Model DL Sensor Instruction Manual

December 1992

Micro Motion

FISHER-ROSEMOUNT™ Managing The Process Better.™

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1 General Information

Micro Motion's Model DL mass flow sensors deliver highly accurate flow measurement while performance remains unaffected by changes in fluid temperature, density, viscosity, conductivity or flow profile.

Installing Micro Motion Model DL single-tube flow sensors differs from installing Model D standard sensors. This instruction manual tells how to select and prepare an installation site for Micro Motion Model DL sensors.

Section 2 explains how to find the best location for the sensor. Section 3 tells how the sensor should be mounted for optimal performance. Section 4 explains wiring and cable connections. Section 5 discusses special considerations to keep in mind when installing a DL sensor with Micro Motion RFT9712, FlowScale or REU transmitters. Section 6 explains startup, setting of instrument zero, and troubleshooting. Finally, the Appendix explains how to fabricate mounting legs for DL sensors.

Model DL sensors meet 3-A Sanitary Standard #28-01, Flowmeters For Milk and Milk Products, and meet USDA requirements. Each Model DL sensor has a single flow tube constructed of 316L stainless steel. This "clean-in-place" design enables the sensor to withstand sterilization. The single flow tube makes cleaning easier if clogging occurs and won't destroy shear-sensitive fluids.

Model DL sensors work with all Micro Motion transmitters and peripheral devices to provide exceptionally accurate mass flow and density measurement. Micro Motion transmitters include the microprocessor-based RFT9712, the FlowScale transmitter for custody transfer, and the REU. Micro Motion peripherals include the Digital Rate Totalizer (DRT) for totalizing flow, the Flow Monitoring System (FMS-3) for batch control, the Density Monitoring System (DMS) for density measurement, the Net Oil Computer (NOC) for measuring net oil, and the Net Flow Computer (NFC) for measuring net material flow.

For 24-hour, toll-free assistance, phone the Micro Motion Customer Service Department at **1-800-522-MASS** (1-800-522-6277). From outside the U.S., phone 1-303-530-8400.

Table 1-1
DL65 Specifications

Maximum flow range	0 to 250 lb/min (0 to 113 kg/min)	
Minimum flow range	0 to 12.5 lb/min (0 to 5.6 kg/min)	
Flow accuracy	±0.2% of rate ± zero stability*	
Zero stability	0.025 lb/min (0.011 kg/min)	
Operating temperature	-400° to 350°F (-240° to 177°C)	
Rated operating pressure	1500 psi (103 bar)	
Wetted parts	316L stainless steel	
Sensor housing	Hermetically sealed, 304 stainless steel	
Fluid fittings	Standard:	1-inch (25-mm) sanitary tri-clamp style
	Optional:	1-inch, 150-lb lap joint flange 1-inch, 300-lb lap joint flange 3/4-inch NPT female union
Area classification		
UL listed, CSA approved	Sensor: Class I, Div. 1, Groups C and D; Class II, Div. 1, Groups E, F, and G; Class I, Div. 2, Groups A, B, C, and D when properly connected to RFT9712, FlowScale or REU transmitter	
CENELEC approved	Ex ib IIB T6 when properly connected to RFT9712, FlowScale or REU transmitter	
Weight	See Figure 3-3, DL65 Dimensions	

* Zero set at process temperature ± 20°F (± 11°C).

Table 1-2
DL100 Specifications

Maximum flow range	0 to 800 lb/min (0 to 363 kg/min)	
Minimum flow range	0 to 40 lb/min (0 to 18.1 kg/min)	
Flow accuracy	±0.2 % of rate ± zero stability*	
Zero stability	0.08 lb/min (0.036 kg/min)	
Operating temperature	-400° to 350°F (-240° to 177°C)	
Rated operating pressure	900 psi (62 bar)	
Wetted parts	316L stainless steel	
Sensor housing	Hermetically sealed, 304 stainless steel	
Fluid fittings	Standard:	1-inch (25-mm) sanitary tri-clamp style
	Optional:	1-inch, 150-lb lap joint flange
		1-inch, 300-lb lap joint flange
Area classification		
UL listed, CSA approved	Sensor: Class I, Div. 1, Groups C and D; Class II, Div. 1, Groups E, F and G; Class I, Div. 2, Groups A, B, C and D when properly connected to RFT9712, FlowScale or REU transmitter	
CENELEC approved	Ex ib IIB T6 when properly connected to RFT9712, FlowScale or REU transmitter	
SAA approved	Ex ib IIB T6 when properly connected to RFT9712 transmitter	
Weight	See Figure 3-4, DL100 Dimensions	

* Zero set at process temperature ± 20°F (± 11°C).

Table 1-3
DL200 Specifications

Maximum flow range	0 to 3500 lb/min (0 to 1590 kg/min)	
Minimum flow range	0 to 175 lb/min (0 to 79.5 kg/min)	
Flow accuracy	±0.2% of rate ± zero stability*	
Zero stability	0.35 lb/min (0.16 kg/min)	
Operating temperature	-400° to 400°F (-240° to 204°C)	
Rated operating pressure	740 psi (51 bar)	
Wetted parts	316L stainless steel	
Sensor housing	Hermetically sealed, 304 stainless steel	
Fluid fittings	Standard:	2-inch (50-mm) sanitary tri-clamp style
	Optional:	2-inch, 150-lb lap joint flange
		2-inch, 300-lb lap joint flange
Area classification		
UL listed, CSA approved	Sensor: Class 1, Div. 1, Groups C and D; Class II, Div. 1, Groups E, F and G; Class I, Div. 2, Groups A, B, C and D	
CENELEC approved	Ex ib IIB T4 when properly connected to RFT9712, FlowScale or REU transmitter	
SAA approved	Ex ib IIB T6 when properly connected to RFT9712 transmitter	
Weight	See Figure 3-5, DL200 Dimensions	

* Zero set at process temperature ± 20°F (± 11°C).

2 Sensor Location

2.1 General

Model DL sensors accurately measure density and mass flow in a wide variety of working environments.

Locate the sensor at least 2 feet (0.6 meter) from any large transformer or motor. The sensor employs magnetic fields in its operation; DO NOT locate the sensor near a large interfering electromagnetic field.

Locate the sensor so it remains full or, if the process line needs purging, locate the sensor so it can be completely emptied of fluid. Mount the sensor in a horizontal position to drain process fluids. Keeping the sensor full will help minimize the effects of slug flow. To prevent gas from accumulating inside the sensor during processing of liquids, avoid locating the sensor in a high point in the process piping.

Special attention is required in choosing a location for the sensor if it operates where its flow tubes can acquire gases, in the form of slugs, carried through piping. This condition, known as slug flow, severely affects the sensor's performance. **Section 2.4** explains how to minimize the effects of slug flow.

Vibrations in most process plants do not adversely affect flowmeter performance; however, you should carefully select the location of the sensor. Proper location, mounting and distance between sensors mounted in series can minimize crosstalk, which occurs when process piping between sensors conducts sensor tube vibrations. **Section 3.1** explains how to mount the sensor to avoid crosstalk caused by resonant vibration.

2.2 Flow Direction

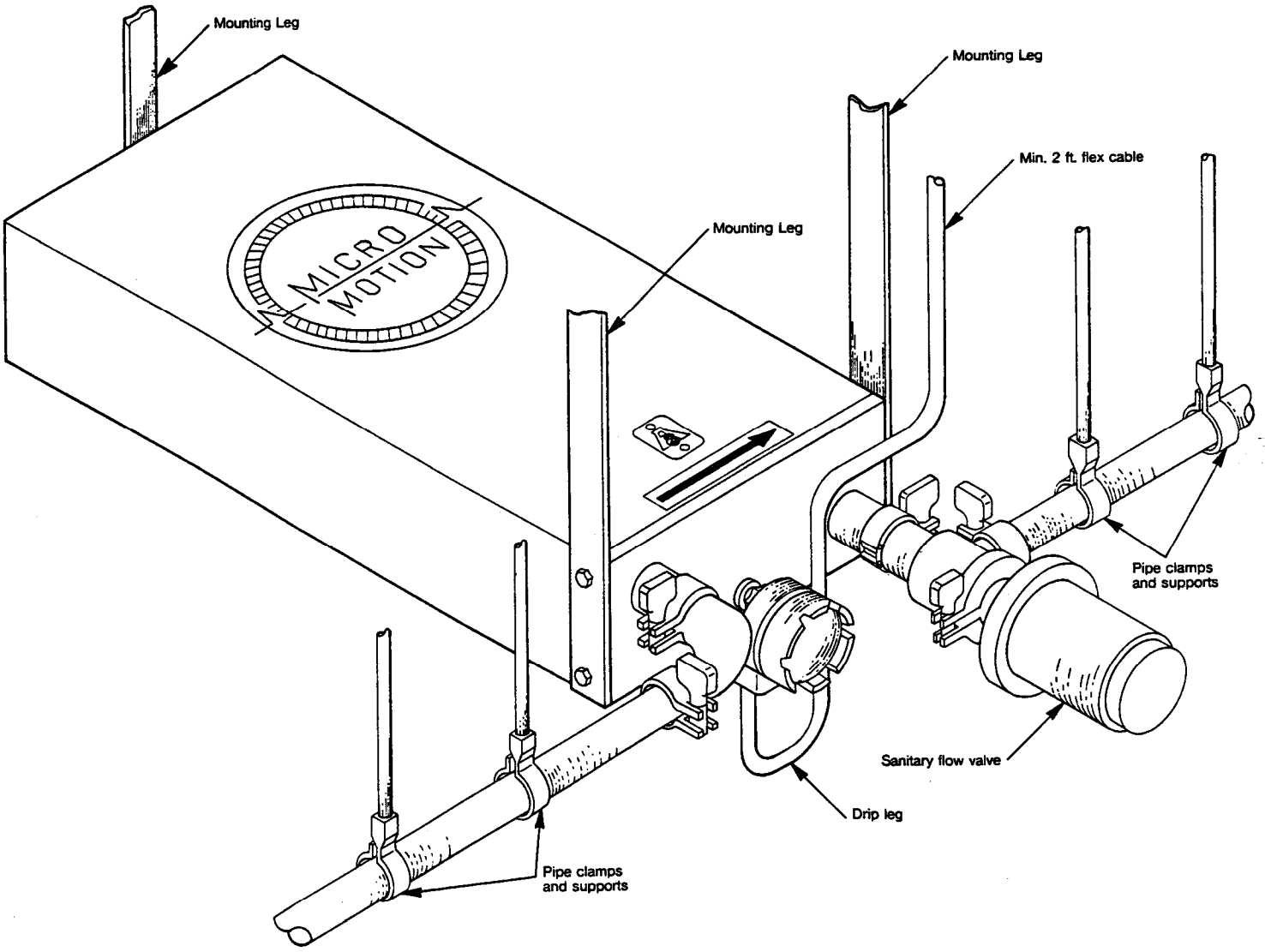
The sensor measures accurately regardless of flow direction. Note that the arrow on the DL sensor housing indicates normal forward flow direction. *Remote Flow Transmitter Model RFT9712 Instruction Manual*, *FlowScale System Instruction Manual* and *Remote Electronics Unit Instruction Manual* describe how to set the transmitter for output corresponding to flow direction. **Figure 2-1** shows a typical DL sensor installation.

