The World Leader in Vibrating Wire Technology

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Instruction Manual

Model 4425

VW Convergence Meter

(Doc Rev K, 6/13)

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1. INTRODUCTION

The Model 4425 Vibrating Wire Convergence Meter is designed to detect the deformation of rock or soil masses by measuring the contraction (or elongation) between 2 fixed anchor points. Anchor points are established in the mass, and connecting rods from one anchor lead back to transducer assembly located at the second anchor point. Changes in distance between the 2 anchors are conveyed by the connecting rods and measured by the transducer.

The Model 4425 Convergence Meter consists of 3 basic components. They are 1) the 2 anchor points, 2) 6 mm (¼") diameter connecting rods, and 3) the spring-tensioned vibrating wire transducer assembly. See Figure 1. Essential accessories include a vibrating wire readout and an installation tool kit (supplied).

The transducer consists of a vibrating wire sensing element in series with a heat treated, stress relieved spring which is connected to the wire at one end and a connecting rod at the other. The unit is fully sealed and operates at pressures of up to 250 psi. As the connecting rod is pulled out from the gage body, the spring is elongated causing an increase in tension which is sensed by the vibrating wire element. The tension in the wire is directly proportional to the extension, hence, the convergence can be determined very accurately by measuring the strain change with the vibrating wire readout box.

The convergence meter can operate in horizontal, inclined or vertical orientations. In areas where construction traffic is expected or where the instrument may be left in an exposed location, some form of protective housing should be considered.

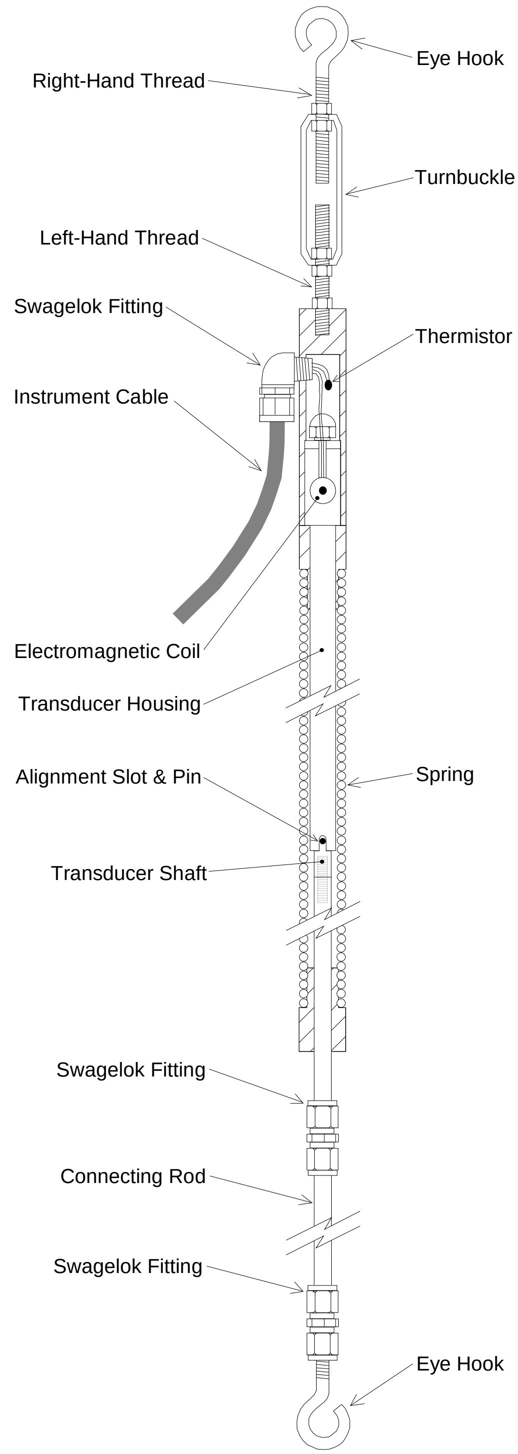


Figure 1 - Model 4425 Convergence Meter

2. INSTALLATION

2.1. Preliminary Tests

Upon receipt of the instrument, the gage should be checked for proper operation (including the thermistor). See Section 3 for readout instructions. In position "B" the gage will read around 2000 when the threaded connector is pulled out approximately 3 mm (0.125"). **Do not extend the connector more than the range of the gage.** The threaded connector on the end of the gage should not be turned independently of the gage body.

Checks of electrical continuity can also be made using an ohmmeter. Resistance between the gage leads should be approximately 180 Ω, ±10 Ω. Remember to add cable resistance when checking (22 AWG stranded copper leads are approximately 14.7Ω/1000' or 48.5Ω/km, multiply by 2 for both directions). Between the green and white should be approximately 3000 ohms at 25° (see Table B-1), and between any conductor and the shield should exceed 2 megohms.

2.2. Convergence Meter Installation

The first step is to unpack all the various components and lay them on a flat surface in their relative positions (see Figure 1).

Next, the two anchor points must be installed. When the locations have been decided, drill holes to accomodate the anchors. Cement the eyebolt anchors in place using quick-set (hydraulic) cement or epoxy. Allow the cement or epoxy to set completely before attempting the installation of the convergence meter.

