied as a spare or to make all sections available for branch installation.

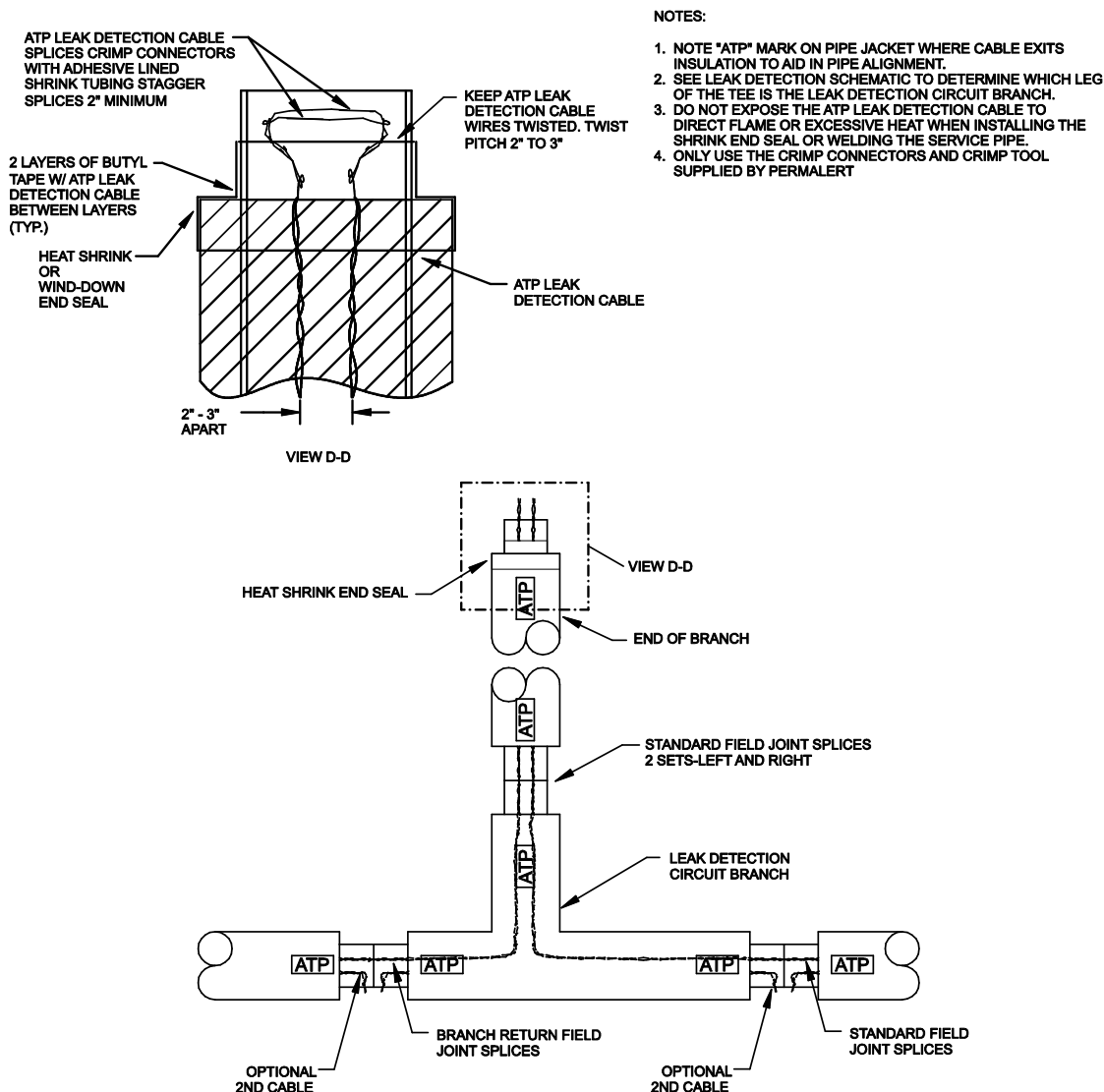
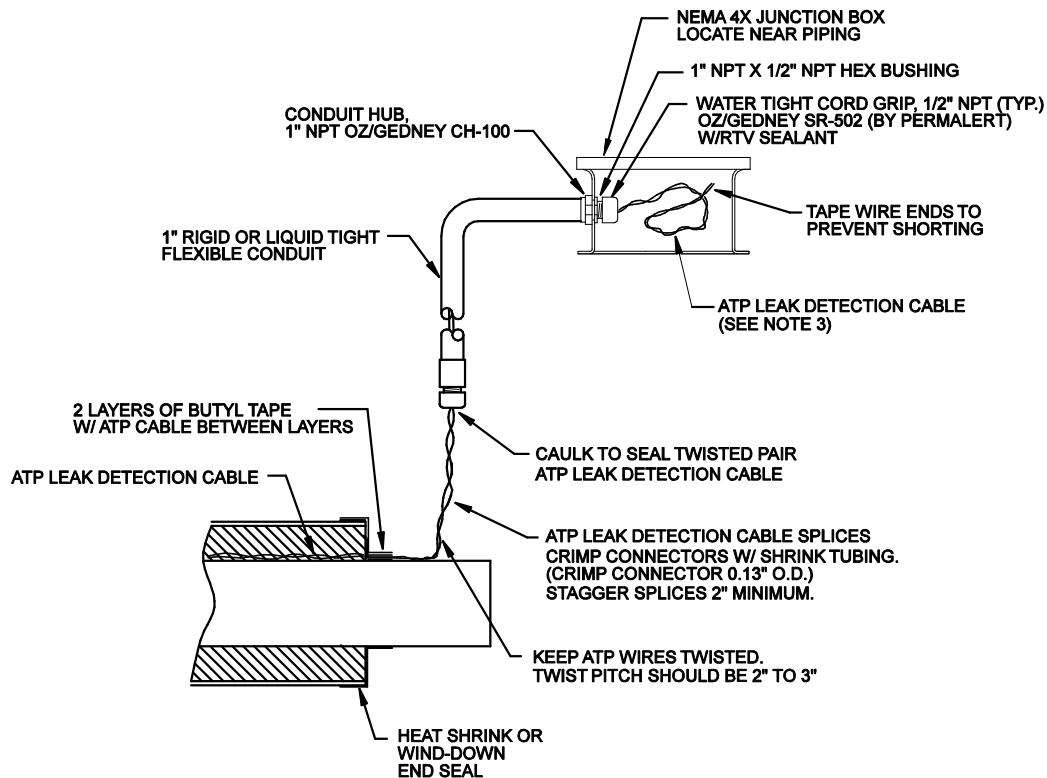


