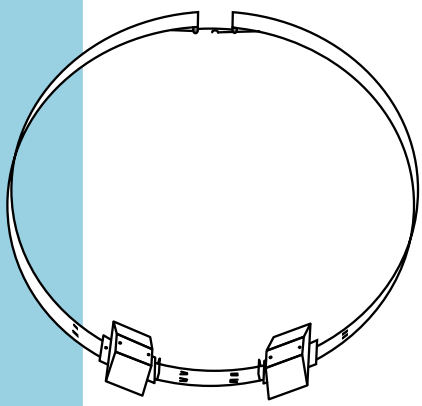
Channel Mag
PM2 - Magnetic Flowmeter
For Full &/or Partially-Full Pipes



The ChannelMag PM Series is a bi-directional magnetic flowmeter suitable for full and partially full pipes 20” - 120” (500 - 3000 mm) Ø. The PM Series is suitable for raw sewage, storm water, river water or similar. The electrodes may be permanently coated with sewage grease, algae, calcium carbonate or similar, without the need to clean and without affecting accuracy.

The ChannelMags are used singularly or in multiples to measure mean velocity, dependant on pipe size. They are retained by a magnetic enhancement band that is secured to the pipe inside diameter by an expansion mechanism. As such, they are ideal for use in concrete pipes since no holes or fixtures are required for installation. A high-resolution hydrostatic level transducer is built into the ChannelMag PM sensors when used for partially filled pipe measurement. The hydrostatic level transducer has automatic compensation for change in barometric pressure. Alternatively, an ultrasonic level transducer may be used and mounted separately to the ChannelMag sensors.

A remote 4411e Pulsed AC bi-directional transmitter calculates volumetric flow from the mean velocity and level sensor inputs. It displays rate and totals, and is programmable to show net forward totals from storm water back up. Transmission signals include two 4 – 20 mA outputs from separate terminals, scaleable pulse frequency output, RS233 and RS484 and HART protocol.

See separate data sheets for ChannelMag CM Series for rivers and open channels, or diameters < 20” (500 mm) and for the 4411e transmitter.

CHANNELMAG FEATURE	BENEFIT
Patented Coil Excitation 1-5 A @ 40 Hz	Produces a high accuracy linear signal, unaffected by permanent coatings such as sewage grease, calcium carbonate, algae.
No sensor cleaning necessary	High energy magnetic flux over the complete cross sectional areato generate a true weighted voluemteric flow signal.
Suitable for existing pipes of any material	No restrictions, no gradients, no spool piece required.
USA NIST and international traceable calibrated accuracy	Suitable for custody transfer, with high accuracy and wide ranges.
Solid state sensors, no moving parts	Virtually maintenance free.

I. Channel Mag - Method of Operation

The ChannelMag PM2 Series is suitable for full or partially full pipes from 20” to 120” (500 - 3000 mm). They meet or exceed the requirements of ISO 9213 and are calibrated in a long open tank, believed to be the largest NIST traceable facility available. ChannelMags are calibrated in accordance with ISO* approved methods. Each ChannelMag system is normally supplied with a NIST traceable Calibration Certificate.

Magnetic enhancement plates are fixed to and calibrated with the ChannelMag sensor(s). The enhancement plates are custom made to the required diameter of the channel. Their purpose is to determine the distribution pattern of magnetic flux on calibration in the test laboratory and to insure it is the same as the distribution on-site. In this way, the test calibration is the same as on-site. The other function of the enhancement plates is to retain the ChannelMag sensors in place in the pipe. They incorporate an expander mechanism which holds the sensor(s) firmly in place, without the need of further fixtures or to cut holes in the pipe.

ChannelMag sensors generate a uniquely powerful magnetic field over the whole cross sectional area of the pipe. They operate using Faraday’s Law, where a conductor moving in a magnetic field induces a voltage, the amplitude of which is proportional to the velocity of the conductor. The conductor is the media being measured. Large conical electrodes on the PM2 sensor measure the voltage signal, which is the mean velocity “weighted” to account for the complete cross sectional velocity profi le. The signal is unaffected by media viscosity or density.

