User Manual

HIGH TEMPERATURE DISPLACEMENT SYSTEM

****
DO NOT MAKE ANY MODIFICATIONS TO CABLE LENGTH, SENSOR OR CALIBRATED TARGET MATERIALS WITHOUT PRIOR CONSULTATION WITH A KAMAN APPLICATION ENGINEER
****

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Rev. C

KAMAN

Kaman Instrumentation

High Temperature Displacement System

User Manual

A guide to the use of KDM1925,
KDM1950, and KDM1975
displacement measuring systems

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Kaman Instrumentation

High Temperature Displacement System

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Introduction

The Kaman Instrumentation line of High Temperature Displacement Transducers are designed to provide accurate non-contacting measurement of conductive surface motion in hostile environments. Output is directly proportional to displacement yielding a linear transfer function for the specific target used in calibration. Use at elevated temperatures is facilitated by thermal compensation techniques that maintain sensitivity and linearity with small zero shifts.

The Eurocard packaging format common to other Kaman transducers allows for rack mounting in either a full subrack or a half rack instrumentation case. Function modules such as Summation/Comparator and Voltage to Current conversion (4-20 mA) are also available in the Eurocard format.

This manual is provided to help the user obtain optimum performance with this displacement measuring system. Basic information necessary for installation and operation are provided. The staff at Kaman Instrumentation is available for consultation on specific applications or aspects not covered here.

The system consists of precision instrumentation and it must be handled with equivalent precision. It is strongly recommended that this complete manual be studied prior to adjusting or operating the system in any manner. For further information on the electronics packaging, manuals on the 7200 and 8200 systems may be of further assistance depending on the application.

General Operating Procedures

Kaman Instrumentation high temperature, noncontacting displacement measuring system is composed of three basic separate components that must be assembled into and operational system. A diagram of the basic set of 8200 electronics required is shown in figure 1. The components of the system are the signal conditioning electronics (items 1,2,3), a low-temperature interconnecting cable (item 4), and sensor (item 5, with integral metal sheathed high temperature cable),. Note that active sensor coil is denoted by an 'A' and the inactive coil is denoted by a 'B'. In the case of the 7200 or 8200 KDM1925 systems the active coil may connect to the sensor marked 'B' (and the inactive to 'A') depending on the target configuration. It is easy to tell if they are hooked up backwards because the output will not go more positive as the target moves away from the sensor.
The sensor dimensions are shown in appendix C.

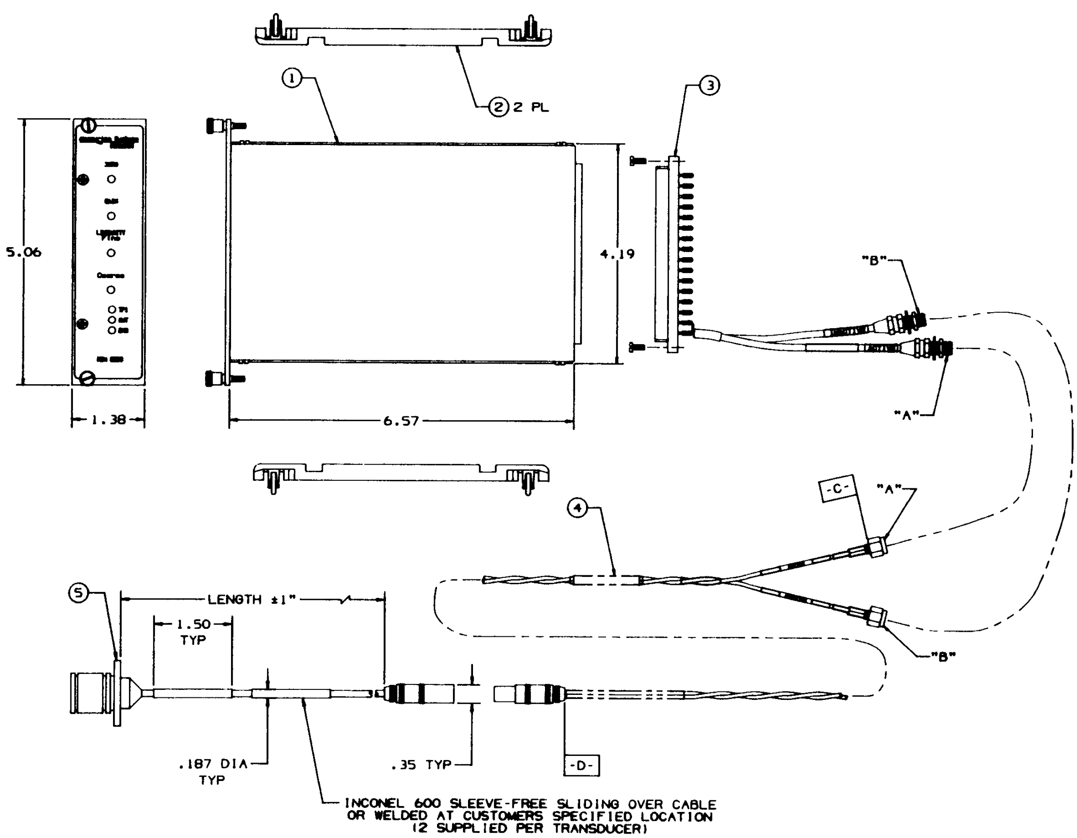
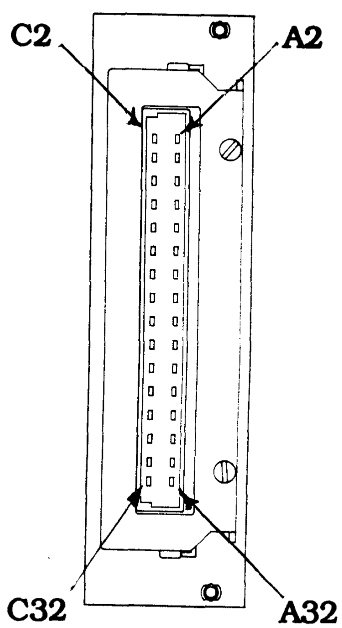


