Tempsonics®
Intrinsically Safe Position Sensors

Ordering Guide &
Installation and Instruction Manual

Part Number 550420
Revision D 2/20/98
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## GENERAL INFORMATION

### MTS PHONE NUMBERS

<table>
<thead>
<tr>
<th>To place orders:</th>
<th>Contact your local distributor or call:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1-800-633-7609 or 919-677-0100</td>
</tr>
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<table>
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<tr>
<th>Application questions:</th>
<th>1-800-633-7609</th>
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<tr>
<td>Service:</td>
<td>1-800-248-0532</td>
</tr>
<tr>
<td>Fax:</td>
<td>919-677-0200</td>
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### SHIPPING ADDRESS

MTS SYSTEMS CORPORATION
Sensors Division
3001 Sheldon Drive
Cary, North Carolina 27513

### HOURS

- **Monday - Thursday**
  - 8:00 a.m. to 6:30 p.m. EST or EDT
- **Friday**
  - 8:00 a.m. to 4:30 p.m. EST or EDT
1. INTRODUCTION

Temposonics position sensors can be used in hazardous environments when connected to approved safety barriers. Factory Mutual approval permits the use of intrinsically safe Temposonics position sensors in Class I, Division 1, Groups A, B, C, and D hazardous locations (see Table 1A below).

Table 1A Hazardous Location Classifications

<table>
<thead>
<tr>
<th>Class</th>
<th>Division</th>
<th>Atmospheres containing Acetylene</th>
<th>Atmospheres such as:</th>
<th>Atmospheres such as:</th>
<th>Atmospheres such as:</th>
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<tr>
<td>Class I</td>
<td>Division 1</td>
<td>Butadiene</td>
<td>Ethylene Oxide</td>
<td>Cyclopropane</td>
<td>Acetone</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Propylene Oxide</td>
<td>Acrolein</td>
<td>Ethyl Ether</td>
<td>Alcohol</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Hydrogen</td>
<td></td>
<td>Ethylene</td>
<td>Ammonia</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Benzene</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Benzol</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Butane</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Gasoline</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Hexane</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Lacquer Solvent</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Vapors</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Naptha</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Natural Gas</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Propane</td>
</tr>
</tbody>
</table>

Intrinsic Safety (IS) is based on the principle of restricting the electrical energy transmitted into a hazardous area, thereby ensuring that any sparks or heated surfaces that may occur as a result of electrical failures are insufficient to cause ignition. With intrinsically safe systems, a safe operating environment is provided for personnel and equipment -- voltages are low and no threat of an explosion exists.
2. SYSTEM COMPONENTS

COMPONENTS -- INTRINSICALLY SAFE SYSTEMS:

- Temposonics I Linear Displacement Transducer
- (1 ea.) MTL-728 Shunt Diode Safety Barrier (P/N 370140)
- (2 ea.) MTL-710 Shunt Diode Safety Barrier (P/N 370141)
- 24-28 Vdc Power Supply (P/N 380009)
- ±15 Vdc Power Supply -- required with digital systems and some analog system configurations
- 5 Vdc power Supply -- required with digital systems
- A signal conditioning interface module (see Figure 1.1 -- 'Signal Conditioning')

![Typical System Configuration](image)

