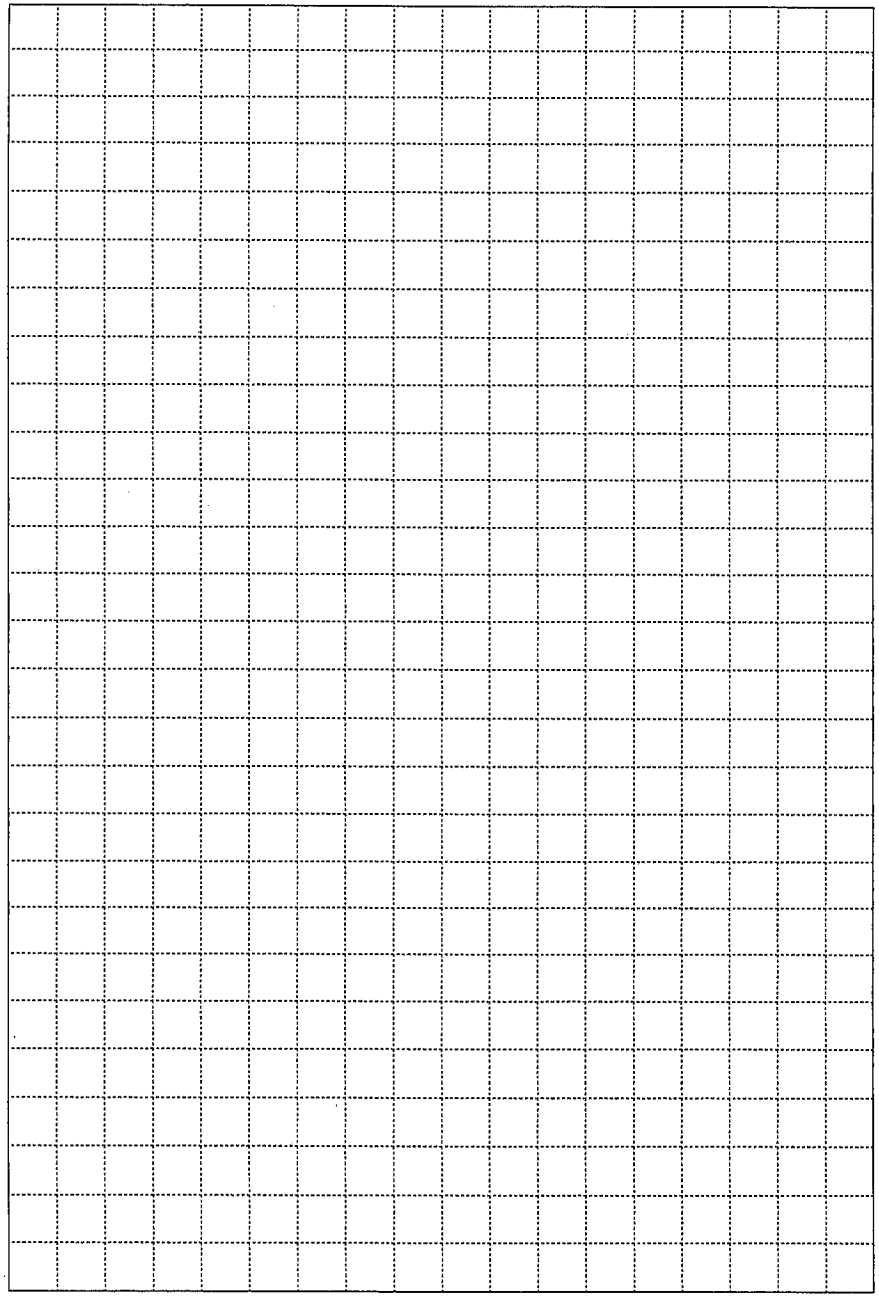
USER'S GUIDE

Operating Instructions
Model PDFM20
Portable Doppler Flow Meter
Series 6.0

Greyline instruments inc.



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Operating Instructions
Portable Doppler Flow Meter
Greyline Model PDFM20 - Series 6.0

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Important Note: This instrument is calibrated and tested to meet product specifications. Please read this manual carefully before installation and operation. Any unauthorized repairs or modifications to this instrument may result in a suspension of the product warranty.

1. INTRODUCTION - PORTABLE DOPPLER FLOW METER

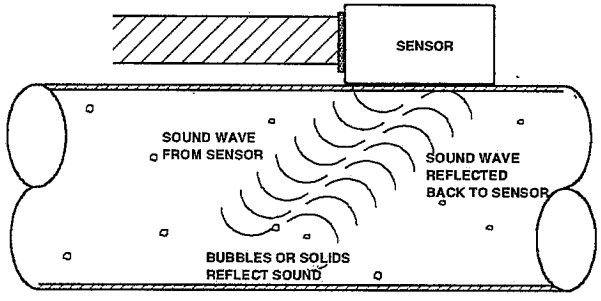
The Greyline portable doppler flow meter consists of an encapsulated ceramic transducer, a transmitter/receiver unit, electronic circuitry to separate the doppler frequency from the transmitted frequency, a digital meter reading flow velocity in feet/second or meters/second (switch selectable) and a programmable totalizer.

The standard portable flow meter is housed in a NEMA4X (raintight) carrying case with an integrated battery charger. Features include switchable damping, sensitivity control, metric scale and a battery test display.

Optional features include current loop outputs, 220VAC input and external DC (24VDC) input.

2. PRINCIPLE OF OPERATION

Greyline flow instruments continuously inject sound into the flowing liquid and measure the change in frequency of any echoes received from suspended particles, air bubbles, etc. in the liquid.



The sound frequency of 640,000 wave-lengths/second travels through the liquid at 4,800 feet/second (1460 meters/second) in water. The 640,000 wave-lengths occupy 4,800 feet. If the target is moving away from the receiver, the same number of wave-lengths has to occupy a bigger distance and so each wave-length appears longer. The longer wave-length means fewer wave-lengths/second or a lower frequency.

The reverse is true if the target moves towards the receiver; the distance is shortened, the wave-length appears shorter and the frequency higher.

