

Installation and Grounding of Magmeters in Typical and Special Applications

CONTENT

- Purpose of Grounding
- Background including Magmeter Operating Principle, Faraday's Law, Earth/Safety Grounding, Basic Process Grounding, and Ground Rings vs. Ground Electrodes
- Recommendations for Electrolytic Process Applications
- Recommendations for Cathodic Protection Applications
- Summary

PURPOSE

As a major manufacturer of magnetic flowmeters, Rosemount Inc. often receives questions from customers regarding the proper grounding and installation of magnetic flowmeters, such as:

- When should I use ground rings or a ground electrode?
- When should I use ground rings versus a ground electrode?
- Should I always connect the flowmeter to earth ground?

The purpose of this paper is to address some of the basic questions about magmeter installation and grounding, and to address these same issues in the more complicated situations of electrolytic process and cathodic protection applications.

Proper installation and grounding of magnetic flowmeters is important for accurate, reliable measurement performance. Stray AC or DC currents through the fluid or instrument can produce noise signals that may in turn interfere with the relatively low flow signals generated in today's modern pulsed DC magmeter. Manufacturers provide a variety of elements (ground straps, ground electrode, ground rings, lining protectors) and directions for the standard grounding of the magmeter.

Applications exist in which the user cannot or should not make use of the traditional grounding connection to adjacent piping and to earth ground. These flow measurement applications are frequently encountered in electrolytic processes and cathodic protection applications. In this case, the fluid passing through the magmeter sensor may be at a potential significantly higher or lower than earth ground, and a connection to earth ground may be detrimental to the performance and even the reliability of the magmeter. These applications are typically compounded by the use of non-conductive or lined pipe and may feature acid or caustic flows which may necessitate the use of expensive wetted electrodes and grounding materials such as titanium, platinum, or tantalum. Please refer to section titled "Special Applications" for complete details regarding these special installation requirements.

For the remainder of this paper, the term "grounding" will be defined as: the arrangement of process wetted metal materials (piping, ground rings, lining protectors, ground electrode), cabling (ground straps, ground wires), and connections to stable references (often, but not always earth ground) required to achieve satisfactory operation of a magnetic flowmeter. As such, it applies to the instrumentation aspect of grounding, rather than to "safety grounding". However, the subject of "safety ground" will also be addressed for these specific applications.

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BACKGROUND

Magmeter Operating Principle

The operating principle of the magnetic flowmeter is based on Faraday's law of electromagnetic induction, which states that a voltage will be induced in a conductor moving through a magnetic field.

Faraday's Law: $E = kBDV$

The magnitude of the induced voltage E is directly proportional to the velocity of the conductor V , conductor width D , and the strength of the magnetic field B . The secondary (or transmitter) supplies the controlled current to the coils to generate the magnetic field, and amplifies, filters, and converts the resulting signal to user outputs such as 4 - 20 mA, frequency, or digital communication information (HART, FOUNDATION fieldbus, Profibus). In the modern pulsed DC magmeter, the generated signal is actually quite small: typically on the order of 100 μV per foot per second flow velocity (300 μV per meter per second velocity). Because this signal is so small, magmeter designers and users must take steps to minimize noise and to maximize noise rejection. One of these steps is proper grounding of the system.

TYPICAL APPLICATIONS

Earth/Safety Grounding

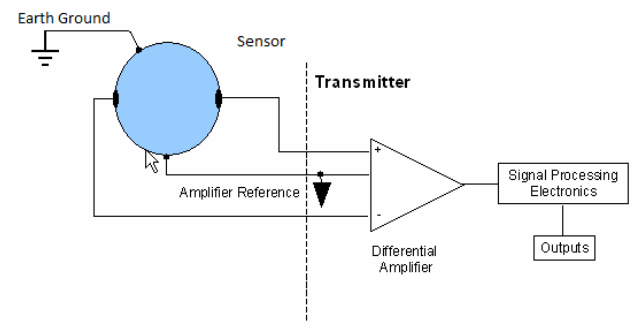
To prevent hazards to operating personnel, electrical equipment must always be installed and wired per local electrical code. For AC powered equipment, this usually takes the form of connection of the case of the equipment to Earth ground. This is usually done through the connection of the earthed green wire to the ground lug provided in the wiring area of the magmeter transmitter. If the transmitter is integrally mounted to the sensor, this automatically connects the sensor to earth ground as well.