2.3 Valving

Install a downstream shutoff valve to ensure actual zero flow during sensor zeroing. For batching operations, locate the sensor and shutoff valve near the receiving tank to minimize batching errors. DO NOT install flexible piping between the sensor and the shutoff valve. Because flexible piping may expand and contract appreciably in response to system pressure, flexible piping between the sensor and the shutoff valve can cause batching errors.

Some installations require a bypass loop to isolate the sensor from the process piping. Install the valves in locations that prevent any valve leakage from accumulating in the sensor. Install inlet and outlet valves so their added weight does not impinge on the process connections.

Figure 2-1
Typical DL Sensor Installation



2.4 Slug Flow

Special attention is required during sensor mounting if the sensor operates where its flow tubes can acquire gases, in the form of slugs, carried through piping. Slug flow affects sensor performance by creating imbalanced vibration of the sensor's flow tubes. Such imbalance causes an inaccurate flow-rate reading. The flow metering system will recover as soon as fluid fills the sensor tubes.

If the fluid process causes slug flow, mount the sensor horizontally and level. This configuration should prevent slugs of gas from becoming trapped in the sensor tubes.

2.5 Loading/Unloading

In loading/unloading applications, the sensor is typically empty at startup, a batch runs, and the sensor is then purged of liquid. For such applications, mount the sensor horizontally and level. A downstream check valve will prevent fluid from flowing back into the sensor, and being re-measured, during unloading. Install the check valve as near as possible to the sensor.

The performance of the sensor largely depends on its installation. Each application requires sound engineering judgment. The following startup technique has worked well for loading and unloading applications:

1. Mount shutoff valves upstream and downstream from the sensor.

2. Close the upstream valve.

3. Partially open the downstream valve.

4. Slowly open the upstream valve to force the air out and to fill the sensor. This procedure will minimize the amount of fluid not measured at startup.

5. When the flow metering system begins counting, slowly open the downstream valve until it is completely open. The amount of time until the downstream valve can be fully opened is usually less than 2 minutes, but the timing depends on the application.

As with slug flow, a portion of the fluid flow might not be measured during loading/unloading. The amount of fluid not measured will depend on piping arrangement, sensor location, fluid properties, flow rate, and purging method. However, if startup and purge operations are always performed in the same manner, the amount of fluid not measured by the sensor can be characterized.

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3 Sensor Mounting

3.1 General

Install DL sensors at least 3 sensor-case widths from each other if the sensors will operate in series (in the same pipe line). **Install pipe clamps on process piping between sensors installed in series.** Pipe clamps and proper distance between sensors mounted in series will minimize crosstalk, which occurs when process piping between sensors conducts tube vibrations. Crosstalk can severely hamper proper adjustment of the zero flow setting (can cause unstable zero).

Using appropriate interconnection cable, you can mount the sensor up to 1000 feet (305 meters) from the RFT9712 or FlowScale transmitter and up to 500 feet (152 meters) from the REU. **Section 4.2** explains how to prepare cable and lists the parts, included with the sensor, needed to perform this task.

3.2 Orientation

Figures 3-1 and 3-2 show the sensor in several mounting configurations. Pay attention to the following points when mounting a DL sensor:

1. **Mount the sensor case so it is rigidly supported.** For example, if the sensor is mounted horizontally and is supported by the mounting inserts located near the flanges, sensor vibration can decrease flow-signal stability from the sensor. A third mounting leg, attached at the inserts on the end of the sensor case, can provide a more stable and secure mounting.

DO NOT allow the sensor case to rest on mounting brackets unless it is attached to them. Excessive vibration, transmitted through process piping, or other motion can cause the sensor to shake or bounce on the brackets. The sensor's movement can distort the flow-rate signal.

2. **DO NOT use fluid process connections as the sensor's only supports.** Doing so could damage process connections by putting undue stress on them.

3. **Attach all support brackets to the same stable surface.** Stable surfaces include concrete floors, ceilings, load-bearing walls and I-beams. Secure all the mounting legs to the same surface. Settling, thermal expansion or contraction can cause separate or jointed surfaces to move relative to each other. Such relative movement can cause a shift of zero adjustment (can cause unstable zero) in the flowmeter. The more solid and inflexible the surface, the better the mount. The mounting surface should not vibrate or move.

4. **Securely attach support brackets to a wall or ceiling when the wall or ceiling is used as a mounting surface.** If you choose a solid floor as a mounting surface, you can mount the brackets into the floor or rest them on the floor.

5. **Never attach the mounting brackets to two different surfaces unless they are rigid with respect to each other.** For example, you can mount the sensor with the mounts

attached to a floor and wall that are rigid with respect to each other. However, DO NOT attach the supports to two I-beams. The I-beams could move independently of each other. Such independent movement can damage the sensor case and tube assembly.

6. **Always support the sensor while connecting the piping.** After properly connecting piping to the sensor, secure the sensor case so that it does not put undue stress on the sensor fittings. DO NOT use the sensor flanges to torque the piping into place.

7. **If you cannot find a stable and secure surface on which to mount the sensor, consult the factory for recommendations.**

Figure 3-1 shows the Model DL sensor mounted in recommended horizontal configurations to comply with 3-A Sanitary Standard #28-01, Flowmeters For Milk and Milk Products. Figure 3-1 shows the sensor mounted on a floor, attached to a support bracket fixed onto a wall, and hanging from a ceiling. In these positions, the sensor is self-draining except for normal fluid clingage. In these configurations, with 4 or more inches between the sensor case and the mounting surface, the sensor mounting complies with 3-A recommended mounting practices. In any other configuration, the sensor is not self-draining and therefore will not comply with 3-A recommended mounting practices.

Figure 3-2 shows the sensor mounted to a wall in two different ways. These wall-mount configurations are acceptable, but the sensor is not self-draining, and they will not comply with 3-A recommendations. Securely attach mounting brackets to the sensor case and to the mounting surface.

Figures 3-1 and 3-2 intend to show the DL sensor as it is ordinarily positioned. The DL sensor can function while mounted at any angle if proper mounting procedures are followed.

Although the sensor's angle does not by itself affect the flowmetering system's operation, you need to consider the following recommendations:

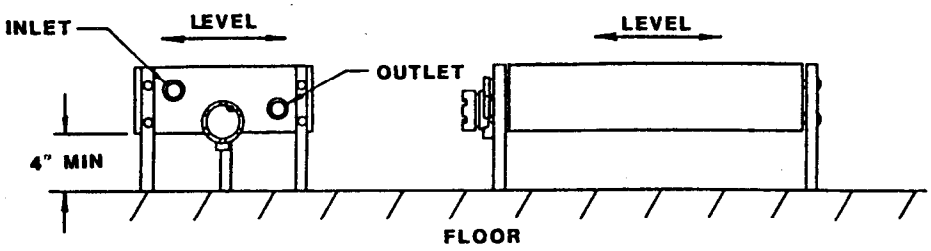
1. For 3-A applications and other self-draining applications, the sensor housing must be horizontal and level, with the inlet process connection preferably higher than the outlet process connection.

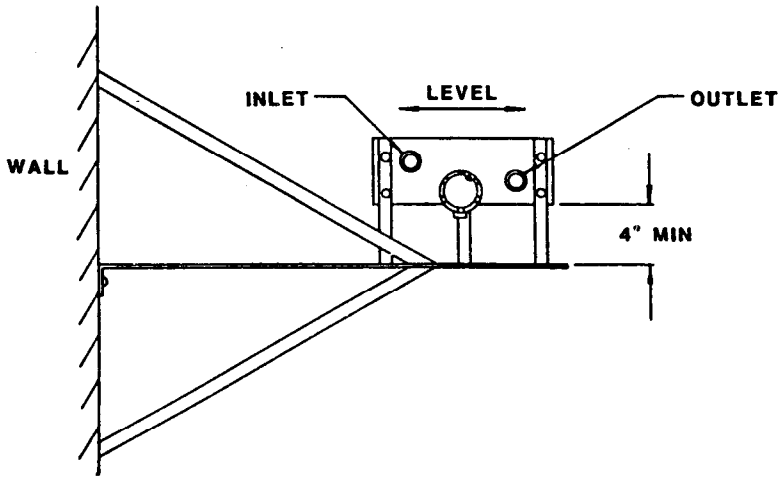
2. When the installation does not require that the sensor be self-draining, the inlet process connection should be lower than the outlet to help ensure that the sensor remains full.

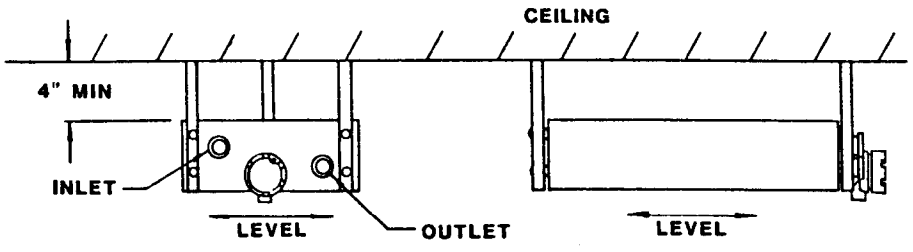
3. Install the sensor horizontally and parallel to the floor to prevent accumulation of liquid-slurry particles in the flow tube.

4. When the sensor is installed vertically, process fluids should be pumped upward through the sensor to prevent fluid cascading.