Figure 10-3
ATP Cable at Tee and End of Branch

10.9 End of Run Termination

Install a NEMA 4X [IP66] junction box near the end of the pipe. Electrical conduit should be used to protect the wire if the box is more than a few inches from the pipe end seal. The ATP cable from the pipe should be spliced to 50 ft [15 m] of ATP cable that is coiled in the junction box (100 ft [30 m] is required if the cable length is greater than 3300 ft [1000 m]). Make sure the ATP cable remains twisted. The splices to the red and white wires should be staggered and encapsulated with shrink tubing as described previously.



NOTES:

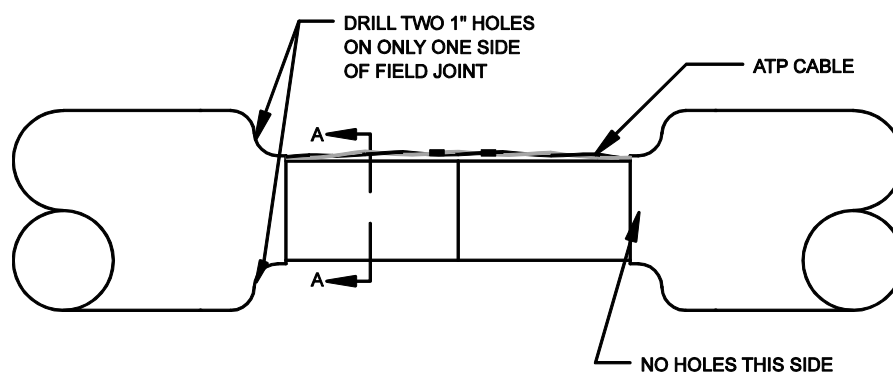
1. DO NOT EXPOSE THE ATP LEAK DETECTION CABLE TO DIRECT FLAME OR EXCESSIVE HEAT WHEN INSTALLING THE SHRINK END SEAL OR WELDING THE SERVICE PIPE.
2. ONLY USE THE CRIMP CONNECTORS AND CRIMP TOOL SUPPLIED BY PERMALERT.
3. ATP LEAK DETECTION CABLE LENGTHS:
50' MINIMUM FOR LEAK DETECTION CIRCUIT < 3300 FT.
100' MINIMUM FOR LEAK DETECTION CIRCUIT > 3300 FT.
4. NOTE "ATP" MARK ON PIPE JACKET WHERE CABLE EXITS INSULATION TO AID IN PIPE ALIGNMENT.