Each ChannelMag PM2 sensor contains an exciter coil, powered by a remote 4411e transmitter. The 4411e is a microprocessor based patented Pulsed AC technology transmitter. The uniquely powerful and far-reaching magnetic field is created by energizing the coil with a magnetizing current up to 5 Amps at an exciter frequency of 40 Hz (for 60 Hz supply) or 33 Hz (for 50 Hz supply). This combination provides a signal to media noise ratio typically 50 times superior to traditional pulsed DC technology. As such, the electrodes may be permanently coated with sewage grease, calcium carbonate and similar without loss of accuracy. Cleaning the ChannelMag is not necessary. The sensors may be installed such that the electrodes remain above non-moving silt deposits on the bed of the channel.

Volumetric flow in partially filled pipes is computed in the 4411e by multiplying level x mean velocity. The level signal is linearized in the 4411e. Level is measured normally by a high resolution pressure transducer, which is used under the ramps of the ChannelMag velocity sensor. This has the advantage of being supplied with the PM2 sensor as a single unit, as well as being virtually insensitive to froth on the surface of the media. However, an ultrasonic level transducer is available, which must be mounted in a suitable manhole.

* Relevant ISO standards ISO 2537, ISO 3455, and ISO/TR 11974.

II. Channel Mag - Equation

The basic equation performed by the 4411e transmitter is:

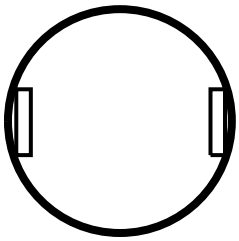
$$Q = K V H^n$$

where Q = volumetric flow
K = calibration constant
V = mean velocity
H = linearized level
n = exponent depending on size and shape of channel

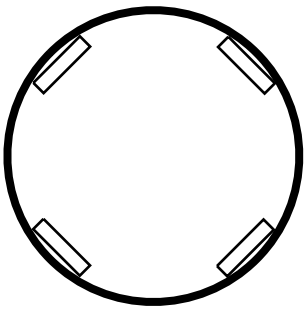
III. Channel Mags for Full Pipe Flow Measurement

ChannelMag PM Series sensors are used for full pipe flow measurement from 20” - 120” (500 - 3000 mm) diameter. For 20” - 47” (500 - 1195 mm) diameter a single sensor or double sensor is used, dependant on the number of straight lengths of pipe available. For 48” - 120” (1200 - 3000 mm) diameters either 2 sensors or 4 sensors are used, again dependant on available straight pipe lengths.

The sensor(s) are attached to a stainless steel retention band designed for a specific pipe internal diameter. The retention band is equipped with an expander mechanism, which opens out against the pipe internal diameter to secure the sensors. In this way the pipe wall does not require holes or fixtures and is ideal for concrete tunnels. box when the cable is longer than 33 feet (10 m). The cables are run in plastic conduits to the pipe exterior.



Full Pipes -- Single or Double Sensors
20” - 47” (500 - 1195 mm) Diameters

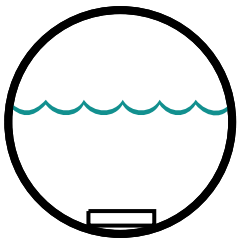


Full Pipes -- Double or Quadruple Sensors
48” - 120” (1200 - 3000 mm) Diameters

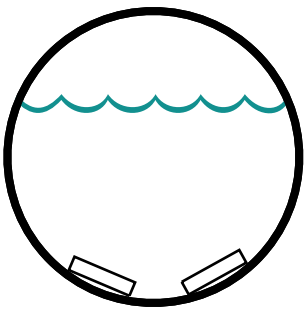
IV$_a$. Channel Mags for Partially-filled Pipe Flow Measurement (20" - 120")

The ChannelMag PM Series sensors are used in partially filled pipes from 20” - 120” (500 - 3000 mm) diameter. For pipes 20” - 36” (500 - 915 mm) a single ChannelMag sensor is installed in a retention band at the bottom of a horizontal pipe. For larger pipes two sensors are used at the bottom of the pipe, with their center lines equally dispersed at 15 degrees from the pipe center.

For partially filled pipes a hydrostatic level transducer is incorporated in a ramp on the upstream end of the sensor. The level transducer cable includes a “breather” tube, which is vented in the remote 4411e transmitter, or in a junction box when the cable is longer than 33 feet (10 m). The cables are run in plastic conduits to the pipe exterior.