Figure 3-1
Installations Meeting 3-A Recommended Practices

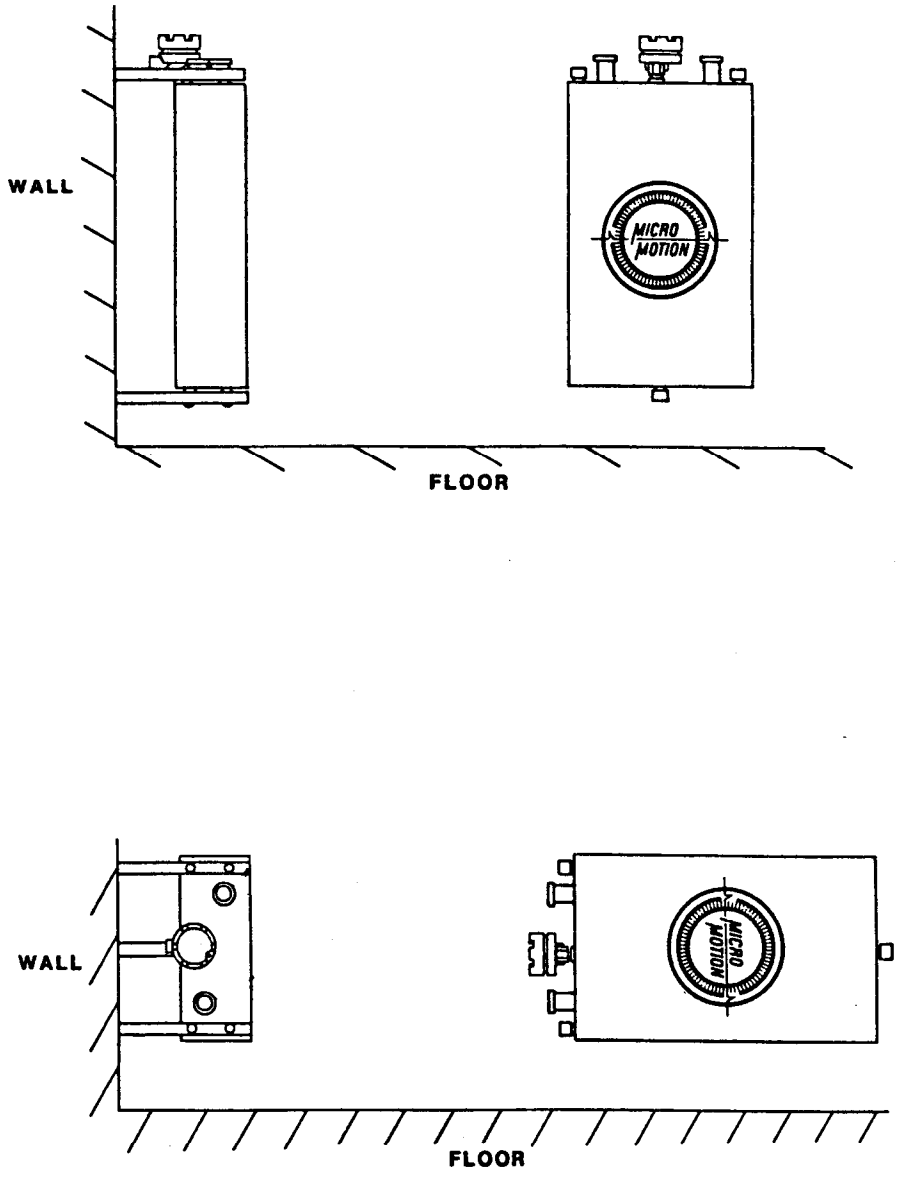






3-A INSTALLATIONS

Figure 3-2
Wall-Mount Installations



3.3 Mounting Legs

Micro Motion does not supply mounting legs for the various sensor mounting configurations previously described. However, the Appendix at the end of this instruction manual provides instructions for fabricating mounting legs such as those shown in **Figures 3-1** and **3-2.**

3.4 Mechanical Connections

WARNING: **DO NOT attach pipe supports to sensor fittings.**

Observe good piping practices during sensor installation. For best results, install pipe supports near the fittings. DO NOT use the sensor fittings as pipe supports. DO NOT attach pipe supports to sensor fittings. See **Figure 2-1** for a typical installation of a DL sensor. The arrow on the sensor case indicates normal forward flow direction.

Use appropriate anchors, guides, expansion joints, hangers, or other mechanical support systems to install inlet and outlet piping.

Minimize pipe stress and vibration in the sensor by clamping or attaching the piping to a stable structure at two locations upstream and two locations downstream from the sensor. (Put one clamp close to the process connections and another clamp near the first elbow -- or within 10 to 20 pipe diameters -- upstream and downstream from the sensor). Use correct center-to-center dimensions of process connections while aligning piping and installing the sensor in the process line.

3.5 Pipe Supports

WARNING: **Pipe supports should support the piping. DO NOT use the sensor to support process piping. Attach three mounting supports onto the sensor housing to support the sensor.**

Install pipe supports or clamps on the same reference plane upstream and downstream from the sensor. If multiple sensors will operate in series, piping to each sensor must have its own supports or clamps. Crosstalk can occur if sensors share the same pipe supports.

In high-vibration areas, install pipe supports that isolate vibration (such as those manufactured by Stauff, phone 201-444-7800, or Behringer, phone 201-642-0546). You can install flexible piping for process connections to minimize vibration transmitted into the sensor. DO NOT install flexible piping between the sensor and the downstream valve.

Normal piping vibrations usually do not present a problem, but clamping of the piping can considerably dampen any interfering vibrations.

3.6 Process Fittings

WARNING: Process fluid pressure must not exceed the pressure rating of the process fitting.

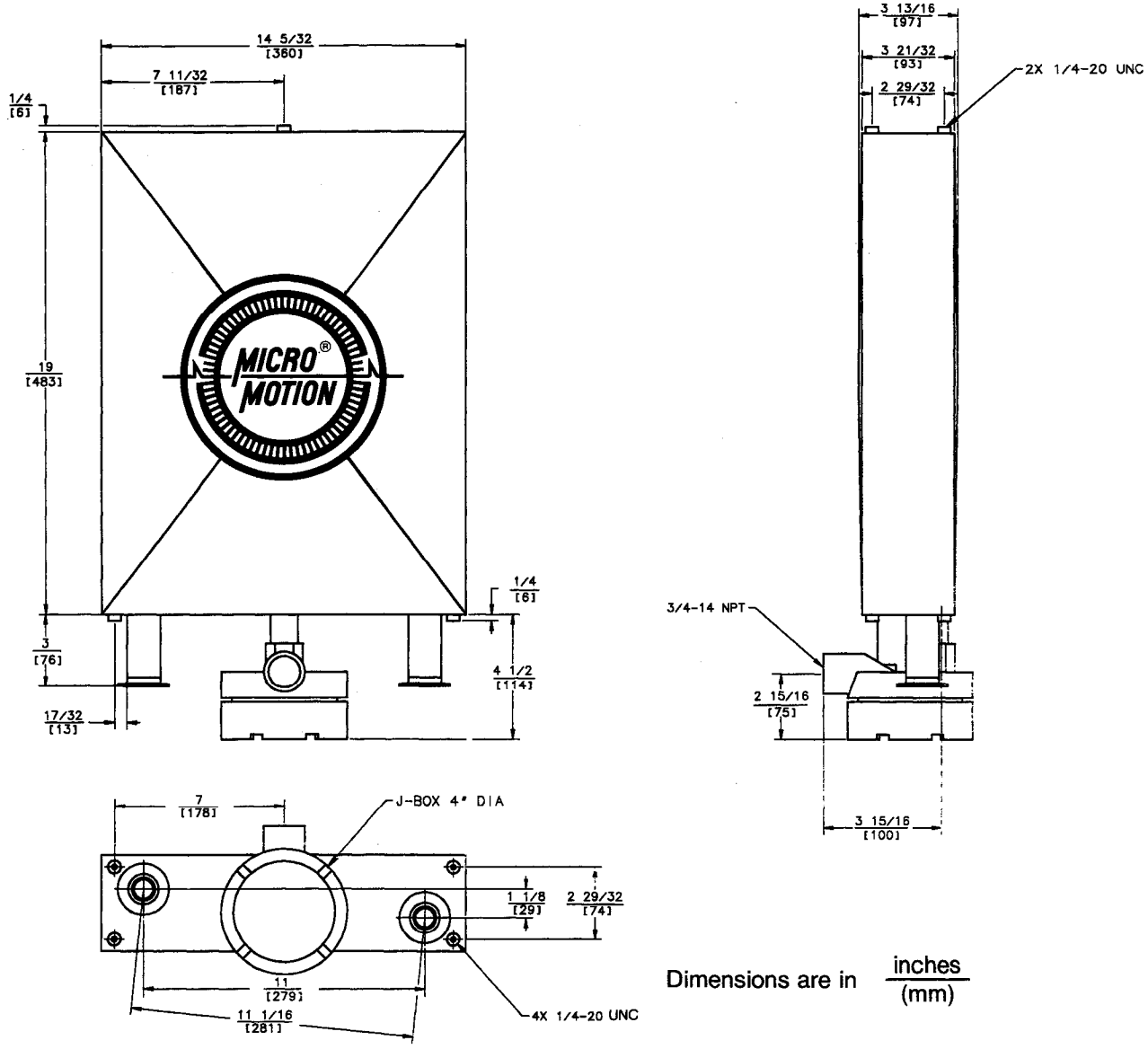
Make sure the installation minimizes axial and lateral pipe stresses imposed on the sensor process connections.

If the sensor operates at more than 50°F (28°C) above ambient temperature, check the coupling or bolts after the first cooldown period. Recheck the fitting if a leak occurs during operation at elevated temperatures.

When sanitary fittings are installed, pressure ratings depend on the type of clamp used. Micro Motion does not supply clamps with DL sensors.

WARNING: Make sure process piping has an electrical ground. If piping is not grounded, use the sensor ground connection.