Figure 10-4
ATP Cable End of Run Detail

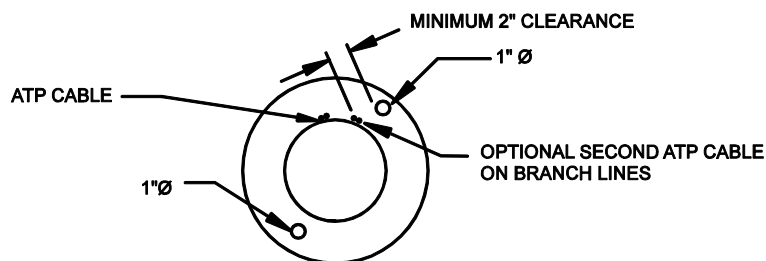
10.10 Requirements for Field Joints with Wind-Down End Seals

This procedure only applies to field joints where two pipes with wind-down end seals are joined together. **It should not be performed until immediately before the insulation and shrink sleeve are applied to seal the field joint.**

1. Drill two 1" diameter holes through the jacket **in the wind-down portion of only one** of the end seals. It does not matter which of the two end seals is drilled (see Figure 10-5).
2. **The holes should be spaced at least 2" away from the ATP cable to prevent accidental damage to the cable during drilling.**
3. One hole should be located in the top half on the end seal and the other approximately opposite it in the bottom half.
4. **Be careful not to damage the ATP cable or pipe when drilling the holes.**
5. Test the ATP wires for continuity and insulation as described above after drilling the holes.
6. Proceed with the normal field joint closing procedure.



TYPICAL FIELD JOINT W/WIND-DOWN END SEALS



SECTION A-A

Figure 10-5
Wind-Down End Seal Modification

Appendix A – Special Instructions

A.1 Supply Power

Supply Power shall be provided by a UL Recognized Power Supply Cat No PS-35-24, manufactured by Meanwell Enterprises, or a Listed Class 2 Power Supply.

A.2 Control Drawing

Refer to control drawing LD-4901-A0, shown in Figure A-1, for intrinsic safety requirements.

A.3 Zener Barrier Panel (ZBP)

Sensing cable strings that are located in hazardous areas must connect to a Zener Barrier Panel (ZBP), which is located in an unclassified area. Inside the ZBP is one Zener Barrier Assembly (ZBA) for each cable sensing string to connect the PAL-AT panel to the ZBP.

The following information for the ZBP is provided for proper connection and installation:

Model ZBP, Part No. 8028115 1 2 3 4

This Leak Detection Equipment (Associated Apparatus) provides intrinsically safe circuits for use in Class I Division 1 Groups C and D hazardous locations when the unit is installed in accordance with control drawing (Descriptive System Document) LD-4901-A0.

Maximum input voltage: $U_m = 250 \text{ VAC}$

WARNING - SUBSTITUTION OF COMPONENTS MAY IMPAIR INTRINSIC SAFETY.

Each zener barrier assembly (ZBA) is assigned the following output parameters:

U_o :	16.02 V dc	C_o :	1.0 μF
I_o :	1.125 A	L_o :	56.5 μH
P_o :	1.248 W	L_o/R_o :	31.58 $\mu\text{H}/\Omega$

ATEX/IECEX Certificate number:



DEMKO 12 ATEX 1014815X

II (1) G [Ex ia] IIB
IECEX UL 11.0028X
[Ex ia Ga] IIB

Ambient Temperature:

$-20^\circ\text{C} \leq T_{amb} \leq 60^\circ\text{C}$

A.4 Probe Integrator

Probe integrators connect probes to the sensing strings. Probes supplied by PermAlert include the probe integrator. The following information for probe integrators is provided for proper connection and installation:

Probe Integrators, part numbers 8027629, 8027930, 8027932, 8027934, for use with ZBP.

