McMILLAN COMPANY

MODEL 100 FLO-SENSOR

FREQUENTLY ASKED QUESTIONS

May 1996

1. **Since the Model 100 Flo-Sensor uses the Pelton Turbine Wheel Principle, how in general, is its behavior when comparing its operation to either a ball and tube rotameter or a mass flow sensor?**

   Turbine wheel gas flow sensors behave very closely in operation to that of ball and tube rotameters in many ways, but, it, of course, provides a linear D.C. output voltage proportional to flow rate. Unlike thermal mass flow senors, Model 100, due to its design, has no zero drift problems.

2. **Linearity is quoted at ± 3% full scale. At what % of full scale does the maximum non-linearity occur and is this % position the same for all ranges of flow sensors?**

   ± 3% full scale linearity is a safe tolerance for production of flow sensors. (see figures III through V). There will be no absolute pattern, but many units shipped are quite linear. Others fall near maximum limits. We offer a $200.00 calibration service for individuals who desire the actual data. This price is subject to change without notice and excludes hydrogen gas.

3. **Are the Flo-Sensors sensitive to mounting orientation?**

   Yes, the flow sensors, like conventional ball and tube flow meters, are sensitive to mounting orientation and have been tested at factory in horizontal position. Units can be recalibrated vertically or on their sides but calibration data will differ. Refer to INSTALLATION information on page 4 of X-100 instruction manual. Models 100-3 and 100-4 only operate horizontally.

4. **Do you recommend using an in-line filter before the sensor?**

   Yes, an in-line filter is quite beneficial and will insure longer life and minimize fouling up sensor. We suggest 7 or 10 micron filtering. Also, when operating with most gases, sensor should be kept slightly warmer than the gases (within limit of its maximum operating temperature) to prevent moisture from condensing so that water droplets get into sensor. This can stop the operation of flow sensor until all liquid droplets have been baked out of sensor.

5. **Quoted maximum operating pressures is 40psi 20° C. Is this absolute or gauge pressue? Can unit be operated above 40psi? Is sensor sensitive to line pressure in reading flow rate? What is the typical pressure drop across flo-sensor?**

40psi is 40 psig. We do not suggest operation at pressures in excess of this value. Although in proof pressure tests, failure of a plastic tube fitting at 380psig was first failure noted (test was at 25° C.). It is perfectly okay to operate sensor at 30psig all the time but sensor is sensitive to line pressure. See enclosed technical data, figure I. Pressure drop across sensor varies with flow rate. Model 100-3 pressure drop is 20 inches of water at 100ml/min of dry air flow, while model 100-5 is only 3 inches of water at 500ml/min of dry air flow. Models 100-6 through 8 have 2 inches of water pressure drop at their rated flows.

6. **Below the minimum specified flow rate (say less than 20 ml/min for the 100-3 Flo-Sensor) does the turbine wheel actually stop rotating or is it just that the output voltage is unreliable or non-linear? Do you intend to supply a flow sensor capable of measuring gas flows below 20ml/min?**

   For 100-3, the turbine wheel typically stops rotating at about 8ml/min. Between 8ml/min and 20 ml/min, the flow sensor would actually send out at D.C. voltage signal but it would be somewhat lower in voltage than the straight line voltage vs. flow rate curve indicates. Here again, since these units are mass produced, we cannot give you any specific curve since every unit would be a little different. We do not currently anticipate producing a gas flow sensor for measurement of gases below 20ml/min. See figures III through V.

7. **Can the Flo-Sensors be damaged by flow rates much higher than their maximum rated flow rates?**

   Flow sensors can be continuously operated up to 6 VDC without damage. This is about 20% higher than rated flow rate. Units can be subjected to 3 to 4 times normal maximum rated flow without damage so long as the unit is only momentarily hit with such a high flow rate. Life expectancy is increased 9 times longer when operating at ⅓ rated flow.

8. **Can the Flo-Sensors be used for corrosive gases such as SO_2, NO_2, NO, or H_2S?**

   Yes, units are operating on many gases including SO_2, NO_2, and H_2S.

9. **What is the expected life of the sensors? What components are most lively to fail first?**

   Guaranteed life is one year. We do not yet have sufficient field experience to tell us expected life. Bearings and turbine wheel shaft are the only items we expect will fail. See question 7.