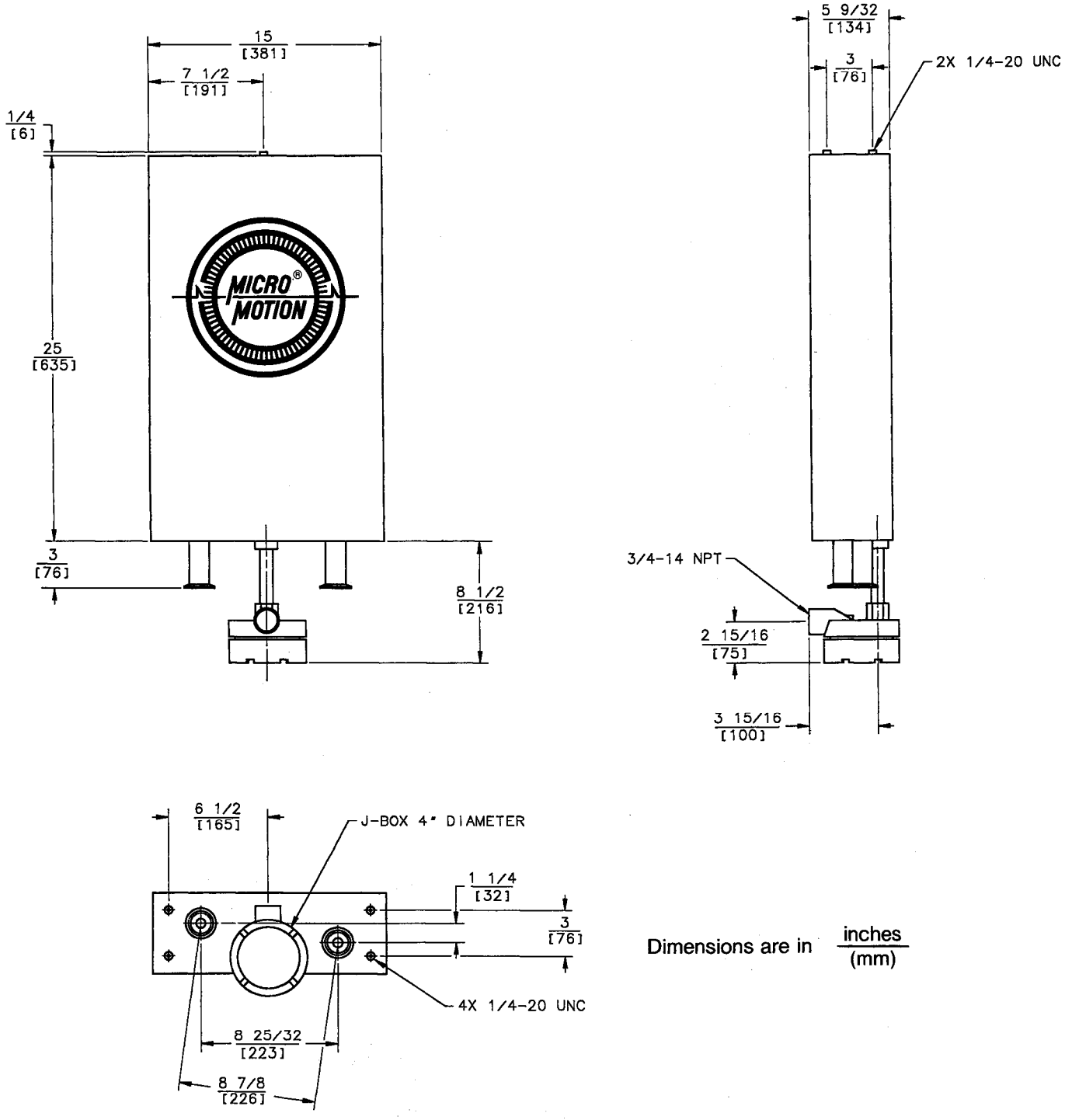
Figure 3-3
DL65 Sensor Dimensions



Dimensions are in $\frac{\text{inches}}{(\text{mm})}$

Fluid Connections	Approximate shipping weight
1-inch sanitary tri-clamp style	26 lb (12 kg)
1-inch, 150-lb lap joint flange	30 lb (13.5 kg)
1-inch, 300-lb lap joint flange	32 lb (14.5 kg)
3/4-inch NPT female union	26 lb (12 kg)

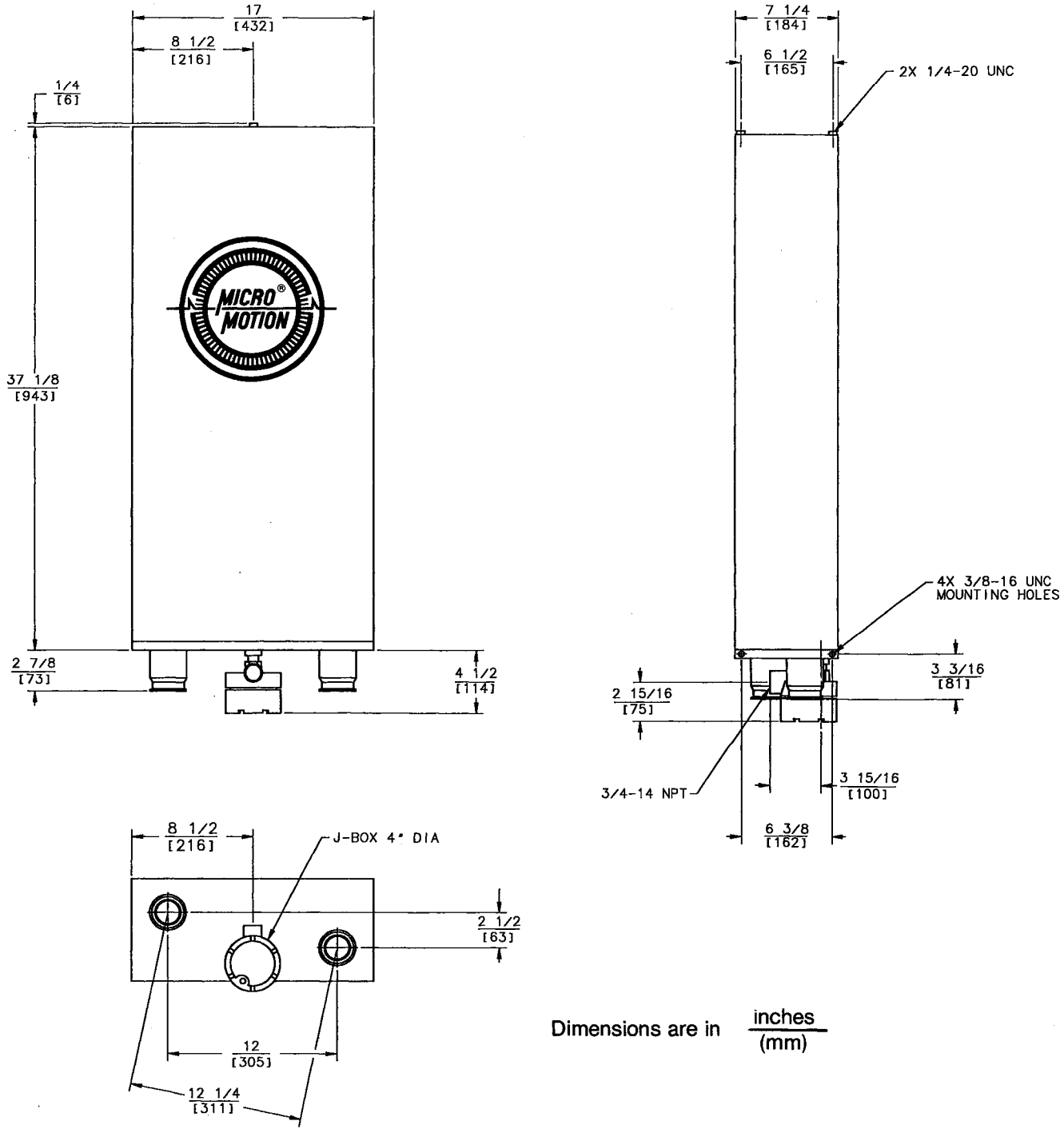
Figure 3-4
DL100 Sensor Dimensions



Dimensions are in inches (mm)

Fluid Connections	Approximate shipping weight
1-inch sanitary tri-clamp style	49 lb (22 kg)
1-inch, 150-lb lap joint flange	53 lb (24 kg)
1-inch, 300-lb lap joint flange	55 lb (25 kg)

Figure 3-5
DL200 Sensor Dimensions



Dimensions are in $\frac{\text{inches}}{(\text{mm})}$

Fluid Connections	Approximate shipping weight
2-inch sanitary tri-clamp style	90 lb (41 kg)
2-inch, 150-lb lap joint flange	100 lb (45 kg)
2-inch, 300-lb lap joint flange	104 lb (47 kg)

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4 Wiring

4.1 General

WARNING: **If you install interconnecting cable other than Micro Motion color-coded cable, make sure the conductors are properly paired and shielded, and are the correct AWG gauge, to ensure reliable flowmeter performance.**

For detailed information about transmitter wiring and installation, refer to the appropriate transmitter instruction manual. The appropriate manual is included with the transmitter when it is shipped from the factory. For instructions about intrinsically safe wiring, see *Installation Instructions TYPE UL-D-IS* (shipped with all UL-approved sensors).

Since the sensor employs magnetic fields in its operation, DO NOT drape sensor-to-transmitter interconnection cable over equipment, such as an electric motor, that produces a magnetic field.

WARNING: **To maintain intrinsic safety and to minimize electrical noise, DO NOT install power cables and flowmeter signal cables inside the same conduit or cable tray.**

Use Teflon(R) plastic-shielded wiring supplied by Micro Motion for cable tray installations.

If you install bare cables, make sure the cable jacket material is compatible with the application environment. Install corrosion-resistant cable or conduit and conduit connections if the flowmeter operates in a highly corrosive environment. When conduit is used, install a drip loop and weather-tight connectors to prevent moisture from leaking into the terminal box.

Locate the transmitter in an easily accessible Division 2 hazardous area or safe area where the ambient temperature does not exceed 130°F (55°C).

WARNING: **Install cables and wiring so they meet local code requirements.**

If you install a sensor and a Model RFT9712 Remote Flow Transmitter, you can replace the sensor and transmitter separately, because each sensor is factory calibrated and marked with its own density and mass flow calibration factors. *Remote Flow Transmitter Model RFT9712 Instruction Manual* provides more information about flow and density calibration factors. The SMART FAMILY Interface 268 allows you to interface with an RFT9712 transmitter. (Refer to *Using the SMART FAMILY Interface 268 with the Micro Motion Remote Flow Transmitter.*) No other calibration or equipment is needed.

The FlowScale transmitter has internally programmable Meter-Type and Meter-Factor settings. Meter-Type switches allow the FlowScale transmitter to be matched to any sensor. Meter-Factor switches are used to establish the calibration of the flowmeter. The Meter-Type and Meter-Factor switches are factory set to appropriate positions and may be changed if necessary. (Refer to *FlowScale System Instruction Manual.*)

If you install a sensor and an REU, they must have matching serial numbers. If you install multiple sensors and REUs, make sure to match each sensor with its corresponding REU. A

calibration data label inside the REU's large compartment cover provides information about REU outputs. (Refer to *Remote Electronics Unit Instruction Manual.*)

4.2 Cable Preparation

If the sensor operates above 150°F (65°C) or below 32°F (0°C), install the Micro Motion cable jacketed in light blue Teflon(R) plastic. For applications in which temperatures stay between 32° and 150°F (0° and 65°C), install the Micro Motion cable jacketed in medium blue PVC. Using Micro Motion cable, you can install up to 1000 feet of cable between the sensor and the RFT9712 or FlowScale transmitter. Micro Motion supplies 10 feet (3 meters) of PVC-jacketed cable as standard with DL sensors. Additional cables from 10 to 1000 feet long are available from Micro Motion.