It is common that the adjacent piping to the magmeter will provide a connection to Earth ground. A connection to Earth ground is also commonly made at the transmitter through the power connections. It is important that if both Earth ground connections are established, the impedance between them must be very low. If the impedance between these earth ground connections is high, it can result in a high current through the coil shield wire.

Basic Process Grounding

Establishing a process ground is one of the most important installation details. Proper process grounding ensures that the sensor and fluid are at the same potential so that only the induced flow signal is measured. Why is this necessary? To answer this question, let's look at how the magmeter sensor and the transmitter are connected electrically (Figure 1). In a typical pulsed DC magmeter, the flow signal is connected to a differential amplifier that is electrically isolated from the case of the transmitter. The process of grounding provides a stable reference for this differential amplifier. In the majority of applications, the best and most stable reference is earth ground itself. By connecting the magmeter sensor, the fluid, and the reference for the amplifier to a stable, noise free reference point, the user is ensured of getting the best performance from their magnetic flowmeter.

Figure 1. Basic electrical connection between sensor and transmitter



The grounding arrangement is determined primarily by the type of pipe in which the magmeter is installed. The recommended grounding arrangements for conductive unlined pipe, conductive lined pipe, and non-conductive pipe are shown in Figure 2 - Figure 4.

Technical Note

00840-2400-4727, Rev BA
September 2013

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Figure 2. Recommended Grounding for conductive pipe or conductive lined pipe with Ground electrode⁽¹⁾

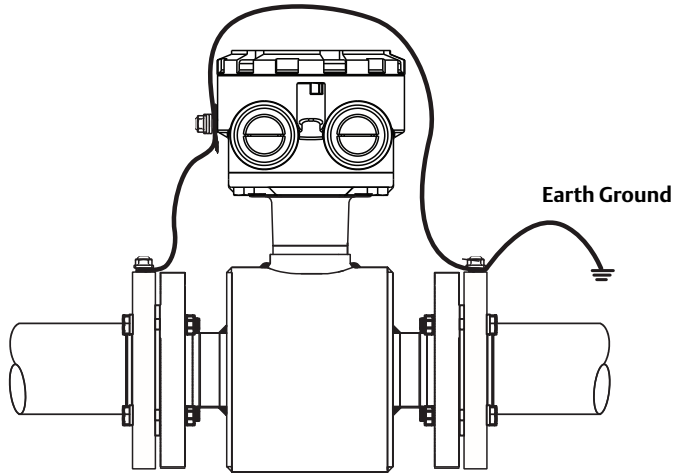


Figure 4. Recommended Grounding for Non-conductive pipe with Ground rings or Lining Protectors