fig. 1 -- 8200/8200HT Base System

The electronics type may be either 7200, 8200, or 8200HT type electronics for the KD-1925, but the KD-1950 and KD-1975 systems are only available in the 8200HT version. The main difference is the frequency of operation which may vary depending on the application. The standard operating frequencies are listed in appendix B for each sensor.

The output voltages are per the table in appendix A unless otherwise specified. The pinout of a measuring channel for the 8200 and 8200HT electronics are as shown in figure 2. The pinout for the 7200 system (1925 only) is shown in figure 3. Recording or measuring instruments (such as voltmeters, recorders, or oscilloscopes) should have ranges consistent with the maximum output voltage listed for the sensor in appendix A (unless otherwise specified) and an impedance of at least 150 ohms. Approximately 1 hour should be allowed for stabilization of the electronics.



function	Pin C	Pin A	function
V+	2	2	V+
N/C	4	4	N/C
V-	6	6	V-
N/C	8	8	N/C
Gnd	10	10	Gnd
N/C	12	12	N/C
Out+	14	14	Out+
Out-	16	16	Out-
N/C	18	18	N/C
N/C	20	20	N/C
N/C	22	22	N/C
Aux	24	24	Aux
Gnd	26	26	Gnd
Sync Out	28	28	Sync In
Gnd	30	30	Gnd
Sen B	32	32	Sen A

fig. 2 -- 8200/8200HT Connector Pinout

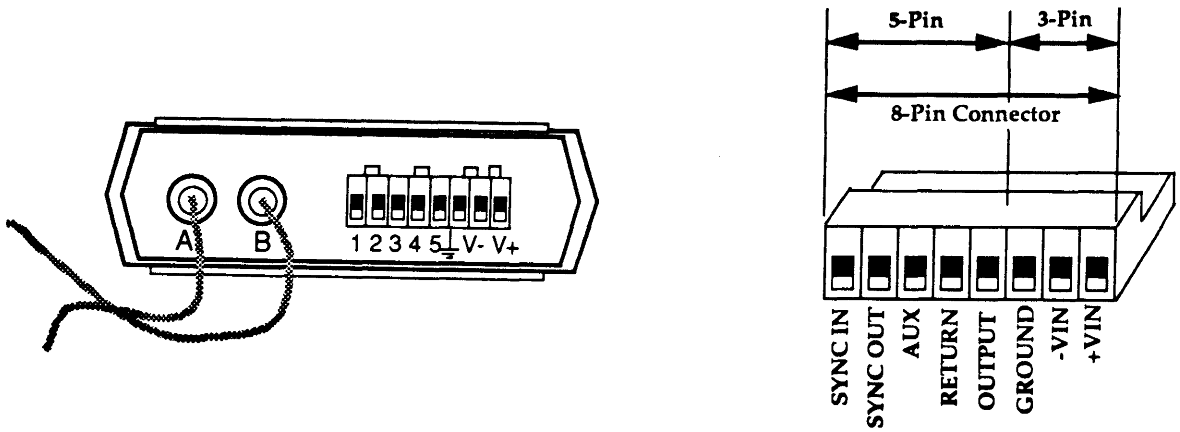


fig. 3 -- KDM7200 Pinout

During factory calibration the grounding was maintained via the electronics only. Further grounding along the cabling or sensor should have minimal effect on the sensitivity since special high temperature cabling was developed to alleviate this effect.

Careless handling of the sensor either directly during installation or indirectly during operation may seriously damage the sensitive front portion of the sensor. Impinging high velocity debris, including bulk contaminants, may be as injurious as an impacting target.

The standard "zero" calibrated displacement is the offset as listed in appendix A from the front of the sensor for safety. This offset can be modified or eliminated by recalibration. Calibration data furnished with each sensor lists output voltage versus the absolute displacement values from the face of the sensor. Sensitivity and linearity performance at elevated temperatures are similar the ambient temperature record except for a zero shift related to the sensing technique and the properties of the target material. Typical performance curves for some standard targets are shown in figures 4, 5, and 6.