Partially Filled Pipes -- Single Sensor
20” - 36” (500 - 915 mm) Diameters

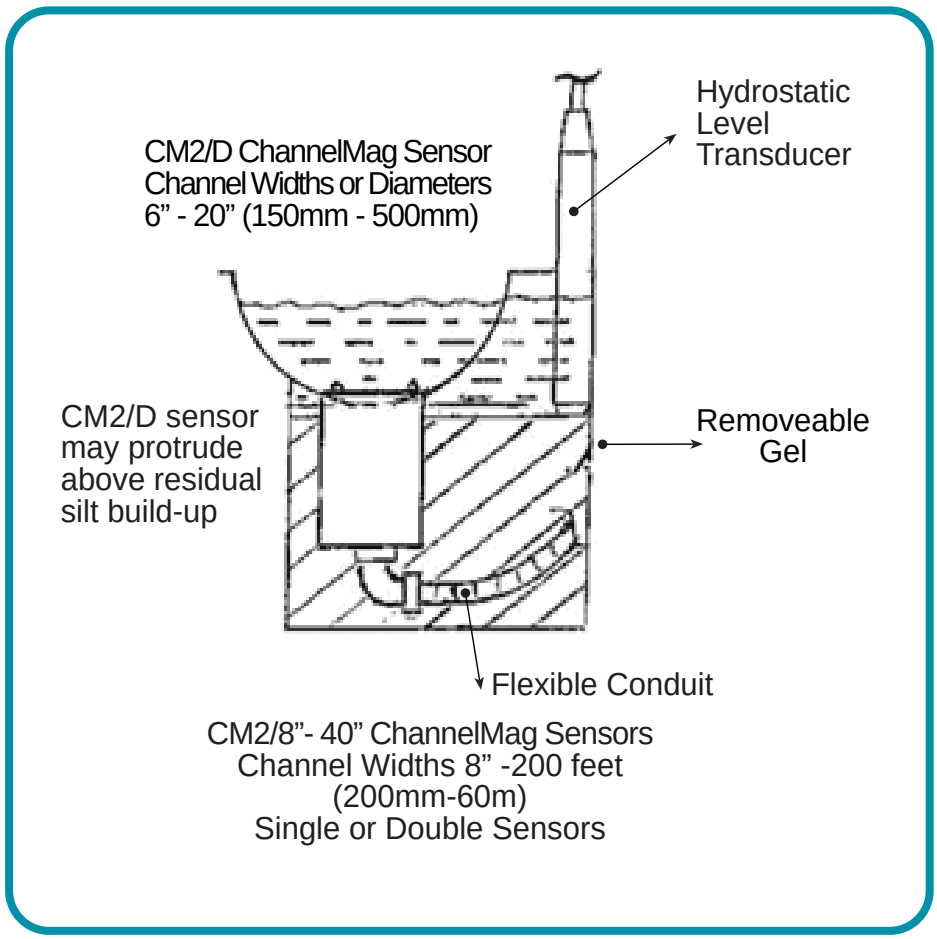


Partially Filled Pipes -- Double Sensors
38” - 120” (920 - 3000 mm) Diameters

IV$_b$. Channel Mags for Partially-filled Pipe Flow Measurement (6" - 20")

For partially filled pipe flow measurement from 6" to 20" (150 mm to 500 mm), the CM2/D mean velocity sensors are suitable. A single sensor will be installed flush in the bottom of the pipe.

For partially filled pipes a hydrostatic sensor shall be used. The level transducer cable includes a breather tube, wich is vented in the remote 4411e transmitter, or in a junction box when the cable is longer than 50 feet (15 mts).