10. **You specify two types of tube fittings, Acetal and Kynar. When would you use one fitting rather than the other? You specify two types of "O" rings, silicone and citon, when would you use one type of "O" ring rather than the other?.**

    See enclosures pretaining to "O" rings and fittings, table I & II.

11. **What tubing diameter do you suggest for connecting to the various Flo-Sensors?**

    All low flow range sensors are designed for operation up to and including 1 liter/minute using 1/8" tubing. At flow rates in excess of 1 liter/minute, we go to fittings designed to accept 1/4" tubing. (above 20L/min. use 3/8" O.D. tubing.) Above 50 L/min. use ½" O.D. tubing.

12. **What is the output impedance of the 0-5 VDC output voltage?**

    Output impedance of flow sensor is virtually 0 ohms, but if a load lower than 2500 ohms is applied across output, the internal circuitry begins to artificially add impedance up to 300 ohms to prevent a short circuit malfunction. So we suggest that customer not draw more than 1 milliampere from our flow sensor to insure best operation. This would mean sensor would drive into a load of at least 5000 ohms.

13. **When operating Flo-Sensor on gases other than air, does the calibration change?**

    Yes, like a conventional ball and tube rotameter, model 100 Flo-Sensor needs to be calibrated on the gas type that will be flowing through it. See curve enclosed showing calibration adjustments for gases other than air. Customer should specify gas type when ordering. Otherwise, all Flo-Sensors are routinely calibrated using air. Figure II

14. **Temperature sensitivity is how in relation to increasing temperature or decreasing temperature?**

    Increasing temperature causes a rise in output voltage at rate of 0.2%/°C. or less without any change in actual gas flow rate. Likewise decreasing temperature causes a decrease in output voltage at rate of 0.2%/°C. or less without any change in actual gas flow rate. A step change in temperature will not cause an instantaneous error to occur in output signal. Time constant for error change to occur due to step change in temperature is approximately 15-30 minutes.

15. **Can Flo-Sensors operate at voltages other than the specified 12.5VDC ± 2VDC?**

    Yes, 100B models operate at 3-6 VDC. Special units can be ordered to operate from 9 VDC to in excess of 16 VDC. Contact factory for details.

16. **Can you provide a pulse output?**

    Yes, we can furnish an unbuffered 0-500 pps output that corresponds to flow rate where 500 pps is full scale flow output.

17. **Since turbine wheel shaft and/or sapphire bearings are subject to wear and will eventually fail, what is the policy for repair and replacement of these worn components?**

    Units shipped to us freight prepaid will be repaired at no charge if within our one year warranty. If out of warranty, a $75.00 repair charge

will apply as of January 1, 1991. Repair charges for out of warranty repairs are subject to change without notice. This charge of $75.00 includes retest of unit on air to insure its proper operation. Shipment will normally be U.P.S. and freight charges will be added to invoice charges. A simple change out of a saddle assembly which takes 5 minutes includes bearings, turbine wheel and shaft and is simple to install. Current cost is $57.50. Customer can install these saddle assemblies.

18. **Would you show us typical flow rate versus voltage output curves for the various gas flow sensors?**

    Three curves are enclosed as representative. Note, however, that each flow sensor shipped could deviate within specification limits from these representative flow rate versus voltage curves. If it is desired to have the actual calibration data for a particular flow sensor, this can be furnished at added cost. Contact factory for details and specify gas that will be used. Actual pressure inside housing that unit will experience during operation.

19. **What is response time constant of flo-sensor?**

    Typically 8-10 seconds for 0-63% of final value. Appox. 30 seconds for 98% of final value.

TABLE I

SUITABILITY OF "O" RINGS

Gases	Silicone	Viton
Acetone vapors	poor	poor
Acetylene	good	excellent
Ammonia (cold)	excellent	poor
Ammonia (hot)	excellent	poor
Benzene	poor	poor
Butane	poor	excellent
Carbon dioxide	excellent	excellent
Carbon monoxide	excellent	excellent
Carbon tetrachloride	poor	excellent
Chlorine (dry)	--	excellent
Chlorine (wet)	--	excellent
Chloraform	poor	excellent
Denatured alcohol vapors	excellent	excellent
Diesel oil vapors	poor	excellent
Dry cleaning fluids	--	excellent
Ethane	poor	excellent
Ethyl alcohol vapors	excellent	excellent
Ethylene	--	excellent
Freon 11	poor	excellent
Freon 12	poor	good

