020U-1

MKS INSTRUMENTS, INC.

The following data was measured on the MKS Baratron pressure sensor identified below. Calibration was performed using MKS transfer standard S/N 34862-1 which is calibrated with a CEC Air Dead-weight Tester, traceable to the National Institute of Standards and Technology via test report number(s); P-8227A P-8227B P-8227C 731/243203 737/234759

390 | 1.0 TORR

PRES. OUT STD.	V OUT STD.	V OUT UUT	ERROR mV
0.00000	0.0000	0.0000	0.0
.11026	1.1026	1.1032	.6
.20336	2.0336	2.0337	.1
.31143	3.1143	3.1142	-.1
.41058	4.1058	4.1055	-.3
.51083	5.1083	5.1078	-.5
.60839	6.0839	6.0836	-.3
.70844	7.0844	7.0847	.3
.80764	8.0764	8.0774	1.0
.90812	9.0812	9.0833	2.1
1.00728	10.0728	10.0765	3.7

Data by: MM

Checked by: BW

Sys. Ck.: 10.052

Date: 6-14-90

Ser. No. 10421-2

NOTES:
1. Temperature regulated units must be on for a minimum of 4 hours prior to making any adjustments.
2. All pressure sensors are calibrated at ambient temperature unless otherwise noted.

MKS

Instruction Manual

TYPE:
390 / 590 ABSOLUTE
398 DIFFERENTIAL
HIGH ACCURACY
PRESSURE TRANSDUCERS

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1. 390/398 & 590 HIGH ACCURACY PRESSURE TRANSDUCERS

1-1 GENERAL

This manual describes the MKS-390 Series (Absolute) and 398 Series (Differential) Baratron[R] Pressure Transducers. The 590 is a 70°C version of the 45°C (sensor control temperature) 390 transducer. There are no other differences.

These transducers, when used with their required MKS Type 270 Signal Conditioner/Readout or MKS Type 170M-6C Signal Conditioner, represent the best pressure measurement system (sensor/transducer, signal conditioner, digital readout) currently produced by MKS. For further information on the companion Signal Conditioner/ Readouts, please refer to the 270B or 170M-6C instruction manuals.

These precision pressure measurement systems are available with high basic accuracies, wide dynamic range, and a typical Zero Coefficient of 1-2 ppm/°C and a Span Coefficient of 10-15 ppm°C.

1-2 FUNCTIONAL DESCRIPTION

The 390/398 Baratron[R] is composed of four (4) sub-sections assembled within a precision die-cast housing. These are: 1) an Inconel variable capacitance diaphragm sensor; 2) an electronic preamplifier and bridge circuits; 3) an inner temperature control housing; 4) a P.C. Board. The all Inconel sensor, together with its high impedance bridge circuit and preamp, is mounted within a thick-walled, temperature-controlled aluminum housing. This miniature "environmental chamber" reduces the ambient temperature effects upon the sensor and bridge circuit by more than a factor of 50.

The main P.C. Board mounted outside the temperature-controlled housing consists of those circuits necessary to convert a low level 10 KHz signal to a precise 1/4 V/V output that is linearly proportional to pressure. Also, that circuit necessary to maintain the housing temperature is located on this board. All gain controlling components are selected for maximum stability (wire-wound resistor, NPO capacitor, etc.). A "system check" circuit is used which will point out any gain change experienced at any point in the electrical system.

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The 390 Baratron[R] is able to make a reliable absolute pressure measurement by virtue of its own built-in "zero" pressure reference cavity. During production, the low pressure side (P_R) of the sensor is pumped to less than $1x10^{-7}$ mmHg, outgassed thoroughly, chemically gettered, and permanently sealed. The extremely low gas loads and active gettering material in the reference cavity assure the user of many years of useful service.

The 398 Baratron[R] is unique, in that the entire differential sensor is surrounded by an Inconel case. Ambient line pressure (P_R) appears between the sensor and this case, thus eliminating sensitivity changes due to line pressure induced stress variations within the sensor structure. Careful deadweight testing has shown a variation of less than .01% of reading as the line pressure varies from 1 to 15 psiA.