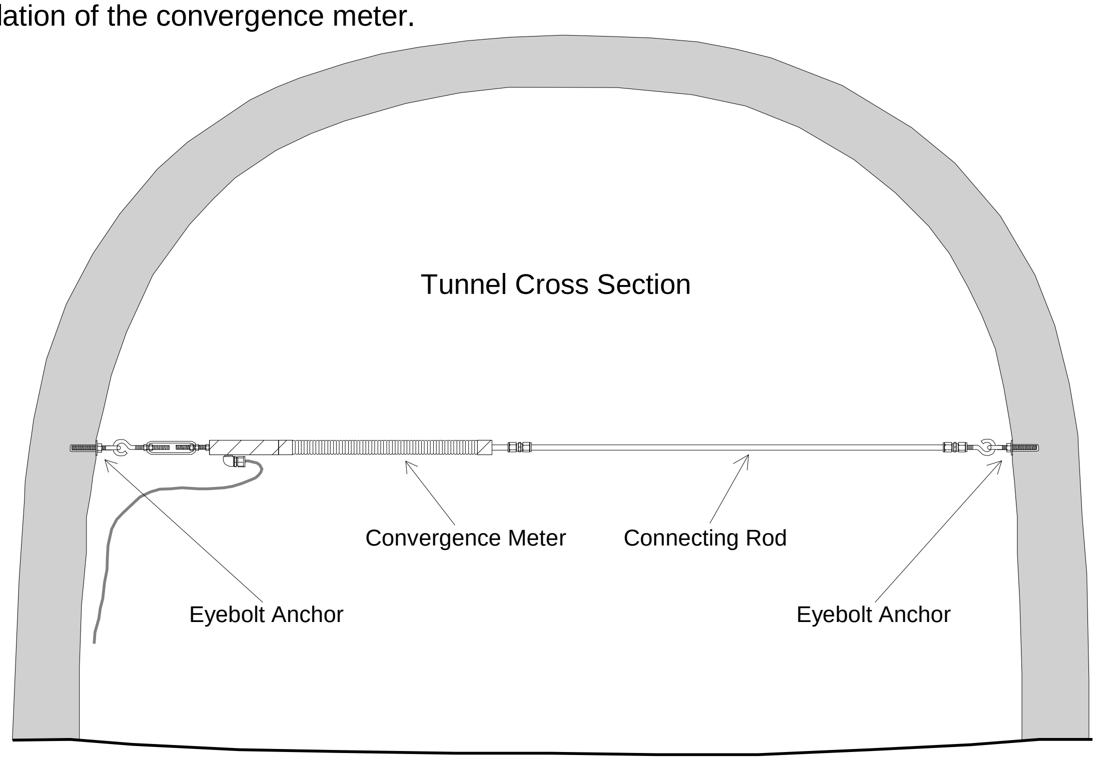


Figure 2 - Model 4425 Convergence Meter Installation

Follow these steps to install the convergence meter;

1. Attach the turnbuckle assembly to the convergence meter by screwing in the left-hand threaded portion. Use thread locking cement and tighten the lock nut. Set the turnbuckle such that about 10-12 mm (0.5") of thread is inside from each end.
2. Measure the total distance from anchor eyebolt to anchor eyebolt, inside to inside at the points where they will touch the convergence meter eyehooks.
3. Check and confirm the convergence meter length against the length shown in the table below. (The measurement is made from inside the eyehooks, at the point where they touch the anchor eyebolts, to the end of the Swagelok fitting. To calculate the rod length that will be needed, subtract the convergence meter length from the anchor eyebolt to anchor eyebolt distance, now add 30mm (1.2") to account for the distance the rod penetrates the Swagelok fittings, This is the nominal rod length that will be required.

Range:	**12 mm 0.50 inches**	**25 mm 1 inch**	**50 mm 2 inches**	**100 mm 4 inches**	**150 mm 6 inches**
Convergence Meter Length including Swagelok eyehook assembly:	710 mm 28"	710 mm 28"	865 mm 34"	1195 mm 47"	1615 mm 63.5"

4. Next, the connecting rods must be assembled. This is achieved using the Swagelok fittings supplied with the instrument and the appropriate wrenches. Appendix C details additional fitting assembly instructions.

   Connect the first length of connecting rod to the sensor using the Swagelok fitting. Push the rod into the fitting until it hits the stop. Tighten the nut 1½ turns, holding the body with one wrench while tightening the nut with the other. Connect the second and successive rods using the Swagelok fittings as described above.
5. Connect the Swagelok eyehook to one end of the rods and the convergence meter to the other.
6. Hook the eyehook end into the installed eyebolt <u>first</u>.
7. Now, hook the convergence meter into the other eyebolt. It should go in without having to extend the convergence meter spring. **Remember that if the spring is extended beyond the range of the transducer the transducer could be damaged.**
8. Connect the readout box. To set the transducer to mid-range, rotate the turnbuckle until a reading of approximately 5500 digits is obtained. To use the total range in convergence, set the meter at 8000. To use the total range in extension, set the meter at 2500.
9. Tighten the locknuts on the turnbuckle. The installation is now complete.
10. To remove the system, loosen the turnbuckle all the way and then remove the convergence meter. Disconnect the Swagelok fittings on the rods and disassemble the rods to a manageable length. If the rod string needs to be lengthened (or shortened) for the next installation, cut off the ferrules and reinstall new ferrules for the next installation.