Greyline Instruments Inc.
Model PDFM20 Portable Doppler Flow Meter

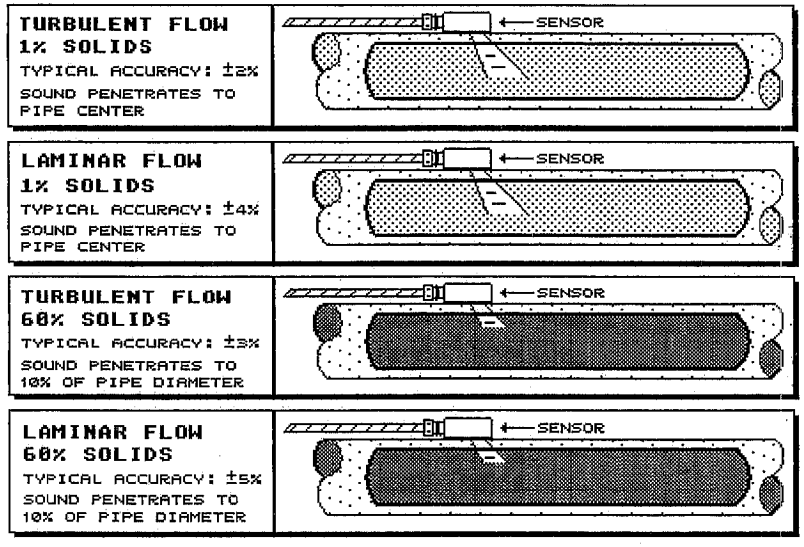
CONVERSION GUIDE

FROM	TO	MULTIPLY BY
US GALLONS	CUBIC FEET	0.1337
US GALLONS	IMPERIAL GALS	0.8327
US GALLONS	LITRES	3.785
US GALLONS	CUBIC METERS	0.003785
US GALLONS	BARRELS	0.0238
LITRES/SEC	GPM	15.85
INCHES	MM	25.4
DEGREES F	DEGREES C	(^{O}F-32) x 0.556
POUNDS	KILOGRAMS	0.453
PSI	BAR	.0676
PSI	KPa	6.895
FOOT^2	METER^2	0.0929

2.1 LAMINAR & TURBULENT FLOW

Two basic conditions exist in flowing liquids. One is turbulent flow, where the velocity of the fluid is the same at the pipe wall as it is in the center. The other is laminar flow, where the flow at the pipe wall is very slow and gradually increases to a maximum at the center of the pipe.

In the factory, all equipment is calibrated and tested against water with a 0.25% entrained air as the reflective medium. Some typical results that may be expected in different situations are shown:



If the sound cannot penetrate to the center of the pipe, a laminar flow condition may cause the flow meter to read low due to a lower flow rate existing at the point at which sound reflection occurs.

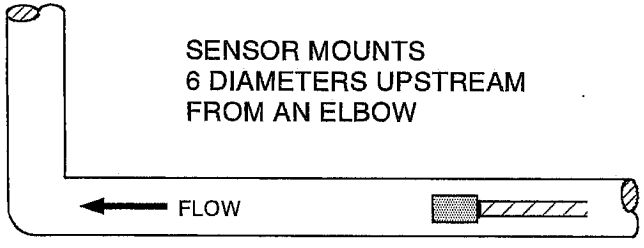
3. APPLICATIONS BACKGROUND

LIQUIDS CONTAIN SOLIDS AND GASES - Flow of most liquids can be measured with a Greyline doppler instrument. Successful applications range from potable water to sewage and ore slurries. As a guideline the measured liquid should contain solids or gas bubbles in concentration of 75 ppm, with a minimum size of 100 microns.

SENSOR COUPLING - The transducer can be attached permanently to the pipe with a fast setting epoxy resin or temporarily with a silicone grease coupling (Dow Corning #4) and a hose clamp or electrician's tape. A coupling compound kit is supplied with each Greyline doppler instrument. The pipe is prepared for sensor mounting by sanding or brushing to remove any loose paint or rust.

The sensor is designed with a flat face so that it can be installed on the outside of a pipe of any diameter. The instrument is designed to produce a high frequency sound that will be reflected by air bubbles, so the air gap between the sensor and the round pipe wall must be filled with a material which readily transmits the sonic energy, rather than reflecting it back to the sensor.

SENSOR POSITIONING - Elbows, flanged connections and tees tend to introduce desirable conditions of an evenly distributed flow profile with some air or gases entrained in the flow. Sensor mounting 6 diameters upstream or 10 diameters downstream from these disturbances is generally optimum.



FLOW CHART - Litres per Minute
Velocity in m/sec

Pipe I.D. mm	Velocity in Metres per Second											
	5.5	6.0	6.5	7.0	7.5	8.0	8.5	9.0	9.5	10.0
15	58.3	63.6	68.9	74.2	79.5	84.8	90.1	95.4	100.7	106.0
20	103.7	113.1	122.5	131.9	141.4	150.8	160.2	169.6	179.1	188.5
25	162.0	176.7	191.4	206.2	220.9	235.6	250.3	265.1	279.8	294.5
32	265.4	289.5	313.7	337.8	361.9	386.0	410.2	434.3	458.4	482.5
40	414.7	452.4	490.1	527.8	565.5	603.2	640.9	678.6	716.3	754.0
50	648.0	706.9	765.8	824.7	883.6	942.5	1001.4	1060.3	1119.2	1178.1
65	1095.0	1194.6	1294.1	1393.7	1493.2	1592.8	1692.3	1791.9	1891.4	1991.0
80	1658.8	1809.6	1960.4	2111.2	2261.9	2412.7	2563.5	2714.3	2865.1	3015.9
90	2099.4	2290.2	2481.1	2671.9	2862.8	3053.6	3244.5	3435.3	3626.2	3817.0
100	2591.8	2827.4	3063.1	3298.7	3534.3	3769.9	4005.5	4241.2	4476.8	4712.4
125	4049.7	4417.9	4786.0	5154.2	5522.3	5890.5	6258.6	6626.8	6995.0	7363.1
150	5831.6	6361.7	6891.9	7422.0	7952.2	8482.3	9012.4	9542.6	10072.7	10602.9
200	10367.3	11309.7	12252.2	13194.7	14137.2	15079.6	16022.1	16964.6	17907.1	18849.6
250	16198.8	17671.5	19144.1	20616.7	22089.3	23562.0	25034.6	26507.2	27979.8	29452.4
300	23326.3	25446.9	27567.5	29688.1	31808.6	33929.2	36049.8	38170.4	40290.9	42411.5
350	31749.7	34636.1	37522.4	40408.7	43295.1	46181.4	49067.8	51954.1	54840.4	57726.8
400	41469.0	45238.9	49008.9	52778.8	56548.7	60318.6	64088.5	67858.4	71628.3	75398.2
450	52484.2	57255.5	62026.8	66798.1	71569.4	76340.7	81112.0	85883.3	90654.6	95425.9
500	64795.4	70685.9	76576.3	82466.8	88357.3	94247.8	100138.3	106028.8	111919.3	117809.8
600	93305.3	101787.6	110269.9	118752.2	127234.5	135716.8	144199.1	152681.4	161163.7	169646.0

