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*Instruction Manual*

# Model 4700

## VW Temperature Gage

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## 1. Theory of Operation

The theory of operation is described in the Model 4700 brochure.

## 2. Installation

The Model 4700 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.

## 3. Readout Procedures

Connect the black and red leads to the GK-401, GK-403 or GK-404 VW Readout Box and read on channel B. If the GK-403 Readout Box, GK 404 Readout Box or Micro-10 Datalogger is used, the thermistor readout can be displayed directly in °C. If a GK-401 Readout Box is used, the thermistor can be read on the green and white conductors using a digital ohmmeter in conjunction with the conversion Table in Appendix A. Allowance for cable resistance may be necessary (22 gage cable has a resistance of 20Ω/300 meters).

## 4. Data Reduction

The temperature (**T**) is given by the formula:

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

*Where:* **R<sub>0</sub>** is the initial reading on channel B at 0°C

**R<sub>1</sub>** is the subsequent reading on channel B

**G** is the gage factor

A typical calibration sheet showing the gage factor is given on page 3.

## 5. Trouble Shooting

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Maintenance and trouble shooting of vibrating wire temperature sensors are 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 (20Ω/300m).
- A normal resistance between white and green conduction depends on the temperature (see table on page 4).

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

## 6. Specifications

|                        |   |
|------------------------|---|
| <b>Range</b>           | Standard: -20°C to +80°C<br>Optional: any 200°C span from -200°C to +200°C. |
| <b>Resolution</b>      | 0.04°C (approximate)  |
| <b>Accuracy</b>        | ±0.5% F.S.  |
| <b>Frequency Range</b> | 1400 – 3500 Hz  |
| <b>Diameter</b>        | 19mm  |
| <b>Length</b>          | 125mm   |
| <b>Weight</b>          | 115gm   |
| <b>Cable</b>           | 4 conductor shielded .22awg   |

|  |         |  |   |
|--|---------|--|---|
| <b>GEOKON</b>  |         | 48 Spencer Street, Lebanon, New Hampshire 03766 U.S.A. |   |
| <b>Vibrating Wire Temperature Gage Calibration Report</b>  |         |  |   |
| Model Number: _____  | 4700    | Mfg. Number: _____                                     | 99-304  |
| Job Number.: _____   |         | Serial Number: _____                                   |   |
| Customer: _____  |         | Calibration Date: _____                                | October 27, 1999                              |
| Cust. I.D. #: _____  |         | Cal. Std. Control #(s): _____                          | 403, 140-23                                   |
| Calibration Technician: _____  |         |  |   |
| Temperature<br>(°C)  | Reading | Calculated Temp.<br>(°C)                               | Linearity<br>(%FS)    Polynomial<br>Fit (%FS) |
| -20.2  | 3849    | -20.50   | -0.35    0.12                                 |
| 4.0  | 4555    | 4.04   | -0.01    -0.24                                |
| 28.2   | 5263    | 28.64  | 0.47    0.00                                  |
| 52.3   | 5956    | 52.73  | 0.46    0.24                                  |
| 77.0   | 6638    | 76.43  | -0.59    -0.12                                |
| <b>Linear Gage Factor (G):</b> _____ <b>-0.034752</b> _____ (°C/digit)   |         |  |   |
| <b>Polynomial Gage Factors:</b> A: <u>4.6354E-07</u> B: <u>0.029892</u> C: <u>-141.964</u>   |         |  |   |
| <b>Calculated Temperature: Linear, <math>T = G(R_0 - R_1)</math></b>   |         | <b>Polynomial, <math>T = AR_1^2 + BR_1 + C</math></b>  |   |
| <b>Reference Reading at 0°C (R<sub>0</sub>):</b> <u>4439</u> (Regression Zero)   |         |  |   |
| Calibration Procedure: Title: CI-4700    Revision: B   |         |  |   |
| Calibration results: above instrument is found to be within tolerance in all operating ranges.                                     |         |  |   |
| The above named instrument has been calibrated by comparison with standards traceable to the NIST, in compliance with ANSI Z540-1. |         |  |   |
| <b>Reading at shipment:</b>  |         |  |   |
| GK-401 Pos. B: _____   |         | Temp: _____  | Date: _____                                   |
| Checked/Issued By: _____   |         |  |   |
| Wiring Code: Red and Black: Gage    White and Green: Thermistor    Bare: Shield  |         |  |   |
| This calibration document shall not be reproduced except in full without written permission of Geokon, Inc.                        |         |  |   |

**Figure 1. Typical Calibration Sheet.**

## Appendix A:

Thermistor Linearization using Steinhart and Hart Log Equation

Tech Memo 91-03 Doc Rev 6-94, Geokon, Inc.