Figure 1.1
Typical System Configuration
### 2.1 System Specifications

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Specification</th>
</tr>
</thead>
</table>
| **Input Voltage** | • Position Sensor: 26 Vdc  
                    • Interface Modules: ± 12 to ± 15 Vdc  
                    • Counter Card: 5 Vdc                     |
| **Displacement** | Up to 25 feet (7620 millimeters)                                              |
| **Dead Space**  | For stroke lengths up to 200 inches: 5 inches (127 millimeters)  
                    For stroke lengths over 200 inches: 7 inches (177.8 millimeters) |
| **Sensor Styles** | 3 Styles:  
                    1) Standard, dust-tight  
                    2) Ruggedized, dust-tight (similar to NEMA 1)  
                    3) Ruggedized, splash-proof (similar to NEMA 4) |
| **Non-linearity** | < ± 0.05% of full scale or ± 0.002 inch (± 0.05 mm), whichever is greater    |
| **Repeatability** | ± 0.001% of full scale or ± 0.0001 inch (± 0.002 mm), whichever is greater   |
| **Frequency Response** | Stroke dependent, 200 to 50 Hz for strokes ranging from 12 to 100 inches (305 to 2540 mm). Wider response is available. For digital systems, output is updated at discreet intervals. |
| **Temperature Coefficient** |  
                    Transducer (length dependent): 3 ppm/°F (5.4 ppm/°C)  
                    Electronics: < 0.00011 in./°F (< 0.00503 mm/°C) |
| **Operating Temperature** |  
                    Head Electronics:  
                    Transducer Rod: - 40 to 150 °F (- 40 to 66 °C)  
                    - 40 to 185 °F (- 40 to 85 °C)  
                    Analog Output Module: - 40 to 180 °F (- 40 to 82 °C)  
                    Digital Interface Module: 35 to 150°F (2 to 65°C)  
                    MK 292 Digital Output Module: 32 to 140°F (0 to 60°C)  
                    Sensor Operating Pressure: Factory Mutual certified to 3000 psi continuous, 8000 psi static |
| **Outputs (absolute)** |  
                    Analog: Standard: 0 to 10 Vdc (other voltage outputs are available),  
                    Optional: 4 - 20 mA  
                    Digital: Natural Binary, BCD, Gray Code |
| **Velocity Output (optional)** |  
                    0 to ± 10 Vdc, polarity of output defines direction of travel  
                    (optional 4-20 mA velocity output is available -- contact MTS for details) |
| **Magnet Requirement** | Part Number: 201542 (standard) or 201554 if sensor stroke length is over 200 inches |
| **Mounting Distances** |  
                    • Temposonics position sensor to safety barriers: 200 feet maximum  
                    • Temposonics position sensor to Digital Interface Box: up to 200 feet with Belden 9931 cable  
                    • Digital Interface Box to MK 292 Module up to 300 feet with Belden 8227 cable  
                    • Temposonics position sensors to Analog Output Module: up to 200 feet with Belden 9931 cable |

Specifications are subject to change without notice. Consult MTS for verification of specifications critical to your application.
3. HOW TO ORDER SYSTEM COMPONENTS

3.1 Temposonics Intrinsically Safe Position Sensor

Enclosure Style
1 = Standard, dust-tight (similar to NEMA 1)
2 = Ruggedized, dust-tight (similar to NEMA 1)
3 = Ruggedized, splash-proof (similar to NEMA 4)

Stroke Length Units
U = U.S. Customary (inches and tenth -- xxx.x inches)
M = Metric (millimeters)

Stroke Length
The value to enter depends on stroke length units indicated above.
For example:
0120 = 12.0 inches or 120 mm
1200 = 120.0 inches or 1200 mm

Null/Dead Space
5 = 5 in. dead space, 2 in. null—standard for strokes up to 200 inches
7 = 7 in. dead space, 2 in. null—standard for strokes over 200 inches
9 = Special (must be specified at time of order)

Cable/Connector (See IMPORTANT NOTE below)
1 = 5 ft. cable with standard, 6-pin connector (for use with Enclosure Style "1")
2 = 5 ft. cable with pigtail connection (for use with Enclosure Style "1")
3 = No cable -- extension cable required, connector attached directly to head assembly (for use with Enclosure Styles "2" or "3")
4 = 25 ft. cable with standard, 6-pin connector (for use with Enclosure Style "1")

IMPORTANT NOTE
Consult Applications Engineering for any installation with cable lengths that exceed 200 feet of total distance between the position sensor and the external conditioning module (analog or digital).