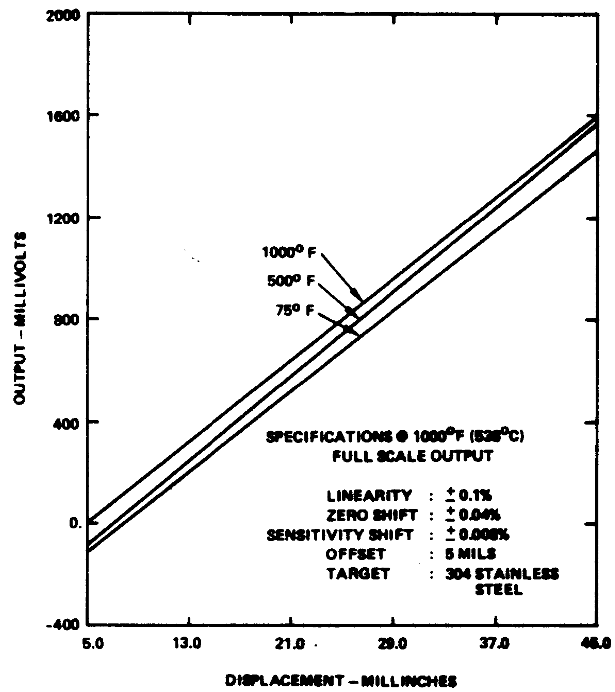


fig. 4 -- KD-1925 Performance

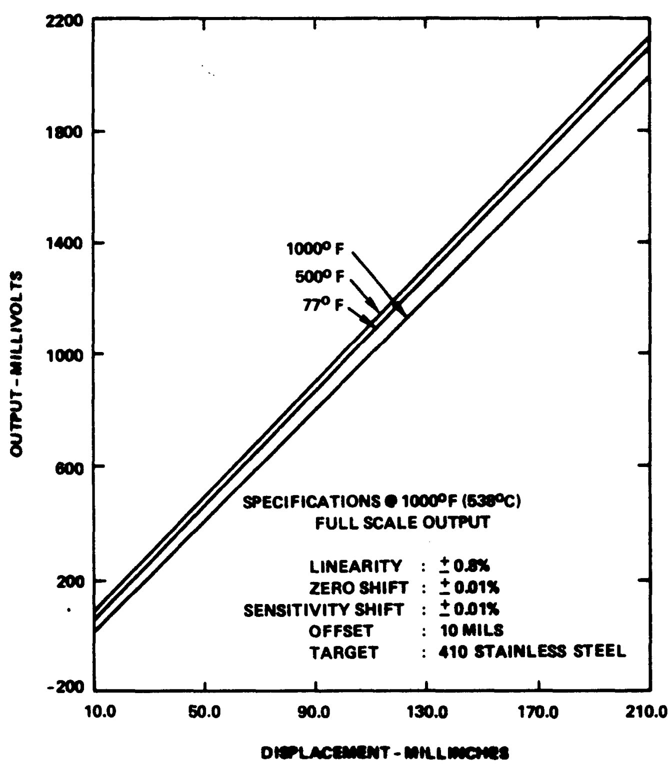


fig. 5 -- KD-1950 Performance

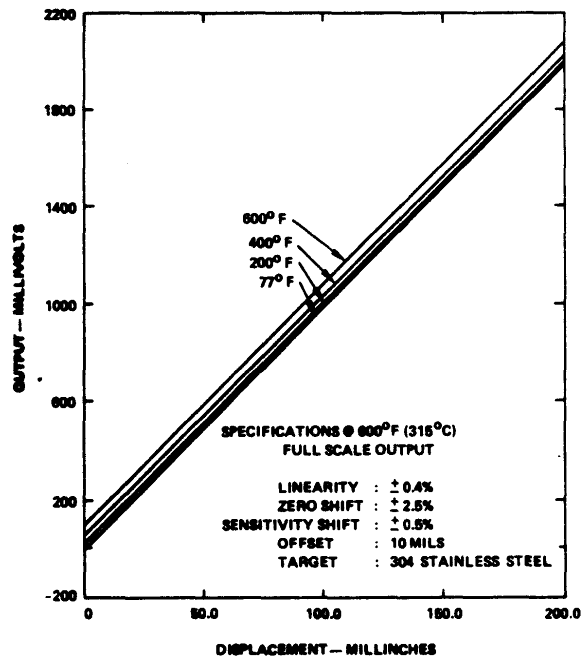


fig. 6 -- KD-1975 Performance

The sensor were calibrated per the specifications listed in appendix A or as specified in the sales order.

The measuring system is somewhat susceptible to metal objects within its environs besides the target being measured. Change in the calibration may result if metal objects are brought to within approximately 1/2 of the sensor diameter from the side of the sensor. Recommended sensor mounting for the three sensors are shown in Appendix C. Should it be necessary to violate the rule of thumb for mounting or installation purposes, readjustment of the signal conditioner controls may be required. Optimum performance of the system is obtained by simulating the actual mounting geometry using a side loading ring during factory calibration.

