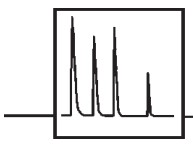
GENERAL SERVICE BULLETIN

For Repair of Thermal Conductivity Cells



GOW-MAC®
INSTRUMENT CO.

Contents

NOTICE

This General Service Bulletin is intended for reference only and *not* as a complete instruction manual. GOW-MAC recommends that all our customers take advantage of our 65+ years experience and employ the resources of our Repair Department.

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Analytical Instruments Since 1935

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I INTRODUCTION

GOW-MAC® offers a variety of detector elements for Thermal Conductivity Cells. It is the purpose of this brochure to outline the methods used for the field replacement of these elements.

Thermal conductivity detectors (TCDs) are used in on-stream applications as well as in gas chromatographs. The cells differ only in internal volume and speed of response. The detector elements are the same.

The choice of elements is based on the application and corrosive properties of the gaseous stream. The characteristics of the GOW-MAC filaments are described in Bulletin SB-13. Since many gas chromatographs use thermistors rather than hot wires, thermistor installation procedures are also covered in this bulletin.

The majority of TCDs use filaments held in place by means of tube nuts which screw into the cell and make a mechanical seal between the flange on the filament holder and the seat in the cell. (Fig. 1)

GOW-MAC filaments are mounted on either two or three pin glass to metal seals. The 9225 and 333 mounts are gold plated Kovar with glass insulation. GOW-MAC also offers (a) a hermetic seal type, and (b) a concentric filament type (730 mount) as used in Model 10-952 Cell. (Fig. 2) Hermetic seal and concentric filament type cells must be returned to GOW-MAC for filament replacement. However, filaments can be replaced in the field in cells having mechanical seals by following the instructions in the bulletin.

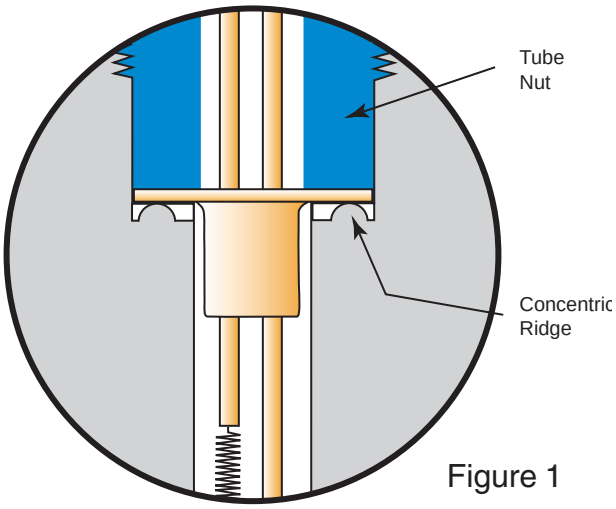


Figure 1

Filaments are sold in pairs and quads. A pair consists of two matched filaments. Most cells require two pairs, or four filaments. In order to make a well balanced cell, all four filaments should be closely matched. Several pairs may be required to obtain the proper match between pairs.

GOW-MAC offers filaments in sets of four matched elements called “Quads.” The four elements have been matched under test conditions simulating the installation in a thermal conductivity detector. A quad is shipped in an aluminum block with lead extensions.

Installation of the quad results in a far superior cell from an electrical as well as pneumatic standpoint. A quad should give far longer life than the installation of two matched pairs because the initial balance will be closer to a true electrical zero.

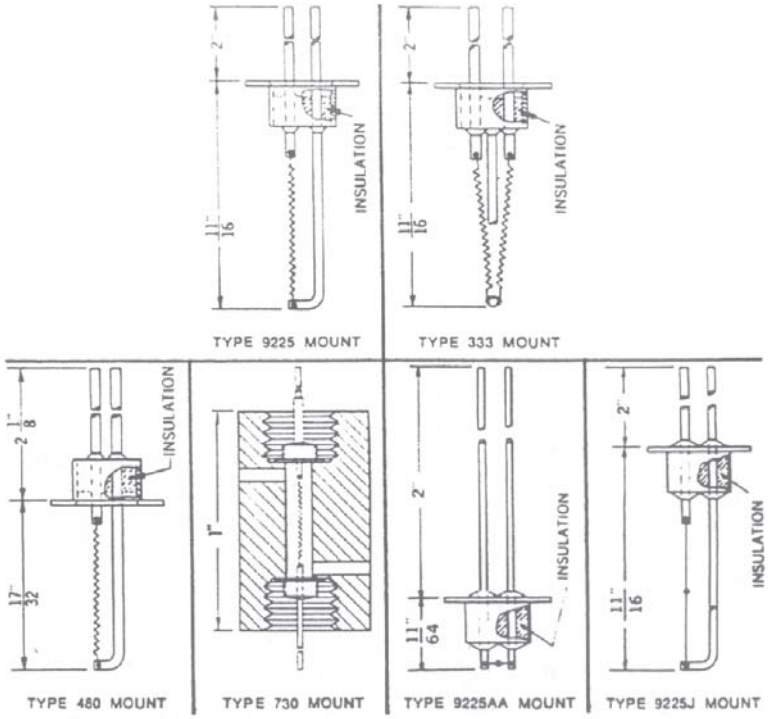


Figure 2

Matching of filaments at GOW-MAC is done under controlled conditions to obtain identical current resistance as well as heat dissipation characteristics. Cold resistance measurements are not significant except for identification.

It should be noted that the terms “Sample” and “Reference” are used throughout this bulletin. Since most GOW-MAC cells are double pass, these terms are used to differentiate side A and side B. In gas chromatography, they would refer to the carrier gas from column A and column B.

The electrical circuits used will vary with manufacturers but almost all incorporate the Wheatstone Bridge. Normally four elements are used but many instruments use two element bridges, especially thermistors. Figs. 3, 4 and 5 illustrate typical bridges with the zero adjustment between two elements in the conventional style. Fig. 6 shows the more modern approach, but note that it is still a “bridge” circuit.

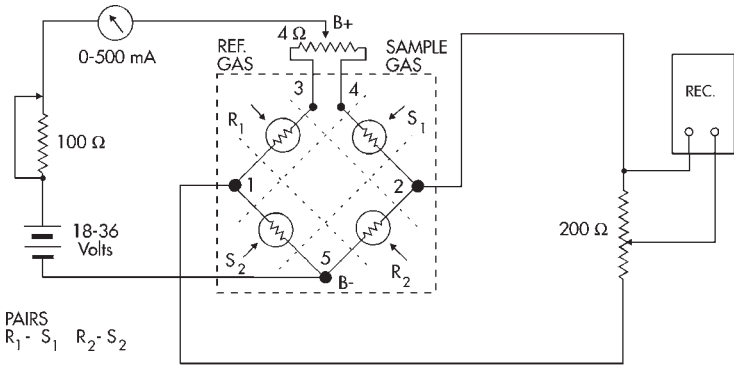
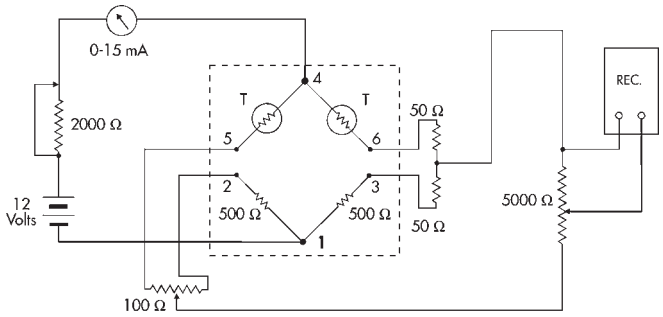