FLOW CHART - Litres per Minute
Velocity in m/sec

Pipe I.D. mm	Velocity in Metres per Second 0.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0
15	5.3	10.6	15.9	21.2	26.5	31.8	37.1	42.4	47.7	53.0
20	9.4	18.8	28.3	37.7	47.1	56.5	66.0	75.4	84.8	94.2
25	14.7	29.5	44.2	58.9	73.6	88.4	103.1	117.8	132.5	147.3
32	24.1	48.3	72.4	96.5	120.6	144.8	168.9	193.0	217.1	241.3
40	37.7	75.4	113.1	150.8	188.5	226.2	263.9	301.6	339.3	377.0
50	58.9	117.8	176.7	235.6	294.5	353.4	412.3	471.2	530.1	589.0
65	99.5	199.1	298.6	398.2	497.7	597.3	696.8	796.4	895.9	995.5
80	150.8	301.6	452.4	603.2	754.0	904.8	1055.6	1206.4	1357.2	1508.0
90	190.9	381.7	572.6	763.4	954.3	1145.1	1336.0	1526.8	1717.7	1908.5
100	235.6	471.2	706.9	942.5	1178.1	1413.7	1649.3	1885.0	2120.6	2356.2
125	368.2	736.3	1104.5	1472.6	1840.8	2208.9	2577.1	2945.2	3313.4	3681.6
150	530.1	1060.3	1590.4	2120.6	2650.7	3180.9	3711.0	4241.2	4771.3	5301.4
200	942.5	1885.0	2827.4	3769.9	4712.4	5654.9	6597.3	7539.8	8482.3	9424.8
250	1472.6	2945.2	4417.9	5890.5	7363.1	8835.7	10308.4	11781.0	13253.6	14726.2
300	2120.6	4241.2	6361.7	8482.3	10602.9	12723.5	14844.0	16964.6	19085.2	21205.8
350	2886.3	5772.7	8659.0	11545.4	14431.7	17318.0	20204.4	23090.7	25977.0	28863.4
400	3769.9	7539.8	11309.7	15079.6	18849.6	22619.5	26389.4	30159.3	33929.2	37699.1
450	4771.3	9542.6	14313.9	19085.2	23856.5	28627.8	33399.1	38170.4	42941.7	47712.9
500	5890.5	11781.0	17671.5	23562.0	29452.4	35342.9	41233.4	47123.9	53014.4	58904.9
600	8482.3	16964.6	25446.9	33929.2	42411.5	50893.8	59376.1	67858.4	76340.7	84823.0

The sensor must be mounted away from flow obstructions such as pumps, valves, orfice plates or venturis which tend to increase flow velocity. Partially closed valves often cause cavitation and readings downstream will show much higher velocity.

Depending on velocity, flow will have resumed normal characteristics at a point downstream from the velocity increasing device. Onsite experimentation will usually determine an appropriate up or downstream sensor mounting position. As a guideline, 25 to 40 diameters from the velocity increasing device, flow will be evenly distributed.

TESTING SENSOR POSITION - Before permanently mounting a doppler sensor some onsite testing is recommended. With a sensor mounting position selected, use a temporary coupling compound (supplied with each Greyline instrument) and move the sensor to several positions upstream and downstream from the original location. If varied readings occur another pipe section should be selected to obtain constant readings.

PIPE MATERIAL - Sound conductivity varies according to the density of the pipe wall material. Porous materials such as concrete or wood cause sound attenuation and doppler performance may be erratic. Steel, cast iron, copper, aluminum, PVC, fibreglass and other plastic and metal pipes are generally ideal, with minimal sound attenuation.

Avoid pipes with loose insertion liners where sound transmission may be broken by air gaps. Sound refraction may occur with some liner materials such as cement or coal tar as the doppler signal travels through different densities of the liner and the pipe wall. The resulting error will be constant and can normally be corrected by calibration adjustment in situ.

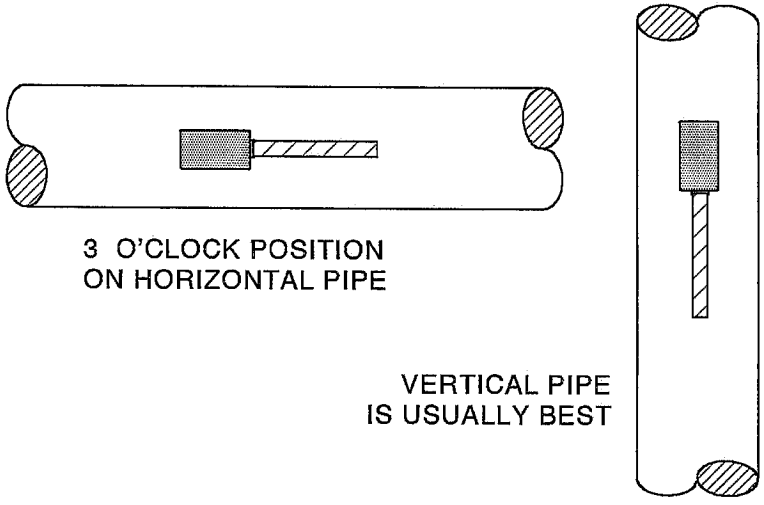
PIPE MEASUREMENT - A doppler instrument measures flow velocity. Volumetric readings are obtained by correlating flow velocity and pipe I.D. Errors in volumetric readings will occur where incorrect pipe cross-section measurements are used.