The sensor required thermal equilibrium for its operation. Furthermore, the target and sensor should be at nearly the same temperature to maintain proper calibration and reduce repeatability errors.

Installation

Since sensors and signal conditioning electronics are irreversibly paired during calibration such that zero and sensitivity thermal shifts are minimal, it is imperative that this same pairing be maintained during installation and operation. Calibration records include serial numbers for each component of a particular system and installation must be consistent with these numbers for proper operation.

The end of the sensor is fragile and if damaged can alter or impair the system performance. The protective cover used during shipping should be maintained until immediately prior to installation. Any modification or damage to the front surface of the sensor will irreversibly change the system response.

During installation, the cables should be protected since cutting the cables would irreparably damage the sensor. Particular care is required when routing the cables through difficult passageways in a complex installation to avoid even minor damage to the sheathing. For instance, any exposure of the inorganic insulation via small nicks and cuts in the sheathing will create disastrous effects as neither the insulation nor the center conductor can tolerate moisture or corrosive environments such as steam.

In operation, the semi-rigid cable must be fastened to avoid vibration fatigue. It is recommended that clamps be used to fasten the cables at intervals consistent with vibration requirements. These clamps must not excessively swage, dent, or otherwise damage the cable.

If practical, the cable should be completely isolated from ground points between sensor and matching electronics to avoid potential ground loops. The sheath of the cable is at ground potential (this is vital to the operation of the transducer); thus care must be exercised to avoid having these lines "short out" other circuits.

The metal sheathed cables and transducer will withstand a minimum continuous service temperature of 1000^{o}F (See appendix A for exact numbers which depend on the sensor). This sheathed cable is designed to withstand a 6.35mm (.25 inch) minimum bend radius without degradation providing an appropriate mandril is used. The first bend should be as far from the sensor as practical to avoid bends at the cable-sensor weld. The cabling is shipped in a coil approximately 30.5 centimeters (12 inches) in diameter. Bending this cable work hardens the sheath such that repeated bends are made with increasing rigidity and therefore risk. Thus it is strongly recommended that the sensor cable be bent a minimum number of times (preferably only once) during testing and use. Use a mandril to bend the cabling in less than a 25.4 mm (1.0 inch) radius to avoid buckling. Since the cabling and its terminations are a vital and costly part of the system, they should be handled with the same care given the sensor. The sensor is connected to its matching electronics unit via flexible, interconnecting cable. The identification number on the cable must also be matched properly to the records. Since the cables, both metal sheathed inorganic insulated and flexible organic insulated, are a portion of the bridge network, any modifications to there length will negate the factory calibration. Thus it is of paramount importance that only the cabling provided by Kaman Instrumentation is used. Cable length modifications such as shortening the metal sheathed cable or lengthening the interconnecting cable can be provided at a later date if desired. This would require recalibration at additional cost by Kaman Instrumentation.

Operating temperatures of the interconnecting cable and connector are as follows:

Interconnecting Cable:	-55^{o}C to 105^{o}C	(-67^{o}F to 220^{o}F)
Interconnecting Connector:	-75^{o}C to 150^{o}C	(-100^{o}F to 300^{o}F)

A metal seal can be used at either flange surface to obtain a gas tight seal if desired. One possible configuration using a Haskel HS4 series "K" type seal is recommended. The sealing surfaces of the sensor, mount, and metal seal must be thoroughly cleaned with a solvent prior to assembly. Furthermore, the flange of the sensor and mount must be polished and have a finish compatible with the seal. Radial scratches and abrasions will preclude making a tight seal. The Haskel "K" type seal is fabricated of silver plated Inconel 750 with a gold flash. Such a finish can probably be removed if not compatible with the testing environment, however, the absence of the sealing function attributable to the plating may prevent an adequate seal. Further information can be found in the Haskel literature from:

Bulletin S-6
Design Handbook
Plated Metal Spring Type Flange Seals
Haskel Engineering and Supply Company
100 East Graham Place
Burbank, California 91502

Importance of Oscillator Frequency

The Oscillator frequency used will vary depending on the sensor and type of target used. The high temperature displacement systems generally operate at a lower frequency than other Kaman transducers. The reason they operate at low frequencies is to allow the transducer to "see through" the protective covering on the sensor (normally Inconel) and to optimize the sensor output from a specific target material. The lower frequencies are responsible for limitations in frequency response of the system and how thin a target material can be. Minimum thickness of the target material depends on the permeability, conductivity, and frequency of operation but generally is not a factor for thickness of .5" or greater. Frequency response of the system is generally set at least 10 times less than the oscillator frequency.