CONTINUED TO PAGE 5

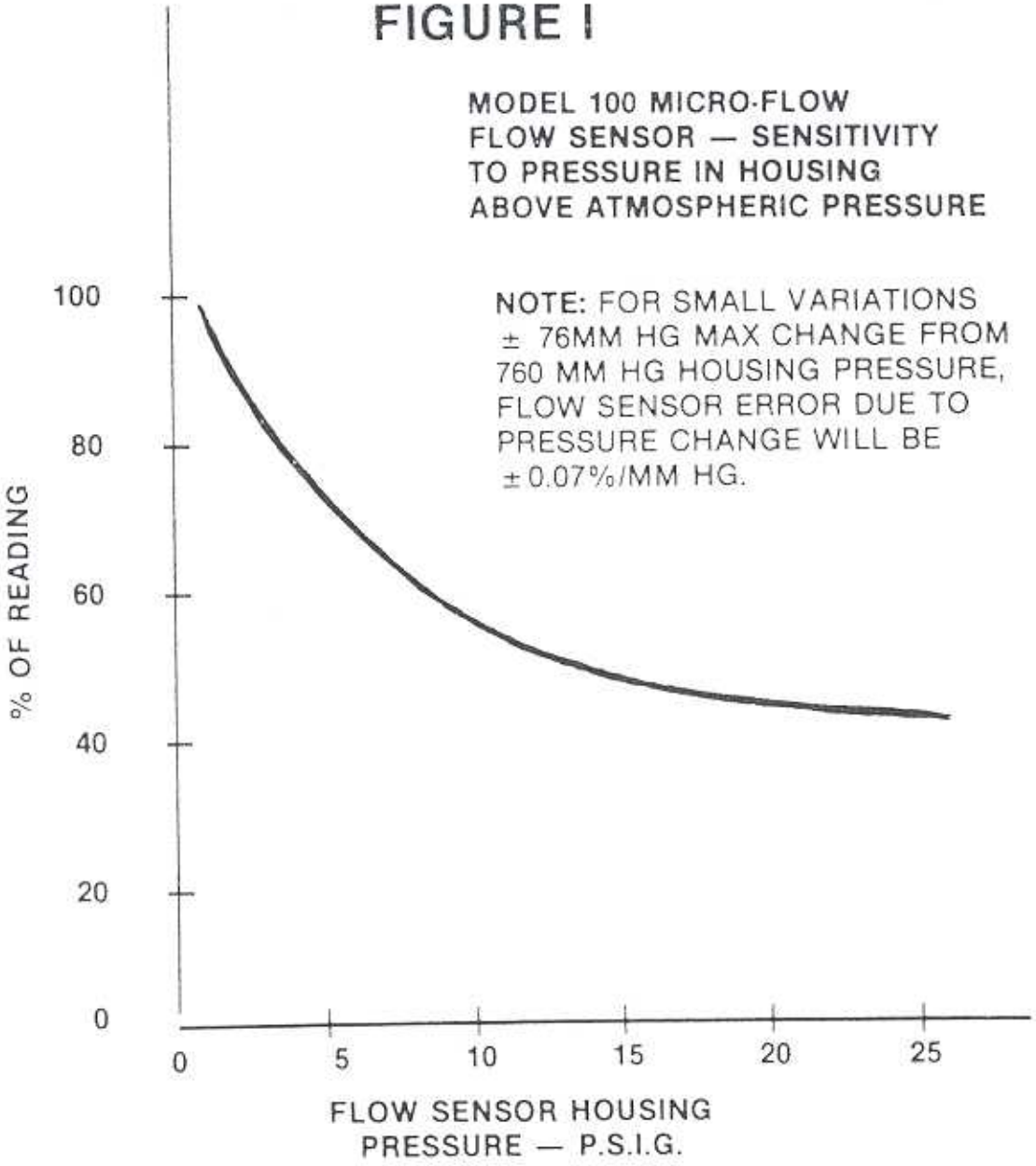
TABLE I (continued from page 4)