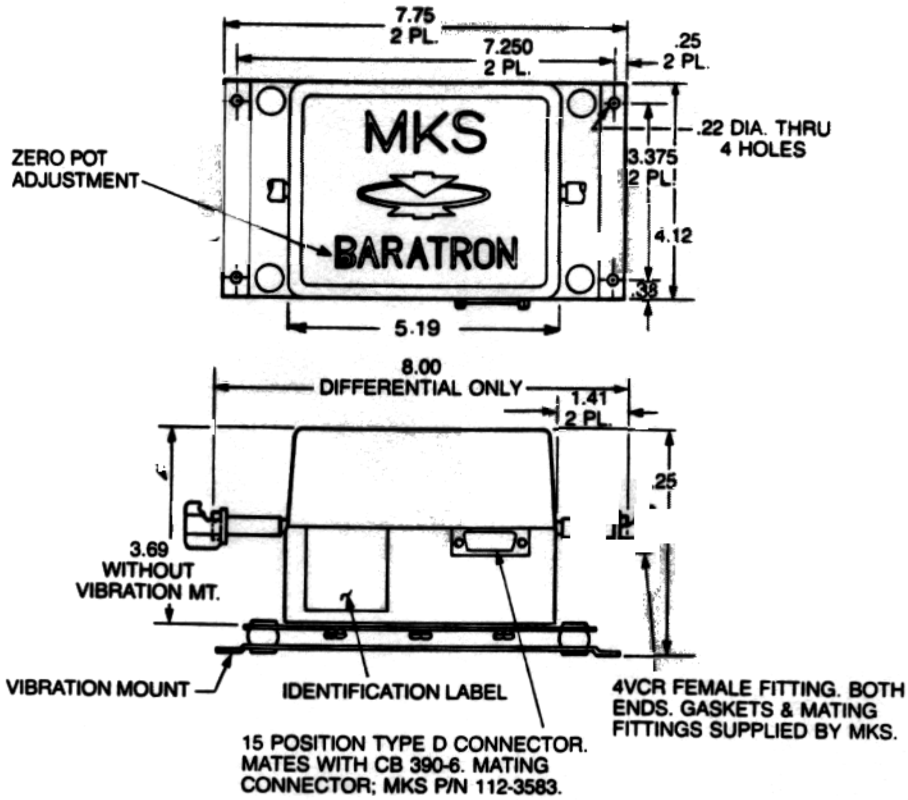
1-3 SPECIFICATIONS

Sensor Model Number	390	398
Type of Measurement	Absolute	Differential, Gauge
Sensor Type	Single-Sided	Single Sided
Measurement Side (P_x) Media Compatibility	Any gas compatible with Inconel, 304SS	Any gas compatible with Inconel, 304SS
Volume (P_x)	2 cc	2 cc
Reference Side (P_R) Media Compatibility	Not applicable	Any dry gas compatible with Inconel, 304/306SS Fosterite, Palladium
Ref. Side Volume	Not Applicable	8cc
Inlet Tube Fitting/s	Cajon[R] 4VCR (female)	Cajon[R] 4VCR (female)
Accuracy	STD: 0.08% of Reading ± zero/span coeff. OPT: 0.05% of Reading ± zero/span coeff.(1) OPT: 0.12% of reading ± zero/span coeff.	STD: 0.08% of Reading ± zero/span coeff. OPT: 0.05% of Reading ± zero/span coeff.(1) OPT: 0.12% of reading ± zero/span coeff.
Temperature Effects on Zero	<4ppm, FS/°C (Temp controlled @ 45°C) (0.12% of R Accuracy: <15PPM, FS/°C) (Temp controlled @ 45°C)	<4ppm, FS/°C Temp controlled @ 45°C) (0.12% of R. Accuracy: <15PPM, FS/°C) (Temp controlled @ 45°C)
Temperature Effects on Span	<0.002% R/°C	<0.002% R/°C
Ambient Temperature Operating Range	15-40°C (40°C Maximum)	15-40°C (40°C Maximum)
Pressure Ranges Available (F.S.)	1, 10, 100, 1000, 5,000, 10,000, 20,000, 25,000 Torr	1,10,100,1000 Torr

(1) 0.05% available only on 1, 10, 100, and 1000 mmHg units.