Synchronization

If you are using a multiple channel system or you have several single channel systems with the sensors in close proximity, the modules will require synchronization done at the factory. If you ordered a multichannel 8200 system the modules will have been synchronized in either a daisy chain or parallel configuration. When the modules are synchronized you will have one 'master' module and several 'slave' modules which will be labeled accordingly on the side of the modules. The 'master' module provides the oscillator frequency from its 'sync out' pin to the other 'slave' modules 'sync in' pins. If it is a daisy chain configuration each successive module provides the oscillator to the next module. This has the advantage of allowing more modules to be tied together, but if any modules in the chain are disconnected, all of the modules downstream from it won't work. The parallel configuration relies on one module to have the master oscillator and all of the other modules get there oscillator from that one master module. The parallel configuration will work only until there are so many modules that one oscillator can no longer driver them adequately. The system will drive up to eight modules in parallel. The 'master' module is normally located in the leftmost slot in the chassis (next to the power supply if there is one). In either case, if the master module oscillator is not functioning, no other modules in the chassis will work.

Front Panel Controls

The front panel consists of 4 potentiometer adjustments to be used during calibration. The front panels are shown in figure 7 and 8 for reference.

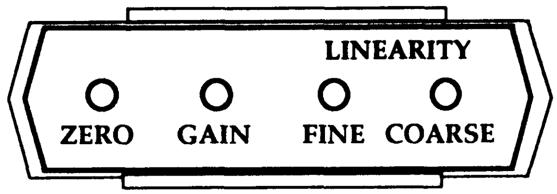


fig. 7 -- 7200 front panel

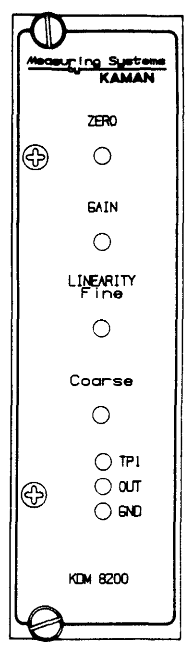


fig. 8 -- 8200/8200HT front panel

The Zero Control

The Zero control allows you to adjust the offset voltage in the system. It is influenced slightly by the gain control -- so if you adjust the gain you will probably need to readjust the zero slightly. The effect of the zero control on the output is shown in figure 9

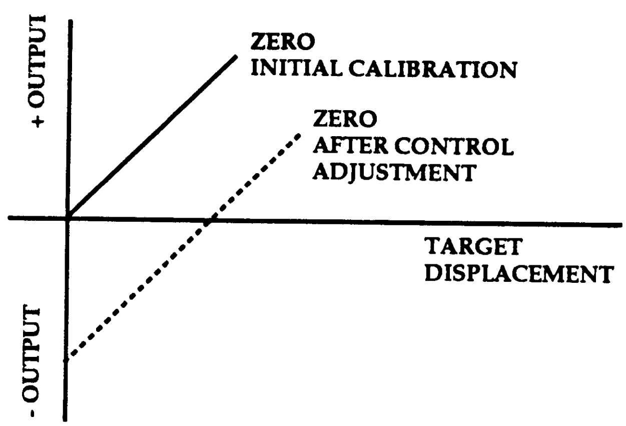


fig. 9 -- effect of zero control

The Gain Control

The gain control affects the slope (generally referred to as the sensitivity) of the system output. The effect of this control is depicted in figure 10.

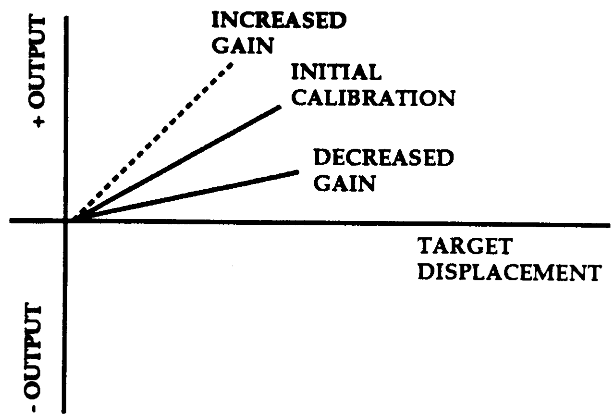


fig. 10 -- effect of gain control

The Coarse and Fine Linearity Controls

The Coarse and Fine linearity controls affect the linearity of the system output. They are an offset to the system output *ahead* of the log amplifier.

Calibration Procedure

All the sensors were calibrated at Kaman Instrumentation using a flat or curved target either specified or furnished by the customer. The target thickness is a minimum of 12.7 mm (.50 inches). Calibration of the sensors was optimized at 25^{o}C (77^{o}F using the mounting geometry described in appendix C.

The following procedure (using suitable micrometers or their equivalent to vary the spacing from the sensor to target) is used for adjustment of the transducer. Adjustments should be made only if deemed absolutely necessary, since for most target materials, the thermal compensation is influenced by the linearity control.

Step 1 With the target at "zero" displacement (at the recommended or desired offset from the face of the transducer) adjust the **ZERO** control until the output reads zero volts (i.e. 0 mV for .25mm (.01 inches) for the standard 1975 sensor).

Step 2 Move the target away from the transducer to the displacement equal to half the full range (plus offset). Adjust the **GAIN** control to obtain a half-scale voltage reading at the output (i.e. for the standard 1975 system 1000 mV for 2.75mm (.11 inches) for nonmagnetic targets).