3.2 Extension Cables

Cable Type
S = Standard (Belden 9931)
H = Heavy Duty (Belden 9730)

Length (ft.)
Examples: 25 ft. = 025; 100 ft. = 100
Maximum Length: 200 ft.

Mating Connector
1 = Standard, PN 370018
(For use with sensor Enclosure Style "1")
2 = Ruggedized, P/N 370011
(For use with sensor Enclosure Style "2", refer to Section 3.1 above and Figure 3.1 on next page)
3 = Ruggedized, P/N 370062
(For use with sensor Enclosure Style "3", refer to Section 3.1 above and Figure 3.1 on next page. Also, this connector is available with standard cable only—not compatible with Heavy Duty cable)
NOTES:
1. Safety Barriers are hard-wired using a pigtail connection.
2. Maximum cable length between the Temposonics position sensor and the safety barrier is 200 feet.

**Table 3A Position Sensor Cable Connections**

<table>
<thead>
<tr>
<th>Connector Pin #</th>
<th>Belden 9931 (standard)</th>
<th>Belden 9730 (heavy duty)</th>
<th>Functional Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Red</td>
<td>Red</td>
<td>26 V</td>
</tr>
<tr>
<td>B</td>
<td>Black</td>
<td>Black (twisted with Red wire)</td>
<td>Common</td>
</tr>
<tr>
<td>C</td>
<td>Brown</td>
<td>Green</td>
<td>Return Pulse</td>
</tr>
<tr>
<td>D</td>
<td>Blue</td>
<td>Black (twisted with Green wire)</td>
<td>Common</td>
</tr>
<tr>
<td>E</td>
<td>White</td>
<td>White</td>
<td>Interrogation Pulse</td>
</tr>
<tr>
<td>F</td>
<td>Green</td>
<td>Black (twisted with White wire)</td>
<td>Common</td>
</tr>
</tbody>
</table>
### 3.3 Analog Output Module for Intrinsically Safe Systems

#### Enclosure Style
- **31**: Standard, Strain-relief Connectors
- **32**: 5 & 6 Pin MS Style Connectors
- **35**: Plug-in Card, rack mountable

*Note: Style '35' requires a 15-pin edge connector (P/N 370034) or card holder (P/N 370170)*

#### Displacement Output
**Voltage Outputs:**
- **10**: 0 to 10 Vdc
- **20**: 0 to 10 Vdc, reverse acting
- **50**: -10 to +10 Vdc
- **60**: -10 to +10 Vdc, reverse acting
- **01**: 0 to -10 Vdc
- **02**: 0 to -10 Vdc, reverse acting

**Current Outputs:**
- **03**: 4 to 20 mA ungrounded
- **04**: 4 to 20 mA ungrounded, reverse acting
- **05**: 4 to 20 mA grounded
- **06**: 4 to 20 mA grounded, reverse acting

**Special Outputs:**
- **09**: Dual Channel
- **90**: Differential Output

#### DC Power Supply Requirement
- **0**: –15 Vdc (for retrofits)
- **1**: 26 Vdc

#### Velocity Option
- **0**: None
- **1**: Forward acting voltage output
- **2**: Reverse acting voltage output
- **3**: Forward acting current output (grounded)
- **4**: Reverse acting current output (grounded)
- **5**: Forward acting current output (ungrounded)
- **6**: Reverse acting current output (ungrounded)

#### Maximum Velocity
- **___ ___ ___ = Maximum Velocity, range = 1 to 400 inches/second or 0.01 to 9.99 meters/second**

*Note: The 3 digit code represents either inches/second or meters/second depending on the Stroke Length Units selected.*

### 3.3.1 Accessories for AOM
- 5 pin female MS connector (P/N 370017)
- 6 pin female MS connector (P/N 370015)
Figure 3.2
Analog Output Module Dimensions
3.4 Digital Interface Box for Intrinsically Safe Systems