EFFECTS OF PIPE DIAMETER AND FLOW PROFILE - Standard Greyline DFM sensors are deisigned to mount on pipes 1 inch (25mm) diameter or larger, (an optional small pipe sensor is also available from Greyline). Accuracy of the instrument is affected by both flow profile and pipe diameter.

In large diameter pipes carrying liquids with a high concentration of solids or gases, the doppler signal may not penetrate very deeply into the flow

stream before being reflected back to the sensor. Because fluids tend to move more slowly at the pipe wall than in the center, accuracy may be reduced in large diameter pipes, particularly if measured on a long horizontal pipe run.

VERTICAL OR HORIZONTAL PIPE - Vertical pipe runs are recommended for sensor installation. They generally provide evenly distributed flow conditions. On horizontal pipes the sensor should be mounted at the 3 or 9 o'clock position to avoid concentrations of gas at the top of the pipe and solids on the bottom.



FLOW VELOCITY - The doppler's accuracy tends to be reduced at very slow flow velocities (ie: 5% of scale or less). At low flow rates the doppler signal to noise ratio is substantially reduced and environmental noise may contribute to the flow readings. Engineers will usually design piping systems for velocity in the 10 fps range which is ideal for doppler instruments.

PIPE MATERIAL
Sound conductivity varies according to density of the pipe material. Porous materials such as concrete or pitted cast iron cause sound attenuation and doppler performance may be erratic. Steel, aluminum, copper, PVC and other plastic pipes are generally ideal with minimal sound attenuation.

FLOW CHART - US Gallons per Minute
Velocity in ft/sec

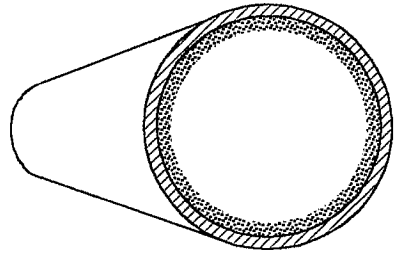
Pipe I.D.in	Velocity in feet per second										
	11	12	13	14	15	16	17	18	19	20
.5	6.7	7.3	7.9	8.5	9.2	9.8	10.4	11.0	11.6	12.2
.75	15.1	16.5	17.9	19.3	20.6	22.0	23.4	24.8	26.1	27.5
1	27.0	29.4	31.9	34.3	36.8	39.2	41.7	44.1	46.6	49.0
1.25	42.1	45.9	49.7	53.6	57.4	61.2	65.0	68.9	72.7	76.5
1.5	60.6	66.1	71.6	77.1	82.7	88.2	93.7	99.2	104.7	110.2
2	107.7	117.5	127.3	137.1	146.9	156.7	166.5	176.3	186.1	195.9
2.5	168.4	183.7	199.0	214.3	229.6	244.9	260.2	275.5	290.8	306.1
3	242.4	264.4	286.5	308.5	330.5	352.6	374.6	396.6	418.7	440.7
3.5	329.9	359.9	389.9	419.9	449.9	479.9	509.9	539.9	569.9	599.9
4	430.9	470.1	509.3	548.5	587.6	626.8	666.0	705.2	744.3	783.5
5	673.3	734.5	795.7	856.9	918.2	979.4	1040.6	1101.8	1163.0	1224.2
6	969.6	1057.7	1145.9	1234.0	1322.2	1410.3	1498.5	1586.6	1674.8	1762.9
8	1723.7	1880.4	2037.1	2193.8	2350.5	2507.2	2663.9	2820.6	2977.3	3134.0
10	2693.3	2938.1	3183.0	3427.8	3672.7	3917.5	4162.4	4407.2	4652.1	4896.9
12	3878.4	4231.0	4583.5	4936.1	5288.7	5641.3	5993.9	6346.4	6699.0	7051.6
14	5278.9	5758.8	6238.7	6718.6	7198.5	7678.4	8158.3	8638.2	9118.1	9598.0
16	6894.9	7521.7	8148.5	8775.3	9402.2	10029.0	10655.8	11282.6	11909.4	12536.2
18	8726.3	9519.6	10312.9	11106.2	11899.5	12692.8	13486.1	14279.4	15072.7	15866.0
20	10773.2	11752.6	12731.9	13711.3	14690.7	15670.1	16649.5	17628.8	18608.2	19587.6
24	15513.5	16923.8	18334.2	19744.5	21154.8	22565.1	23975.4	25385.8	26796.1	28206.4

