Overview

The Thermal Conductivity Detector (TCD) is the most universal detector available. Depending on the compound, the TCD responds with a detection range of 0.01% to 100% (100-1,000,000 ppm). The SRI TCD consists of four filaments housed in a stainless steel detector block. The TCD detector block is installed in its own thermostatically-controlled oven for stability. The TCD oven is mounted on the right rear of the column oven. The TCD filament control switch and the bridge terminal block to which the filament leads are connected are located to the immediate right of the detector oven. Since the four TCD filaments can be damaged or destroyed if energized in the absence of carrier gas flow, a TCD filament protection circuit is provided in all TCD-equipped SRI GCs.
**DETECTORS**  
**Thermal Conductivity Detector - TCD**

**Theory of Operation**

The TCD detector measures the difference in thermal conductivity in the carrier gas flow and the analyte peaks. Every compound possesses some degree of thermal conductivity, and may therefore be measured with a TCD detector. Due to its high thermal conductivity and safety, helium carrier is most often used with TCD detectors. However, other gases may be used such as nitrogen, argon, or hydrogen.

The Wheatstone Bridge circuit design in the SRI TCD uses four general-purpose tungsten-rhenium filaments for sample analysis. Two of the filaments are exposed to the sample-laden carrier gas flow and provide the actual chromatographic signal. The other two filaments are provided with clean carrier flow, enabling them to be used as a baseline reference signal. When the effluent from the column flows over the two sample stream filaments, the bridge current is unbalanced with respect to the reference signal. This deflection is translated into an analog signal which is sent to the data system for analysis.

The four pairs of filament leads are color-coded in two-color units; each color is used on two different leads. All eight wires are connected to the bridge current supply via four setscrew-type terminal connectors on the top control panel of the GC. Silkscreened labelling on the chassis indicates which color wire connects to each terminal.

The TCD detector block is divided into two cells containing two filaments each. One cell holds the reference pair while the other cell holds the sample pair. All four TCD filaments are physically identical except for their color-coding. The carrier gas is plumbed so that it exits the Electronic Pressure Controller module, flows through the polishing filter, through the reference side of the TCD bridge, then through the injection port to the column, and from the column to the sample side of the TCD bridge. After the flow passes through the sample cell, it is directed back out of the TCD oven and into the column oven through the TCD detector outlet, where it may be routed to a subsequent detector or to vent. All four TCD detector inlet/outlet tubes are 1/16” stainless steel.
**Expected Performance**

**TCD Noise Run**

Carrier: Helium @ 10mL/min  
TCD gain = LOW  
TCD temp = 100°C  

Temperature program:  
Initial Hold Ramp Final  
80°C 15.00 0.00 80°C  

![Graph showing TCD noise averages 10μV from peak to peak]

**Factory Test Run of a TCD-equipped SRI GC**

Sample: natural gas standard, 1mL sample loop  
Columns: 1m Molecular Sieve, 2m Silica Gel  

**Events:**  
0.00 ZERO  
0.050 G ON (valve inject)  
6.00 G OFF  

**Temperature program:**  
Initial Hold Ramp Final  
40°C 5.00 10.00 220°C  
220°C 16.00 0.00 220°C  

**Results:**  

<table>
<thead>
<tr>
<th>Component</th>
<th>Retention</th>
<th>Area</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oxygen</td>
<td>1.633</td>
<td>19.7500</td>
</tr>
<tr>
<td>N2</td>
<td>2.150</td>
<td>121.0880</td>
</tr>
<tr>
<td>Methane</td>
<td>3.033</td>
<td>563.6130</td>
</tr>
<tr>
<td>Ethane</td>
<td>7.550</td>
<td>128.2185</td>
</tr>
<tr>
<td>CO2</td>
<td>9.983</td>
<td>11.9860</td>
</tr>
<tr>
<td>Propane</td>
<td>13.683</td>
<td>113.9220</td>
</tr>
<tr>
<td>Iso-Butane</td>
<td>18.150</td>
<td>69.4960</td>
</tr>
<tr>
<td>N-Butane</td>
<td>18.766</td>
<td>67.4460</td>
</tr>
<tr>
<td>Iso-Pentane</td>
<td>22.550</td>
<td>20.1490</td>
</tr>
<tr>
<td>N-Pentane</td>
<td>22.866</td>
<td>19.1560</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>1134.8245</strong></td>
<td></td>
</tr>
</tbody>
</table>
**Expected Performance**