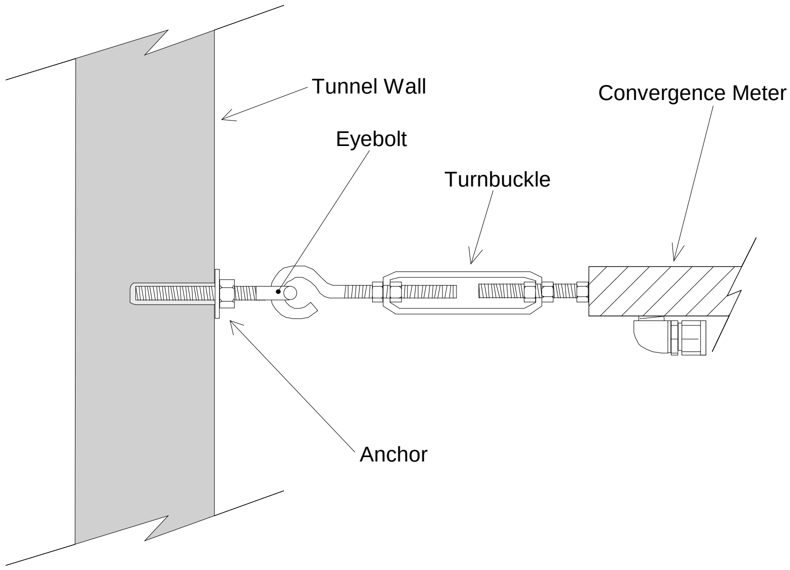


Figure 3 - Convergence Meter Installation Detail - Turnbuckle End

2.3. Cable Installation

The cable should be routed in such a way so as to minimize the possibility of damage due to moving equipment, debris or other causes.

Cables may be spliced to lengthen them, without affecting gage readings. Always waterproof the splice completely, preferably using an epoxy based splice kit such the 3M Scotchcast™, model 82-A1. These kits are available from the factory.

2.4. Electrical Noise

Care should be exercised when installing instrument cables to keep them as far away as possible from sources of electrical interference such as power lines, generators, motors, transformers, arc welders, etc. **Cables should never be buried or run with AC power lines!** The instrument cables will pick up the 50 or 60 Hz (or other frequency) noise from the power cable and this will likely cause a problem obtaining a stable reading. Contact the factory concerning filtering options available for use with the Geokon dataloggers and readouts should difficulties arise.

2.5. Initial Readings

Initial readings must be taken and carefully recorded along with the temperature at the time of installation.

3. TAKING READINGS

3.1. Operation of the GK-403 Readout Box

The GK-403 can store gage readings and also apply calibration factors to convert readings to engineering units, ie. inches or millimeters. Consult the GK-403 Instruction Manual for additional information on Mode "G" of the Readout. The following instructions will explain taking gage measurements using Mode "B".

Connect the Readout using the flying leads or in the case of a terminal station, with a connector. The red and black clips are for the vibrating wire transducer, the white and green clips are for the thermistor and the blue for the shield drain wire.

1. Turn on the Readout. Turn the display selector to position "B". Readout is in digits (see Equation 1).

2. Turn the unit on and a reading will appear in the front display window. The last digit may change one or two digits while reading. Press the "Store" button to record the value displayed. If the no reading displays or the reading is unstable see section 5 for troubleshooting suggestions. The thermistor will be read and output directly in degrees centigrade.

3. The unit will automatically turn itself off after approximately 2 minutes to conserve power.

3.2 Operation of the GK404 Readout Box

The GK404 is a palm sized readout box which displays the Vibrating wire value and the temperature in degrees centigrade.
The GK-404 Vibrating Wire Readout arrives with a patch cord for connecting to the vibrating wire gages. One end will consist of a 5-pin plug for connecting to the respective socket on the bottom of the GK-404 enclosure. The other end will consist of 5 leads terminated with alligator clips. Note the colors of the alligator clips are red, black, green, white and blue. The colors represent the positive vibrating wire gage lead (red), negative vibrating wire gage lead (black), positive thermistor lead (green), negative thermistor lead (white) and transducer cable drain wire (blue). The clips should be connected to their respectively colored leads from the vibrating wire gage cable.

Use the **POS** (Position) button to select position **B** and the MODE button to select **Dg** (digits). Other functions can be selected as described in the GK404 Manual.

The GK-404 will continue to take measurements and display the readings until the OFF button is pushed, or if enabled, when the automatic Power-Off timer shuts the GK-404 off.

The GK-404 continuously monitors the status of the (2) 1.5V AA cells, and when their combined voltage drops to 2V, the message **Batteries Low** is displayed on the screen. A fresh set of 1.5V AA batteries should be installed at this point

3.3 Operation of the GK405 Readout Box

The GK-405 Vibrating Wire Readout is made up of two components:

- the Readout Unit, consisting of a Windows Mobile handheld PC running the GK-405 Vibrating Wire Readout Application
- the GK-405 Remote Module which is housed in a weather-proof enclosure and connects to the vibrating wire sensor by means of:

1) Flying leads with alligator type clips when the sensor cable terminates in bare wires or,
2) by means of a 10 pin connector..