Sensor Model Number	390	398
Usable Resolution	5 Decades	5 Decades
Overpressure	125% F.S. or 20 psia (whichever is greater) NOTE: 20 psia = 5 psia @ ref atmospheric pressure of 760 mmHg.	
Maximum Line Pressure	N/A	150 psi
Line Pressure Effects on Span	N/A	<.003%/150 psi
Time Constant With 270 in Fast Position	<25 ms	<25 ms
Std Position	40 ms	40 ms
Slow Position	400 ms	400 ms

DIMENSIONS



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1.4 INSTALLATION

The Type 390/398 transducer may be mounted horizontally upon vibration isolation base with the following points noted:

A. All units are supplied with vibration isolators which should be used for maximum stability. A flexible bellows connection is suggested to minimize vibration. Furthermore, it is recommended that the sensor be mounted such that the sensor diaphragm plane is perpendicular to the major axis of vibration (diaphragm plane is perpendicular to port axis).

B. Access should be provided to the zero pot which is mounted immediately below the hole in the lower part of the "B" in "Baratron".

C. Ambient temperature around the 390/398 transducer must not rise above 40°C as this will cause the 45-47°C control temperature to go out of regulation, thus destroying the system stability.

D. Mount the transducer as far from RFI and EMI sources as possible. Field experience has shown that care in positioning the transducer initially will prevent future difficulties. The MKS system is internally protected against RFI and EMI. However in system where several ground potentials are possible, a noisy environment may cause output to be unstable. When this happens we have found the only solution has been an examination and correction of the source of RFI/EMI.

   Example:

   An SCR supply used in some systems should have the power carrying wires that run to the chamber twisted to cancel high frequency magnetic fields. Never run the 390 to Signal Conditioner cable in the same wiring bundle as RF or SCR signals.

E. If a dirty pressure medium is expected, mount the sensor with port facing down so that dirt will not fall onto the diaphragm.

F. Connection cables are as follows:

   390/398 to 170M-6C = CB-390-6
   390/398 to 170A/B = CB-270-2-10

G. The vibration mount assembly is shipped from MKS with four shipping screws in place. For noise-free operation, these screws must be removed. However, when this Baratron is subsequently reshipped on a piece of equipment, these screws MUST BE REINSTALLED as the rubber feet will withstand no more than 3 g's force in transit.

H. When installing a 398 Differential Transducer, allow for a cross-porting manifold; i.e. connecting the two ports together. In order to properly set the zero of any differential sensor, there must be equal pressure on both sides of the sensor.

I. <u>Vacuum Connections:</u> The sensor should be connected to the vacuum system via an appropriate isolation valve and bellows tubing.

a. To maximize the life and zero repeatability of the sensor, an isolation valve should be used. Set its closing point at or slightly above the transducer's full scale range.

An isolation valve serves to protect the sensor in two ways:

First: from overpressure, which is common in processing systems that incorporate pressure purging cycles in excess of sensor specifications (125% of F.S. or 20 PSIA, whichever is greater).
<u>Note</u>: 20 PSIA = 5 PSIG @ 1 standard atmosphere of 760 mmHg.

Second: from contamination by moisture, which is present when a process system is vented to atmosphere. Moisture can often combine with residue on the sensor and/or system surfaces, and form acids such as HCL when Chlorine - based processes are used.

Any good quality electric, or air-operated valve, such as a Nupro[R] Type 4BK or MKS P/N 108818, or equivalent, is recommended.

b. The sensor inlet should be connected to the isolation valve via an appropriate length of stainless steel bellows tubing with welded mating Cajon[R] fittings. Both VCR fittings and flexible tubing are products of the Cajon Company.