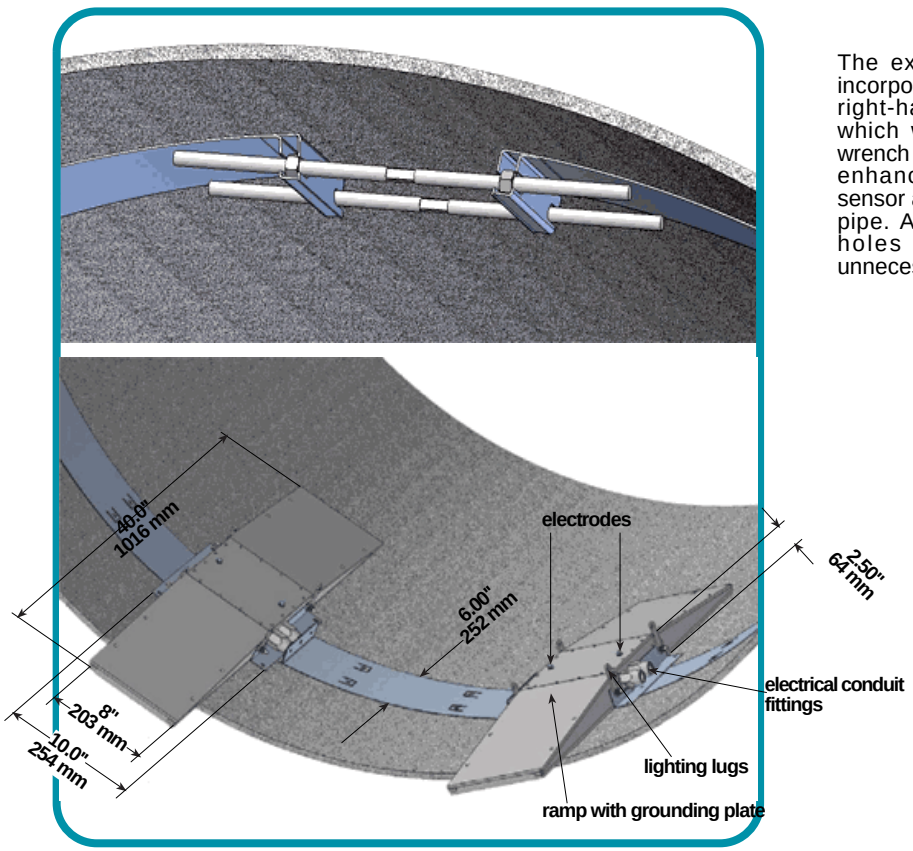
V. Channel Mag PM series - Installation

The ideal location in the pipe is where there is maximum straight length. The table below provides recommendations of minimum straight lengths of pipe for various pipe configurations. Shorter lengths or other configurations affect published accuracy, dependant on pipe size and velocity range.

Diametrically opposite sensors are either 1 pair or 2 pair.

When an ultrasonic level transducer is used for partially filled pipe applications it must be located at least 8” (200 mm) before or after the ends of the ramps to avoid drops in level due to sub-critical flows, or rises in level due to super-critical flows. When the hydrostatic level transducer is employed its level sensing position is virtually at the start of the upstream ramp and avoids critical flow rises and falls.

PIPE CONFIGURATION	SINGLE SENSOR Number or Straight PIpe Diameters D		MULTIPLE SENSORS Number of Straight Pipe Diameters D	
	Upstream	Downstream	Upstream	Downstream
90º bend upstream and downstream	10 D	5 D	5 D	2 D
After a tee	15 D	5 D	8 D	2 D
Upstream partially closed valve	25 D	5 D	15 D	2 D
Downstream partially closed valve	--	8 D	--	5 D



The expander mechanism incorporates 2 left-hand and right-hand threaded rods, which when turned with a wrench (spanner), secure the enhancement plates and sensor assembly firmly in the pipe. Additional fixtures or holes in the pipe are unnecessary.

VI. Channel Mag PM2 - Sensor Specification

Specification

Non Full Pipe Calibrated Accuracy	± 2% of rate for mean velocities > 2 fps (0.6 m/s) ± 0.04 fps (0.012 m/s) for < 2 fps (0.6 m/s)
Full Pipe Calibrated Accuracy	± 1.0% of rate for mean velocities > 1.5 fps (0.45 m/s) ± 0.0015 fps (0.0045 m/s) for < 1.5 fps (0.45 m/s)

Note: For media such as ferric chloride, ferric sulphate and similarly high conductivity media additives, consult ARKON.

NOTE: ChannelMags are calibrated to meet or exceed the requirements of the UK Environmental Agency mCERTS, as well as ISO 2537, ISO 3455 and ISO/TR 11974. Overall accuracy depends on accuracy of measuring effect ive internal diameter of pipe into which ChannelMag is installed.

Minimum Level	5.0” (125 mm) for pipes 36” (915 mm) and less 12” (300 mm) for pipes 38” (920 mm) and larger Adjustable
Mean Velocity Range	0-2 fps (0-0.6 m/s) to 0-10 fps (0-3 m/s)
PM2 Sensor Body Material	PVC with fusion bonded epoxy steel fittings
Fitings Magnetic Enhancement Band Material	Ferritic steel with fusion bonded epoxy protection and stainless steel expander screw mechanism

NOTE: Fusion bonded epoxy conforms to USA National Sanitation Foundation NSF61 and AWWA Standard C213 for drinking water.