ATEX/IECEX Certificate number:



DEMKO 12 ATEX 1014815X

II 1G Ex ia IIB T4
IECEX UL 11.0028X
Ex ia Ga IIB T4

Ambient Temperature:

$-20^\circ\text{C} \leq T_{amb} \leq 60^\circ\text{C}$: Temp Code T4

A.5 Probe Integrator Static Precautions

WARNING FOR HAZARDOUS LOCATIONS - Probe integrators are encapsulated in plastic and present a possible electrostatic hazard. They are not intended to be cleaned, but if they are, a damp cloth should be used.

A.6 ZBP Enclosure Fittings

Appropriate fittings, hubs and blanking elements for use on holes on the ZBP enclosure shall contain one of the following type ratings: 4, 6, 6P, 12, 12K or 13, to maintain the type rating of the selected fitting.

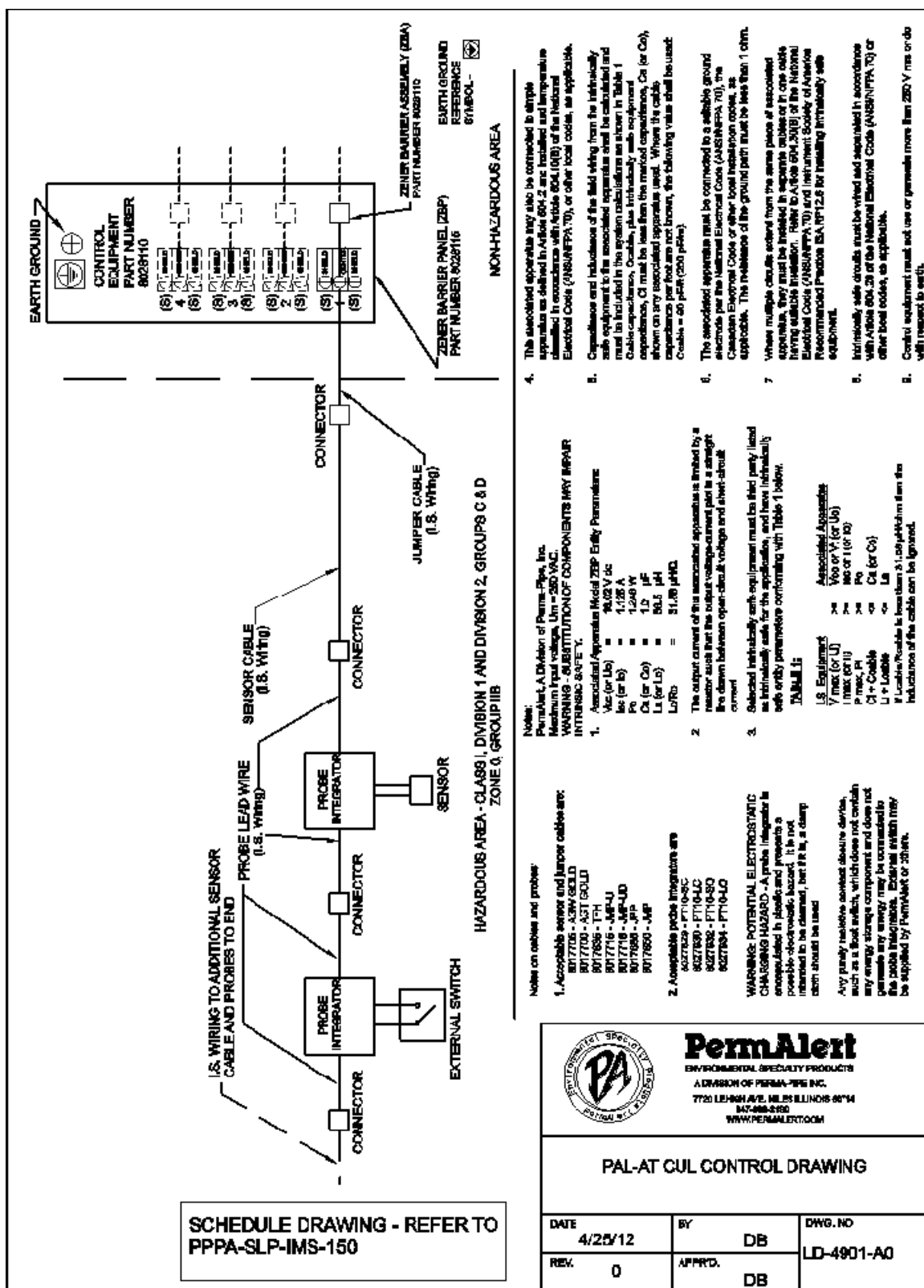


Figure A-1
PAL-AT Control Drawing

WARRANTY

Seller warrants that the PermAlert Leak Detection System (the "System") will be free from defects in materials and workmanship for a period of twelve (12) months from the date of first use of the System or eighteen (18) months from the date of shipment by Seller to Buyer of the System; whichever is earlier. Seller is not responsible for damage to the System occurring in transit or arising from the installation, alteration or repair of the System by persons other than Seller's employees, or from any abnormal or improper use of, negligence with respect to or accident affecting the System. Seller's sole obligation and liability, and Buyer's sole remedy, under this warranty shall be the repair or replacement, at Seller's election, by Seller of any defective materials or workmanship covered by this warranty, without the charge to Buyer. Repaired or replacement materials shall be delivered to Buyer f.o.b. Seller's plant or f.o.b. such other location as Seller shall designate. Seller shall not be responsible for any product returned to Seller without Seller's prior express consent. Buyer shall be responsible for returning the defective or non-conforming product(s) to Seller at Buyer's expense. No claim shall be permitted under the warranty contained herein unless Buyer notifies Seller in writing within ten (10) days after Buyer first hears of facts giving rise to any such claim