Figure 3

Circuitry For 4-filament Cells

Figure 4



Circuitry For Thermistor Cells

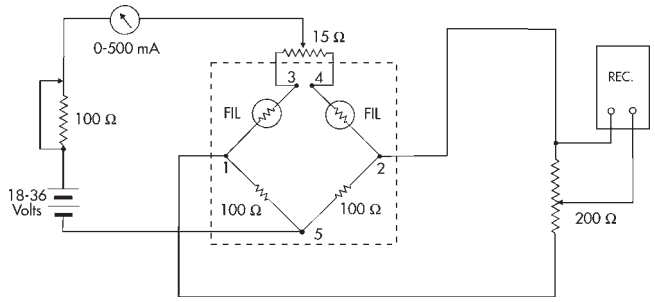
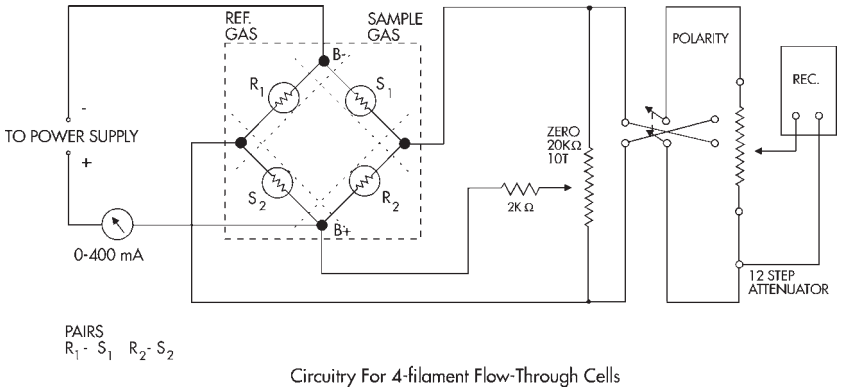


Figure 5

Circuitry For 2 Filament Cells

Figure 6



Circuitry For 4-filament Flow-Through Cells

II REPAIR BY GOW-MAC

A. Cells of most major manufacturers may be returned to GOW-MAC for installation of new filaments. We will clean, repair and re-filament your thermal conductivity detector to the specifications of the original manufacturer. GOW-MAC service includes:

1. Cleaning of inside of cell block.

2. Replacement of all filaments.

3. Replacement of electrical leads with new silver-solder connections and fibre glass insulation.

4. Complete pneumatic and electrical leak-testing to the original new performance specifications on potentiometric recorders. See IV. A. 5. for specifications.

B. GOW-MAC also offers new replacement T/C Cells for most of the major gas chromatographs on the market today, including many discontinued and obsolete models.

III FIELD REPAIR

A. The orientation of the filaments in the detector cell is *most important*. The gas passages in most cells are usually referred to as sample and reference, even in dual column systems. In some cells the sample and reference gas enters on one side and passes directly through the cell and exits on the opposite side. In other cells the sample gas enters and leaves on the same side with the reference gas entering and leaving the other side. It is important to establish the gas flow passages as related to the element cavities for proper installation of the filaments or thermistors. This is easily done by noting the column connections before removal of the cell from the instrument.

B. Since some cells use bridge wiring different from that shown in this manual it is recommended that notation be made of connections from each filament before removal from the instrument.

C. Filaments should always be replaced in pairs. It is impractical to attempt to replace single filaments. Consult GOW-MAC Engineering Department for recommendations in case of doubt as to the proper elements to use.

D. The tools required are:

Vise
1/2" box wrench (some cells require use of an open-end wrench)
Torque wrench, if possible
Silver solder
Flux
Torch with small flame tip

Since most TCDs used in GC operate at elevated temperatures, the use of soft solder is not feasible. For this reason GOW-MAC offers filaments with extended leads. Once the leads are out of the detector oven, soft solder may be used.

E. Four Filament Cells

1. Disconnect the electrical connections to the filaments.

2. Remove the detector block from the instrument according to the instructions found in the instrument's operating instruction manual (included with your instrument).

3. Place cell in vise and cut off extended leads (save leads).

4. Back off tube nuts. Usually these can be reused. If not, they are available from GOW-MAC, Part No. 176-110. Beckman cells use nuts with a different thread; Call our Repair Dept. for details.

5. Clean cavities of cell block, tubing and drilled sections with acetone. If water rinse is used, make sure all water is removed and cell is dry before installing filaments. This is most easily accomplished by baking the detector block at 150°C for six (6) hours in an oven with a N_2 flow. All internal surfaces must have same finish for uniform heat dissipation. Inspect cavity seats for deposits, dirt or chips.

ACETONE IS EXTREMELY FLAMMABLE. USE CARE WHEN USING. DO NOT EXPOSE ACETONE TO OPEN FLAMES OR SMOKING MATERIALS. DISPOSE OF WASTE PROPERLY.

6. Loosen the tube nuts and remove the filaments (one at a time) from the shipping QUAD. Place the filaments in the proper detector cavity (REFERENCE AND SAMPLE according to the detectors' flow configuration, Fig. 7) making sure to keep the filament helix away from gas flow inlet. If you are installing pairs of filaments, make sure you pass the leads through the tube nuts before inserting them into the detector block. Quads are shipped with tube nuts for use when replacing the new filaments.

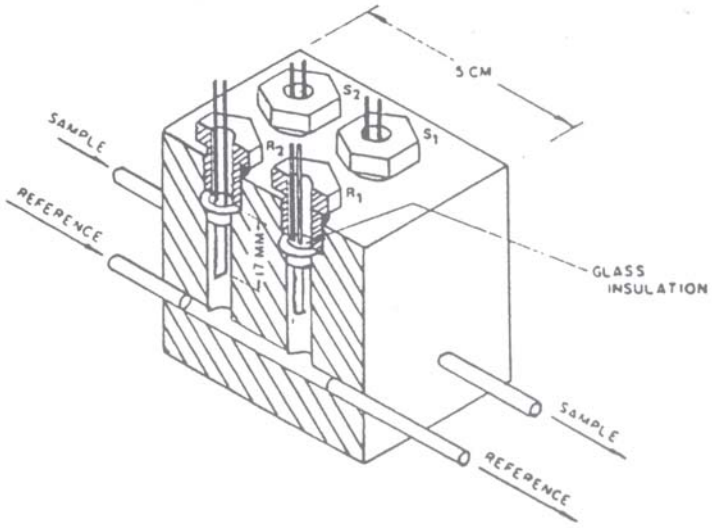


Figure 7

NOTE

THE QUAD IS NOT A DETECTOR. IT IS USED ONLY AS A CONTAINER TO PROTECT THE FILAMENTS FROM DAMAGE DURING SHIPPING.

WHEN INSTALLING FILAMENTS FOLLOW THE DIAGRAM ABOVE AND INSERT THEM IN THE SAMPLE AND REFERENCE OF THE DETECTOR CORRESPONDING TO THE SAMPLE AND REFERENCE OF THE ALUMINUM QUAD.

7. Tighten tube nuts to 12 - 15 ft. lbs on flat seat type or 7 - 8 ft. lbs. on ring seat type filaments. Note: All GOW-MAC TCDs are ring seat type.

CAUTION

EXCESSIVE TIGHTENING OF THE TUBE NUTS MAY CRACK THE GLASS INSULATORS. ALWAYS USE GOW-MAC TUBE NUTS.

8. A preliminary electrical check of the detector should be made using clip leads rather than soldering leads to extensions. Connect to proper terminals. If cell is removed from the instrument wrap in glass wool or other insulation.

9. Purge cell with carrier gas, nitrogen or air, for 5-10 minutes before turning on power.

10. Use current value from Chart (Fig. 8) dependent on gas used, and allow warm-up time of 15-20 minutes. At this time the Zero control on the instrument should be set at the center position of travel. A well balanced cell will permit maximum use of the Zero control in either direction.

11. Observe zero trace on recorder with helium carrier gas at 30 ml/min flowing through both passes, first at specified current, and then at 10mA less. The current change will check for “current-zero shift” which will not occur if pairs are compatible and have been correctly installed.

12. If cell shows a minor unbalance, interchange two filaments in any matched pair, and observe new trace. This means that R1 should be placed in S1 position and vice versa, not that a new pair should be inserted in the cell block. Also try interchanging R2 and S2.