Parts List

The cable preparation package contains the following:

Two pieces of 1-inch (25-mm) black tubing
One piece of 3-inch (75-mm) yellow tubing
One piece of 4-inch (100-mm) yellow tubing
One piece of 4-inch (100-mm) black tubing
Nine spade lugs

Some installations do not require all the parts.

WARNING: **Carefully prepare cables to avoid grounding the shields to the transmitter case or to conduits.**

The factory ordinarily prepares the cable end connecting to the transmitter. If conduit is used, run the transmitter cable through conduit before preparing the sensor end of the cable.

4.2.1 Sensor-End Cable Preparation

To prepare the cable end connecting to the sensor, perform the following steps:

1. Remove a 3-inch (75-mm) length of sheathing from the cable, and remove the fibrous material between the wires. DO NOT yet separate the twisted pairs of shielded wires.

2. Remove the foil wrapping around the **violet/orange** pair of wires, separate them and separate the shield from this pair.

3. Slip the 3-inch (75-mm) piece of yellow tubing over the shield of the **violet/orange** pair of wires. Leave as little distance as possible between the yellow tubing and the cable sheathing to reduce the amount of exposed wire.

4. Remove the foil wrapping around the other 3 pairs of shielded wires and separate them. Clip each shield off as close as possible to the cable sheathing.

5. Slip one piece of the 1-inch (25-mm) black heat-shrink tubing over the all the wires and cable sheathing. The black tubing should completely cover all portions of the **violet/orange** wire shield remaining exposed next to the cable sheathing.

6. Without burning the cable, use a heat gun to shrink the tubing.

7. After the cable has cooled, strip 1/4 inch (6 mm) of insulation from the individual wires. If less than 1/4 inch (6 mm) of shielded wire extends from the yellow tubing, trim the tubing.

4.2.2 RFT9712 and FlowScale Transmitter-End Cable Preparation

WARNING: **Carefully prepare cables to avoid grounding the shields to the transmitter case or to conduits.**

Micro Motion cable is shipped with the prepared cable end which connects to the RFT9712 or FlowScale transmitter. If you install conduit, run the transmitter cable through the conduit and seal fitting from the transmitter to the sensor before preparing the cable ends.

To prepare the cable end connected to the RFT9712 or FlowScale transmitter, perform the following steps:

1. Remove a 4-inch (100-mm) length of sheathing from the cable, and remove the fibrous material between the wires. DO NOT yet separate the twisted pairs of shielded wires.

2. Remove the foil wrapping around the **violet/orange** pair of wires and separate them.

3. Slip the 4-inch (100-mm) piece of yellow tubing over the shield of the **violet/orange** pair of wires. Leave as little distance as possible between the yellow tubing and the cable sheathing to reduce the amount of exposed shield.

4. Remove the foil wrapping around the other 3 pairs of shielded wires and separate them. Twist the 3 remaining shields together. Slip the 4-inch (100-mm) piece of black tubing over these 3 shields and push the tubing as close as possible to the cable sheathing.

5. Slip one piece of the 1-inch (25-mm) black heat-shrink tubing over the wires and cable sheathing. The tubing should completely cover all exposed portions of the shields.

6. Without burning the cable, use a heat gun to shrink the tubing.

7. After the cable has cooled, strip 1/4 inch (6 mm) of insulation from the individual wires. If less than 1/4 inch (6 mm) of shielded wire extends from the yellow or black tubing, trim the tubing.

4.2.3 REU Transmitter-End Cable Preparation

When a DL sensor is ordered with an REU, the unit will be shipped with 7-wire cable. The factory prepares the cable end which connects to the sensor. These instructions describe the preparation of the transmitter end of the cable. Carefully prepare cables to avoid grounding the shields to the sensor case or to conduit. If you install conduit, run the cable through the conduit and/or seal fitting before preparing the cable ends. In most installations, the unprepared end of the cable is run through conduit from the sensor to the transmitter.

To prepare the cable end connecting to the REU, perform the following steps:

1. Without cutting the individual wires or stripping their insulation, remove a 4-inch (100-mm) length of sheathing from the cable. Remove the fibrous material between the wires, and the foil and cellophane joining the twisted pairs of shielded wires.

2. Twist all the wire shields together.

3. Slip the 4-inch (100-mm) piece of yellow tubing over the shields. Leave as little distance as possible between the yellow tubing and the cable sheathing to reduce the amount of exposed shield.

4. Slip one piece of 1-inch (25-mm) shrink tubing over the wires and the cable sheathing. The tubing should completely cover all exposed portions of the shields.

5. Without burning the cable, use a heat gun to shrink the tubing.

6. After the cable has cooled, strip 1/4 inch (6 mm) of insulation from the individual wires. If less than 1/4 inch (6 mm) of shielded wire extends from the yellow tubing, trim the tubing.

7. Slip the stripped ends of the individual wires into the spade lugs. DO NOT leave any bare wire exposed. Crimp the spade lugs onto the wires.

4.3 Sensor Wiring Connections

Wiring connections to DL sensors are made within the supplied junction box or with the optional Cam-lok quick-connector. The junction box is not attached to the sensor when shipped. Unscrew the junction box cover to access the 9-position terminal strip. **Figure 4-1** illustrates sensor junction box wiring. Attach and position the junction box to the sensor base as desired.

Wiring instructions are placed in the junction box when it is shipped with a sensor from the factory. Refer to those instructions, which are repeated in Figure 4-1 of this instruction manual, when making connections to the sensor. Insert the stripped ends of the individual wires into the removable terminal block inside the sensor junction box. No bare wires should remain exposed. Make sure to match the wire colors of the interconnecting cable with the wire colors at the DL sensor wiring terminal as shown below:

Terminal Number	Wire Color
1	Brown
2	Red
3	Orange
4	Yellow
5	Green
6	Blue
7	Violet
8	Gray
9	White

The conduit fitting on the DL sensor junction box is a 3/4-inch NPTF opening. Connect the opening to a 3/4-inch NPT male cable grip or flexible conduit. The cable grip must be compatible with the operating environment. For example, install corrosion-resistant cable grip or conduit and conduit connectors in corrosive environments. Use conduit connectors and seals to prevent moisture from accumulating in wiring terminals.

Install UL-approved flexible conduit for explosion-proof applications. Intrinsic safety can be maintained without explosion-proof conduit, although connections must be waterproof.

Model DL sensors are available with an optional Cam-lok quick-connector. **Figure 4-2** provides a wiring diagram for the Cam-lok quick-connector. With this option, Micro Motion supplies 20 feet (6 meters) of PVC-jacketed cable and a 9-pin connector for the sensor junction box. For cable runs longer than 20 feet, splicing or a user-supplied junction box will be required.

4.4 Transmitter Connections

4.4.1 RFT9712 Transmitter

Remove the detachable terminal connections from the RFT9712's wiring compartment. Connect the stripped ends of the individual wires as described below. Insert the wired terminal connections into the RFT9712. Replace and tighten the terminal-connection cover before operating the flowmeter.

RFT9712
Terminal Number

0 . . . Black wire	1 . . . Brown wire
2 . . . Red wire	3 . . . Orange wire
4 . . . Yellow wire	5 . . . Green wire
6 . . . Blue wire	7 . . . Violet wire
8 . . . Gray wire	9 . . . White wire

4.4.2 FlowScale Transmitter

Remove the detachable terminal connection from the FlowScale transmitter's wiring compartment. Connect the stripped ends of the individual wires as described below. Insert the wired terminal connection into the FlowScale transmitter. Replace and tighten the terminal-connection cover before operating the flowmeter.

FlowScale
Terminal Number

1 . . . Black wire	6 . . . Brown wire
2 . . . Red wire	7 . . . Orange winre
3 . . . Yellow wire	8 . . . Green wire
4 . . . Blue wire	9 . . . Violet wire
5 . . . Gray wire	10 . . .White wire

4.4.3 REU Transmitter

Connect the spade lugs to the REU terminal strip as shown below:

REU
Terminal Number

1 . . . Brown wire
2 . . . Red wire
3 . . . Orange wire
4 . . . unused
5 . . . unused
6 . . . Yellow wire (shield-ground)
7 . . . Green wire
8 . . . Blue wire
9 . . . Violet wire

NOTE: **Figure 4-5 illustrates a gray and white wire in the interconnecting cable at the REU transmitter. Since terminals 4, 5 and 6 are common in the REU, the gray and white wires are not required at the transmitter. Additionally, this means the yellow wire could be connected at 4, 5 or 6 without affecting flowmeter performance.**