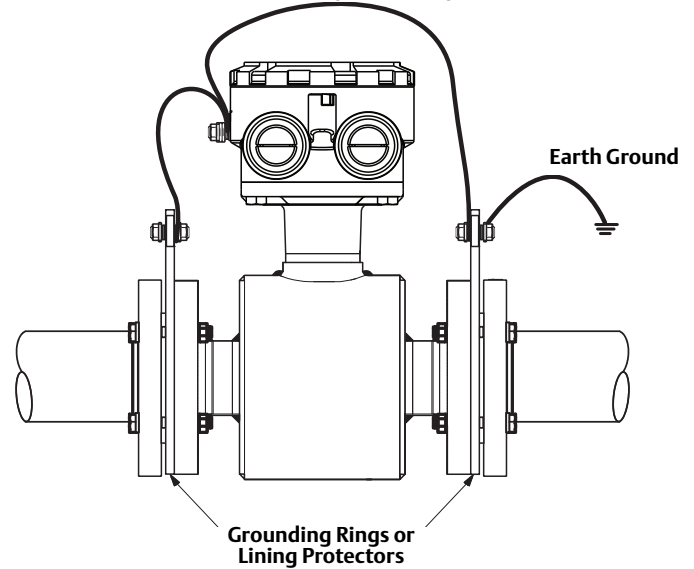
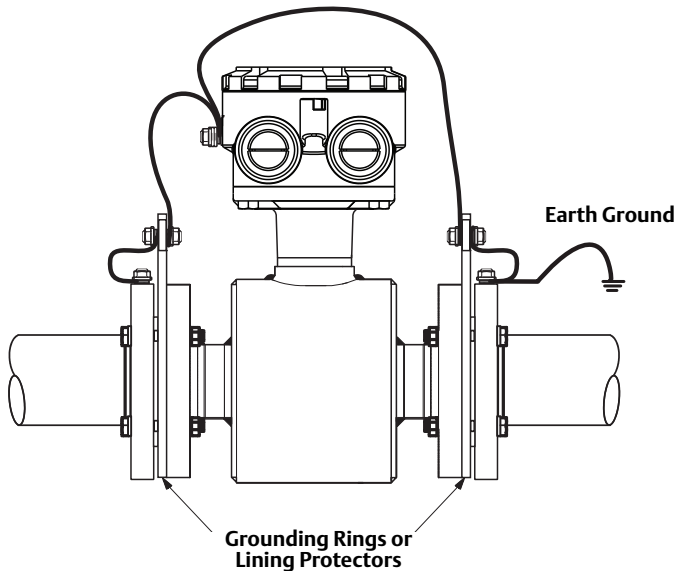


Figure 3. Recommended Grounding for conductive lined pipe with Grounding rings or Lining Protectors⁽¹⁾



Ground Rings vs. Ground Electrode

As shown in the previous figures, ground rings or ground electrode are required when the piping adjacent to the magmeter does not provide a good electrical connection to the fluid; i.e., the pipe is lined or made of non-conductive material. Ground rings or a ground electrode provide the required electrical connection to the process fluid. Ground electrodes are integral to the sensor, so installation is easier and less expensive, particularly when “exotic” materials are required. Ground rings provide a larger surface area connection to the process fluid, and limit the effects of the conductivity of the adjacent piping, which is important for wafer style sensors. Therefore ground rings are recommended over a ground electrode in the following situations:

- The fluid conductivity is less than 100uS/cm
- Wafer style sensors installed in non-conductive piping or lined piping
- Applications that may cause a coating or build-up on the bottom of the pipe
- Electrolytic process or cathodic protection applications (described in the “Special Applications” section)

(1) When a low impedance Earth ground connection is provided elsewhere on the pipe, a local Earth ground connection may not be necessary. See the installation manual for more details.

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SPECIAL APPLICATIONS

Electrolytic Process Applications

In typical electrolytic processes, magmeters are used to measure the flow of feedstock fluids into the cell(s). Large DC currents (1000's of amps or higher) are fed into the cells to drive the electrolytic process. The resultant liquids and gasses may also be monitored by additional flowmeters. The electrolytic process may occur in one reactor or very many cells. In the latter case, each cell may have its own magmeter for feedstock flow measurement.

Whatever the arrangement, the large voltages and currents present may cause currents to flow in unexpected ways. The current flows of interest here are generally of two types:

- Current flow in the fluid through the magmeter
- Current flow through grounding components

Both types of current may be present in a typical application of these types. In the first case, the flow of current in the fluid passing through the sensor generates noise that may interfere with the low-level flow signal. Testing at Rosemount indicates that this noise varies with current level and has components that can easily interfere with the flow signal. The result is usually not an inaccurate flow measurement, but rather an unstable flow measurement that can make control difficult or impossible. In this situation, ground rings provide a path to shunt the current around the fluid in the magmeter.