Freon 13	poor	excellent
Freon 21	poor	poor
Freon 22	poor	poor
Gasoline vapor	poor	excellent
Hexane	poor	excellent
Hydrogen	fair	excellent
Hydrogen sulphide (concentrated/wet)	fair	poor
Mustard gas	excellent	poor
Naptha	poor	excellent
Natural gas	good	excellent
Methane	poor	excellent
Methyl Ethyl Ketone vapors	poor	poor
Nitrogen	excellent	excellent
Nitric oxide	poor	excellent
Nitrogen dioxide	poor	excellent
Ozone	excellent	excellent
Producer gas	good	excellent
Propane	poor	excellent
Tolvene vapors	poor	excellent
Water vapor	excellent	excellent

TABLE II
SUITABILITY OF TUBE FITTINGS

	Acetal	Kynar (Polyvinylidene Flouride)
Weak bases and salts	excellent	excellent
Aliphatic solvents	excellent	excellent
Esters and Keystones	excellent	poor
Chlorinated solvents	good	excellent
Strong bases	excellent	excellent
Aromatic solvents	excellent	excellent
Strong oxidents	fair	good to excellent
Halogens	poor	excellent
Strong acids	unacceptable	excellent
Inert gases	excellent	excellent

FIGURE I



TEST CONDITIONS:
ATM. PRESSURE — 760 MM HG.
AMBIENT TEMP. — 25°C

WITH TRUE GAS FLOW MAINTAINED CONSTANT, FLOW SENSOR OUTPUT VOLTAGE DROPS AS BACK PRESSURE INCREASES IN FLO-SENSOR HOUSING ACCORDING TO CURVE ABOVE WHICH FOLLOWS EQUATION:

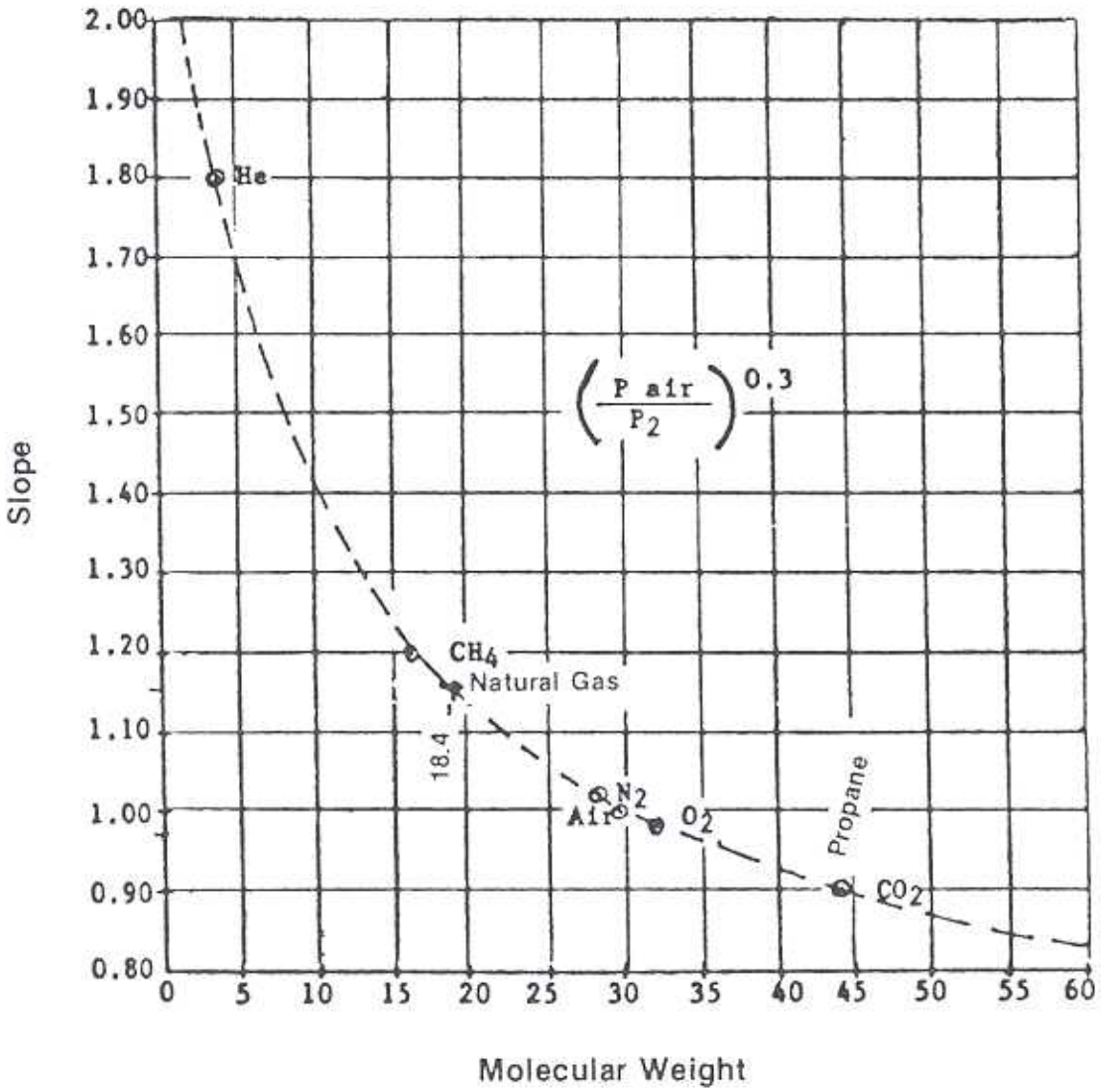
INDICATED FLOW (V.D.C.) = ACTUAL FLOW X $\sqrt{\frac{P_{STD.}}{P_{HOUSING}}}^{0.84}$