13. After obtaining satisfactory experimental construction tighten tube nuts with torque wrench to 12-15 ft. lbs. on flat seat and 7-8 ft. lbs. on ring seat (all GOW-MAC TCD's are ring seat) and leak test pneumatically, at two atmospheres. Release pressure gradually. In some cells the filaments can be destroyed by a rapid change in gas flow.

14. Silver-solder long lead connections, remove flux and replace insulation, observing color coding.

15. Test again as above with air or carrier gas flow at specified current for noise level, drift, etc.

    Do not expect to get perfect results in field replacement. It requires patience and experience, also trial and error to obtain perfectly balanced bridges.

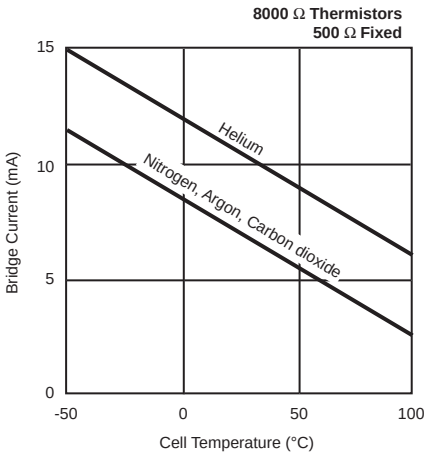
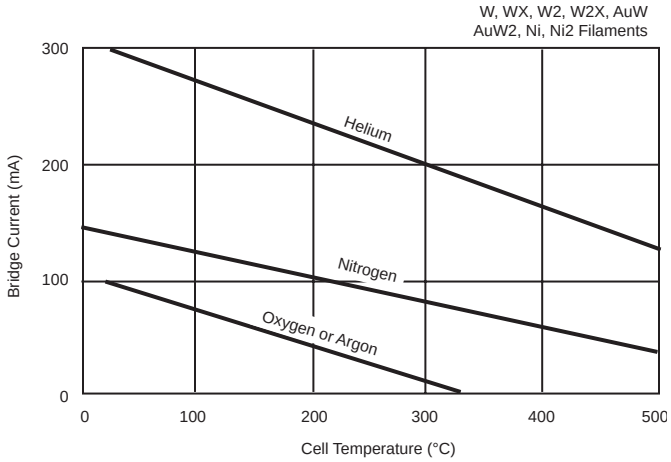


Figure 8



F. TWO FILAMENT CELLS

1. Cell in vise. Back off tube nuts. Remove elements.

2. Note position of support assemblies. 333 W2 long support wire faces inlet. (Fig. 2). 9225-A and AA (thermistor) is at right angles to axis of inlet. (Fig. 2)

3. Clean as described in III. E. 3. above.

4. Position new detector elements as observed in “2" above and proceed as de scribed in III. E. 5-6 above.

5. Check bridge electrically.

    a. For thermistor detector check bridge in static air. If satisfactory check with appropriate reference gas.

    b. For filament detector check bridge with appropriate carrier gas at a flow approximately 10 - 20 cc/min.

6. Note possible temperature effect of external resistors, if any. Wrap in glass wool, or immerse in oil bath, if unduly sensitive.

IV CHANGING REFERENCE/CARRIER GAS

A. GOW-MAC Thermal Conductivity Cells for gas chromatography are tested under the following conditions:

1. Specified carrier gas at nominal 50 mL/min for two hours outgassing with passes in series, (5 mL/min for micro cell).

2. Atmospheric pressure.

3. Ambient temperature with cell thermally lagged. Allow to warm up.

4. Cell current: 100 mA in helium.

5. Circuit in accordance with Figs. 3, 4, 5 or 6 should result in:

   a. Nominally balanced bridge.

   b. Noise level: ±10 µV maximum.

   c. Drift: <10 µV in 10 minutes after warm-up.

6. Most gas chromatography detectors are tested on helium. Changing to carriers sometimes requires change in current, to give satisfactory operating characteristics (check appropriate chart). The following steps should be taken after leak testing each passage:

   a. Introduce new carrier gas into system at the recommended flow rate. Allow time for a complete purge.

   b. Set bridge current as follows:

Recommended Starting Current Settings (milliamperes) at Ambient Temperature

Gas	Hot Wire	8K Thermistors
Argon	**80 mA**	**6 mA**
Helium	**100 mA**	**8 mA**
Nitrogen	**80 mA**	**6 mA**

c. Turn on recorder and set attenuator for maximum sensitivity.

d. Adjust zero control until recorder reads ZERO.

e If zero cannot be obtained, follow the procedure outlined below:

i. Set zero control at center of travel.

ii. Set decade box with range of 20,000 ohms at 20,000.

iii. Place one lead on “B-” terminal of T/C cell (terminal 5). (Fig. 9).

iv. Place second lead to Galvo terminal 1 or 2 (whichever drives recorder toward zero). (Fig. 9).

v. Adjust decade box until recorder reads ZERO.

vi. Remove decade box and replace with resistor of same value as indicated on decade box.

vii. Minimum trim adjust values:

4 single-helix cell	2,000 Ω
4 double-helix cell	8,000 Ω

f. The power required by the W2 and W2X filaments produces selfheating of the cell block. This results in a longer warm-up time than is normally encountered with W/WX filaments.

A minimum operating temperature of the oven will be about 70-80 °C unless forced air ventilation permits heat dissipation.

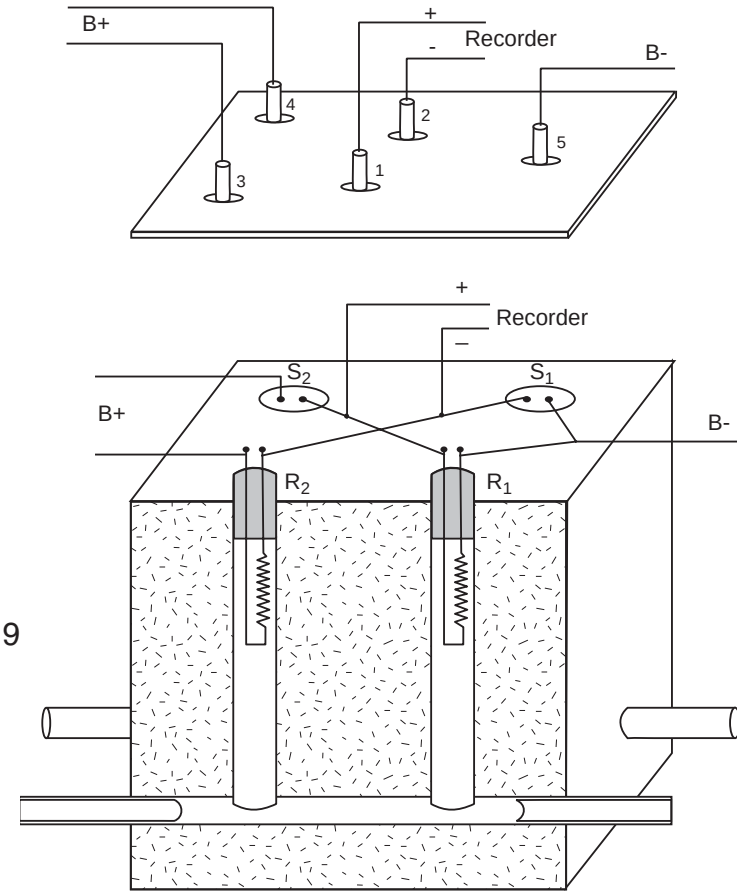


Figure 9

Pairs: R_1 - R_2 and R_2 - S_2

V MISCELLANEOUS NOTES

1. Filament life may be extended by operating at low current and low cell temperatures. The cell temperature should only be as high as needed for samples used, and current should be as low as possible consistent with sensitivity required. It is better to operate the system at an attenuation of 1X or 2X at low bridge currents than at higher currents with higher attenuation.

2. Sensitivity increases 4 to 8 times as filament current increases by a factor of 2. However, increasing filament current excessively results in baseline instability and possible filament burnout. Care must be observed in arbitrarily changing bridge current.