Interrogation
- I = Internal Interrogation
- E = External Interrogation

Recirculation Count
- 0 = 1 Circulation
- 1 = 2 Recirculations
- 2 = 4 Recirculations
- 3 = 8 Recirculations
- 4 = 16 Recirculations
- 5 = 32 Recirculations
- 6 = 64 Recirculations
- 7 = 128 Recirculations
- 9 = Other

Style
- 0 = Standard, ±15 Vdc P.S.; Temp. Range: 35 to 150°F (1.67 to 66°C)
- 2 = ±12 Vdc P.S.; Temp. Range: 35 to 150°F (1.67 to 66°C)
- 9 = Special

Unit of Measurement (Sensor Length)
- U = US Customary (inches and tenths)
- M = Metric (millimeters)

Stroke Length of Sensor
__ __ __ __ = Stroke Length

Note: This 4 digit code represents either inches and tenths or millimeters depending in the Unit of Measurement selected.

Figure 3.3
Digital Interface Box Dimensions

3.4.1 Accessories for Digital Interface Box
- 10-pin female MS connector (P/N 370013)
- 6-pin female MS connector (P/N 370015)
3.5 MK 292 Digital Output Module for Intrinsically Safe System

MK 292 Digital Output Module

Hardware
10 = Card
11 = Card with Analog Sub-board Assembly
   (Sub-board assembly: AK294, 0 to 10 Vdc or 10 to 0 Vdc output)
50 = Module
51 = Module with Analog Sub-board Assembly
   (Sub-board assembly: AK294, 0 to 10 Vdc or 10 to 0 Vdc output)

Software
01 = For use with Intrinsically Safe Sensor and Digital Interface Box

Figure 3.4
MK 292 Module Dimensions
4.1 Installing a Temposonics Position Sensor

Before beginning installation, be sure you know the following dimensions (as illustrated in Figures 4-1 to 4-3):

- Null Space
- Stroke
- Dead Zone

![Figure 4.1](image)

*Temposonics Intrinsically Safe Position Sensor Dimension*

1. Use the 3/4 inch (19 mm), 16 UNF thread of the position sensor to mount it at the selected location. Leave room to access the hex head. If a pressure or moisture seal is required, install an O-ring (type MS 28778-8 is recommended) in the special groove. Use the hex head to tighten the position sensor assembly.

2. Install the permanent magnet over the sensor rod. Mount the permanent magnet to the movable device whose displacement will be measured. To minimize the effect of magnetic materials (i.e. iron, steel, etc.) on the magnetic field of the permanent magnet, ensure the minimum spacing requirements are met as shown in Figures 4.2a-c. (Any non-magnetic materials can be in direct contact with the permanent magnet without affecting performance.)

![Figure 4.2a](image)

*Minimum Magnet Clearance Using Magnetic Supports*
Notes:
1. The magnet must not contact ferromagnetic materials (such as iron or steel). Clearances are required between the surface of the magnet and ferromagnetic material, as shown. Non-ferrous material (such as copper, brass, or 300 series stainless steel) may contact the magnet without affecting sensor performance.
2. Standard Null Space is 2 inches. There is no maximum limit for Null Space. Less than 2 inches can be specified if magnet clearances meet requirements illustrated above.

**NOTE**

Clearance between the magnet and the sensor rod is not critical. However, contact between the components will cause wear over time. The installation of supports and/or readjustment of the supports is recommended if the magnet contacts the sensor rod.

3. Move the permanent magnet full-scale to check that it moves freely. If not (if the magnet rubs on the sensor rod) you can correct this by mounting a support bracket to the end of the position sensor. Long sensors may need additional supports to be attached to the sensor rod. Transducer supports are described later in this section.

4.2 Types of Sensor Supports

Long sensors (48 inches or longer) may require supports to maintain proper alignment between the sensor rod and the permanent magnet. When sensor rod supports are used, special, open-ended permanent magnets are required.