Current flow through grounding components may occur if:

1. multiple magmeters are used in a system;
2. they are at different potentials and;
3. the grounding components for multiple magmeters are tied to a common point. The most frequent common point may be through the grounded green wire. Situations like this have resulted in high corrosion of grounding components, up to and including the loss of sealing around a ground electrode. In addition, current through grounding components generates noise that can result in an unstable magmeter output.

Prioritized Recommendations for Electrolytic Process Applications

1. **Isolate from Earth Ground:** In these situations, the magmeter should be connected electrically only to the process. Because the magmeter is not earth grounded, isolated DC power (~24 VDC) should be used to avoid safety issues. If isolated DC power is not available, then the transmitter will have to be remotely mounted from the sensor. Always follow all applicable national and local safety codes.
2. **Use ground rings or lining protectors, not ground electrode:** Ground rings expose more surface to the process; if currents flow, less noise will be produced, providing a more stable reference for the amplifier. Using two ground rings will provide a path to shunt the current around the fluid in the magmeter.
3. **Connection specifics:** Ground rings or lining protectors should be connected as shown in Figure 5. It is very important to connect both ground rings to the sensor case to minimize the current flow through the process fluid near the electrodes.
4. **Select 37 Hz coil drive frequency:** The noise generated in these applications typically has a 1/f characteristic; i.e., the amplitude of the noise decreases with increasing frequency. Because of this characteristic, there is less noise at a higher coil drive frequency, and a more stable output is attained.

Technical Note

00840-2400-4727, Rev BA
September 2013

Rosemount Magnetic Flowmeters

NOTE

For Electrolytic Process Applications:

Empty pipe is detected by making a low frequency impedance measurement. Electrolytic applications can generate high levels of low frequency noise that can cause sporadic false Empty Pipe indications. If the transmitter is experiencing false Empty Pipe indications the Tunable Empty Pipe Detection may require adjustment. The Empty Pipe Trigger Level and Empty Pipe Counts parameters may need to be increased in order operate properly in the presence of high levels of low frequency noise that is common in these applications. If necessary, first increase the Empty Pipe Trigger Level from the default value of 100 to 500 or higher as required.

To determine the necessary level:

1. Observe the Empty Pipe Value under normal operating full pipe conditions for at least a few minutes.
2. Set a value for the Empty Pipe Trigger Level that is about 50 to 100 points higher than the highest observed value that was present consecutively for more than the number of Empty Pipe Counts.
3. Validate the new Empty Pipe Trigger Level value by checking the Empty Pipe Value when the pipe is empty and dry to ensure the Empty Pipe Trigger Level has been set below the value of a true empty pipe condition.
4. If increasing the Empty Pipe Trigger Level alone doesn't solve the false empty pipe indications, then increase the Empty Pipe Counts from the default value of 5 to 10 or higher as required. Be aware that increasing the Empty Pipe Counts will delay the response time of empty pipe indication.

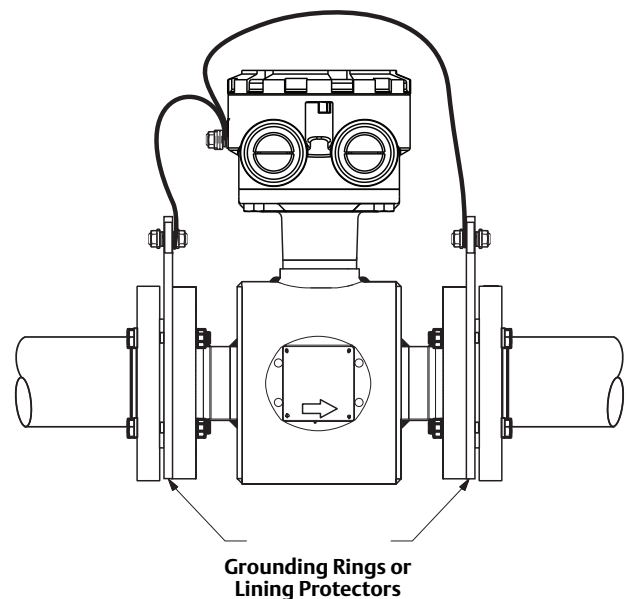
For further details on Tunable Empty Pipe please refer to the transmitter manual.