3. Occasionally filaments will gradually unbalance. This occurs for several reasons. The most common is a leak in the system. Small leaks can develop at fittings. Even though the system is under pressure, air can aspirate into the system oxidizing the filaments. When this happens one side of the bridge resistance changes and is out of balance. This is evidenced by a long term drift in one direction. A dynamic leak check will determine if leaks are present. If so, then the operator must seek them out. This may be difficult since the leak may develop when the instrument is hot. A GOW-MAC Gas Leak Detector was designed specifically for this type of application; soap solution may also be used.

   Unbalance may also occur because of samples which oxidize or corrode one side of the detector. This is demonstrated by a peak not returning to the old baseline and establishing a new baseline above the old. Another injection will again require zero adjustment. Correction of this phenomenon is accomplished by either lowering the bridge current, detector temperature or changing to a more corrosive resistant detector element.

4. Occasionally filaments will go out of balance because one side of a dual column instrument is used all the time and sees only the sample, and the other side only pure helium. Under these conditions both sides of the instrument should be fitted with the same column and the sample alternated from one side to another.

5. In the event filaments are burned out, and the instrument can no longer be balanced as in 3 above, the procedure outlined in section IV.5. can be used to obtain a balanced cell. This should be used as an emergency procedure only. Essentially the addition of resistance to one side of the bridge decreases sensitivity and linearity.

6. A word about SERVICE: GOW-MAC detectors are made from materials of the best grade with simplicity of design, and are thoroughly tested before shipment. In these days of service contracts, guarantees, warranties and service networks the best guarantee really, is the reputation of the manufacturer.

7. If you encounter problems or have questions concerning TCDs or repairs, call GOW-MAC technical or engineering sales at 610/954-9000.

VI TROUBLE SHOOTING GUIDE

TROUBLE	PROBABLE CAUSE	CHECKS AND/OR REMEDY
1. No signal	a) Detector or power switch off. switch off.	Make sure carrier is flowing and turned on. Set bridge current to desired setting.
	b) Recorder improperly connected.	Connect recorder.
	c) Detector filaments burned out.	Replace elements. (See manual).
	d) Open circuit on detector cell.	Check for broken lead wires, loose terminal screws and broken filament(s).
2. Low cell current	a) Power Supply voltage inadequate (likely to occur with change from from lower resistance element to higher resistance element).	Increase power supply capacity.
3. Recorder can't be zeroed.	a) Excessive bridge current.	Reduce bridge current (refer to operating charts).
	b) Detector contaminated.	Clean cell cavities and elements. Replace elements if required.
	c) Loose or corroded electrical connections.	Check connections.
	d) Detector elements oxidized bridge out of balance.	Replace all four elements.
4. Drift.	a) Change in flow sample and/or reference gas pressure.	Check flow gauges. Creeping regulator or reducing valve.
	b) Warm-up period too short.	Allow sufficient purge and temperature equilibration.
	c) Changes in ambient temperature.	Protect instrument from drafts, direct sunlight, or nearby sources of hot or cool air.
	d) Carrier gas flow leaks.	Tighten all fittings so they are leak-free.
	e) Detector contaminated.	Clean detector cell.
	f) Contamination in column.	Recondition column.
	g) Filament ageing.	As a temporary measure, switch sample and reference passes of the cell. Eventually replace elements.
	h) Decompression chill by the reference gas.	Install heater or buffer volume.

TROUBLE	PROBABLE CAUSE	CHECKS AND/OR REMEDY
	i) Cell mass (micro cells) is insufficient.	Increase heat sink mass. Heat insulate dummy resistors (in 2 element bridge).
5. Short filament life.	a) Improper start-up/shutdown procedure.	*First* turn on gas. Wait, turn on filament current. Turn off current first - gas off last.
	b) Corrosive samples.	Check other filament materials which might have higher corrosive resistance.
6. Cycles in zero trace.	a) Oven thermostat not functioning properly.	Install unit of proper rating. Check location. (Should be near heat source).
	b) Oven heater wattage excessive.	Reduce wattage.
	c) Oven fan or circulating pump failure.	Replace.
	d) Oven insulation is inadequate.	Change material and/or cabinet design.
7. Noise in signal trace (pneumatic sources).	a) Loose or worn column connections.	Install new unions or ferrules.
	b) Septum leaks.	Replace with new septum.
	c) Leaks in sample line.	Pressure check to 2 atmospheres; components, all connections, septum and gas sampling device.
	d) Leaks in reference line.	Check: tubing, pressure regulators, and gas cylinder connections.
	e) Leaks in T/C cell.	Remove cell from instrument and check for loose tube nuts, bad seats, or a cracked header. Replace parts as required.
	f) Impurities in reference gas.	Install purifier or new cylinder.
	g) Back diffusion into	Install tail pipe (24" min.) cell.
	h) Ambient pressure changes.	Air conditioned labs may require venting to doors.
	i) Tubing, etc., not inert.	Replace.
	j) GC column contaminated.	Back flush, Remove and bake.

TROUBLE	PROBABLE CAUSE	CHECKS AND/OR REMEDY
8. Noise in signal trace (water vapor sources).	a) Water vapor in reference or sample gas.	Install drier. (Especially important for H_2 ref. gas).
	b) Condensate in gas flow system.	Avoid traps and valleys in tubing runs. All horizontal runs should slope 5°/min.
9. Noise, blips, or hash in signal trace (electrical sources).	a) Recorder defective.	Service recorder. Install voltage regulator.
	b) Line voltage variations.	Install voltage regulator.
	c) Line frequency variations.	Check the frequency.
	d) Non-shielded recorder leads.	Replace.
	e) Ungrounded recorder.	Provide common ground for all electrical components.
	f) Vibration and shock.	Cushion apparatus.
	g) Intermittent electrical connections.	Connections not clean or mechanically secure. (Clean and resolder). Replace any plug and socket connections.
10. Loss of signal sensitivity. (Reduced signal from known sample).	a) Bridge current incorrect	Check milliammeter against standard.
	b) Recorder attenuator changed.	Check with signal generator.
	c) Detector contaminated.	Clean cell cavities and detector elements. Replace elements if necessary.
	d) Leaks in gas train. Low filament current. Low temperature of cell block. Poor recorder connections and incorrect range setting.	Check.
	e) Carrier gas impure.	Install purifier or replace cylinder.
	f) Column impaired.	Replace.
	g) Cell wired incorrectly.	Refer to Figs. 3, 4, 5 or 6.
11. Loss of signal sensitivity. (Increases response time or lower peaks from known sample).	a) Detector contaminated.	Clean cell cavities and detector elements. Replace elements if necessary.

TROUBLE	PROBABLE CAUSE	CHECKS AND/OR REMEDY
	b) Improper rate of flow and/or pressure of sample gas.	Check.
12. Signal peaks inverted.	a) Cell is incorrectly wired.	Check, and refer to Figs. 3, 4, 5 or 6.
13. Zero adjust is over sensitive.	a) Recorder range set too high.	Change recorder span or attenuator.
	b) Potentiometer too coarse.	Replace with unit of lower resistance. Install shunt or vernier.
	c) Dirty potentiometer contacts.	Rotate contact arm several times. Replace unit if necessary.
	d) Detector filaments too hot.	Reduce bridge current.
	e) Filaments are excessively	See number 4.