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

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

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 +150° C. span.*

**Resistance versus Temperature 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   | 149.0 | 111  |
| 174.5K | -48  | 14.90K      | -8        | 2221  | 32   | 490.9 | 72   | 145.0 | 112  |
| 162.7K | -47  | 14.12K      | -7        | 2130  | 33   | 474.7 | 73   | 141.1 | 113  |
| 151.7K | -46  | 13.39K      | -6        | 2042  | 34   | 459.0 | 74   | 137.2 | 114  |
| 141.6K | -45  | 12.70K      | -5        | 1959  | 35   | 444.0 | 75   | 133.6 | 115  |
| 132.2K | -44  | 12.05K      | -4        | 1880  | 36   | 429.5 | 76   | 130.0 | 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        | 965.0 | 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  | 64.0  | 144  |
| 21.89K | -15  | <b>3000</b> | <b>25</b> | 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   | 162.0 | 108  | 58.3  | 148  |
| 17.53K | -11  | 2523        | 29        | 543.7 | 69   | 157.6 | 109  | 56.8  | 149  |
|        |      |             |           |       |      |       |      | 55.6  | 150  |

## APPENDIX B - HIGH-TEMPERATURE THERMISTOR LINEARIZATION

### High Temperature Thermistor Linearization using Steinhart-Hart Log Equation

Thermistor Type: Thermometrics BR55KA822J    Basic Equation:  $T = \frac{1}{A + B(\ln R) + C(\ln R)^3} - 273.2$

Where:  $T$  = Temperature in °C       $\text{Ln}R$  = Natural Log of Thermistor Resistance  
 $A = 1.02569 \times 10^{-3}$        $B = 2.478265 \times 10^{-4}$        $C = 1.289498 \times 10^{-7}$