Figure 4-1
DL Sensors Junction Box Wiring

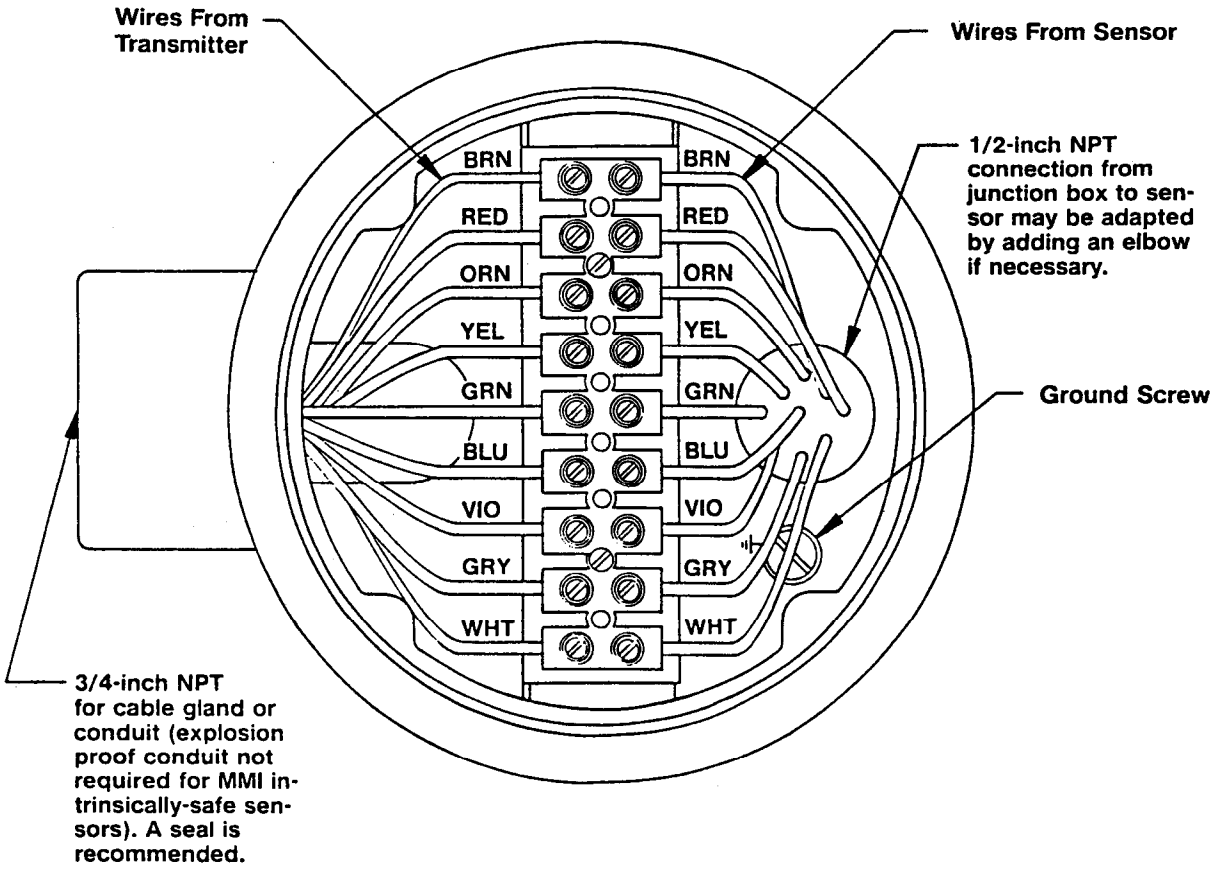
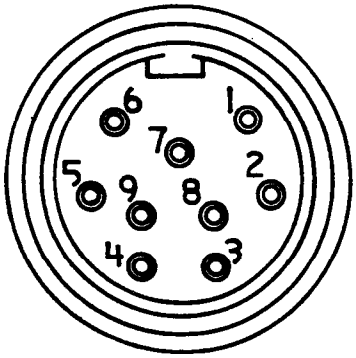
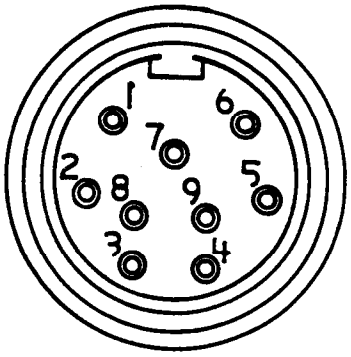


Figure 4-2
DL Sensor Cam-lok(R) Connector Wire Guide

Cable End
(female)



Sensor End
(male)



Coil & Temp. Sensor	Wire Color
Right position detector	Blue & gray (blue & yellow at REU)
Left position detector	Green & white (green & yellow at REU)
Drive coil	Brown & red
RTD	Yellow & violet
Lead length compensator	Yellow & orange

Cam-lok Pin Number	Wire Color
1	Brown
2	Red
3	Orange
4	Shields
5	Green
6	Blue
7	Violet
8	Gray
9	White