VII RELATIVE THERMAL CONDUCTIVITY

A. ORGANIC GASES

	(RELATIVE TO AIR = 1.000)		
	80°F 26.7°C	100°F 37.8°C	100°F 93.3°C
Air	1.000	1.000	1.000
Acetone	0.438		0.555
Acetonitrile			0.477
Acetylene	0.815		0.946
Amylamine	0.497		
Benzene	0.398		0.525
i-Butane	0.624		0.766
n-Butane	0.611		0.743
i-Butylamine	0.536		
Carbon Tetrachloride	0.257		0.289
Chloroform	0.287		0.322
Cyclohexane	0.450		0.584
Decane		0.480	0.586
Diethylamine	0.543		
Dimethylamine	0.636		
Dipropylamine	0.456		
Ethane	0.834		1.013
Ethyl Acetate	0.411		0.506
Ethyl Alcohol	0.562		0.701
Ethylamine	0.603		
Ethyl Bromide	0.371		
Ethyl Chloride	0.470		0.562
Ethylene	0.780		0.978
Ethyl Ether	0.579		0.700
Ethyl Iodide	0.258		
Freon 12	0.371		0.431
Freon 113	0.293		0.370
Heptane	0.459		0.592
Hexane	0.490		0.637
Methane	1.312		1.416
Methyl Acetate	0.450		0.545
Methyl Alcohol	0.547		0.698
Methyl Amine		0.690	
Methyl Bromide	0.272		0.326
Methyl Chloride	0.409		0.502
Methylene Chloride	0.285		0.331
Methyl Iodide	0.199		0.236
Nonane		0.491	0.573
Octane		0.536	0.634
Pentane	0.581		0.705
Propane	0.700		0.837
Proplyamine		0.536	
Toluene		0.573	0.669
Triethylamine	0.483		
Trimethylamine	0.589		
Xylene		0.523	0.551

B. INORGANIC GASES

	(RELATIVE TO AIR = 1.000) 80°F 26.7°C	100°F 37.8°C	100°F 93.3°C
Air	1.000	1.000	1.000
Ammonia	0.941		1.052
Argon	0.678		0.677
Bromine Vapor		0.187	
Carbon Dioxide	0.636		0.710
Carbon Disulfide	0.305		
Carbon Monoxide	0.964		0.972
Chlorine	.340		0.365
Deuterium	5.379		5.343
Fluorine	1.067		1.107
Helium	5.734		5.497
Hydrogen	6.943		6.778
Hydrogen Bromide	0.331		0.348
Hydrogen Chloride	0.555		0.579
Hydrogen Cyanide	0.477		0.522
Hydrogen Sulphide		0.573	
Iodine Vapor			
Krypton		0.361	
Neon	1.886		1.812
Nitric Oxide	.991		0.998
Nitrogen	.994		0.986
Nitrogen Dioxide			2.681
Nitrous Oxide	0.664		0.759
Oxygen	1.023		1.031
Sulphur Dioxide	0.367		0.409
Water Vapor	0.692		0.769
Xenon		0.215	0.218

VIII REFERENCES

A. For further information on thermal conductivity detectors and separations the following books are recommended:

1. Dal Nogare, S., and Juvet, R.S., Jr., “Gas-Liquid Chromatography,” Interscience Pub., New York, 1962.

2. Purnell, H., “Gas Chromatography,” J. Wiley & New York, 1962.

3. David, D. J., “Gas Chromatographic Detectors,” Wiley-Interscience, New York, 1974.

4. Miller, J. M., “Separation Methods in Chemical Analysis,” Wiley-Interscience, New York, 1974.

5. McNair, H. M., and Bonelli, E. J., “Basic Gas Chromatography,” GOW-MAC Instrument Co., Bethlehem, PA, 1969.

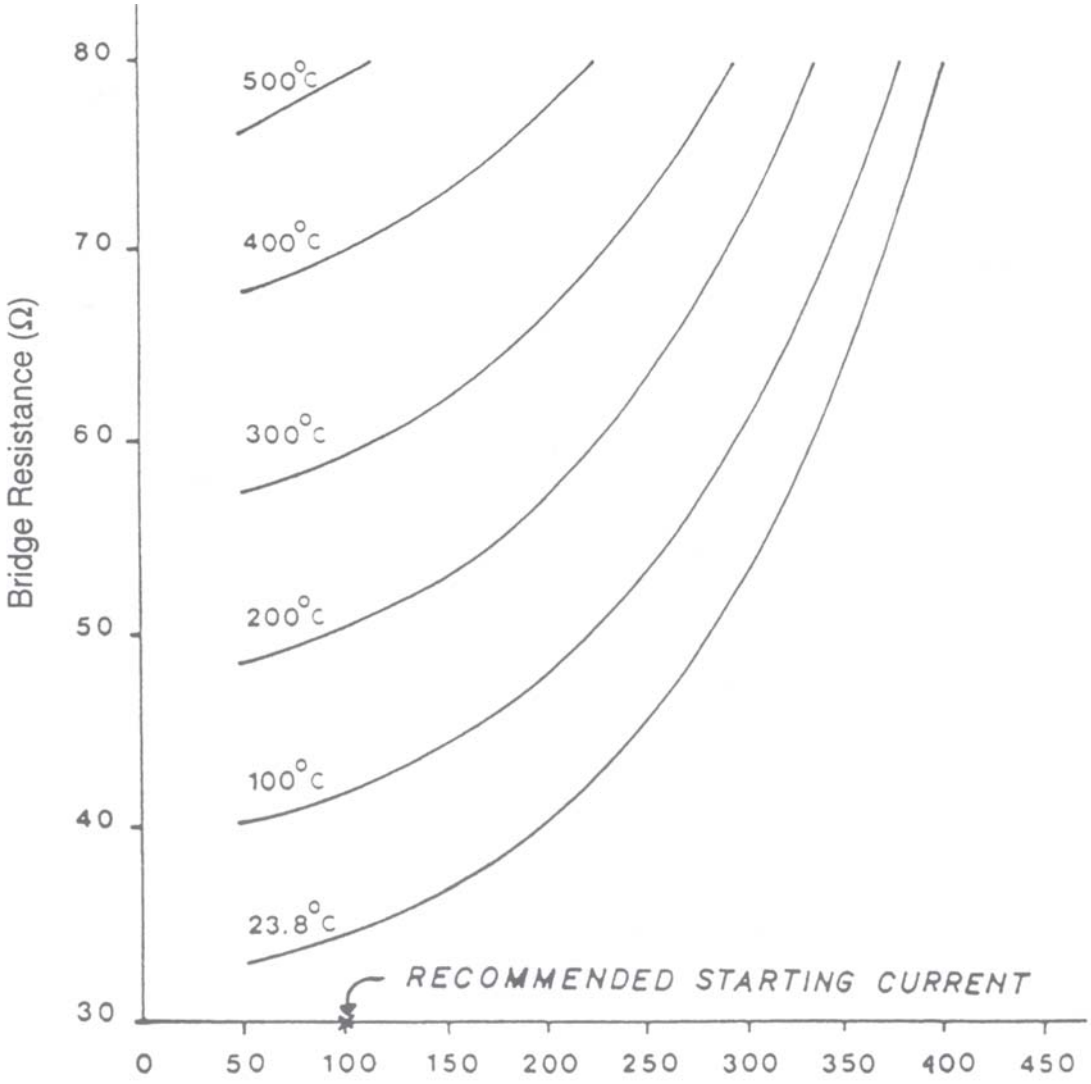
B. The following articles contain extensive bibliography on thermal conductivity detectors:

1. Lawson, A. E., Jr., and Miller, J. M., “Thermal Conductivity Detectors in Gas Chromatography,” *Journal of Gas Chromatography*, August, 1966.