The use of a flexible bellows completes vibration isolation to the sensor, allowing it to function independently of significant system vibration or stress that could be induced during operation or shipment.

* * * * * * * * * * CAUTION * * * * * * * * * * *
* Hard coupling of the sensor inlet tube so *
* that the transducer is suspended by this *
* tube is not recommended as the weight of *
* the entire assembly will cause stress on *
* the sensor. *
* *

c. 398 Differential Sensors: The P_x port must be connected to the high side of any system whose differential pressure is to be measured. The P_R side will then be connected to the low pressure side. If connections are reversed, the instrument will output a negative signal whose accuracy is not specified. A 398 Differential sensor may be used to make an absolute measurement, by continually pumping the P_R port to a pressure below that of the resolution of the sensor. (Example: 1mmHg F.S. x 10^{-6} = $<10^{-6}$ mmHg).

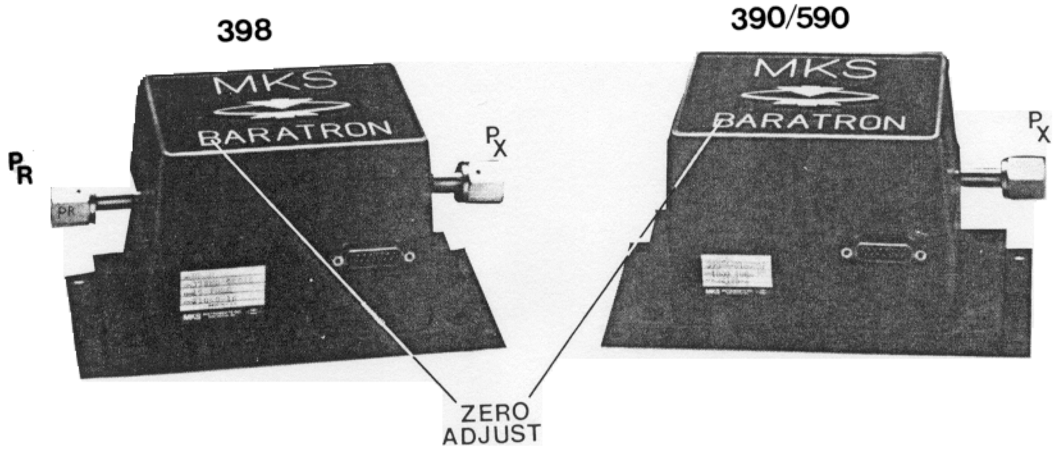
* * * * * * * * * * CAUTION * * * * * * * * * * *
* Do not attempt to change the inlet tube *
* fitting by cutting or welding. If a *
* different fitting is desired, make up an *
* adaptor, or consult MKS for a quotation *
* on a special-version sensor. *
* *

For your convenience, MKS makes available several lengths of these bellows assemblies, including the mating VCR fittings welded to the bellows tubing. To order, specify P/N 6BL 4VCR for a 6" length, or P/N 12BL 4VCR for a 12" length.

1-5 START-UP/OPERATION

IT IS IMPORTANT TO REMEMBER THAT ALL DIAPHRAGM-VARIABLE CAPACITANCE PRESSURE TRANSDUCERS REQUIRE THE USER TO SET "ZERO", AFTER SUITABLE WARM-UP AND PUMPING HAVE BEEN ACCOMPLISHED.

THE FOLLOWING PROCEDURE IS PRESENTED AS AN OPTIMUM GUIDE TO ACHIEVING THE FULL DESIGN POTENTIAL OF THE PRECISION 390/398 PRESSURE MEASUREMENT SYSTEM:



1. (390,398): After the sensor has been installed on the system whose pressure is to be measured, it should be connected to its Electronics Unit via the appropriate cable (See Section 1-4F), and power applied.

2. (390,398): A minimum of four (4) hours, and preferably overnight, should be allowed for the heater in the sensor package to thermally stabilize the sensor at control temperature.