| Temp | R<br>(ohms) | LnR    | LnR <sup>3</sup> | Calculated<br>Temp | Diff  | FS<br>Error | Temp | R<br>(ohms) | LnR   | LnR <sup>3</sup> | Calculated<br>Temp | Diff  | FS<br>Error |
|------|-------------|--------|------------------|--------------------|-------|-------------|------|-------------|-------|------------------|--------------------|-------|-------------|
| -30  | 113898      | 11.643 | 1578.342         | -30.17             | 0.17  | 0.06        | 120  | 407.62      | 6.010 | 217.118          | 120.00             | 0.00  | 0.00        |
| -25  | 86182       | 11.364 | 1467.637         | -25.14             | 0.14  | 0.05        | 125  | 360.8       | 5.888 | 204.162          | 125.00             | 0.00  | 0.00        |
| -20  | 65805       | 11.094 | 1365.581         | -20.12             | 0.12  | 0.04        | 130  | 320.21      | 5.769 | 191.998          | 130.00             | 0.00  | 0.00        |
| -15  | 50684.2     | 10.833 | 1271.425         | -15.10             | 0.10  | 0.03        | 135  | 284.95      | 5.652 | 180.584          | 135.00             | 0.00  | 0.00        |
| -10  | 39360       | 10.581 | 1184.457         | -10.08             | 0.08  | 0.03        | 140  | 254.2       | 5.538 | 169.859          | 140.01             | -0.01 | 0.00        |
| -5   | 30807.4     | 10.336 | 1104.068         | -5.07              | 0.07  | 0.02        | 145  | 227.3       | 5.426 | 159.773          | 145.02             | -0.02 | -0.01       |
| 0    | 24288.4     | 10.098 | 1029.614         | -0.05              | 0.05  | 0.02        | 150  | 203.77      | 5.317 | 150.314          | 150.03             | -0.03 | -0.01       |
| 5    | 19294.6     | 9.868  | 960.798          | 4.96               | 0.04  | 0.01        | 155  | 183.11      | 5.210 | 141.428          | 155.04             | -0.04 | -0.01       |
| 10   | 15424.2     | 9.644  | 896.871          | 9.98               | 0.02  | 0.01        | 160  | 164.9       | 5.105 | 133.068          | 160.06             | -0.06 | -0.02       |
| 15   | 12423       | 9.427  | 837.843          | 14.98              | 0.02  | 0.01        | 165  | 148.83      | 5.003 | 125.210          | 165.08             | -0.08 | -0.03       |
| 20   | 10061.4     | 9.216  | 782.875          | 19.99              | 0.01  | 0.00        | 170  | 134.64      | 4.903 | 117.837          | 170.09             | -0.09 | -0.03       |
| 25   | 8200        | 9.012  | 731.893          | 25.00              | 0.00  | 0.00        | 175  | 122.1       | 4.805 | 110.927          | 175.08             | -0.08 | -0.03       |
| 30   | 6721.54     | 8.813  | 684.514          | 30.01              | -0.01 | 0.00        | 180  | 110.95      | 4.709 | 104.426          | 180.07             | -0.07 | -0.02       |
| 35   | 5540.74     | 8.620  | 640.478          | 35.01              | -0.01 | 0.00        | 185  | 100.94      | 4.615 | 98.261           | 185.10             | -0.10 | -0.04       |
| 40   | 4592        | 8.432  | 599.519          | 40.02              | -0.02 | -0.01       | 190  | 92.086      | 4.523 | 92.512           | 190.09             | -0.09 | -0.03       |
| 45   | 3825.3      | 8.249  | 561.392          | 45.02              | -0.02 | -0.01       | 195  | 84.214      | 4.433 | 87.136           | 195.05             | -0.05 | -0.02       |
| 50   | 3202.92     | 8.072  | 525.913          | 50.01              | -0.01 | -0.01       | 200  | 77.088      | 4.345 | 82.026           | 200.05             | -0.05 | -0.02       |
| 55   | 2693.7      | 7.899  | 492.790          | 55.02              | -0.02 | -0.01       | 205  | 70.717      | 4.259 | 77.237           | 205.02             | -0.02 | -0.01       |
| 60   | 2276.32     | 7.730  | 461.946          | 60.02              | -0.02 | -0.01       | 210  | 64.985      | 4.174 | 72.729           | 210.00             | 0.00  | 0.00        |
| 65   | 1931.92     | 7.566  | 433.157          | 65.02              | -0.02 | -0.01       | 215  | 59.819      | 4.091 | 68.484           | 214.97             | 0.03  | 0.01        |
| 70   | 1646.56     | 7.406  | 406.283          | 70.02              | -0.02 | -0.01       | 220  | 55.161      | 4.010 | 64.494           | 219.93             | 0.07  | 0.02        |
| 75   | 1409.58     | 7.251  | 381.243          | 75.01              | -0.01 | 0.00        | 225  | 50.955      | 3.931 | 60.742           | 224.88             | 0.12  | 0.04        |
| 80   | 1211.14     | 7.099  | 357.808          | 80.00              | 0.00  | 0.00        | 230  | 47.142      | 3.853 | 57.207           | 229.82             | 0.18  | 0.06        |
| 85   | 1044.68     | 6.951  | 335.915          | 85.00              | 0.00  | 0.00        | 235  | 43.673      | 3.777 | 53.870           | 234.77             | 0.23  | 0.08        |
| 90   | 903.64      | 6.806  | 315.325          | 90.02              | -0.02 | -0.01       | 240  | 40.533      | 3.702 | 50.740           | 239.69             | 0.31  | 0.11        |
| 95   | 785.15      | 6.666  | 296.191          | 95.01              | -0.01 | 0.00        | 245  | 37.671      | 3.629 | 47.788           | 244.62             | 0.38  | 0.13        |
| 100  | 684.37      | 6.528  | 278.253          | 100.00             | 0.00  | 0.00        | 250  | 35.055      | 3.557 | 45.001           | 249.54             | 0.46  | 0.16        |
| 105  | 598.44      | 6.394  | 261.447          | 105.00             | 0.00  | 0.00        | 255  | 32.677      | 3.487 | 42.387           | 254.44             | 0.56  | 0.19        |
| 110  | 524.96      | 6.263  | 245.705          | 110.00             | 0.00  | 0.00        | 260  | 30.496      | 3.418 | 39.917           | 259.34             | 0.66  | 0.23        |
| 115  | 461.91      | 6.135  | 230.952          | 115.00             | 0.00  | 0.00        |      |             |       |                  |                    |       |             |