

Vibrating Wire Temperature Sensor User Manual



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Section 1 : Theory of Operation

The Theory of operation is that a tensioned steel wire is clamped axially inside a cylindrically shaped, stainless steel body and is made to vibrate at its fundamental frequency by means of electrical pulses fed from a readout box, through a cable, to an electronic coil and permanent magnet assembly mounted close to the wire. Temperature changes cause the stainless steel body to expand and contract at a different rate than the vibrating wire. This causes a corresponding change in the wire tension and in its frequency of vibration.

Vibration of the wire in the permanent magnetic field induces an alternating current in the electronic coil with the same frequency. The readout box used to pluck the wire is now used to measure this frequency, which can then be related to the temperature by means of a calibration factor supplied with each gauge.

Section 2 : Installation

The Vibrating Wire Temperature Sensor can be installed inside boreholes, buried in fill, or cast inside concrete. They are fully waterproof. No particular requirements are needed. Preliminary readings should be taken to ensure that the sensor is functioning properly. Most models incorporate a thermistor that can be used as a check on the vibrating wire readout.

2.01 Readout procedures

Connect the black and red leads to the VW Readout Box and take the reading.

The thermistor readout can be displaced directly in °C or the thermistor can be read on the green and white conductors using a digital ohmmeter in conjunction with the conversion Table B-1 in Appendix A. Allowance for cable resistance may be necessary (22 gage cable has a resistance of 20Ω/300 meters).

Section 3 : Data Reduction

The temperature (T) is given by the formula:

$$T = K (R_0 - R_1) \text{ in degrees centigrade}$$

Where: R_0 is the reference reading at 0°C
 R_1 is the subsequence reading
K is the gage factor

A typical calibration sheet showing the gauge factor is shown in Appendix A.

Section 4 : Trouble Shooting

Maintenance and trouble shooting of vibrating wire temperature sensors confined to periodic checks of cable connections and maintenance of terminals. The transducers themselves are sealed and cannot be opened for inspection.

- A normal resistance between black and red conduction is $180\Omega \pm 5\Omega$ plus cable resistance ($20\Omega/300m$).
- A normal resistance between white and green conduction depends on the temperature

If the resistance deviates from the norms, inspect the cable for damage.

Section 5 : Configuring the System

Range	Standard: -20°C to +80°C Optional: any 200°C span from -200°C to 200°C
Resolution	0.04°C (approximate)
Accuracy	±0.5% F.S
Frequency Range	2000-3000Hz
Diameter	19mm
Length	125mm
Weight	115gm
Cable	4 conductor shielded .22awg



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Appendix A. Typical Calibration Sheet



BS EN ISO 9001:2008
FM 553710

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CALIBRATION CERTIFICATE VIBRATING WIRE THERMOMETER

Model Number : T3-1.1 Date of Calibration : 15-Jan-04
Serial Number : 03-32709 Cal. Std : 402, 140-2
Calibrated By : S. Bell
Wiring code: Red and Black = Thermometer White and Green = Thermistor

CALIBRATION RESULTS

Temperature Applied (°C)	Readings In (F*1000)	Calculated Temperature		Error	
		Linear (°C)	Polynomial (°C)	Linear (%FS)	Polynomial (%FS)
-18.5	4905	-19.13	-18.38	-0.63	0.12
6.5	5888	6.65	6.27	0.15	-0.23
31.6	6427	32.29	31.56	0.69	-0.04
56.8	7171	57.43	57.09	0.83	0.29
83.2	7907	82.30	83.06	-0.90	-0.14

Linear Gauge Factor (K) : -0.03379 (°C / digit)

Calculated Temperature (Linear): $T = K (R_T - R_0)$

Polynomial Gauge Factors : A: 6.6143E-07 B: 0.0253172 C: -158.475

Calculated Temperature (Polynomial): $T = AR_1^2 + BR_1 + C$

Reference reading at 0°C (R_0) : 5471 (Regression zero)

SOIL INSTRUMENTS LIMITED certifies that the instrument detailed hereon has as applicable been inspected, tested and calibrated in accordance with ISO 9001 approved procedures and unless otherwise indicated, performs within $\pm 0.5\%$ as specified. This conforms in all respects to our relevant specifications and drawings.

Certified :

Line Manager

Appendix B. Thermistor Linearization using Steinhart and Hart Log Equation

Thermistor Type: YSI 44005, Dale #1C3001-B3, Alpha#13A3001-B3

$$\text{Basic Equation: } T = \frac{1}{A + B(\text{Ln}R) + C(\text{Ln}R)^3} - 273.2$$

Where;

T = Temperature in °C

LnR = Natural Log of Thermistor Resistance

$$A = 1.4051 \times 10^{-3}$$

$$B = 2.369 \times 10^{-4}$$

$$C = 1.019 \times 10^{-7}$$

Note: Coefficients calculated over -50° to +149° C. span.