3. (390): While waiting for the sensor to reach stable thermal equilibrium, the appropriate vacuum pump/s in the processing System should be engaged, so as to pump down the sensor below its minimum usable resolution.

   (398): While waiting for the sensor to reach stable thermal equilibrium, the appropriate vacuum pump/s in the Processing System should be engaged, in such manner as to provide equal pressure on both sides of the sensor. (This can also be accomplished by cross-porting, i.e., connecting the two ports together).

4. (390,398): After the above warm-up time and pumping requirements have been met, the zero can be properly set.

Each full scale range has different pumping criteria. The following chart summarizes the basic pressures needed prior to setting the "Zero."

	SENSOR MODEL NUMBER	RANGE FULL SCALE	HIGHEST PRESSURE FOR PROPER ZERO ADJUST	WARM-UP TIME BEFORE ADJUSTING ZERO
	HA-0001	1 Torr	<1 X 10^{-6} Torr	4 Hours Minimum
	HA-00010	10 Torr	<1 X 10^{-5} Torr	
or	HA-00100	100 Torr	<1 X 10^{-4} Torr	(It is recommended all temp-controlled transducers be powere continuously)
	HA-01000	1000 Torr	<1 X 10^{-3} Torr	
	HA-10000	10000 Torr	<1 X 10^{-2} Torr	

<u>Note: The best method of zeroing the transducer system is:</u>

First: Center the two pots (course, fine), in the Electronics Unit. This is accomplished by turning each pot to either extreme, noting the voltages at each extreme, and then setting each pot at the half way point.

Next: Now "Zero" the indicated output, using the zero pot on the 390 (located through the lower portion of the 'B' in the word "Baratron" on the top cover). This is a wire-wound control which causes small linear step changes in the output. Leave this pot adjusted half way between any two steps that give an output closest to 'Zero'.

Next: Now Fine Trim the output, using the zero controls on the Electronics Unit. The measurement system is now ready to use.

For reference, the frequency of setting zero will depend on use, variations in ambient temperature, and application. The user will, with experience, gain a feeling for the frequency with which the zero adjustment must be made. For extremely critical measurement of very low pressures, checking the zero more often, and making minor adjustment, will ensure the most accurate measurements attainable with this MKS Baratron[R] transducer system.

NOTE: The span of the sensor is factory set during the calibration, and should never be adjusted by the user unless there are suitable transfer or primary standards available to aid in recalibration.

If the Span potentiometer in the sensor head preamplifier is mistakenly adjusted, please contact your nearest MKS Service Center for assistance, and possible instructions to return the instrument to MKS for recalibration.

System Check

The System Check circuit generates a span calibration signal whose precision depends upon the position of the head's zero pot. For the system check signal to be valid, center the zero pots in the readout unit, using the standard zero control procedure. After zeroing in this fashion, the system check signal will be similar to the value stated on the Calibration Data Sheet (within ±.03% of Full Scale).
(See 270 and 170M-6C manuals for system check operations.)

1-6 TROUBLESHOOTING

SYMPTOM	CAUSE	REMEDY
CANNOT ZERO		
a. With absolute head.	Pressure not below the reading resolution.	Pump down P_x side.
b. When power first applied.	Head not at operating temperature.	Allow time for stabilization (4 hours minumum).
c. On most sensitive ranges.	Amplifier overload or system noise.	Go back to less sensitive range until on scale and try again and/or try better vibration isolation
ZERO SHIFT		
a. After applying power.	Sensor temperature shift.	Allow 4 to 6 hours for sensor stabilization. 16 hours for optimum stability.
b. When changing from atmospheric to vacuum operation.	Different outgassing rates for P_x and P_R at vacuum.	Allow time for outgassing completion.
c. When either raising or lowering line.	Leaks in vacuum system.	Check pressure connections at Head and other fittings
d. Upon turn on of RF power in, for example, a sputtering system. Sudden "negative direction" pressure reading.	Pick up in Sensor Preamplifier.	Replace standard sensor head cable with shielded version or relocate sensor on system or try better grounding.
SYSTEM CHECK		
a. System check voltage different.	Electronics gain has changed.	Check calibration of transducer.