Step 3 Move the target to the full range displacement point (plus offset) and adjust the **LINEARITY** (coarse or fine) control to the full scale output (i.e. for the standard 1975 system 2000 mV at 5.33mm (.21 inches) for nonmagnetic targets).

Step 4 Repeat Steps 1 through 3 until the best linearity is obtained.

See the 7200 or 8200 general instruction manual for other methods of calibration.

Maintenance

The sensor is an irreversibly sealed unit and consequently routine maintenance is limited to care and cleaning. The case will appear as oxidized metal due to the operational temperature. The front of the sensor may appear darker than the rest of the case due to the higher temperatures it encountered during fabrication. Any foreign matter other than these oxides should be removed. The following steps should be used as a guide:

A. The outside of the sensor and sheathed cabling can be wiped clean with a suitable solvent and blown dry using a mild air blast. Protect the flange from scratches or flaws that may impair its mounting and sealing function.

B. Cable connections are subject to contamination under repeated use. These should be inspected for foreign matter on the contacts and cleaned with an electronic contact cleaner as required. Alterations of cable lengths for repair may in turn alter the calibration of the system and thus require factory compensation if minor adjustments do not restore performance.

C. Maintenance of the signal conditioning electronic is limited to periodically cleaning the contacts with electronic contact cleaner.

Troubleshooting

Troubleshooting the system is limited primarily to isolating the malfunction between the various components.

The sensor can be checked for coil integrity as follows.

A. Disconnect the solid sheathed cable from the flexible cable.

B. Using and ohm-meter that has a battery voltage of 1.5 volts or less check continuity form each individual pin of the connector to the sheath. These values should be approximately 4.5 ohms at room temperature.

Anomalous readings could indicate failure at the cable connector, the cable, or within the sensor. Time-Domain-Reflectometer techniques can be used to isolate the failure region. Generally only the connector is readily repairable.

The flexible cable can likewise be checked in a similar manner by attaching the sensor and taking corresponding resistance measurements.

Minor changes in sensitivity are covered in the sections pertaining to installation, calibration, and adjustment. Some changes may be attributable to changes in grounding modified mounting or installation, and high resistance contacts. The first two conditions may require readjustment of the electronics to maintain desired sensitivity and linearity. The latter will require contact cleaning as described in the maintenance section.

Construction and Corrosion Resistance

The exterior of the sensor is fabricated of Inconel Alloy 625*, an alloy that is particularly useful in contact with high temperature steam. Since no dissimilar material joints are exposed to steam, corrosion by galvanic action should be minimal. Cable sheaths are of Inconel Alloy 600.

All internal materials and components are sealed from the test environment. Standard assembly procedures include leak testing at numerous steps during construction to assure proper integrity of the sensor in a steam environment.

Coils, cable terminations, and other internal parts are similar to Kaman's standard transducers and consist of materials appropriate for high temperature use.

* Engineering data on Inconel Alloy 625 can be found in the following pertinent publications:

1. "Huntington Alloys - Resistance to Corrosion"
2. "Inconel Alloy 625"

Both are published by: Huntington Alloy Products division
The International Nickel Company, Inc.
Huntington, West Virginia 25720