The two components communicate wirelessly using Bluetooth®, a reliable digital communications protocol. The Readout Unit can operate from the cradle of the Remote Module (see Figure 4) or, if more convenient, can be removed and operated up to 20 meters from the Remote Module

Figure 4 GK405 Readout Unit

For further details consult the GK405 Instruction Manual.

3.4. Measuring Temperatures

Each Vibrating Wire Convergence Meter is equipped with a thermistor for reading temperature. The thermistor gives a varying resistance output as the temperature changes. Usually the white and green leads are connected to the internal thermistor. Note: The GK-403, gK-404 and GK-405 readout boxes will read the thermistor and display temperature in °C automatically

1. If an Ohmmeter is uded connect the ohmmeter to the two thermistor leads coming from the convergence meter. (Since the resistance changes with temperature are so large, the effect of cable resistance is usually insignificant.)

2. Look up the temperature for the measured resistance in Table B-1 (Appendix B). Alternately the temperature could be calculated using Equation B-1 (Appendix B). For example, a resistance of 3400 ohms equivalent to 22° C. When long cables are used the cable resistance may need to be taken into account. Standard 22 AWG stranded copper lead cable is approximately 14.7Ω/1000' or 48.5Ω/km, multiply by 2 for both directions.

4. DATA REDUCTION

4.1. Deformation Calculation

The basic units utilized by Geokon for measurement and reduction of data from Vibrating Wire Convergence Meters are "digits". The units displayed by the all Readout Boxes in position "B" are digits. Calculation of digits is based on the following equation;

$$\text{Digits} = \left(\frac{1}{\text{Period(in seconds)}}\right)^2 \times 10^{-3} \quad \text{or} \quad \text{Digits} = \text{Hz}^2 \times 10^{-3}$$

Equation 1 - Digits Calculation

To convert digits to deformation the following equation applies;

$$\mathbf{D_{uncorrected} = (R_1 - R_0) \times G \times F}$$

Equation 2 - Deformation Calculation

Where: $D_{uncorrected}$ is the calculated deformation.
R_1 is the current reading.
R_0 is the initial reading usually obtained at installation (see section 2.4).
G is the calibration factor, usually in terms of millimeters or inches per digit.
F is an engineering units conversion factor (optional), see Table 1.

From→ To↓	**Inches**	**Feet**	**Millimeters**	**Centimeters**	**Meters**
Inches	1	12	0.03937	0.3937	39.37
Feet	0.0833	1	0.003281	0.03281	3.281
Millimeters	25.4	304.8	1	10	1000
Centimeters	2.54	30.48	0.10	1	100
Meters	0.0254	0.3048	0.001	0.01	1

Table 1 - Engineering Units Conversion Multipliers

For example, the initial reading, R_0, at installation of a convergence meter with a 12 mm transducer range is 4919 digits. The current reading, R_1, is 6820. The Calibration Factor is 0.00258 mm/digit. The deformation change is;

$$D_{uncorrected} = (6820 - 4919) \times 0.002402 = +4.566\text{mm}$$

Note that increasing readings (digits) indicate increasing extension.

A typical calibration sheet is shown in figure 5.

GEOKON 48 Spencer St. Lebanon, NH 03766 USA

Vibrating Wire Displacement Transducer Calibration Report

Range: 12.5 mm

Calibration Date: August 23, 2012

Serial Number: 1224097

Temperature: 23.9 °C

Calibration Instruction: CI-4400

Technician: [signature]

GK-401 Reading Position B

Actual Displacement (mm)	Gage Reading 1st Cycle	Gage Reading 2nd Cycle	Average Gage Reading	Calculated Displacement (Linear)	Error Linear (%FS)	Calculated Displacement (Polynomial)	Error Polynomial (%FS)
0.0	2333	2331	2332	-0.02	-0.15	0.00	0.00
2.5	3383	3382	3383	2.50	0.04	2.50	0.00
5.0	4429	4427	4428	5.02	0.13	5.00	0.00
7.5	5469	5467	5468	7.51	0.12	7.50	-0.01
10.0	6505	6504	6505	10.00	0.04	10.00	0.01
12.5	7535	7535	7535	12.48	-0.15	12.50	0.00

(mm) Linear Gage Factor (G): 0.002402 (mm/ digit)

Regression Zero: 2340

Polynomial Gage Factors: A: 5.388E-09 B: 0.002349 C: ______

Calculate C by setting D = 0 and R_1 = initial field zero reading into the polynomial equation

(inches) Linear Gage Factor (G): 0.00009458 (inches/digit)

Polynomial Gage Factors: A: 2.1213E-10 B: 0.00009249 C: ______

Calculate C by setting D = 0 and R_1 = initial field zero reading into the polynomial equation

Calculated Displacement: **Linear, $D = G(R_1 - R_0)$**

Polynomial, $D = AR_1^2 + BR_1 + C$

Refer to manual for temperature correction information.

The above instrument was found to be in 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.