NOTE

AC Power: If the only available power is standard AC then additional steps must be taken to isolate the sensor from earth ground. A remote mounted transmitter must be used. To completely float the sensor, the shield wire for the coil signal should be disconnected, eliminating the connection between the sensor and the grounded transmitter chassis.

1. It is preferred to disconnect the coil shield wire at the transmitter.
 2. If disconnecting the coil shield at the transmitter results in a noisy flow reading, then disconnect the coil shield wire at the sensor.
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Figure 5. Recommended connection for electrolytic and cathodic protection process applications



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CATHODIC PROTECTION APPLICATIONS

Cathodic protection is a technique used to limit the corrosion of a metal surface by making it the cathode in an electrochemical cell. Another piece of more easily corroded metal becomes the anode in the electrochemical cell. In long pipelines a large DC current is run through the process fluid to drive the cathodic protection. It is important that only the anode has a connection to earth ground in these applications. If another earth ground connection is present it may also provide the anodic material for the cathodic protection system. Therefore all piping and instrumentation, including magmeters, must be isolated from earth ground.

Prioritized Recommendations for Cathodic Protection Applications

1. **Isolate from Earth Ground:** In these situations, the magmeter should be connected electrically only to the process. Because the magmeter is not earth grounded, isolated DC power (~24 VDC) should be used to avoid safety issues. If isolated DC power is not available, then the transmitter will have to be remotely mounted from the sensor. Always follow all applicable national and local safety codes.
2. **Use ground rings or lining protectors, not ground electrode:** Ground rings expose more surface to the process; if currents flow, less noise will be produced, providing a more stable reference for the amplifier. Using two ground rings will provide a path to shunt the current around the fluid in the magmeter.
3. **Connection specifics:** Ground rings or lining protectors should be connected as shown in Figure 5. It is very important to connect both ground rings to the sensor case to minimize the current flow through the process fluid near the electrodes.
4. **Special Differential Amplifier:** In some installations, the transmitter output may be driven to 0 even though there is flow in the pipe. This is caused by the DC voltage of the cathodic protection system interfering with the operation of the standard differential amplifier in the electrode signal circuitry of the transmitter. If this situation occurs, a new transmitter with special option F0100 should be ordered from your Rosemount sales contact.

NOTE

AC Power: If the only available power is standard AC then additional steps must be taken to isolate the sensor from earth ground. A remote mounted transmitter must be used. To completely float the sensor, the shield wire for the coil signal should be disconnected, eliminating the connection between the sensor and the grounded transmitter chassis.

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Technical Note

00840-2400-4727, Rev BA
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SUMMARY

Proper grounding of a magmeter is one of the most important installation details. Grounding arrangements for typical applications have been discussed, including recommendations for the use of ground electrodes versus ground rings. Different grounding arrangements are required when magmeters are installed in electrolytic process and cathodic protection applications where the traditional connection to earth ground could actually create problems. While this paper provides general recommendations for these applications, each application is different. Please contact your Rosemount salesperson if you have any questions. Above all, user safety should always be first and foremost in the wiring and installation of any instrument. Electrolytic processes and cathodic protection applications can create special safety considerations for all equipment, not just the magnetic flowmeters.

Rosemount Magnetic Flowmeters

Technical Note
00840-2400-4727, Rev BA
September 2013

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