and unless notice is given within the warranty period as provided above. In order to be valid, any notice sent to Seller in connection with said claim under this warranty must reasonably specify the defect which is the subject of such claim. Buyer shall be responsible for testing and inspecting the System promptly after receipt and thereafter at such intervals as are reasonably prudent so as to inform Seller of any defects which exist in the System. Notwithstanding the filing of a claim hereunder, this warranty shall expire after the warranty period in respect to materials and workmanship which are not then the subject of a proper claim.

To the maximum extent permitted by law, Buyer irrevocably waives all claims against Seller for money damages relating to the condition, use and performance of the goods sold pursuant hereto, including claims based upon tort, strict liability, negligence and product liability. Notwithstanding the provisions of the preceding sentence, if money damages are assessed against Seller, in no event shall Seller's liability for such damages exceed the purchase price of products sold by Seller.

IN NO EVENT, WHETHER BECAUSE OF A BREACH OF WARRANTY OR REPRESENTATION OR ANY OTHER CAUSE, WHETHER BASED UPON CONTRACT, TORT, WARRANTY OR OTHERWISE, ARISING OUT OF THE PERFORMANCE OR NON-PERFORMANCE BY SELLER OF ITS OBLIGATIONS UNDER THIS AGREEMENT OR WITH RESPECT TO THE PRODUCTS SOLD PURSUANT HERETO SHALL SELLER BE LIABLE FOR LOST EARNINGS, INCOME OR PROFITS OR INDIRECT, INCIDENTAL CONSEQUENTIAL DAMAGES.

THE IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE AND, EXCEPT AS SPECIFICALLY SET FORTH HEREIN, ALL OTHER WARRANTIES AND REPRESENTATIONS, EXPRESS OR IMPLIED, ARE HEREBY DISCLAIMED AND EXCLUDED. NOTHING SHALL BE CONSTRUED AS AN ADDITIONAL WARRANTY UNLESS SPECIFICALLY DESIGNATED AS SUCH IN WRITING AND SIGNED BY THE SELLER, IN WHICH CASE SUCH ADDITIONAL WARRANTY SHALL BE SUBJECT TO THE PROVISIONS OF THE APPROPRIATE PARAGRAPHS HEREIN AS TO DURATION AND LIMITATION OF REMEDY UNLESS SUCH ADDITIONAL WARRANTY EXPRESSLY VARIES SUCH PROVISIONS.

Extended warranty period may be available. Contact PermAlert for more information.