Figure 5 A typical Calibration Sheet

4.2. Temperature Correction

The Model 4425 Vibrating Wire Convergence Meter has a very small coefficient of thermal expansion so in most cases correction is not necessary. However, if maximum accuracy is desired or the temperature changes are extreme (>10° C) corrections may be applied. The following equation applies;

$$D_{temperature} = (T_1 - T_0)(K + LK_R + K_T)$$

Equation 3 - Temperature Correction

Where: $D_{temperature}$ is the deformation due to temperature change.
T_1 is the current temperature in degrees C.
T_0 is the initial temperature in degrees C.
K is the thermal coefficient of transducer, see Equation 4.
K_R is the thermal coefficient of the connecting rod, see Table 3.
L is the length of the connecting rod, in millimeters or inches.
K_T is the thermal coefficient of the turnbuckle/spring, 0.0007" or 0.0178 mm/°C.

Tests have determined that the transducer thermal coefficient, K, changes with the position of the transducer shaft. Hence, the first step in the temperature correction process is determination of the proper transducer thermal coefficient based on the following equation;

$$K = ((R_1 \times M) + B) \times G$$

Equation 4 - Transducer Thermal Coefficient Calculation

Where: K is the transducer thermal coefficient.
R_1 is the current reading in digits.
M is the multiplier from Table 2.
B is the constant from Table 2.
G is the calibration factor from the supplied Calibration Sheet.

Model:	**4425-12 mm 4425-0.5"**	**4425-25 mm 4425-1"**	**4425-50 mm 4425-2"**	**4425-100 mm 4425-4"**	**4425-150 mm 4425-6"**
Multiplier (M):	0.000295	0.000301	0.000330	0.000192	0.000216
Constant (B):	1.724	0.911	0.415	0.669	0.491

Model:	**4425-200 mm 4425-8.0"**	**4425-300 mm 4425-12"**			
Multiplier (M):	0.000305	0.000245			
Constant (B):	0.240	0.564			

Table 2 - Transducer Thermal Coefficient Calculation Constants

All of the above thermal corrections describe an expansion of components with an increase in temperature. Hence, the calculated thermal corrections must be ***added*** to the deformation calculated using Equation 2.

$$D_{tcorrected} = D_{uncorrected} + D_{temperature}$$

Equation 5 - Thermally Corrected Deformation Calculation

Experience has shown that the most stable readings are obtained when the system is at a stable temperature. Taking readings late at night or early in the morning will eliminate the transient effects of sunlight and rapid warming of sensor components. If a datalogger is used, readings will show the trends associated with thermal effects during the day and through the seasons, and allow corrections for these effects to be accurately made.

4.3. Rod Stretch Correction

$$\text{Rod Stretch} = \frac{PL}{aE}$$

Where; P is the rod tension (lbs. or Newtons).
L is the rod length (inches or mm).
a is the rod area of cross section (sq inches or square mm).
E is the Youngs modulus (lbs/sq inch or MPa).

P depends on the spring rate, S, of the large exterior tension spring and the amount of deformation ($D_{tcorrected}$),

i.e. $P = S\,D_{corrected}$ so that:

$$D_{rodstretch} = \frac{SDL}{aE}$$

Equation 6 – Rod Stretch correction

Values for K_R and E are as follows:

Rod Material	E, Youngs Modulus		K_R Thermal Coefficient
	Lbs/sq in.	MPa	Per º C
Stainless Steel	28.5×10^6	0.196×10^6	17.3×10^{-6}
Graphite	17×10^6	0.117×10^6	0.2×10^{-6}
Invar	21×10^6	0.145×10^6	1.1×10^{-6}
Fiberglass	6×10^6	0.041×10^6	6.0×10^{-6}

Table 3 – Youngs Modulus and Thermal Coefficients

Increasing tensions cause the rod to elongate so that the required correction would be positive, when $\mathbf{D_{tcorrected}}$ is positive.

Values for S are as follows:

	Range		Spring Rate	
Model Number	Inches	mm	lbs/in.	Newtons/mm
4425-12	½	12	34	5.95
4425-25	1	25	34	5.95
4425-50	2	50	17	2.98
4425-100	4	100	17	2.98
4425-150	6	150	8.5	1.49

Table 4 – Spring Rates

4.4 Correction for Sag

Correction for sag = $-LW^2/24P^2$ or $-L^3\omega^2/24P^2$…………… Equation 7 Sag Correction

Where L = length of rods (The distance over which the measurement is made).

W = weight of rods

P = tension. The springs used have an initial tension of 13lbs, (57.8N), and this must be added to the force caused by the diplacement = SD

ω = weight of rods per unit length (See Table 5)

For convergence the correction is negative, for extensions the correction is positive.

For example: consider a horizontal convergence meter consisting of 60ft of graphite rods with spring constant of 17 lbs per inch.

L = length of rods = 60ft (The distance over which the measurement is being made).

W = weight of 60ft of graphite rods = 2 lbs

P_0 = 47lbs and P_1 = 30 lbs (These values are obtained from a knowledge of the spring tension at various extensions), and that an apparent measured convergence of 1.000 inch has taken place.