FLOW CHART - US Gallons per Minute
Velocity in ft/sec

Pipe I.D.in	Velocity in feet per second									
	1	2	3	4	5	6	7	8	9	10
.5	0.6	1.2	1.8	2.4	3.1	3.7	4.3	4.9	5.5	6.1
.75	1.4	2.8	4.1	5.5	6.9	8.3	9.6	11.0	12.4	13.8
1	2.5	4.9	7.4	9.8	12.3	14.7	17.2	19.6	22.1	24.5
1.25	3.8	7.7	11.5	15.3	19.1	23.0	26.8	30.6	34.4	38.3
1.5	5.5	11.0	16.5	22.0	27.6	33.1	38.6	44.1	49.6	55.1
2	9.8	19.6	29.4	39.2	49.0	58.8	68.6	78.4	88.2	98.0
2.5	15.3	30.6	45.9	61.2	76.5	91.8	107.1	122.4	137.7	153.1
3	22.0	44.1	66.1	88.1	110.2	132.2	154.2	176.3	198.3	220.4
3.5	30.0	60.0	90.0	120.0	150.0	180.0	210.0	240.0	270.0	300.0
4	39.2	78.4	117.5	156.7	195.9	235.1	274.2	313.4	352.6	391.8
5	61.2	122.4	183.6	244.8	306.1	367.3	428.5	489.7	550.9	612.1
6	88.1	176.3	264.4	352.6	440.7	528.9	617.0	705.2	793.3	881.5
8	156.7	313.4	470.1	626.8	783.5	940.2	1096.9	1253.6	1410.3	1567.0
10	244.8	489.7	734.5	979.4	1224.2	1469.1	1713.9	1958.8	2203.6	2448.5
12	352.6	705.2	1057.7	1410.3	1762.9	2115.5	2468.1	2820.6	3173.2	3525.8
14	479.9	959.8	1439.7	1919.6	2399.5	2879.4	3359.3	3839.2	4319.1	4799.0
16	626.8	1253.6	1880.4	2507.2	3134.1	3760.9	4387.7	5014.5	5641.3	6268.1
18	793.3	1586.6	2379.9	3173.2	3966.5	4759.8	5553.1	6346.4	7139.7	7933.0
20	979.4	1958.8	2938.1	3917.5	4896.9	5876.3	6855.7	7835.0	8814.4	9793.8
24	1410.3	2820.6	4231.0	5641.3	7051.6	8461.9	9872.2	11282.6	12692.9	14103.2

Avoid pipes with loose insertion liners where sound transmission may be broken by air gaps. Sound refraction may occur with some liner materials such as cement or coal tar as the doppler signal travels through different densities of the liner and pipe wall. The resulting error can normally be corrected by calibration in situ.

DEPOSITS - Scale or sediment deposits reduce the pipe cross-section resulting in high flow volume readings. Deposits can also cause sound attenuation and reduce doppler signal strength.



NOISE INTERFERENCE - Greyline doppler flow meters are designed to lock onto the strong doppler return signal and to ignore most broadband environmental noise. Signal strength is monitored automatically and the instrument will lock out readings from noise or vibration when signal strength is weak. Marginal applications, where very minimal solids or gases are present in the fluid to return the doppler signal are more sensitive to external noise.

PIPE VIBRATION - Severe pipe vibration may cause the doppler to interpret noise caused by the vibration as a doppler signal. Because the doppler sensor is in motion on the vibrating pipe, it may detect a frequency shift even if the liquid inside the pipe is not flowing. An onsite test is recommended where pipe vibration is expected.

ELECTRICAL INTERFERENCE - High voltage sources or DC motors in very close proximity to the doppler sensor, cable or electronics, can interfere with the doppler signal. Equipment within government RFI regulations will not normally interfere with doppler operation. Stray mains voltage (50 or 60 Hz) can occasionally be measured on conductive pipes and care should be taken to eliminate the problem at its source.

POWER LINE FLUCTUATIONS - Voltage variences of +/- 10% of the instrument's nominal input will not affect performance or accuracy.

FLUID TEMPERATURE - Within the sensor tolerances (-10°F to 200°F) the doppler accuracy will not be affected more than 0.3%. Higher or lower temperatures may damage or reduce the operating life of the sensor.

PRESSURE - Gases or air bubbles released in the flow will be affected by pressure inside the pipe. Clean liquids normally carry gas bubbles which are released as the liquid flows through the pipe. These bubbles serve to reflect the doppler signal. Most liquids, including potable water, will carry sufficient bubbles at pressures up to approximately 80 psi (5.4 bar). An onsite test should be conducted to confirm performance at higher pressures. Sensor mounting at the 12 o'clock position on horizontal pipe will often improve doppler signals at high pressures.

HAZARDOUS LOCATIONS - Doppler flow meters and switches can be housed in optional explosion proof enclosures. Greyline sensors are also available with optional intrinsic safety barriers (mounted in the instrument enclosure) which allow sensor installation in a hazardous rated location.

Greyline Instruments Inc.
Model PDFM20 Portable Doppler Flow Meter

LIMITED WARRANTY

Greyline Instruments warrants, to the original purchaser, its products to be free from defects in material and workmanship for a period of one year from date of invoice. Greyline will replace or repair, free of charge, any Greyline product if it has been proven to be defective within the warranty period. This warranty does not cover any expenses incurred in the removal and re-installation of the product.

If a product manufactured by Greyline should prove defective within the first year, return it freight prepaid to Greyline Instruments along with a copy of your invoice.

This warranty does not cover damages due to improper installation or handling, acts of nature, or unauthorized service. Modifications to or tampering with any part shall void this warranty. This warranty does not cover any equipment used in connection with the product or consequential damages due to a defect in the product.

All implied warranties are limited to the duration of this warranty. This is the complete warranty by Greyline and no other warranty is valid against Greyline. Some states do not allow limitations on how long an implied warranty lasts or limitation of incidental or consequential damages, so the above limitations or exclusions may not apply to you.

This warranty gives you specific legal rights, and you may also have other rights which vary from state to state.

Greyline Instruments Inc.

10. APPLICATIONS HOTLINE

For applications assistance, advice or information on any Greyline instrument contact your Sales Representative, write to Greyline or phone the Applications Hotline below.

United States: 1-315-788-9500

Canada & International 1-613-938-8956

GREYLINE INSTRUMENTS INC.

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800 Campbell Street
Cornwall, Ontario K6H 6L7
Canada
FAX: 613-938-4857

R.D. #3, Box 198
S. Racquette River Road
Massena, NY 13662
U.S.A.
Fax: 315-764-0419

11. TO IDENTIFY YOUR INSTRUMENT SERIES

MANUAL SERIES	CIRCUIT BOARD SERIES	REVISION HISTORY	DATE
5.0	7800-5/6	Leather case with signal strength meter	Up to May '88
5.1	7800-6	Fiberglass enclosure Digital readout Switch selectable scale M/Sec and Ft/Sec	June '88
6.0	10200 REV-B	Frequency reference Extended cable option	August '90

4. USE OF THE FLOW METER

4.1 TRANSDUCER

The transducer must be fixed securely to the pipe with coupling material between the transducer face and the pipe. The transducer cable should then be plugged into the transducer socket.