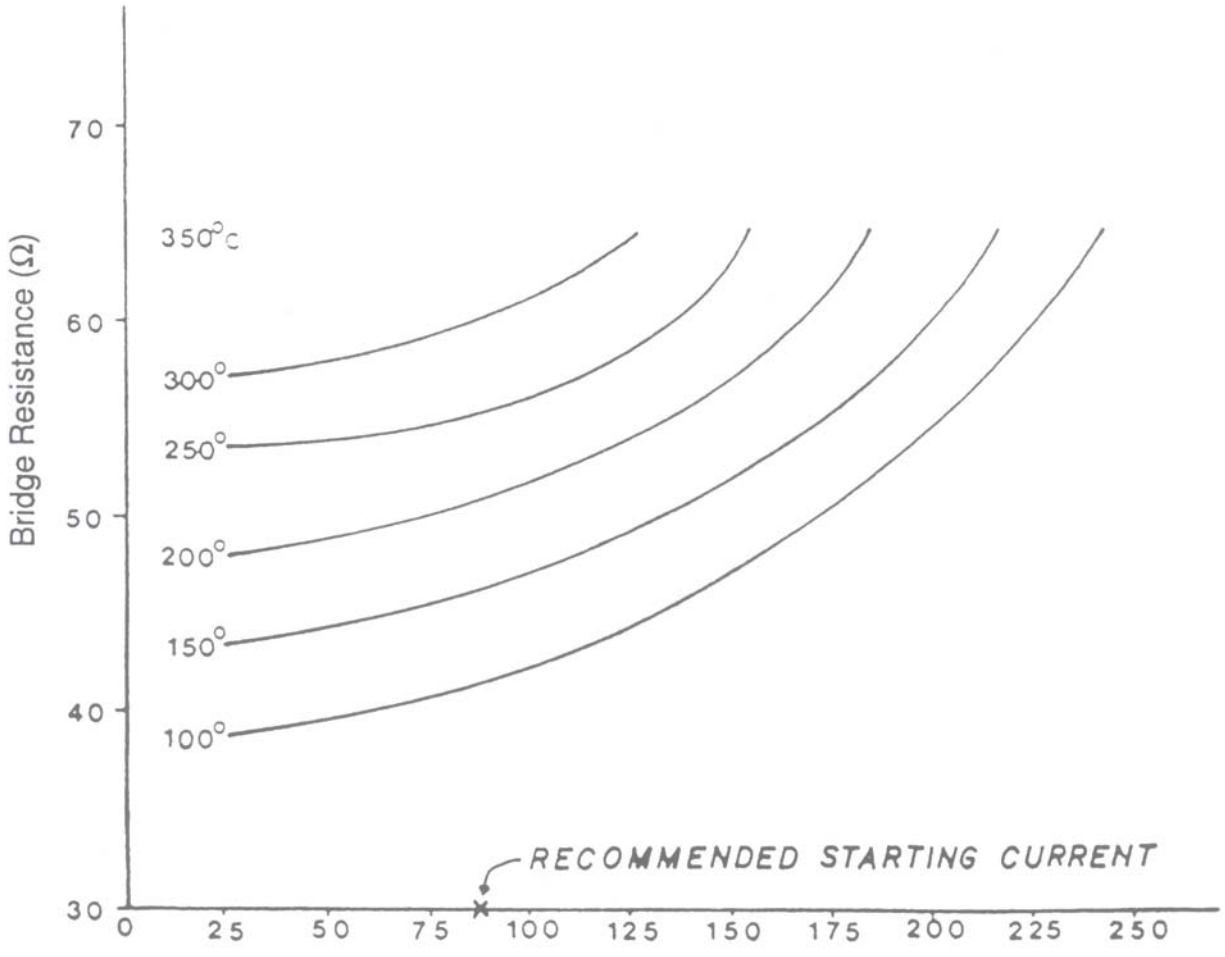
2. Lawson, A. E., Jr., “A Versatile, Low Cost Gas Chromatograph,” *American Laboratory*, May 1969.

3. Richmond, A. B., “Thermal Conductivity Detectors for Gas Chromatograph: A Literature Survey,” *Journal of Chromatographic Science*, Vol. 9, February 1971.

Bridge Resistance vs. Current
Helium Atmosphere
WX Filaments

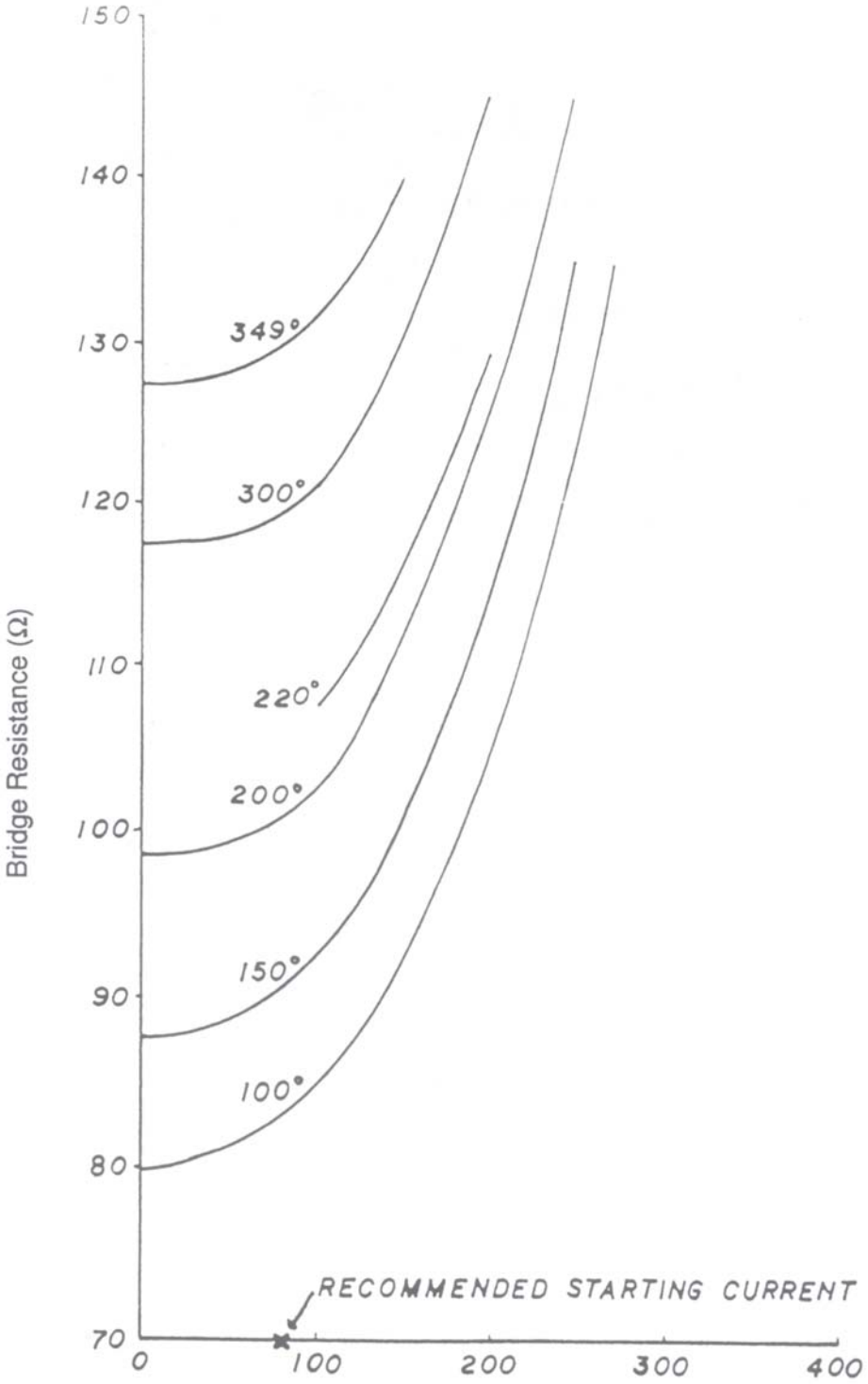


Bridge Resistance vs. Current
Helium Atmosphere
WX7 Filaments, 10-955 TCD

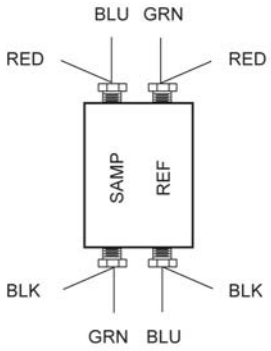


Bridge Current (mA)

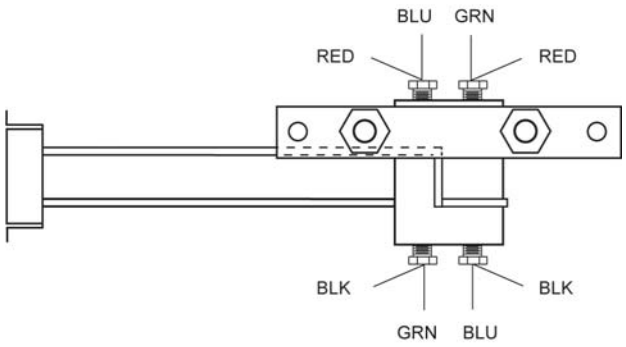
Bridge Resistance vs. Current
Helium Atmosphere
WX7 Filaments, 10-952 TCD



Series 350 and 400 GC Quad/Filament Installation Instructions*



FILAMENT QUAD



DETECTOR (TCD)

1. Disconnect the instrument from AC source.

2. Following the instructions found in the instrument's operating manual, remove the electrical connections to the filaments.