The correction to L for sag initially is -60 x 4 / 24 x 47 x 47 = - 0.0045ft = - 0.054 inches

The correction for sag at T_1 is - 60 x 4 / 24 x 30 x 30 = - 0.0111ft = - 0.133 inches

So after correction for sag the true convergence is 1 – (0.133 – 0.054) = 0.921 inches

Rod Material	Weight per unit length	
	Lbs/inches	Kgm/mm
Stainless Steel	0.0139	248×10^{-6}
Graphite	0.00275	49.1×10^{-6}
Invar	0.0139	248×10^{-6}
Fiberglass	0.0035	62.4×10^{-6}

Table 5 - Densities

Summing all the various effects.

$$D_{corrected} = D_{uncorrected} + D_{temperature} + D_{rodstretch} + D_{sag}$$

Equation 8 - Corrected Deformation

Again, consider the following example from a Model 4425-12 Convergence Meter attached to 30 meters of ¼ inch diameter graphite rod.

R_0 = 4919 digits
R_1 = 6820 digits
T_0 = 15.3° C
T_1 = 32.8° C
$(T_1 - T_0)$ = + 17.5° C
G = 0.002402 mm/digit
L = 30 meters = 30,000mm
S = 5.95 N/mm
a = 31.67 sq mm
$E = 0.117 \times 10^6$ MPa
ω = 0.049Kgm/m = 0.481N/m (0.033 lbs/ft)
P_0 = 133N
P1 = 163N

From Equation 4

$K = ((6820 \times 0.000295) + 1.724) \times 0.002402 = 0.009mm$

From Equation 2

$D_{uncorrected} = (6820 - 4919) \times 0.002402 = + 4.566\ mm$

The plus sign indicates an extension

From Equation 3

$D_{temperature} = + 17.5(0.009 + 0.2 \times 10^{-6} \times 30{,}000 + 0.0178)$

$= + 0.479\ mm$

From Equation 5

$D_{corrected} = + 4.566 + 0.479 = + 5.045\ mm$

From Equation 6

$D_{rodstretch} = 5.95 \times 5.045 \times 30{,}000 / 31.67 \times 0.117 \times 10^6 = +0.243mm$

From Equation 7 (Not required if the convergence meter is vertical)

$D_{sag} = [30^3 \text{ x } 0.481^2 /24 \text{ x } 133 \text{ x } 133] - [30^3 \text{ x } 0{,}481^2/24 \text{ x } 163 \text{ x } 163] = + 4.918\ mm$

From Equation 8

The true extension

$D_{corrected} = + 4.566 + 0.479 + 0.243 + 4.918 \quad = + 10.2\ mm$

4.5 Environmental Factors

Since the purpose of the convergence meter installation is to monitor site conditions, factors which may affect these conditions should always be observed and recorded. Seemingly minor effects may have a real influence on the behavior of the structure being monitored and may give an early indication of potential problems. Some of these factors include, but are not limited to: blasting, rainfall, tidal levels, excavation and fill levels and sequences, traffic, temperature and barometric changes, changes in personnel, nearby construction activities, seasonal changes, etc.

5. TROUBLESHOOTING

Maintenance and troubleshooting of Geokon Vibrating Wire Convergence Meters are confined to periodic checks of cable connections and maintenance of terminals. The Convergence Meters contain no user-servicable components. However, consult the following list of problems and possible solutions should difficulties arise. Consult the factory for additional troubleshooting help.

Symptom: Convergence Meter Readings are Unstable

- ✓ Is the readout box position set correctly? If using a datalogger to record readings automatically are the swept frequency excitation settings correct?
- ✓ Is the transducer shaft of the Convergence Meter positioned outside the specified range of the instrument? Note that when the transducer shaft is fully retracted with the alignment pin inside the alignment slot (Figure 1) the readings will likely be unstable because the transducer is now out of range.
- ✓ Is there a source of electrical noise nearby? Most probable sources of electrical noise are motors, generators, transformers, arc welders and antennas. Make sure the shield drain wire is connected to ground whether using a portable readout or datalogger. If using the GK-401 Readout connect the clip with the green boot to the bare shield drain wire of the pressure cell cable. If using the GK-403 connect the clip with the blue boot to the shield drain wire.

Symptom: Convergence Meter Fails to Read

- ✓ Is the cable cut or crushed? This can be checked with an ohmmeter. Nominal resistance between the two transducer leads (usually red and black leads) is 180Ω, ±10Ω. Remember to add cable resistance when checking (22 AWG stranded copper leads are approximately 14.7Ω/1000' or 48.5Ω/km). If the resistance reads infinite, or very high (>1 megohm), a cut wire must be suspected. If the resistance reads very low (<100Ω) a short in the cable is likely. Splicing kits and instructions are available from the factory to repair broken or shorted cables. Consult the factory for additional information.
- ✓ Does the readout or datalogger work with another Convergence Meter? If not the readout or datalogger may be malfunctioning.

Symptom: Thermistor resistance is too high.

- ✓ Is there an open circuit? Check all connections, terminals and plugs. If a cut is located in the cable, splice according to instructions in Section 2.3.

Symptom: Thermistor resistance is too low.