Electrode Material and Grounding	AISI 316 stainless steel (Hastelloy C electrodes optional)
Electrode Seals	Viton
PM2 Protection and Pressure	Permanently submersible to NEMA 6 and IP 68
Maximum Media Temperature and Pressure	140° F (60° C) @ 15 psig (1 bar g) 100° F (40° C) @ 30 psig (2 bar g)
PM2 Junction Box	Supplied with all PM2 sensors
Cable Lengths From PM2 Junction Box	Standard 50 feet (15 m) from junction box, but without conduits. For distances > 100 feet (30 m) from junction box a pre-amp is installed in the junction box. Maximum distance 300 feet (100 m).
Cables and Conduit Lengths to J-Box	From PM2 sensor(s) to junction box the following is supplied: 33 feet (10 m) with conduit to J-box (special lengths to order)
Cable Types For All PM2 Sensors	3 cables run from the PM2 sensors to the J-box. 1 for the electrodes, 1 for the reference coil(s) and 1 for the exciter coil(s). Each cable is 2 core, 18 SWG (0.75 mm_2) multi-strand shielded. UL listed to UL Standard 1424 and 13 and IEC approved,

NOTE: The junction box is potted on site with re-enterable gel and is submersible to NEMA 6 and IP 68. It is made from fusion bonded polyethylene protected aluminum and is not intended for permanent submersion. The junction box is supplied with potting gel, ½” NPT conduit connectors and flexible plastic conduits. For ATEX Zone 2 explosive area or UL, CSA Ordinary Locations, approved cable connectors are supplied, but without conduits. ATEX requirements are that each connector is used for one cable only.

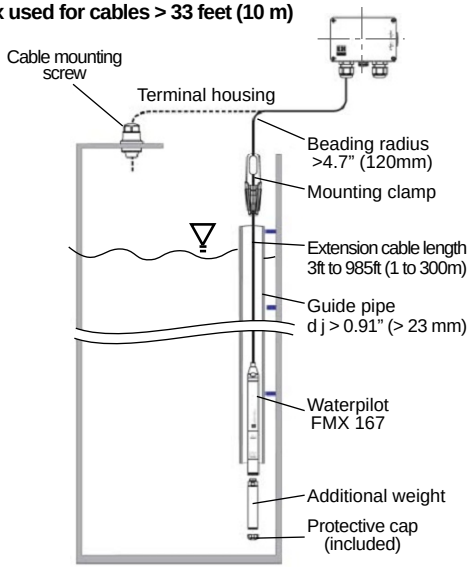
Minimum Conductivity	1 •S/cm (water is typically 200-1000 •S/cm)

VII. FMX 167 - Hydrostatic Level Transducer Specification

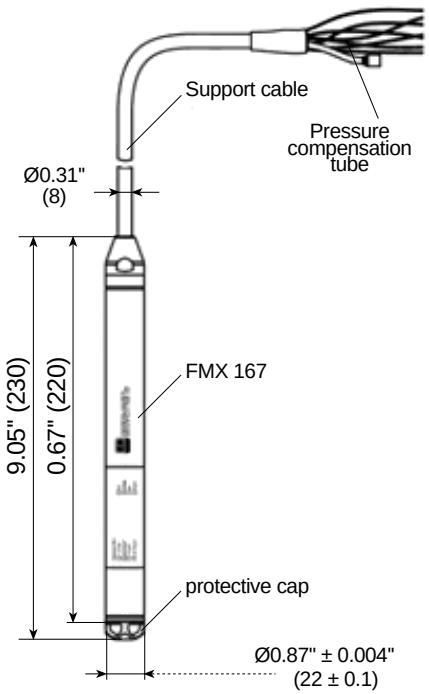
A hydrostatic pressure transducer is standard supply for measuring level in partially filled pipes. It is also normally used when the level sensor needs to be hidden from view, or if there is substantial froth on the surface of the media.The hydrostatic level transducer is normally an integral part of the ChannelMag velocity sensor type PM2.