3. Remove the detector block from the instrument according to the instructions found in the instrument instruction manual and place in a vise.

4. Loosen the tube nuts and remove all of the old filaments from the detector block.

   NOTE: All filaments must be replaced for the TCD to function properly. Not just those that are oxidized or broken.

5. Inspect the cavities of the TCD for cleanliness, the seats for flaws, and the tubing for occlusions. If necessary, clean with acetone. Rinse the TCD with hot water and dry by baking.

6. Remove (one at a time) a filament from the shipping quad and place the filament in the proper detector cavity (Reference and Sample according to the detectors flow configuration) keeping the filament coil away from the gas flow inlet.

   Quads are shipped with tube nuts for use when replacing the new filaments.

   NOTE: The quad is <u>not</u> a detector (TCD). The filaments are shipped in the aluminum housing to protect them from damage during shipping.

   When installing filaments follow the diagram above and insert them in the Sample and Reference of the detector corresponding to the Sample and Reference markings on the aluminum quad.

7. Tighten filaments (tube nuts) to twelve (12) foot pounds using a torque wrench. **Take care when tightening filaments. Excessive tightening may crack the glass insulators.**

8. Leak test the detector.

9. Install the TCD back into the instrument and leak test the instrument.

* Always refer to the instrument operating manual for complete replacement instructions.

Further information concerning our TCDs can be found on our web site at:

www-gow-mac.com

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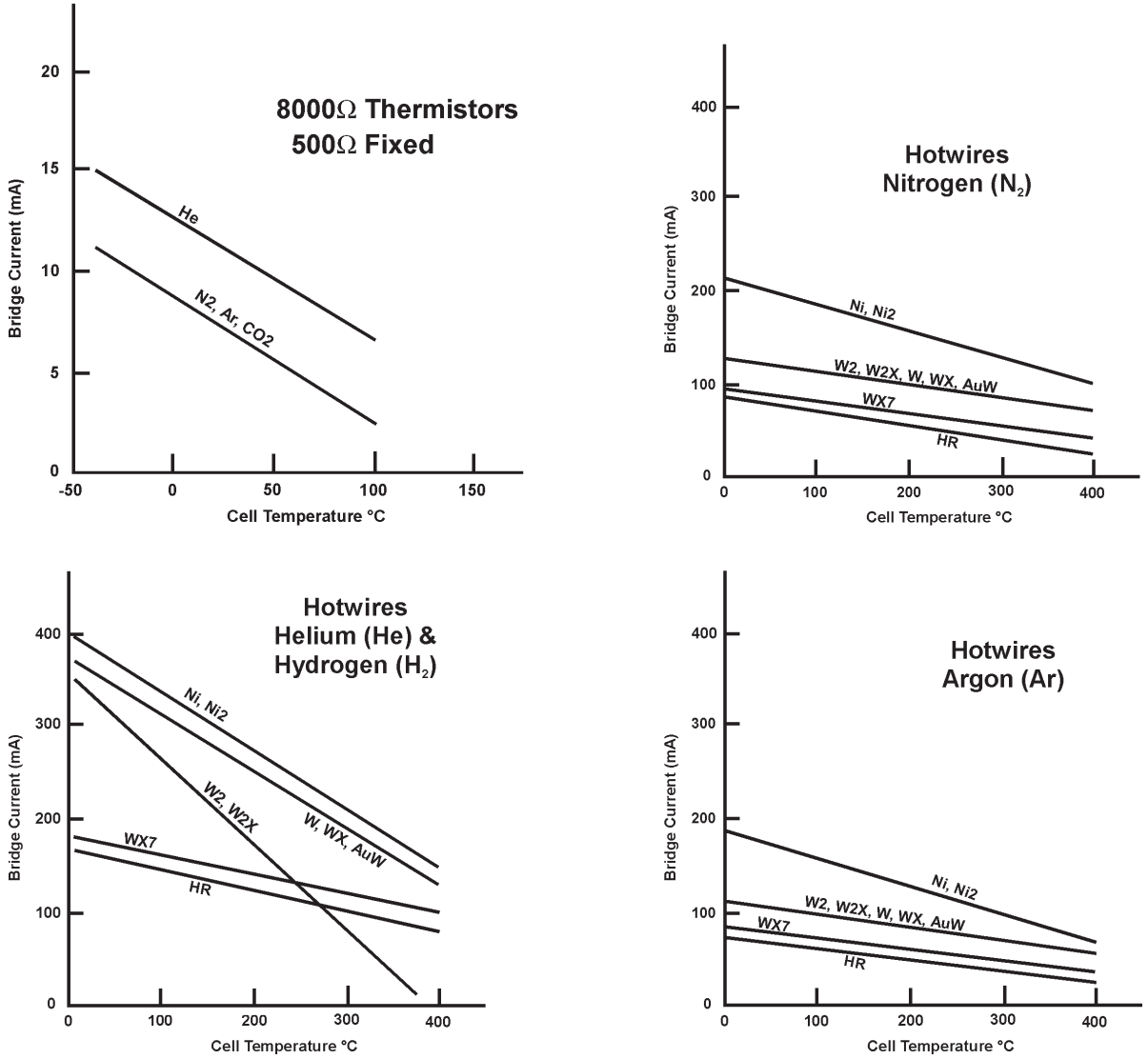
Printed in the U.S.A.

Operating Conditions

The following charts indicate the maximum operating currents for various cell temperatures. It is important to remember that the detector should be operated at the lowest temperture (sic current) consistant with the sensitivity required for analysis. the lower the temperature the longer the filament life. Lower temperatures also reduce noise and increase stability.

Maximum Bridge Currents

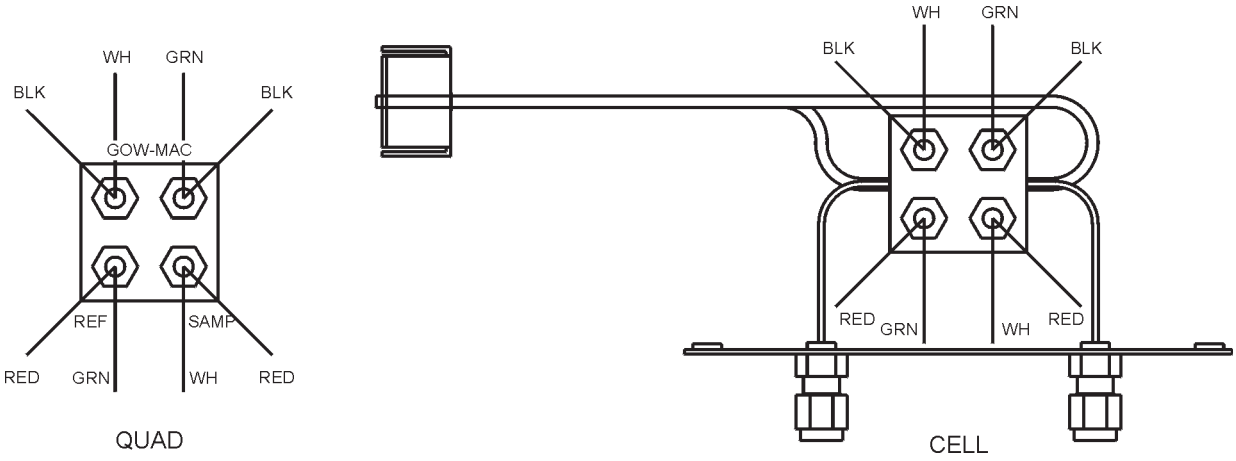


Use of the Above Charts

The filament chart indicates maximum bridge currents. recommended values at any temperature are 60 to 70% of those shown.