- ✓ Is there a short? Check all connections, terminals and plugs. If a short is located in the cable, splice according to instructions in Section 2.3.
- ✓ Water may have penetrated the interior of the Convergence Meter. There is no remedial action.

APPENDIX A - SPECIFICATIONS

A.1. Model 4425 Convergence Meter

Range:	**12 mm 0.50 inches**	**25 mm 1 inch**	**50 mm 2 inches**	**100 mm 4 inches**	**150 mm 6 inches**
Resolution:[1]	0.025% FSR				
Linearity:	0.25% FSR				
Accuracy:	0.1% FSR (with polynomial expression)				
Thermal Zero Shift:[2]	< 0.05% FSR/°C				
Stability:	< 0.2%/yr (under static conditions)				
Overrange:	115% FSR				
Temperature Range:	-40 to +60°C -40 to 120° F				
Frequency Range:	1200 - 2800 Hz				
Coil Resistance:	180 Ω, ±10 Ω				
Cable Type:[3]	2 twisted pair (4 conductor) 22 AWG Foil shield, PVC jacket, nominal OD=6.3 mm (0.250")				
Convergence Meter Length including Swagelok eyehook assembly:	710 mm 28"	710 mm 28"	865 mm 34"	1195 mm 47"	1615 mm 63.5"

Table A-1 Model 4425 Specifications

Notes:
[1] Minimum, greater resolution possible depending on readout.
[2] Depends on application.
[3] Polyurethane jacket cable available.

A.2. Thermistor (see Appendix B also)

Range: -80 to +150° C
Accuracy: ±0.5° C

APPENDIX B - THERMISTOR TEMPERATURE DERIVATION

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

Resistance to Temperature Equation:

$$T = \frac{1}{A + B(LnR) + C(LnR)^3} - 273.2$$

Equation B-1 Convert Thermistor Resistance to Temperature

Where; T = Temperature in °C.
LnR = Natural Log of Thermistor Resistance
$A = 1.4051 \times 10^{-3}$ (coefficients calculated over the –50 to +150° C. span)
$B = 2.369 \times 10^{-4}$
$C = 1.019 \times 10^{-7}$

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	**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	162.0	108	58.3	148
17.53K	-11	2523	29	543.7	69	157.6	109	56.8	149
								55.6	150

Table B-1 Thermistor Resistance versus Temperature

APPENDIX C - SWAGELOK FITTING ASSEMBLY INSTRUCTIONS

INSTALLATION INSTRUCTIONS

SWAGELOK Tube Fittings

SWAGELOK Tube Fittings come to you completely assembled, finger-tight. They are ready for immediate use.

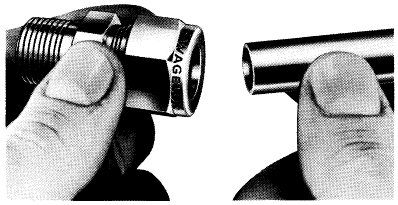
Disassembly before use is unnecessary and can result in dirt or foreign material getting into fitting and causing leaks.

High Pressure Applications or High Safety Factor Systems

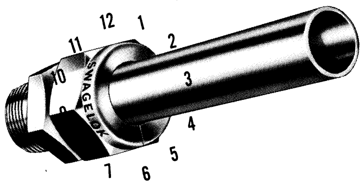
Due to variations in tubing diameters, a common starting point is desirable. Using a wrench, tighten the nut to the SNUG position. Snug is determined by tightening the nut until the tubing will not rotate freely (by hand) in the fitting. (If tube rotation is not possible, tighten the nut approximately 1/8 turn from the finger-tight position). At this point, scribe the nut at the 6 o'clock position and tighten the nut 1-1/4 turns.* The fitting will now hold pressures well above the rated working pressure of the tubing.

Use of the individual Gap Inspection Gage (1-1/4 turns* from snug end) ensures sufficient pull-up.

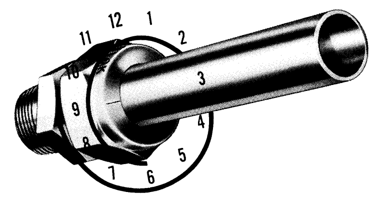
SWAGELOK Tube Fittings are installed in three easy steps:



Simply insert the tubing into the SWAGELOK Tube Fitting. ***Make sure that the tubing rests firmly on the shoulder of the fitting and that the nut is finger-tight.***



Before tightening the SWAGELOK nut, scribe the nut at the 6 o'clock position.



Now, while holding the fitting body steady with a backup wrench, tighten the nut 1-1/4 turns.* Watch the scribe mark, make one complete revolution and continue to the 9 o'clock position.

By scribing the nut at the 6 o'clock position as it appears to you, there will be no doubt as to the starting position. When tightened 1-1/4 turns* to the 9 o'clock position you can easily see that the fitting has been properly installed.

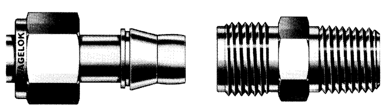
Use of the Gap Inspection Gage (1-1/4 turns* from finger-tight) assures sufficient pull-up.

*For 1/16," 1/8" and 3/16" size tube fittings, only 3/4 turn from finger-tight is necessary.