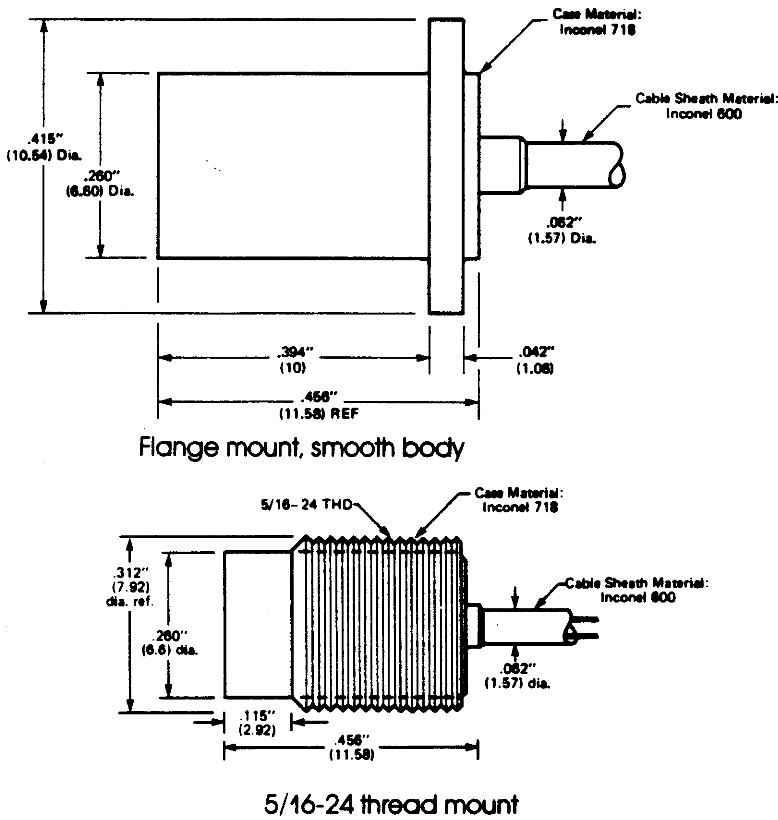
Appendix A -- Sensor Specifications

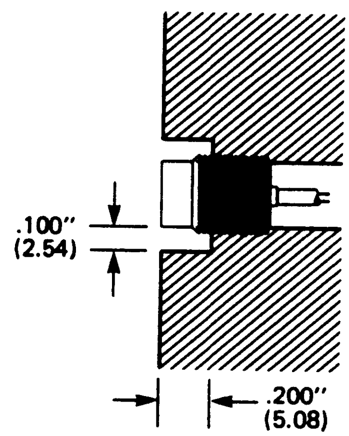
	KD1925	KD1925M	KD1950	KD1950M	KD1975	KD1975M
Measuring Range	.050" (1.27 mm)	.040" (1 mm)	.150" (3.81 mm)	.100" (2.54 mm)	.200" (5 mm)	.100" (2.5 mm)
Sensitivity	50 mV/mil	50 mV/mil	10 mV/mil	10 mV/mil	10 mV/mil	10 mV/mil
Output Voltage	0 - 2.5 Vdc	0 - 2 Vdc	0 - 1.5 Vdc	0 - 1 Vdc	0 - 2 Vdc	0 - 1 Vdc
Offset (typical)	.005" (.127mm)	.002" (.0508mm)	.010" (.254mm)	.005" (.127mm)	.010" (.254mm)	.005" (.127mm)
Resolution (at mid range)						
Static:	30 u"(.00075mm)	30 u"(.00075mm)	50 u"(.0012mm)	50 u"(.0012mm)	100 u"(.0025mm)	100 u"(.0025mm)
Dynamic:	50 u"(.0012mm)	50 u"(.0012mm)	100 u"(.0025mm)	100 u"(.0025mm)	200 u"(.005mm)	200 u"(.005mm)
Repeatability	30 u"	30 u"	100 u"	100 u"	100 u"	100 u"
Nonlinearity (at calibration Temperature)	+/-1.5% FSO	+/-1.5% FSO	+/-1% FSO	+/-1% FSO	+/-1% FSO	+/-1% FSO
Operating Temp. Range (sensor)	-200^{o}C to 25^{o}C or 25^{o}C to 538^{o}C	-200^{o}C to 25^{o}C or 25^{o}C to 538^{o}C	-200^{o}C to 595^{o}C	-200^{o}C to 595^{o}C	-200^{o}C to 595^{o}C	-200^{o}C to 595^{o}C
Typical TempCo (sensor only)						
Zero Shift:	0.054%/^{o}C FSO	0.054%/^{o}C FSO	0.036%/^{o}C FSO	0.036%/^{o}C FSO	0.018%/^{o}C FSO	0.018%/^{o}C FSO
Sensitivity Shift:	0.054%/^{o}C FSO	0.054%/^{o}C FSO	0.036%/^{o}C FSO	0.036%/^{o}C FSO	0.018%/^{o}C FSO	0.018%/^{o}C FSO
Sensor Material	Corrosion resistant high temp. nickel chrome alloy (Inconel 718) all welded and heretically sealed		Corrosion resistant high temp. nickel chrome alloy (Inconel 625) all welded and heretically sealed		Corrosion resistant high temp. nickel chrome alloy (Inconel 625) all welded and heretically sealed	
Cable Material	Nickel chrome alloy (Inconel 600) sheathed, mineral insulated,		Nickel chrome alloy (Inconel 600) sheathed, mineral insulated copper inner sheath		Nickel chrome alloy (Inconel 600) sheathed, mineral insulated copper inner sheath	
Standard lengths:						
Softline:	5 ft.	5 ft.	2 ft.	2 ft.	2 ft.	2 ft.
Hardline:	10 ft.	10 ft.	10 ft.	10 ft.	10 ft.	10 ft.
Target material	Non-magnetic conductors	magnetic conductors	Non-magnetic conductors	magnetic conductors	Non-magnetic conductors	magnetic conductors
Max Operating Pressure	5000 psi	5000 psi	3500 psi	3500 psi	3500 psi	3500 psi