1-7 MAINTENANCE

Generally, nothing needs to be done to maintain the transducer, other than its proper installation and operation. If it fails to operate after doing so for a period of time, return it to MKS for service (obtain from the nearest MKS Service Center an ERA - Equipment Return Authorization - number to expedite handling and assure proper servicing of your transducer). If it fails to operate upon receipt, check the power/signal cable for correct continuity. Also check for shipping damage.

If, after extended use:

1. Measurement goes slowly negative with time. Eventually, one runs out of zero adjustment. This is caused by a reference leak, and requires a new sensor replacement.

2. Measurement goes slowly positive with time. Eventually, one runs out of zero adjustment. This is caused by overpressure, and/or a build-up of contamination in the P_x cavity, which causes the diaphragm to be pushed toward the electrode. Generally, this requires a new sensor replacement.

3. Overrange positive, or negative, signal. This is generally caused by a shorted sensor, or a damaged interconnect cable (sensor to electronics module).

NOTE: If the "zero" output from the transducer is unstable, this is usually caused by the ambient temperature around the sensor or electronics module being too high. The ambient temperature around the sensor must be no higher than 40°C. The ambient temperature around the electronics unit must not exceed 50°C.

2. TRANSDUCER SIMULATOR
TYPE HS-1

2-1 DESCRIPTION

The HS-1 Transducer Simulator is used as a test box for checkout and set-up of a precision pressure measurement system (390/398, 270B, 170M-6C). The simulator provides the following functions:

1. A dummy load for, and LED visual signal of, heater supply power.

2. A visual signal of ±15 VDC power supply function.

3. The generation of a zero, 50% FS, and 100% FS signal.

4. Test points for the measurement of the 6 VRMS excitation signal.

Thru its use, one may accomplish the following:

1. Identify a faulty transducer

2. Identify a faulty cable.

3. Check some of the fundamental functions of the signal conditioner/readout unit.

4. Adjust for transducer-to-signal conditioner cable length.

2-2 HS-1 OPERATING INSTRUCTIONS

SYSTEM CHECKOUT

Disconnect the head cable from the transducer and connect it to the simulator. The red lamp should be ON, indicating that the proper preamp voltage is present at the end of the cable. When the switch is placed in the zero position, a zero signal is developed across the signal input lines. In this position it should be possible to adjust the electronics unit for a stable zero on all ranges. When the switch is placed in the +10V position, the simulator will produce a signal sufficient to produce a stable +10V (full scale) reading on the X1 range.

The HS-1 also contains a resistor to simulate the heater in the sensor. When the heater switch is placed in the REG. position, the heater lamps on the electronics unit will come ON if the supply is working properly. This lamp will not display the same brilliance as it does when attached to a heater due to the higher value of the simulator resistor.

ELECTRONICS UNIT RECALIBRATION

1. Connect a high accuracy AC meter to the jacks on the top of the simulator and measure the amplitude of the oscillator. The proper level is 6.000 VRMS.

2. Place the simulator switch in the zero position, adjust the Null and Full Scale on the indicator and then the zero on all ranges. Then place the range multiplier in the X1 position. Place the simulator switch in the +10V position and adjust the full scale pot on the front of the electronics unit for a reading of +10.00 volts at the output of the electronics unit.

3. Place the simulator switch in the +5V position to check linearity at the 50% point. This should be within 5 mV of 5.00 volts.

OPTIMIZING LONG CABLE OPERATION

When long transducer cables are used in a system, frequently it is necessary to adjust the system gain to optimize system performance which might be degraded due to the cable length. When the simulator is installed on the end of the transducer cable, the system gain is adjusted by using the procedures above. Note that on occasion, the Electronics Unit span adjust may have to be adjusted if the full scale adjustment is insufficient to set full scale.