Basic Type	FMX167
Range	0 - 20” (0 - 500 mm) to 0 - 600 feet (0 - 180 m)
Accuracy	± 0.2% full scale or 0.072” (0.13 mm) eg. accuracy at 10” level = 0.072/20 x 100 = 0.36% accuracy at 36” level = 0.072/36 x 100 = 0.2%
Barometric Pressure Change	Cable contains “breather” tube for compensation Mounted integrally on PM2 ChannelMag sensors Mounted at side of channel for widths < 8” (200 mm)
Cable Length	See ordering code. Normally same length as PM2 cables. Max. length 1000 feet (300 m)
2-wire 4411e Signal	4 - 20mA, 2 wire system, 18 VDC.
Electromagnetic Compatibility	Interference emission to EN 61326 for CE requirements
Protection	NEMA 6 and IP68 indefinately to 700 feet (200 m) w.c Porous Gore-Tex Teflon filter protects internals
Ambient Temperature	14 to 158 degrees F (-10 to 70 degrees C)
Materials of Construction Transducer housing:	316L stainless steel Sensor disphragm: aluminum trioxide ceramic Internal seal: standard Viton, optional EPDM Protective cap: high density polyethelene Cable: polyethelene with Gore-Tex Teflon filter
Explosive Atmospheres	See ordering code
Weight	Probe: 0.63 lb (0.3 kg) Cable: Add 0.13 lb/foot (0.05 kg/m)

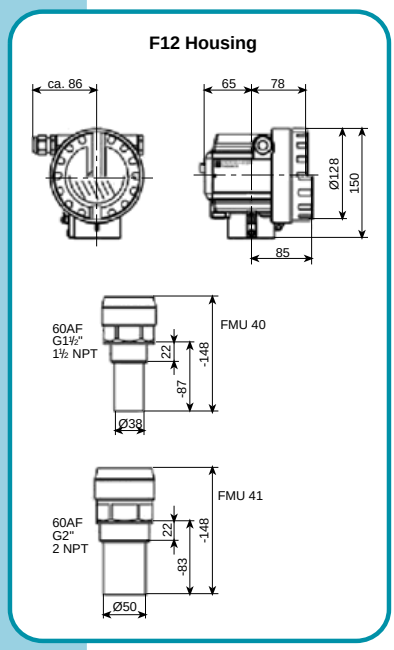
Junction Box used for cables > 33 feet (10 m)



The FMX is normally installed inside the ramps of a PM2 sensor. Alternatively, it may be mounted in a stilling well, most conveniently a PVC tube of internal diameter >0.9” (25 mm). The cable contains a breather tube and is normally terminated in the 4411e transmitter. This cable must not be kinked or blocked. An intermediate terminal housing is available, as well as a cable mounting screw or mounting clamp, as shown.



IX. FMU 40 & FMU 41 - Ultrasonic Level Transducer Specification



As an alternative to the hydrostatic level transducer, an ultrasonic level transducer may be incorporated in a convenient man hole. This must be at least 1 diameter upstream or downstream of the end of the ramps of the PM2 ChannelMag sensor ramps. This avoids critical flow rise or fall errors.

Basic Type	FMU 40
Range	0 - 200" (0 - 5000 mm)
Basic Type	FMU 41
Range	0 - 315" (0 - 8000 mm)
Accuracy	± 0.2% full scale
Minimum Dead Band	10" (250 mm)
Air Density Changes	Automatic temperature compensation
Connection	1½" NPT male for FMU 40 2" NPT male for FMU 41
2-Wire 4411e Signal	4 - 20mA, 2 wire system, 18VDC
HART Communication	Included
Protection	NEMA 6 and IP68 for 24 hours @ 6 feet w.c
Electromagnetic Compatibility	Interference emission to EN 61326
Indication	4 digit LCD
Ambient Temperature	-5 to +40 degrees F (-20 to +60 degrees C)

Note: Outside these temperatures the LCD function is restricted. A protective cover is recommended if operating in strong sunlight.

Cable Entry	½" NPT
Materials of Construction	PVDF sensor with EPDM seal Aluminum enclosure, chromed and powder coated, sea water resistant.
Housing	F12 housing is standard
Explosive Atmospheres	FM and CSA Class 1 Div. 1 or 2 optional
Weight	FMU 40 approx. 5.5 lb (2.5 kg) FMU 41 approx. 6 lb (2.6 kg)

XII. Channel Mag -- System Connection Diagram

The diagram shows how a typical ChannelMag system is connected. The supply of a system is limited to items specifically quoted.