Appendix B -- Electronics Specifications

	KD1925	KD1925M	KD1950	KD1950M	KD1975	KD1975M
Type	7200 or 8200	7200 or 8200	8200HT	8200HT	8200HT	8200HT
Operating Temperature Range (Electronics)	0 - 50^{o}C (32 - 122^{o}F)	0 - 50^{o}C (32 - 122^{o}F)	0 - 50^{o}C (32 - 122^{o}F)	0 - 50^{o}C (32 - 122^{o}F)	0 - 50^{o}C (32 - 122^{o}F)	0 - 50^{o}C (32 - 122^{o}F)
Oscillator Frequency	500 kHz	300 kHz	125 kHz	125 kHz	62.5 kHz	31.25 kHz
Frequency Response (3dB point) (frequency response up to .1xosc available upon request)	10 kHz	10 kHz	10 kHz	10 kHz	2.5 kHz	2.5 kHz
Power Input	+/-15 Vdc @ 60 mA	+/-15 Vdc @ 60 mA	+/-15 Vdc @ 60 mA	+/-15 Vdc @ 60 mA	+/-15 Vdc @ 60 mA	+/-15 Vdc @ 60 mA
Optional Power Input	+/-12 Vdc @ 60 mA	+/-12 Vdc @ 60 mA	+/-12 Vdc @ 60 mA	+/-12 Vdc @ 60 mA	+/-12 Vdc @ 60 mA	+/-12 Vdc @ 60 mA
Typical TempCo (electronics only)						
Zero shift:	+/-0.2%/^{o}C FSO	+/-0.2%/^{o}C FSO	+/-0.2%/^{o}C FSO	+/-0.2%/^{o}C FSO	+/-0.2%/^{o}C FSO	+/-0.2%/^{o}C FSO
Sensitivity Shift:	+/-0.2%/^{o}C FSO	+/-0.2%/^{o}C FSO	+/-0.2%/^{o}C FSO	+/-0.2%/^{o}C FSO	+/-0.2%/^{o}C FSO	+/-0.2%/^{o}C FSO

Appendix C -- Sensor Dimensions and Mounting

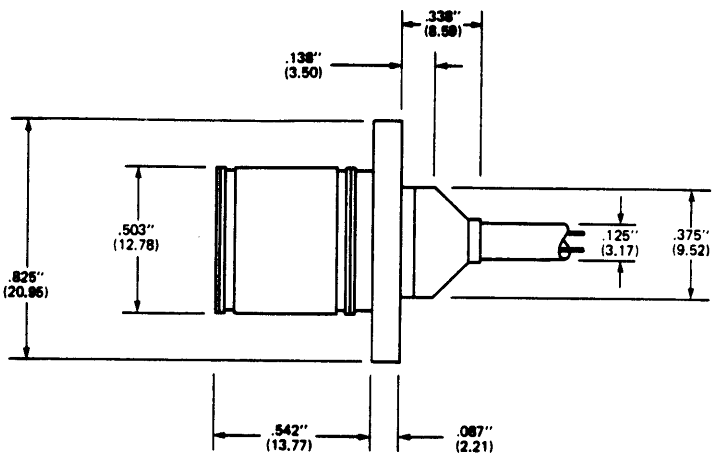




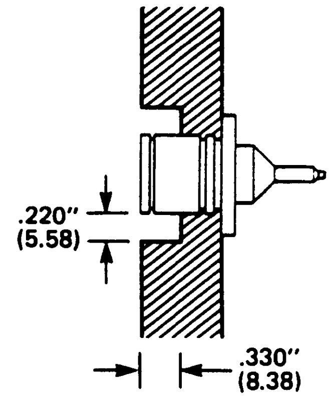
*To meet specifications, this is the minimum clearance for conductive material around the sensor face.

KD-1925 Sensor Dimensions

KD-1925 Mounting

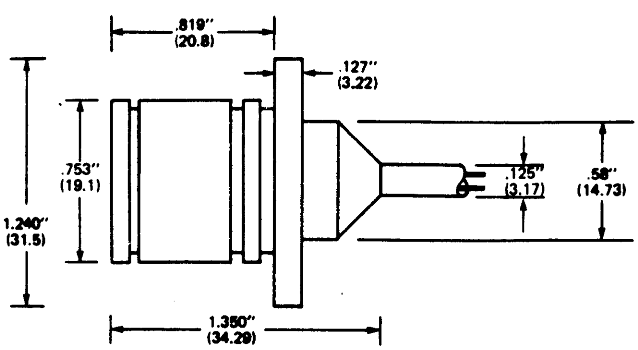


KD-1950 Sensor Dimensions

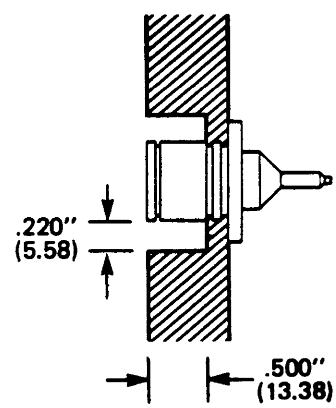


*To meet specifications, this is the minimum clearance for conductive material around the sensor face.

KD-1950 Mounting



KD-1975 Sensor Dimensions



*To meet specifications, this is the minimum clearance for conductive material around the sensor face.

KD-1975 Mounting

Customer Service Information

Should you have any questions regarding this product, please contact an applications engineer at **Kaman Instrumentation Operations** 719-635-6979 or fax 719-634-8093. You may also contact us through our web site at: www.kamaninstrumentation.com.

Service Information

In the event of a malfunction, please call for return authorization:

Customer Service/Repair **Kaman Instrumentation Operations:**

860-632-4442