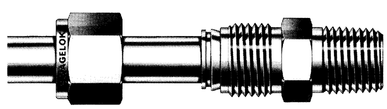
RE-TIGHTENING INSTRUCTIONS

Connections can be disconnected and re-tightened many times. The same reliable, leak-proof seal can be obtained every time the connection is remade.

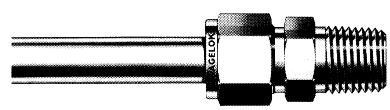
Fitting shown in disconnected position.



Tubing with pre-swaged ferrules inserted into the fitting until front ferrule seats in fitting.



Tighten nut by hand. Rotate nut to the original position with a wrench. (An increase in resistance will be encountered at the original position). Then tighten slightly with the wrench. (Smaller tube sizes will take less tightening to reach the original position, while larger tube sizes will require more tightening. The wall thickness will also have an effect on tightening).



GAP INSPECTION GAGES

The SWAGELOK Gap Inspection Gage is placed in the gap between the nut and body hex. If the gage **will not** fit, the fitting nut is tightened sufficiently.

For multiple sizes

This gage works on five (5) sizes of SWAGELOK Tube Fittings: 1/4," 3/8," 1/2," 6mm, and 12mm.

Ordering Number: MS-IG-468

For individual sizes

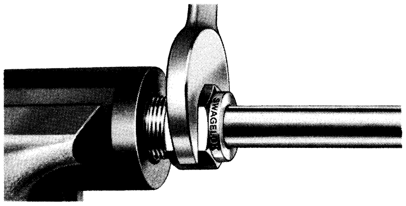
Fitting Size (Inches)	Series
1/16*	100
1/8*	200
3/16*	300
1/4	400
5/16	500
3/8	600
1/2	810
5/8	1010
3/4	1210
7/8	1410
1	1610

*For 1/16," 1/8," and 3/16" size tube fittings, only 3/4 turn from finger-tight is necessary.

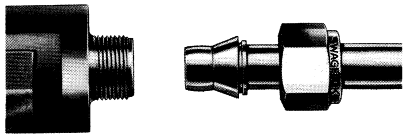
PRE-SWAGING INSTRUCTIONS

When installing SWAGELOK Tube Fittings in cramped quarters or where ladders must be used, it may be advantageous to use a pre-swaging tool. It allows the pre-swaging of ferrules onto the tube in a more open or safe area. After using the tool, simply follow the re-tightening instructions.

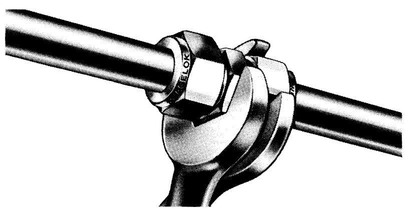
Oversized or very soft tubing may occasionally stick in the tool after pull-up. If this happens, remove the tube by gently rocking back and forth. DO NOT TURN the tube with pliers or other tools as this may damage sealing surfaces.



Assemble SWAGELOK nut and ferrules to pre-swaging tool. Insert tubing through ferrules until it bottoms in the pre-swaging tool, and tighten nut 1-1/4 turns.*



2 The nut is loosened and the tubing with pre-swaged ferrules is removed from the pre-swaging tool.



3 The connection can now be made by following the *Re-tightening Instructions.*

Tube O.D. Size	Part Number
1/16″	[illegible]
1/8″	[illegible]
3/16″	[illegible]
1/4″	[illegible]
5/16″	[illegible]
3/8″	[illegible]
1/2″	[illegible]

While pre-swaging tools can be used many times, they do have a finite life. After frequent use, ask your Authorized Sales & Service Representative to have them checked.

Hydraulic Swaging Units are available in 1/2,″ 5/8,″ 3/4″ and 1″ sizes. See below for further information.

*For 1/16,″ 1/8″ and 3/16″ size tube fittings, only 3/4 turn from finger-tight is necessary.

SWAGELOK Hydraulic Swaging Unit

FOR INSTALLING SWAGELOK TUBE FITTINGS

A Hydraulic Swaging Unit is available for making up to 1/2,″ 5/8,″ 3/4″ and 1″ size SWAGELOK Tube Fittings. The Swaging Unit is ideal for installations where large numbers of SWAGELOK Tube Fittings are made up. The unit is designed to swage the ferrules on the tubing prior to final assembly into a fitting. It assures a safe and reliable, torque-free, leak-proof seal on different tube materials.

The unit consists of a Swaging Tool and a sturdy metal Accessory Case containing a hydraulic pump, hose and service equipment. Advantages include:

- Portable and easy to use by one person
- Requires little physical effort by the installer, reducing installation time
- Ensures proper and sufficient swaging of the ferrules onto the tubing
- Does not place any initial strain on the nut or fitting body threads, or on body seal surfaces

Consult your Authorized Sales & Service Representative for a demonstration.

HOW TO ORDER

[illegible]	For
[illegible]	1/2″ SWAGELOK Fittings
[illegible]	5/8″ SWAGELOK Fittings
[illegible]	3/4″ SWAGELOK Fittings
[illegible]	1″ SWAGELOK Fittings

Units are also available for 1-1/4,″ 1-1/2″ and 2″ SWAGELOK Fittings.