**TCD Room Air Analysis**

- Column: 3' Silica Gel
- Carrier: Helium at 10mL/min
- Sample: 0.5cc room air, direct injection
- TCD current: LOW
- TCD temperature: 100°C

**Temperature Program:**

<table>
<thead>
<tr>
<th>Initial</th>
<th>Hold</th>
<th>Ramp</th>
<th>Final</th>
</tr>
</thead>
<tbody>
<tr>
<td>80°C</td>
<td>4.00</td>
<td>0.00</td>
<td>80°C</td>
</tr>
</tbody>
</table>

**Results:**

<table>
<thead>
<tr>
<th>Component</th>
<th>Retention</th>
<th>Area</th>
</tr>
</thead>
<tbody>
<tr>
<td>O₂, N₂</td>
<td>0.716</td>
<td>1021.3830</td>
</tr>
<tr>
<td>CO₂</td>
<td>2.766</td>
<td>1.5060</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td>1022.8890</td>
</tr>
</tbody>
</table>

The CO₂ content of the room air analyzed is approximately 350ppm.

**TCD Breath Analysis**

- Column: 3' Silica Gel
- Carrier: Helium at 10mL/min
- Sample: 0.5cc human breath, direct injection
- TCD current: LOW
- TCD temperature: 100°C

**Temperature Program:**

<table>
<thead>
<tr>
<th>Initial</th>
<th>Hold</th>
<th>Ramp</th>
<th>Final</th>
</tr>
</thead>
<tbody>
<tr>
<td>80°C</td>
<td>24.00</td>
<td>0.00</td>
<td>80°C</td>
</tr>
</tbody>
</table>

**Results:**

<table>
<thead>
<tr>
<th>Component</th>
<th>Retention</th>
<th>Area</th>
</tr>
</thead>
<tbody>
<tr>
<td>O₂, N₂</td>
<td>0.700</td>
<td>1379.4740</td>
</tr>
<tr>
<td>CO₂</td>
<td>2.700</td>
<td>61.9540</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td>1441.4280</td>
</tr>
</tbody>
</table>
**General Operating Procedure**

1. Check to make sure that the TCD filament current is switched OFF. Plug in and turn on your GC. Allow the TCD detector oven to reach temperature (100°C) and stabilize. With the “Display Select” switch in the UP position, press on the TCD Temperature Actual button on the front control panel to read the TCD cell temperature. The TCD oven block is set to 100°C at the factory, but is adjustable by turning the trimpot with a small blade screwdriver while observing the TCD BLOCK setpoint temperature on the digital display. The trimpot is located on the top edge of the GC’s front control panel, under the red lid.

2. All TCD-equipped SRI GCs are tested with a 1m, 1/8” stainless steel silica gel-packed column. The carrier gas head pressure is preset at the factory to 10mL/min for this type and size column. Look on the right side of the GC for the carrier pressure that correlates to a flow of 10mL/min. Because different columns require different flow rates, the carrier head pressure may be adjusted by the user with the trimpot above the “CARRIER 1” buttons.

3. Make sure that the setpoint and actual pressures are within 1 psi.

4. Damage or destruction of the TCD filaments will occur if current is applied in the absence of flowing carrier gas. ALWAYS verify that carrier gas can be detected exiting the TCD carrier gas outlet BEFORE energizing the TCD filaments. The carrier gas outlet tube is located on the outside of the Column Oven on the same side as the detector. Place the end of the tube in liquid and observe (a little spit on a finger can suffice). If there are no bubbles exiting the tube, there is a flow problem. DO NOT turn on the TCD current if carrier gas flow is not detectable. A filament protection circuit prevents filament damage if carrier gas pressure is not detected at the GC, but it cannot prevent filament damage under all circumstances. Any lack of carrier gas flow should be corrected before proceeding.

5. With the TCD filaments switched OFF, zero the data system signal. Switch the filaments to LOW. The signal’s deflection should not be more than 5-10mV from zero for a brand-new TCD detector. Any more than a 5-10mV deflection indicates partial or complete oxidation of the TCD filaments; more deflection means more oxidation. Therefore, it is a good habit to use the data system signal to check the working order of the TCD filaments.