Figure 4-3
DL Sensor to RFT9712 Transmitter Wiring Diagram

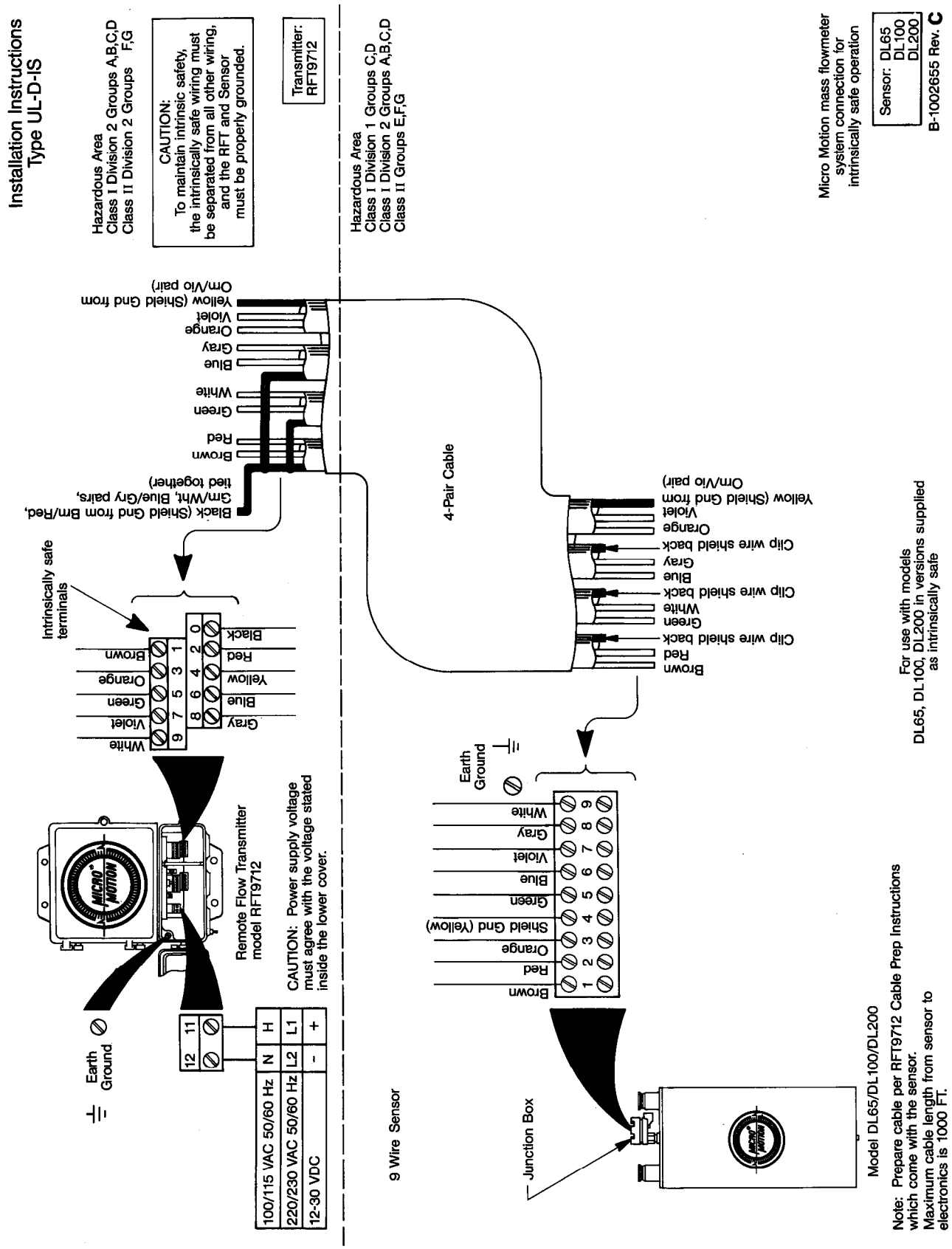


Figure 4-4
DL Sensor to FlowScale Transmitter Wiring Diagram

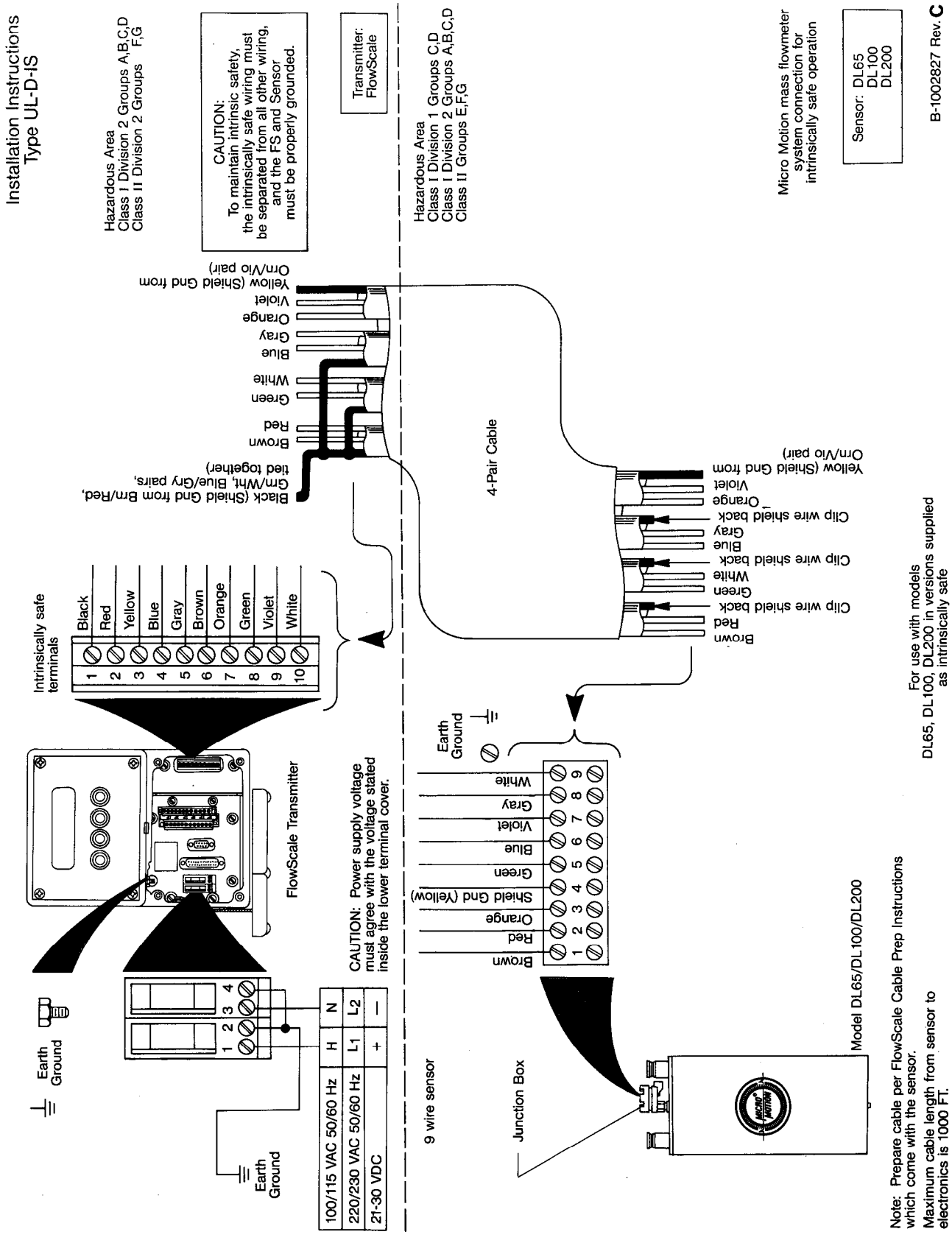
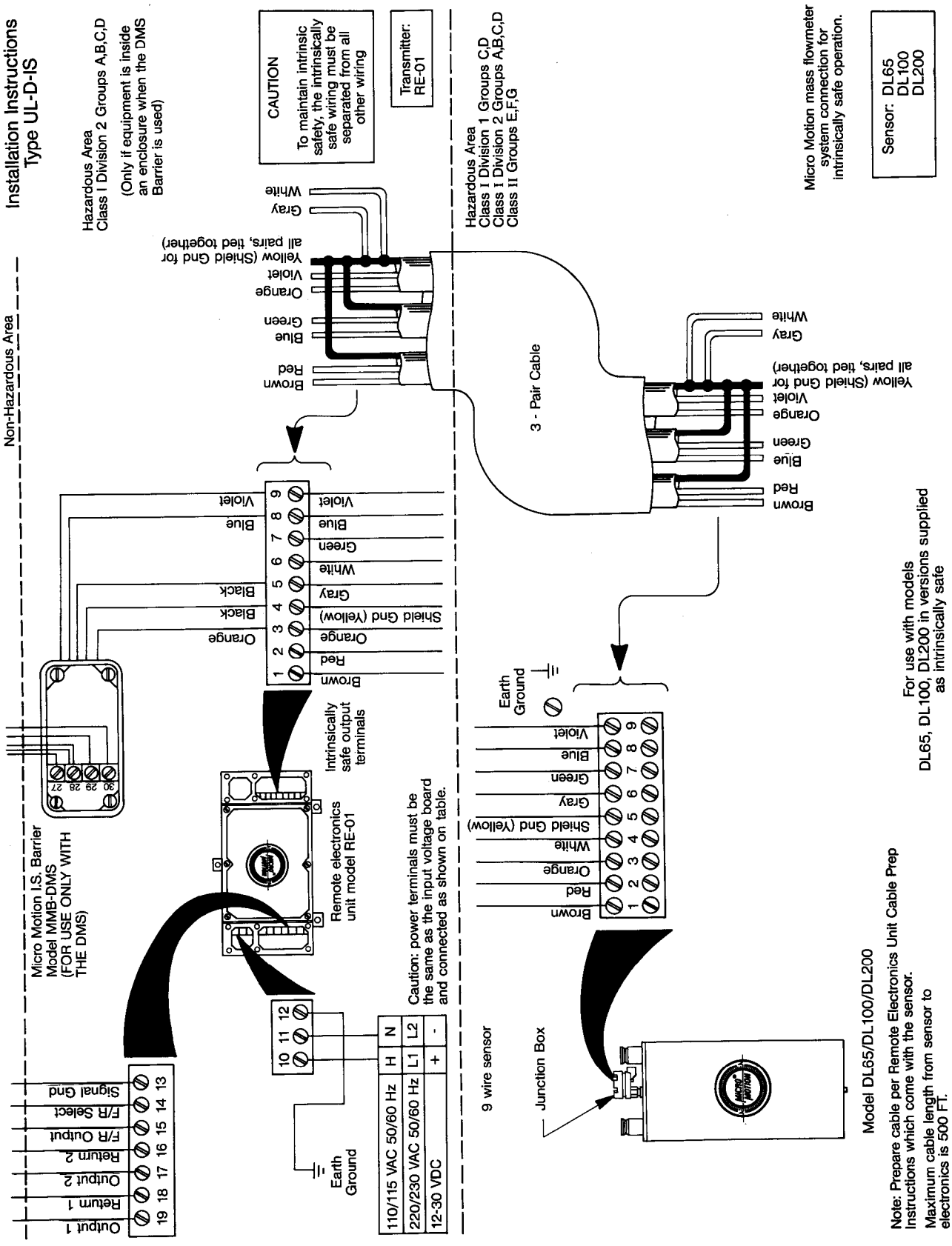


Figure 4-5
DL Sensor to REU Wiring Diagram



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5 Transmitter Considerations

5.1 RFT9712 Transmitter

When a DL sensor is connected to a Model RFT9712 Remote Flow Transmitter, you can replace the sensor and transmitter separately, because each sensor is factory calibrated and marked with its own density and mass flow calibration factors. *Remote Flow Transmitter RFT9712 Instruction Manual* provides detailed information about these flow and density calibration factors. The SMART FAMILY Interface 268 allows you to interface with an RFT9712 transmitter. (Refer to *Using the SMART FAMILY Interface 268 with the Micro Motion Remote Flow Transmitter.*) No other calibration or equipment is needed.

5.1.1 Flow Calibration Factor

The flow calibration factor enables calibration of the RFT9712 transmitter for flow measurement. Refer to *RFT9712 Remote Flow Transmitter Instruction Manual* for details about using and entering this factor into the transmitter. Testing conducted in the Micro Motion Flow Calibration Lab determines the exact value of the flow calibration factor for each individual sensor. Every Micro Motion flow sensor has a label displaying the sensor's flow calibration factor, which consists of 10 characters, including 2 decimal points. The following number is a typical flow calibration factor:

63.1905.13

The first 5 digits on the left, and the first decimal point, represent the sensor's sensitivity in grams per second over the number of microseconds between the moment when the outlet side of the flow sensor's tube crosses the midpoint of the vibration cycle and the moment when the inlet side of the tube crosses the midpoint of the vibration cycle. In the example, the 6 characters on the left indicate that, for every detected microsecond of time between cycle-midpoint crossings, 63.190 grams of fluid per second flow through the sensor. The flow calibration factor's last 3 digits and second decimal point represent the temperature coefficient of the rigidity modulus for the sensor. For 316L stainless steel sensors, the flow temperature coefficient is 5.13 (%/100°C). For Hastelloy-C sensors, the flow temperature coefficient is 3.15 (%/100°C).

5.1.2 Density Calibration Factor

The density calibration factor enables calibration of the RFT9712 transmitter for density measurement. The density calibration factor consists of 14 characters, including 2 decimal points. The following number is a typical density calibration factor:

11394134624.44

The first 5 digits on the left represent the sensor tube's natural vibration period, in microseconds, when the tube contains air that has a density of 0.000 grams per cubic centimeter at 0°C. The next five digits, shown in bold-face type, represent the tube's natural vibration period, in microseconds, when the tube contains water that has a density of 1.000 grams per cubic centimeter at 0°C. The last 3 digits and the decimal point represent the

temperature coefficient of the elasticity modulus for the sensor. For 316L stainless steel sensors, the density temperature coefficient is 4.44 (%/100°C). For Hastelloy-C sensors, the density temperature coefficient is 2.75 (%/100°C).

5.2 FlowScale(R) Transmitter

5.2.1 Meter-Type Switches

The FlowScale transmitter has internally programmable Meter-Type settings. The Meter-Type switches allow the FlowScale transmitter to be matched to any sensor. The Meter-Type switches are factory set to appropriate positions and may be changed if necessary. The correct Meter-Type settings for the switches can be found in *FlowScale System Instruction Manual.*

5.2.2 Meter-Factor Switches

In the FlowScale transmitter, Meter-Factor switches are used to establish the calibration of the flowmeter. The Meter-Factor switches are factory set to appropriate positions and may be changed if necessary. The correct Meter-Factor settings for the switches can be found in *FlowScale System Instruction Manual.*

5.3 REU Transmitter

5.3.1 Span Switches

A series of span switches, located on the signal board, sets the span of the flowmeter. Based on the sensitivity of the individual sensor, the switches are set for the amplitude necessary to achieve approximately 10,000 Hz at the desired maximum full-scale flow rate. The output board uses the information for scaling or conversions, as applicable. *Remote Electronics Unit Transmitter Instruction Manual* contains more information about determining and adjusting frequency span for the REU.

6 Startup and Troubleshooting

6.1 Startup and Power

After the flowmetering system has been correctly connected to process piping and wired to the transmitter, power can be applied. Refer to the appropriate transmitter instruction manual for the warmup time required by the transmitter.

6.2 Meter Zero

Let the material to be measured run through the sensor for about 15 minutes or until the sensor achieves process temperature. Close the shutoff valve downstream from the sensor. Fluid flow to the sensor must **completely** stop or the zero flow setting will be incorrect. Incorrect zero-flow settings occasionally result from leakage through valves.

The sensor should be **completely** filled with the process fluid and should not contain trapped air or gas. A partially filled sensor tube can result in an inaccurate zero setting and, consequently, an inaccurate output signal. Also, the process fluid must not be "flashing" or boiling inside the sensor tube.

Set the zero by following the procedures set forth in the appropriate transmitter instruction manual.

After the sensor and transmitter have been properly mounted and the zero setting adjusted, the flowmetering system is ready for operation. After setting the zero, DO NOT readjust it between batches.

6.3 Troubleshooting

A number of general guidelines should be followed while troubleshooting a Micro Motion flowmetering system. First, before beginning the diagnostic process, become familiar with this manual and with the instruction manual for the transmitter being used. These instruction manuals contain detailed technical information, drawings, and schematics pertaining to all flowmetering system components.

Second, if possible, leave the sensor in place while you troubleshoot a problem. Problems often arise from the specific environment in which the sensor operates.

Third, check all signals under both flow and no-flow conditions. This procedure guarantees that no causes or symptoms will be overlooked. **Table 6-1** shows resistance values for the sensor's drive coil, and for left and right position detectors (pick-off coils).

Table 6-1 Nominal Resistance Values for Model DL Sensor Wiring

- Nominal resistance values will vary by 40% per 100 o C. However, confirming an open coil (mega-ohms) or shorted coil (very few ohms) may be more important when troubleshooting than any slight deviation from the resistance values presented below.
- Resistance of right and left pickoffs should be within 10% of each other.
- Resistance values might not apply to older sensors.