4.2 POWER REQUIREMENTS

The portable doppler flow meter uses a detachable power cord suitable for 110 volt AC power (220 VAC optional).

4.3 SIGNAL STRENGTH METER

Indicates strength of received doppler signal. Used to adjust position of sensor on pipe to find maximum signal. The flow meter will only operate when signal strength is GREEN. This eliminates errors due to noise and interference.

4.4 F/SEC - M/SEC SCALE SWITCH

The calibrated maximum reading in the F/Sec scale is 20.0 ft./sec. Maximum reading in the M/Sec scale is 10.0 m/sec.

4.5 THE METER READING

The meter displays flow velocity or speed in ft./sec. (or m/sec.). Flow volume in gals./min, litres/hr or any other units can be calculated by multiplying the meter readings by the correct value.

FT/SECOND SCALE

US GAL/SEC	= METER READING X (PIPE ID IN)^2 X	0.0408	
IMP GAL/SEC	= METER READING X (PIPE ID IN)^2 X	0.0340	
CUBIC YARDS/SEC	= METER READING X (PIPE ID IN)^2 X	0.2020 X 10-3	
LITRES/SEC	= METER READING X (PIPE ID IN)^2 X	0.1545	
CUBIC M/SEC	= METER READING X (PIPE ID IN)^2 X	0.1545 X 10-3	

METRIC SCALE

LITRES/SEC	= METER READING X (PIPE ID MM)^2 X	7.85398	- 10,000
CUBIC M/SEC	= METER READING X (PIPE ID MM)^2 X	7.85398	- 10,000,000
US GAL/SEC	= METER READING X (PIPE ID MM)^2 X	2.075	- 10,000
IMP GAL/SEC	= METER READING X (PIPE ID MM)^2 X	1.7287	- 10,000
CUBIC FT/SEC	= METER READING X (PIPE ID MM)^2 X	2.7732	- 100,000

4.6 SENSITIVITY CONTROL
Adjust sensitivity potentiometer counterclockwise (-) to reduce signal strength if installation site is noisy or interference is suspected.

4.7 DAMPING SWITCH
Switch the damping switch ON (■) when measuring fluctuating flows. With the damping switch OFF flow trends can be monitored.

4.8 BATTERY TEST
Press the power switch to position TEST and observe the signal strength meter. Charge batteries if the reading is in the red area (including the 50% mark).

4.9 BATTERY CHARGING
To fast charge the PDFM20 (8 hours or less), leave the power switch in the OFF position and plug into a 110V 60Hz (220V 50Hz optional) outlet.

5. TRANSDUCER INSTALLATION

Transducer installation entails three basic steps:

SITE SELECTION, SITE PREPARATION AND
TRANSDUCER BONDING.

1) The transducer should be situated on the bottom or side of any horizontal run of pipe. For vertical pipes, the transducer need only be placed so that its longitudinal axis is parallel to the direction of flow.

2) Select a transducer site several diameters downstream from valves, fittings or pumps. An established flow pattern is necessary for accurate, repeatable velocity measurement.

3) The transducer is designed to mount longitudinally on a straight section of pipe. Do not attempt to mount it on bends, elbows or fittings.

4) In horizontal pipelines, do not mount the transducer on the top of the pipe because vapor trapped during normal flow conditions can cause erratic results.

reflected back to the sensor to indicate flow velocity. Gas bubbles or suspended solids act as reflectors for the doppler signal. As a guideline, Greyline doppler flow meters are recommended for liquids containing solids or bubbles with a minimum size of 100 microns and a minimum concentration of 75 ppm. Most applications will meet this minimum requirement.

Can the sensor be submerged in water?

Yes, for short periods of time or by accident, but not recommended for continuous operation. The sensor is constructed to withstand submersion to 10 psi without damage, but external liquid in contact with the sensor can be interpreted as flow and cause false readings.

What is the purpose of the Signal Strength Meter and Sensitivity adjustment?

Doppler signals below the green band on the signal strength display are not accepted or processed by the instrument. This feature assists in rejection of environmental noise and vibration. For optimum noise rejection the sensitivity control should be adjusted so that signal strength is in the centre of the green band. Note that low flow velocities generally provide lower signal strength than high velocities. In applications with varying flow rates, sensitivity should be adjusted with signal strength in the green band at low velocity.

Can I change the length of the sensor cable?

Yes. Technological advances in Greyline Doppler design allow cable lengths up to 500 ft (152m) with no loss of signal strength. Optional cable extensions with coupling hardware are available from Greyline. Use only RG174U coaxial cable.

COMMON QUESTIONS & ANSWERS

The pipe vibrates\ Will it affect the flow meter?

Common vibration frequencies are far lower than the sonic frequencies used by the Greyline flow meter, and will not normally affect accuracy or performance. However, applications where very weak doppler signal is present (when sensitivity is adjusted to maximum and signal strength shows just above 50%), accuracy may be affected by pipe vibration, or the flow meter may show readings under no-flow conditions. Attempt to relocate the sensor on a pipe section where vibration is reduced, or arrange pipe mounting brackets to reduce vibration at the sensor mounting location.

The flow meter must be installed in a high noise environment\ Will this affect operation?

Greyline flow meters are designed to discriminate between environmental noise and the doppler signal. High noise environments may affect the flow meter's performance where low signal strength and/or low flow velocities are being measured. If adjustment of the flow meter sensitivity does not eliminate noise interference a non-acoustic flow meter should be considered for the application.

Will pipe corrosion affect accuracy of the flow meter?

Yes. Rust, loose paint etc. must be removed from the outside of the pipe before installing a doppler sensor. Severe corrosion on the inside of the pipe may prevent the doppler signal from penetrating into the flow. If the pipe cannot be cleaned, a spool piece (PVC recommended) should be installed for sensor mounting.

What effect do pipe liners have on the flow meter?