Transducer supports attached to the active stroke length must be made of a non-ferrous material, thin enough to permit the permanent magnet to pass without obstruction. Because the permanent magnet does not enter the dead zone, supports connected within the dead zone may be made of any material. The main types of supports are loop, channel, and guide pipe supports.

4.2.1 Loop Supports

Loop supports are fabricated from non-ferrous materials, thin enough to permit free movement of the magnet. Loop supports are recommended for straight position sensors. They may be used alone or with channel supports. Figure 4.3 illustrates the fabrication of a loop support.
4.2.2 Channel Supports

Channel supports, being typically straight, are normally used with rigid sensors. A channel support consists of a straight channel with loop supports mounted at intervals. The loop supports are required to keep the sensor rod within the channel. Figure 4.4 shows a channel support. Channel supports are available from various manufacturers or may be fabricated.

4.2.3 Guide Pipe Supports

A guide pipe support is constructed of non-ferrous material, straight or bent to the desired shape. As shown in Figure 4.5, both inside and outside dimensions of the pipe are critical:

- Because the sensor rod is installed inside the pipe, the inside diameter of the pipe must be large enough to clear the rod.
- The outside diameter of the pipe must be small enough to clear the magnet.

Refer to pipe manufacturers' specifications and dimensions (schedule 10, 40, etc.) to select the appropriate size pipe. Guide pipe is typically supported at each end of the pipe.

4.3 Open Magnets

When using an open magnet, make sure the rod is positioned at all times within the “active” zone of the magnet. The position sensor cannot operate properly unless the entire stroke of the sensor rod is located within this zone. The active zone, as shown in Figure 4.6, lies within the inside diameter of the magnet.

4.4 Spring Loading or Tensioning

The sensor rod can be spring loaded or tensioned using a stationary weight. Attach a spring mechanism or weight to the dead zone of the sensor rod with a clamping device -- make sure that the clamp does not deform the rod. The maximum weight or spring tension is 5 to 7 lbs.
4.5 Cylinder Installation

Figure 4.7 shows a typical cylinder installation. Review the following before attempting this type of installation.

- Use a non-ferrous (plastic, brass, Teflon®, etc.) spacer [1] to provide 1/8 inch (32 mm) minimum space between the magnet and the piston.

- An O-ring groove [2] is provided at the base of the hex for pressure sealing. MTS uses mil-standard MS33514 for the O-ring groove. Refer to mil-standard MS33649 or SAE J514 for machining of mating surfaces.

- The null space [3] is specified according to the installation design and cylinder dimensions. The analog output module provides a null adjustment. Make sure that the magnet can be mounted at the proper null position.

- The piston head [4] shown in Figure 4.7 is typical. For some installations, depending on the clearances, it may be desired to countersink the magnet.

- A chamfered rod bushing [5] should be considered for strokes over 5 feet (1.5 meters) to prevent wear on the magnet as the piston retracts. The bushing should be made from Teflon or similar material.

- A Nylok self locking insert [6] is provided on the threads. An O-ring groove is provided at the base of the hex head for pressure sealing.

- The recommended bore for the cylinder rod is 1/2 inch (13 mm). The 0.375 in. sensor rod includes a 0.44 in. (12 mm) end plug. Use standard industry practices for machining and mounting of all components. Consult the cylinder manufacturer for applicable SAE or military specifications.
4.6 Installing Magnets

If the null adjustment is inadequate, you can design a coupler with adjustments to mount the magnet to the measured member.
5.2 Analog Systems -- Power Supply and Sensor Connections

**SYSTEM**

- Temposonics Position Sensor
- Analog Output Module w/Strain-relief Connectors
- 26 Vdc Power Supply
- ±15 Vdc Power Supply

![Diagram of Analog Systems and Sensor Connections]

**Figure 5.2**
Analog Output Module w/ Strain-relief Connectors
SYSTEM

- Temposonics Position Sensor
- Analog Output Module w/MS-Style Connectors
- 26 Vdc Power Supply
- ±15 Vdc Power Supply