Sensor model number:	Sensor component		
	Drive coil Ω at ambient temperature	Pickoffs Ω at ambient temperature	Platinum RTD Ω at 0°C*
DL65	206 ± 20	5.8 ± 1	100
DL100	107 ± 10	200 ± 10	100
DL200	45 ± 5	200 ± 10	100
Micro Motion wire colors:	Red and brown	Left: green and white Right: blue and gray	Yellow, orange, and violet

*Resistance value of platinum RTD increases .38675 ohms per °C increase in temperature.

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Effective troubleshooting of a malfunctioning flowmetering system depends on accurate identification of failure symptoms. Once this identification is accomplished, the causes of failure can be eliminated. As previously stated, you should specify the problem in as much detail as possible. Here are the four main symptoms found in the field and their definitions:

No Output: There is flow through the sensor and no output is registered.

Unresponsive Output: Output remains constant while actual flow rate changes.

Erratic Output: Random changes in output are unrelated to changes in actual flow rate.

Intermittent Output: Output randomly stops and starts. Output, when present, accurately reflects the flow rate.

In new installations, most malfunctions result from mounting, piping, or wiring problems. Check these sources of problems before attempting to repair the flowmetering system. Transmitter instruction manuals describe troubleshooting procedures and diagnostics for different transmitter-related problems. Follow the procedures in those manuals, in the order presented, to correct problems efficiently.

6.4 Customer Service

For 24-hour assistance, phone the Micro Motion Customer Service Department, toll free, 1-800-522-MASS (1-800-522-6277). From outside the U.S., phone 1-303-530-8400.

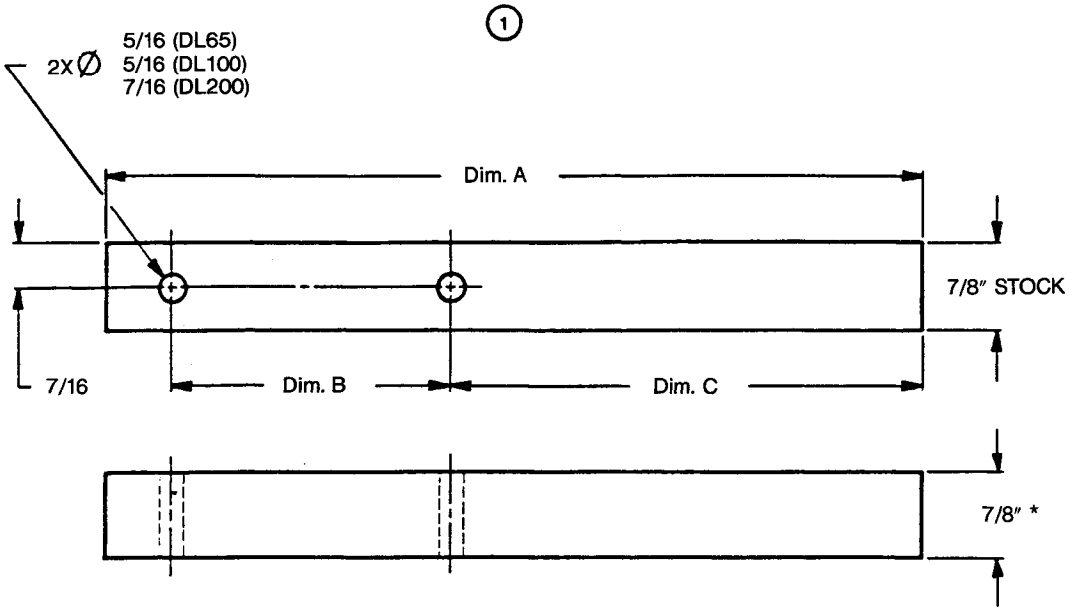
Dimensions in inches

Use materials appropriate for the application environment.

DL65
Dim. A = 8 3/4
Dim. B = 2 29/32 (qty. req'd: three)
Dim. C = 5

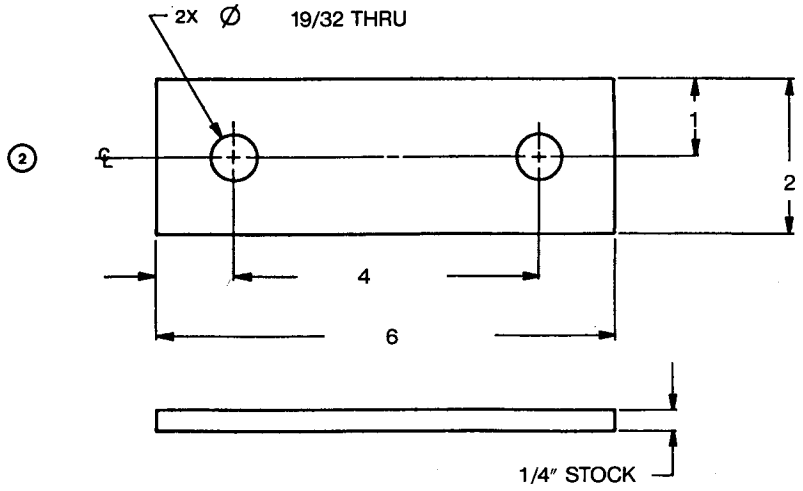
DL100
Dim. A = 8 3/4
Dim. B = 3 (qty. req'd: three)
Dim. C = 5

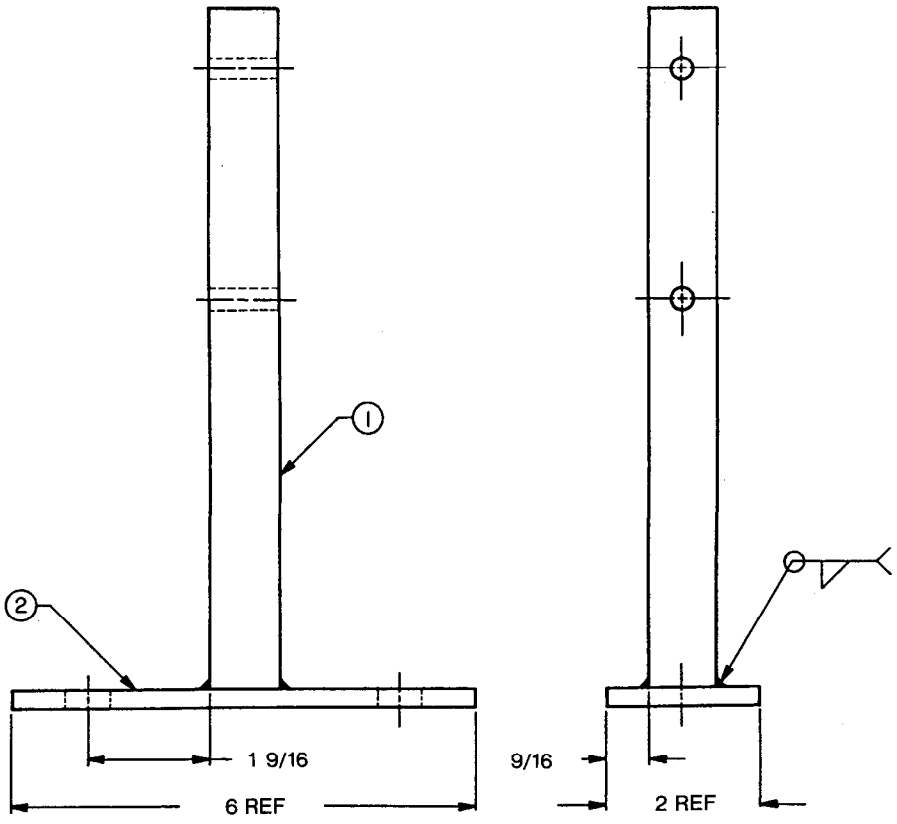
DL200
Dim. A = 12 1/4
Dim. B = 6 3/8 (qty. req'd: two)
Dim. B = 6 1/2 (qty. req'd: one)
Dim. C = 5



* 7/8 x 1/2" stock for DL65

Appendix
Mounting Leg Instructions





List of Micro Motion® Instruction Manuals

Sensors:

ELITE™ Sensor Instruction Manual, 2-92, Rev. B, P/N 3001211
Model D Sensor Instruction Manual, 5-91, Rev. A, P/N 1003467
Model DL Sensor Instruction Manual, 12-90, Rev. C, P/N 1002318
High Temperature Sensor Instruction Manual, 1-90, Rev. B, P/N 1002278

Transmitters:

ELITE™ Model RFT9739 Field-Mount Transmitter Instruction Manual,
2-92, Rev. B, P/N 3001210
ELITE™ Model RFT9739 Rack-Mount Transmitter Instruction Manual,
10-91, Rev. A, P/N 3001217
Model RFT9712 Remote Flow Transmitter Instruction Manual, 1-91, Rev. A, P/N 1003349
FlowScale® System Instruction Manual, 1-90, Rev. B, P/N 1002550
Remote Electronics Unit Instruction Manual, 4-89, Rev. A, P/N 1002337

Communications:

Using the SMART FAMILY® Interface 268 with the Micro Motion ELITE™ Model RFT9739 Transmitter,
1-92, Rev. A, P/N 3001215
Using the SMART FAMILY® Interface 268 with the Micro Motion Remote Flow Transmitter,
10-90, Rev. B, P/N 1002657
Using Modbus® Protocol with the Micro Motion ELITE™ Model RFT9739 Transmitter,
10-92, Rev. B, P/N 3001216
Using ProLink™ Software with Micro Motion 9700 Series Transmitters, 11-92, Rev. A, P/N 3001506

Peripheral Products:

DMS Density Monitoring System Instruction Manual, 9-88, Rev. C, P/N 1001280
DRT Digital Rate Totalizer LCD Instruction Manual, 7-90, Rev. C, P/N 1001421
DRT Digital Rate Totalizer LED Instruction Manual, 9-90, Rev. D, P/N 1000618
FMS-3 Flow Monitoring System LCD Instruction Manual, 7-90, Rev. C, P/N 1001316
FMS-3 Flow Monitoring System LED Instruction Manual, 7-90, Rev. B, P/N 1000558
Net Oil Computer Instruction Manual, 5-92, Rev. A, P/N 1003671
NFC Net Flow Computer Instruction Manual, 12-90, Rev. A, P/N 1003326

Wiring Instructions:

Installation Instructions TYPE UL-D-IS, 12-91, Rev. F, P/N 1002648
Installation Instructions TYPE CSA-D-IS, 12-91, Rev. D, P/N 1003328
Installation Instructions TYPE SAA-D-IS, 5-91, Rev. D, P/N 1003210

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