WHERE P HOUSING IS ALWAYS GREATER

THAN PSTD = 14.7 PSIA.; P HOUSING = P.S.I.A.

FIGURE II

CALIBRATION ADJUSTMENTS FOR GASES OTHER THAN AIR



For example, a flow sensor calibrated on air (760mm Hg, 25°C) to produce 100ml/min output at 5 VDC will give 180ml/min of He at 5 VDC output.

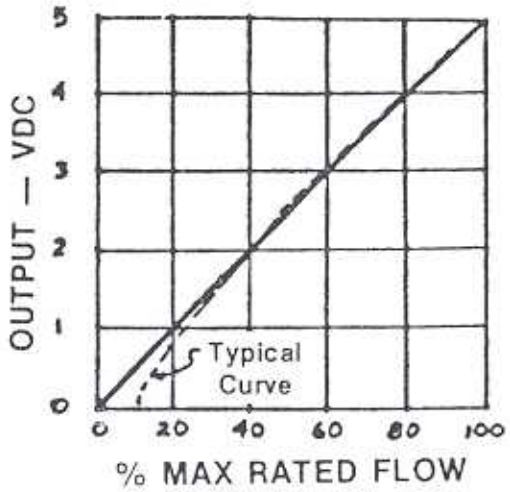
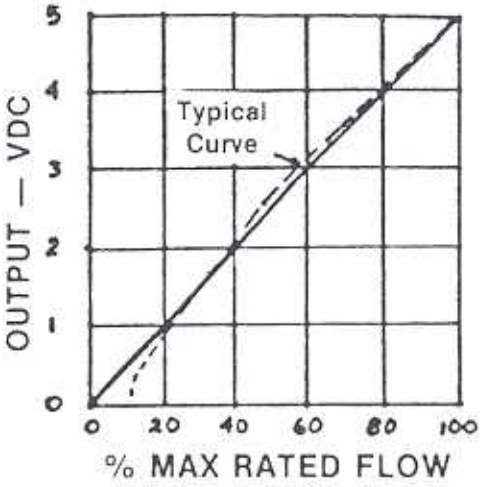


FIGURE III

MODELS 100-3 THRU 100-5

FIGURE IV

MODELS 100-6 AND 100-7



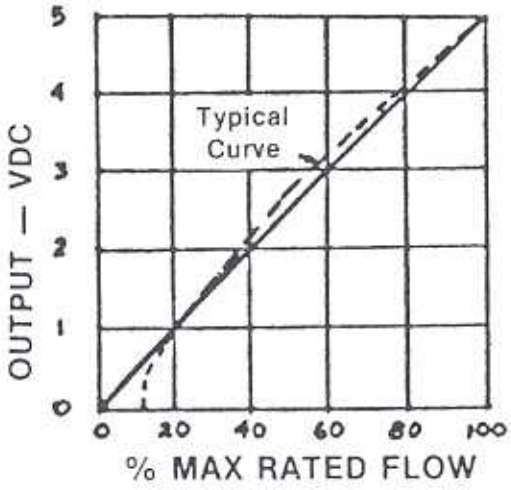


FIGURE V

MODELS 100-8 THRU 100-10