Figure 5.3
Analog Output Module w/MS Style Connectors
**SYSTEM**

- Temposonics Position Sensor
- Analog Output Module w/Strain-relief Connector and 24 Vdc power supply option
- 26 Vdc Power Supply

---

**Figure 5.4**
Analog Output Module w/ Strain-relief Connectors and 24 V Power Supply Option
SYSTEM

- Temposonics Position Sensor
- Analog Output Module w/MS-Style Connectors and 24 Vdc power supply option
- 26 Vdc Power Supply

Figure 5.5
Analog Output Module w/MS Style Connectors and 24 V Power Supply Option
5.2.1 Analog Output Module (AOM) Output Connections (TB1)

**Table 5A** Standard AOM

<table>
<thead>
<tr>
<th>Strain Relief Connection</th>
<th>MS Connector Pin Designation</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>TB1</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A</td>
<td>D</td>
<td>(+) Displacement Output</td>
</tr>
<tr>
<td>B</td>
<td>E</td>
<td>(-) Displacement Output Return</td>
</tr>
<tr>
<td>C</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td>D</td>
<td>n/a</td>
<td>n/a</td>
</tr>
</tbody>
</table>

**Table 5B** AOM w/Velocity Output Option

<table>
<thead>
<tr>
<th>Strain Relief Connection</th>
<th>MS Connector Pin Designation</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>TB1</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A</td>
<td>D</td>
<td>(+) Displacement Output</td>
</tr>
<tr>
<td>B</td>
<td>E</td>
<td>(-) Displacement Output Return</td>
</tr>
<tr>
<td>C</td>
<td>E</td>
<td>(+) Velocity Output</td>
</tr>
<tr>
<td>D</td>
<td>-</td>
<td>(-) Velocity Output</td>
</tr>
</tbody>
</table>

**Table 5C** AOM w/Dual Channel Option

<table>
<thead>
<tr>
<th>Strain Relief Connection</th>
<th>MS Connector Pin Designation</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>TB1</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A</td>
<td>D</td>
<td>Channel 1 (+) Displacement Output</td>
</tr>
<tr>
<td>E</td>
<td>E</td>
<td>Channel 2 (+) Displacement Output</td>
</tr>
<tr>
<td>C</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td>D</td>
<td>n/a</td>
<td>n/a</td>
</tr>
</tbody>
</table>
5.3 Digital Systems -- Power Supply and Sensor Connections

SYSTEM
- Temposonics Position Sensor
- Digital Interface Box
- 26 Vdc Power Supply
- Power Supplies: +15, -15, and 5 Vdc

![Diagram of Digital System Connections](image)

**Figure 5.6**
Digital System

5.3.1 Digital Systems -- Digital Interface Box J1 Connections

<table>
<thead>
<tr>
<th>J1/Pin #</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>DC Common</td>
</tr>
<tr>
<td>B</td>
<td>-15 Vdc Power</td>
</tr>
<tr>
<td>C</td>
<td>+5 Vdc Power</td>
</tr>
<tr>
<td>D</td>
<td>- (External Interrogation Pulse)</td>
</tr>
<tr>
<td>E</td>
<td>+ (External Interrogation Pulse)</td>
</tr>
<tr>
<td>G</td>
<td>+ (Gate Output)</td>
</tr>
<tr>
<td>H</td>
<td>+15 Vdc Power</td>
</tr>
<tr>
<td>J</td>
<td>Case Ground</td>
</tr>
<tr>
<td>K</td>
<td>- (Gate Output)</td>
</tr>
</tbody>
</table>
5.4 MK 292 Digital Output Module Connections

![Diagram of MK 292 Digital Output Module Connections]

**Figure 5.7**
Typical System Configuration -- Intrinsically Safe Position Sensor, Digital Interface Box, and MK 292 Module

**NOTICE:**