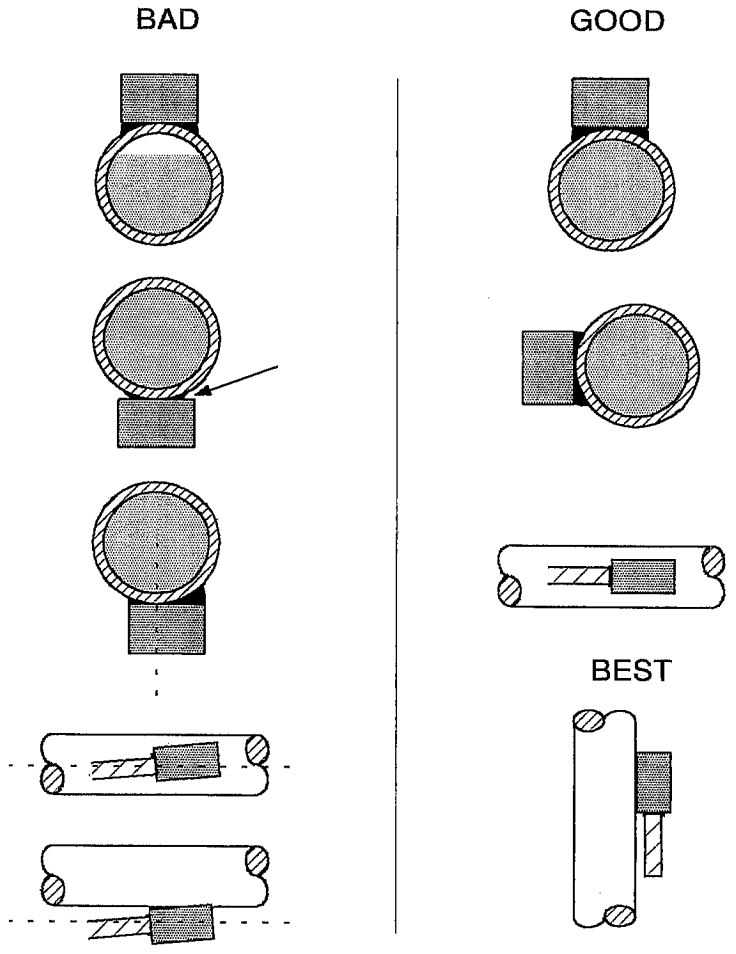
The air gap between loose insertion liners and the pipe wall prevent the doppler signal from entering the flow. Better results can be expected with bonded liners such as cement, epoxy or tar, however an on site test is recommended to determine if the application is suitable for a doppler flow meter.

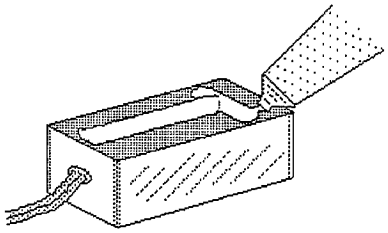
Why is doppler only recommended for liquids containing suspended solids or gases?

The doppler sensor transmits sound into the flow stream which must be

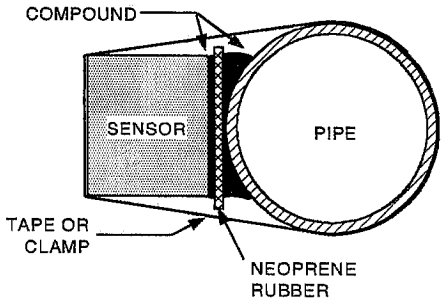
TRANSDUCER MOUNTING

SENSOR COUPLING AND MOUNTING RECOMMENDATIONS





Apply coupling compound to Sensor face, then press Sensor on to the pipe.



Compound must fill the gap between the Sensor face and pipe. Secure in place with tape or pipe clamp. Do not over tighten.

A neoprene rubber pad (supplied) mounted between the sensor and pipe improves performance in many applications

5) Prepare an area 2 in. wide by 3 in. long (5cm by 8cm) for transducer bonding by removing all loose paint, scale and rust. The objective of site preparation is to eliminate any discontinuity between the transducer and the pipe wall which would prevent acoustical coupling.

For temporary bonding, the following can be used:

a) Dow Corning silicon compound #4 (supplied with each new PDFM20).
b) Electrocardiograph gel.
c) Petroleum gel.

The above are arranged in their order of preferred application. B & C are only good for room temperature application.

DO NOT USE: Silicon RTV compound (silicon rubber).

9. TROUBLESHOOTING

METER READING LOWER THAN EXPECTED

Possible Cause:	Lower flow rate than expected.
	Signal not penetrating far enough into the pipe.
	Improper mounting of sensor.
Corrective Action:	Increase sensitivity.
	Check transducer installation.
	Compare velocity with alternative instrument.

METER READING WHEN THERE IS NO FLOW

Possible Cause:	Vibration on pipe.
	Local electrical noise.
Corrective Action:	Reduce sensitivity.

METER READING ERRATIC

Possible Cause:	Sensor mounted too close to valve or other source of cavitation.
Corrective Action:	Change sensor placement.

NO METER DEFLECTION

Possible Cause:	Battery not charged.
	Not enough suspended particles or gases in the fluid.
	Signal unable to penetrate pipe wall.
Corrective Action:	Increase sensitivity
	Charge battery.
	Inject air into pipeline.
	Relocate sensor. Install PVC or steel spool piece.

METER READING TOO HIGH

Possible Cause:	Vibration or noise on the pipeline.
	Mounted too close to a velocity increasing device.
Corrective Action:	Decrease sensitivity.
	Relocate sensor.

8. BATTERY CARE AND MAINTENANCE

The PDFM20 is equipped with an 18 VDC internal gel-type battery pack. With normal use and care the batteries will last indefinitely. Test battery charge condition by pressing the POWER/TEST switch towards TEST and observing the signal strength meter. Deflection in the RED zone indicates a recharge is required. Deflection in the Green zone indicates satisfactory charge.

To prolong battery life:

- Recharge battery (by plugging into 120V [220V optional] outlet with power switch OFF) when charge level is in the red scale. Allow 8 hours for full charge.
- Do not leave power switch ON while PDFM20 is in storage.
- Do not leave batteries for more than 90 days without recharging. If batteries are fully discharged for a long period of time, recharge the flow meter (with the power switch OFF) for 5-10 days to reactivate batteries.