The thermistor chart indicates recommended values for maximum sensitivity. the sensitivity of thermistor cells tends to have a peak value. Exceeding this value can result in lowered sensitivity. Since the cold resistance varies between pairs, it is recommended that the exact value be determined by experimentation, using the chart as a guide.

Series 580 GC Quad/Filament Installation Instructions*



1. Disconnect the instrument from AC source.

2. Following the instructions found in the instrument's operating manual, remove the electrical connections to the filaments.

3. Remove the detector block from the instrument according to the instructions found in the instrument instruction manual and place in a vise.

4. Loosen the tube nuts and remove all of the old filaments from the detector block.

   NOTE: All filaments must be replaced for the TCD to function properly. Not just those that are oxidized or broken.

5. Inspect the cavities of the TCD for cleanliness, the seats for flaws, and the tubing for occlusions. If necessary, clean with acetone. Rinse the TCD with hot water and dry by baking.

6. Remove (one at a time) a filament from the shipping quad and place the filament in the proper detector cavity (Reference and Sample according to the detectors flow configuration) keeping the filament coil away from the gas flow inlet.

   If you are installing pairs of filaments make sure to pass the leads through the tube nuts before inserting them into the detector block. Quads are shipped with tube nuts for use when replacing the new filaments.

   NOTE: The quad is <u>not</u> a detector (TCD). The filaments are shipped in the aluminum housing to protect them from damage during shipping.

   When installing filaments follow the diagram above and insert them in the Sample and Reference of the detector corresponding to the Sample and Reference markings on the aluminum quad.

7. Tighten filaments (tube nuts) to twelve (12) foot pounds using a torque wrench. **Take care when tightening filaments. Excessive tightening may crack the glass insulators.**

8. Leak test the detector.

9. Install the TCD back into the instrument and leak test the instrument.

* Always refer to the instrument operating manual for complete replacement instructions.

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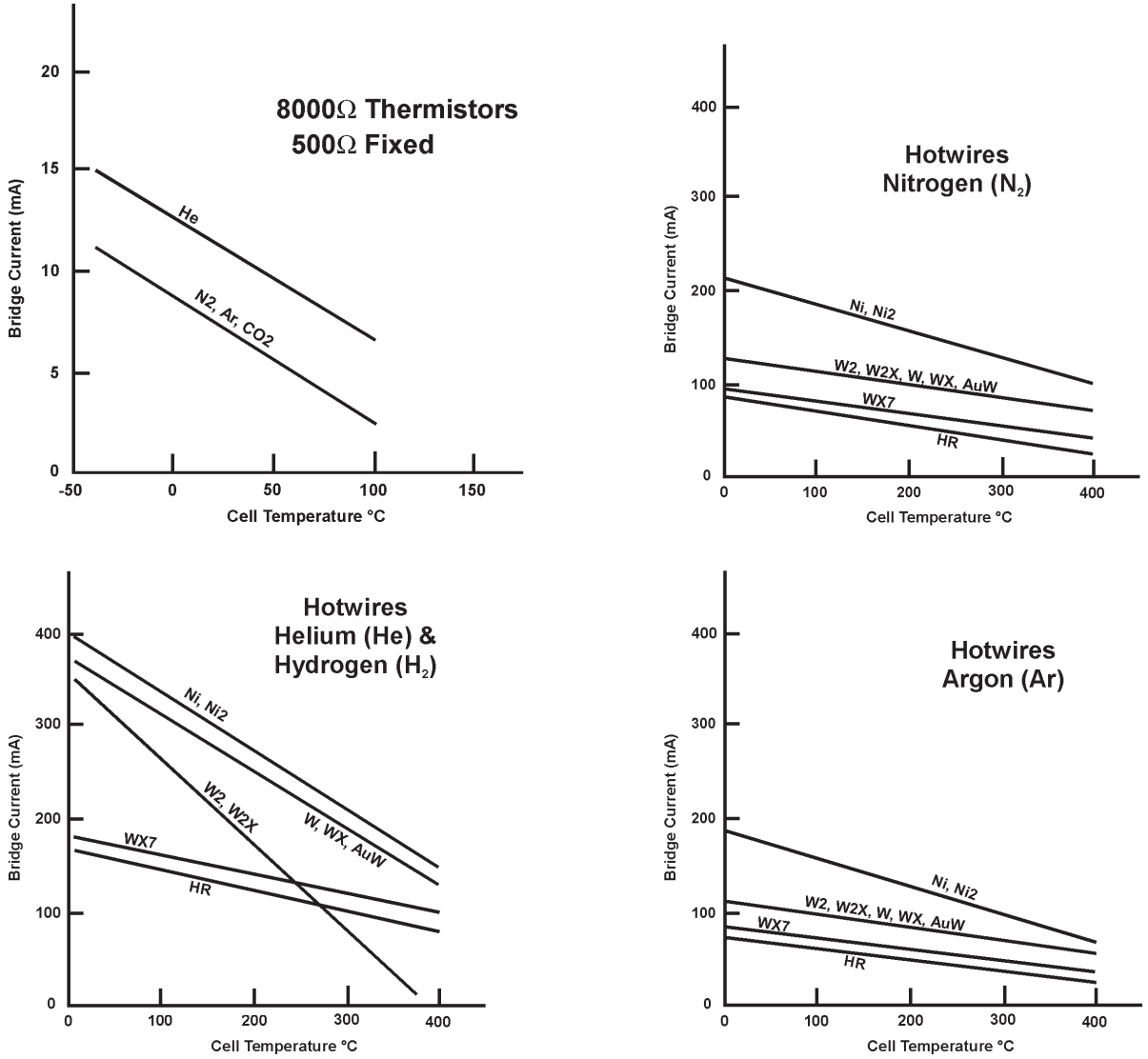

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TYPE OF ELEMENT												
	Hotwire									Thermistor		
Part No.	13-001	13-002	13-003	13-004	13-005	13-006	13-470	13-300	13-330	13-502	13-504	13-506
Code	W	WX	W2	W2X	Ni	Ni2	HR	AuW	AuW2	GBTB	GBTB	GBTB
Mount	9225	9225	333	333	9225	333	9225	9225	333	9225J	9225A	9225AA
Material	Tungsten	Rhenium Tungsten	Tungsten	Rhenium Tungsten	Nickel	Nickel	Nickel Alloy	Gold-sheathed Tungsten		Glass- coated Metallic Oxide		
Resistance Ohms @ 25°C	18	32	40	64	12.5	25	70	24	48	8000	8000	8000
OPERATING CONDITIONS												
Maximum Recommended Bridge Current mA, dc @ 25°C												
He, H_2	375	375	350	350	400	400	160	375	375	10*	10*	10*
N_2	120	120	120	120	200	200	85	120	120	6	6	6
Argon	110	110	100	100	180	180	70	110	110	4	4	4
Maximum Recommended Bridge Current mA, dc @ 200°C												
He, H_2	250	250	175	175	275	275	120	250	250	Not Recommended at Elevated Temperatures		
N_2	90	90	90	90	150	150	50	90	90			
Argon	80	80	80	80	125	125	45	80	80			
Oxidation Resistance												
Relative Resistance	GOOD	VERY GOOD	GOOD	GOOD	VERY GOOD	VERY GOOD	VERY GOOD	EXCELLENT		EXCELLENT		
Corrosion Resistance												
Relative Resistance	FAIR	GOOD (DRY GAS)	FAIR	GOOD (DRY GAS)	EXCELLENT			GOOD		GOOD**		

* THERMISTOR ELEMENTS NOT RECOMMENDED FOR USE WITH H_2 CARRIER GAS
**EXCEPT FOR HF OR FLUOURINE

GOW-MAC® INSTRUMENT CO.