Appendix C. Conversion Table

Ohms	Temp	Ohms	Temp	Ohms	Temp	Ohms	Temp	Ohms	Temp
201.1K	-50	16.60K	-10	2417	+30	525.4	+70	153.2	+110
187.3K	-49	15.72K	-9	2317	31	507.8	71	149	111
174.5K	-48	14.90K	-8	2221	32	490.9	72	145	112
162.7K	-47	14.12K	-7	2130	33	474.7	73	141.1	113
151.7K	-46	13.39K	-6	2042	34	459	74	137.2	114
141.6K	-45	12.70K	-5	1959	35	444	75	133.6	115
132.2K	-44	12.05K	-4	1880	36	429.5	76	130	116
123.5K	-43	11.44K	-3	1805	37	415.6	77	126.5	117
115.4K	-42	10.86K	-2	1733	38	402.2	78	123.2	118
107.9K	-41	10.31K	-1	1664	39	389.3	79	119.9	119
101.0K	-40	9796	+0	1598	40	376.9	80	116.8	120
94.48K	-39	9310	1	1535	41	364.9	81	113.8	121
88.46K	-38	8851	2	1475	42	353.4	82	110.8	122
82.87K	-37	8417	3	1418	43	342.2	83	107.9	123
77.66K	-36	8006	4	1363	44	331.5	84	105.2	124
72.81K	-35	7618	5	1310	45	321.2	85	102.5	125
68.30K	-34	7252	6	1260	46	311.3	86	99.9	126
64.09K	-33	6905	7	1212	47	301.7	87	97.3	127
60.17K	-32	6576	8	1167	48	292.4	88	94.9	128
56.51K	-31	6265	9	1123	49	283.5	89	92.5	129
53.10K	-30	5971	10	1081	50	274.9	90	90.2	130
49.91K	-29	5692	11	1040	51	266.6	91	87.9	131
46.94K	-28	5427	12	1002	52	258.6	92	85.7	132
44.16K	-27	5177	13	965	53	250.9	93	83.6	133
41.56K	-26	4939	14	929.6	54	243.4	94	81.6	134
39.13K	-25	4714	15	895.8	55	236.2	95	79.6	135
36.86K	-24	4500	16	863.3	56	229.3	96	77.6	136
34.73K	-23	4297	17	832.2	57	222.6	97	75.8	137
32.74K	-22	4105	18	802.3	58	216.1	98	73.9	138
30.87K	-21	3922	19	773.7	59	209.8	99	72.2	139
29.13K	-20	3748	20	746.3	60	203.8	100	70.4	140
27.49K	-19	3583	21	719.9	61	197.9	101	68.8	141
25.95K	-18	3426	22	694.7	62	192.2	102	67.1	142
24.51K	-17	3277	23	670.4	63	186.8	103	65.5	143
23.16K	-16	3135	24	647.1	64	181.5	104	64	144
21.89K	-15	3000	25	624.7	65	176.4	105	62.5	145
20.70K	-14	2872	26	603.3	66	171.4	106	61.1	146
19.58K	-13	2750	27	582.6	67	166.7	107	59.6	147
18.52K	-12	2633	28	562.8	68	162	108	58.3	148
17.53K	-11	2523	29	543.7	69	157.6	109	56.8	149

DECLARATION OF CONFORMITY

WITH

COUNCIL DIRECTIVE 73/23/EEC as Amended by 93/68/EEC

<i>Date of Issue:</i>	12 th October 2006	
<i>DoC Ref.:</i>	Soil/CE/LVD/MW/06	
<i>Directive:</i>	72/23/EEC Low Voltage Directive as amended by 93/68/EEC	
<i>Conforming Apparatus:</i>	All Vibrating Wire Instruments Manufactured by Soil Instruments Ltd – see pages 3-10 of Technical File	
<i>Manufacturer:</i>	Soil Instruments Ltd	
<i>Responsible Person:</i>	Chris Rasmussen Soil Instruments Ltd Bell Lane, Uckfield, East Sussex, TN22 1QL	
<i>Standards Referenced:</i>	Annex I of Directive	1.a, 1.b, 1.d, 2.a, 2.b, 2.c, 2.d, 3.a, 3.b & 3.c
<i>Technical File:</i>	Soil Instruments Ltd – EU Low Voltage Directive 73/23/EEC as amended 93/68/EEC Technical Documentation. Issue 1 – October 2006 – Vibrating Wire Instruments	
We hereby certify that the apparatus described above, conforms with the protection requirements of 72/23/EEC Low Voltage Directive as amended by 93/68/EEC on the approximation of the laws of the Member States relating to Low Voltage Equipment.		
<i>Signed:</i>		
<i>Signatory:</i>	Chris Rasmussen Technical Director	