9.1 BATTERY REPLACEMENT

For access to battery compartment remove Phillips head screws from cover hinges, and screws in base of internal storage compartment. Lift off entire face of the instrument. Remove retaining frame from batteries.

6. INSTRUMENT CALIBRATION CHECK

All Greyline flow meters are tested and calibrated at the factory.

To compare readings with another flow instrument, the measured flow must be converted to flow velocity in feet/second (metres/second).

FT/SEC. SCALE	METRIC SCALE
MEASURED FLOW MULTIPLY BY VELOCITY	*MEASURED FLOW MULTIPLY BY VELOCITY*
US GAL/SEC X $\frac{100}{4.08 \times (\text{Pipe ID in})^2}$ = FT/SEC	US GAL/SEC X $\frac{10,000}{2.075 \times (\text{Pipe ID mm})^2}$ = M/SEC
US GAL/MIN X $\frac{1}{2.448 \times (\text{Pipe ID in})^2}$ = FT/SEC	US GAL/MIN X $\frac{100}{1.245 \times (\text{Pipe ID mm})^2}$ = M/SEC
IMP GAL/SEC X $\frac{100}{3.40 \times (\text{Pipe ID in})^2}$ = FT/SEC	IMP GAL/SEC X $\frac{10,000}{1.7287 \times (\text{Pipe ID mm})^2}$ = M/SEC
IMP GAL/MIN X $\frac{1}{2.040 \times (\text{Pipe ID in})^2}$ = FT/SEC	IMP GAL/MIN X $\frac{100}{1.0372 \times (\text{Pipe ID mm})^2}$ = M/SEC
LITRES/SEC X $\frac{10}{1.545 \times (\text{Pipe ID in})^2}$ = FT/SEC	LITRES/SEC X $\frac{10,000}{7.85398 \times (\text{Pipe ID mm})^2}$ = M/SEC
LITRES/MIN X $\frac{1}{9.27 \times (\text{Pipe ID in})^2}$ = FT/SEC	LITRES/MIN X $\frac{100}{4.71239 \times (\text{Pipe ID mm})^2}$ = M/SEC
CUBIC M/SEC X $\frac{10,000}{1.545 \times (\text{Pipe ID in})^2}$ = FT/SEC	CUBIC M/SEC X $\frac{10,000,000}{7.85398 \times (\text{Pipe ID mm})^2}$ = M/SEC
CUBIC M/MIN X $\frac{1,000}{9.27 \times (\text{Pipe ID in})^2}$ = FT/SEC	CUBIC M/MIN X $\frac{100,000}{4.71239 \times (\text{Pipe ID mm})^2}$ = M/SEC
EXAMPLE: 3 in. ID pipe, flow reading 6 l/sec:	*EXAMPLE:* 80 mm ID Pipe, flow reading 6 l/sec
VELOCITY = $\frac{6 \times 10}{1.545 \times 3 \times 3}$ = 4.3 FT/SEC	VELOCITY = $\frac{6 \times 10,000}{7.85398 \times 80 \times 80}$ = 1.1937 M/SEC

7. USE OF THE TOTALIZER

Accumulated flow is indicated on the digital LCD totalizer. The totalizer accumulates flow volume from the fluid velocity, the pipe cross-sectional area and the time period of measurement.

TO PROGRAM THE TOTALIZER:

1) Totalizer switch OFF
2) Calculate volume of flow/second* (see charts below) and leave calculated value on display
3) Press '+'.
4) Press '+' again
5) Press '0' (totalizer display reset)
6) To start totalization switch totalizer ON (■)
7) To stop totalization switch totalizer OFF

NOTE: Totalizer shows units used in the calculation.

TO STORE THE K FACTOR:

1) Totalizer switch 'OFF'
2) Calculate volume of flow/second (see Charts on next page) and leave the calculated value on the display.
3) Press 'M+'
4) Press 'C'. Now the keypad can be used as a regular calculator and the K-factor is stored in memory.

TO RESTORE AND USE A STORED K FACTOR:

1) Press 'C' to clear the totalizer display
2) Press 'MR' to restore the K-factor to the display
3) Press '+'
4) Press '+' again (shows 'K')
5) Press '0' (totalizer display reset)
6) To start totalization switch totalizer ON (■)
7) To stop totalization switch totalizer OFF

TO CLEAR K FACTOR FROM MEMORY:

1) Press 'AC'. The display and memory are cleared and reset to 0.

FT/SECOND SCALE

* VOLUME OF FLOW/SECOND CALCULATION:

Flow/sec At full scale	= (Pipe ID in.)^2	x	$\frac{3.142 \times 20}{4 \times 144}$ = 0.1091 cu. ft.
US Gallons	= (Pipe ID in.)^2	x	0.8161
Imp Gallons	= (Pipe ID in.)^2	x	0.6799
Litres	= (Pipe ID in.)^2	x	3.0894
Cubic Metres	= (Pipe ID in.)^2	x	3.0894 x 10^{-3}

EXAMPLE: 4 ID pipe, to totalize in US gallons

Flow/sec = 4 x 4 x 0.8161
= 13.0576 US gallons
Press '+'. Press '+' again.
Display will now show: K. 13.0576 +
Press '0'.
Switch totalizer 'ON' to accumulate flow.

METRIC SCALE

* VOLUME OF FLOW/SECOND CALCULATION:

Flow/sec At full scale	= (Pipe ID mm.)^2	x	$\frac{3.142 \times 10}{4 \times 1000{,}000}$		= m^3
Cubic Metres	= (Pipe ID mm)^2	x	7.85398	÷	1,000,000
Litres	= (Pipe ID mm)^2	x	7.85398	÷	1,000
US Gallons	= (Pipe ID mm)^2	x	2.0750	÷	1,000
Imp Gallons	= (Pipe ID mm)^2	x	1.7287	÷	1,000

EXAMPLE: 100 mm ID pipe, to totalize in litres

Flow/sec = 100 x 100 x 7.85398 ÷ 1,000
= 78.5398 litres
Press '+'. Press '+' again.
Display will now show: K. 78.5398 +
Press '0'.
Switch totalizer 'ON' to accumulate flow.