6. In PeakSimple, set an isothermal column oven temperature ramp program as follows:

<table>
<thead>
<tr>
<th>Initial Temp.</th>
<th>Hold</th>
<th>Ramp</th>
<th>Final Temp.</th>
</tr>
</thead>
<tbody>
<tr>
<td>80°C</td>
<td>7.00</td>
<td>0.00</td>
<td>80°C</td>
</tr>
</tbody>
</table>

7. Zero the data system signal (clicking on the Auto Zero button at the left edge of the chromatogram window is one way to do it), then start the run (hit the computer keyboard spacebar or hit the “RUN” button on the GC).

8. Inject sample. Injection volumes of 0.5mL for gas and 1µL for liquid is recommended to prolong TCD filament life.
**DETECTORS**  
**Thermal Conductivity Detector - TCD**

**TCD Filament Protection Circuit**

All TCD detectors are susceptible to filament damage or destruction if operated at high current in the absence of carrier and/or reference gas flow. The filaments will incandesce and burn out if the carrier or reference gas flow is interrupted due to a variety of possible factors such as a column break, inadvertent column disconnection during column changes, removal of the septum nut for septum replacement, or when the carrier gas cylinder runs dry during an analysis. The SRI TCD filament protection circuit is a current “cut-out” circuit that monitors the column head pressure during GC operation. Under normal circumstances, there is no reason for the column head pressure to drop below 3psi, with most columns operating at 8psi or above. When the head pressure sensor located in the carrier gas flow path drops below 3psi, the protection circuit is activated, and the current to the TCD filaments is interrupted immediately. A red LED on the GC’s front control panel under “DETECTOR PARAMETERS” will light to indicate that the protection circuit has detected a gas pressure loss and shut down the filament current. The cause of the protection circuit activation should be immediately investigated and corrected. As an additional caution, use HIGH current only with helium or hydrogen carrier gases. With nitrogen carrier, use LOW current only, or the filaments may be damaged. The pressure at which the protection circuit activates is user adjustable with the trimpot on the top edge of the front control panel, above the label reading “TCD PROTECT.”

---

**TCD protection circuit LED lit on an SRI model 8610 GC front control panel**

1- Pressing the LOCAL SETPOINT button displays the filament cut-off setpoint value (factory set at 3psi) in the bright red LED display in the upper right corner of the GC’s front control panel. If the carrier gas pressure reaches or falls below this value, the filament current will immediately be interrupted.
2- Pressing the TOTAL SETPOINT button displays the carrier gas pressure present in the GC system. Under normal operation, this value will be well above the 3psi cut-off setpoint.
3- The STATUS LED glows bright red only when the TCD protection circuit has been activated.
4- Pressing the ACTUAL button displays the voltage present across one half of the TCD bridge. A value of 3.5 to 4.5 volts is typical when using high current; low current will display 2.5-3.5 volts (note: the LED displays 4 volts as “400,” 3.5 as “350,” etc.). Any value lower than these indicates a potential problem in the TCD detector bridge.
TCD Troubleshooting

When the TCD fails to perform normally, review operating conditions to ensure that carrier gas flow to the detector is unimpeded, and that the column oven temperature, carrier gas flow rate, and carrier gas EPC pressure are all within the desired operating parameters. If all conditions are properly met and the detector continues to perform poorly or fails to perform at all, check the TCD filaments for damage. The main diagnostic test is to measure the resistance of each filament using the ohmeter function of a multimeter or volt-ohmeter (VOM). At room temperature, the resistance of each filament should be 32-34 ohms. At 100°C, the filaments are around 40 ohms each. If any filament is significantly different from the others, the TCD bridge will be unbalanced, noisy and drifty. All eight filament wires must be disconnected and tested. Since all the leads are bundled together as they exit the TCD detector assembly, you may need to use the multimeter or VOM to determine the actual pairs. It is normal for each filament to have a slightly different reading within the appropriate operating range, so match the readings to determine the lead pairs.

With the power turned off and the power cord unplugged from the electrical outlet, raise the red lid to access the TCD detector. Exiting the right side of the TCD detector oven is the bundle of 8 insulated, color-coded wires in pairs. Each pair of wires represents one filament and is connected to the appropriately labeled terminal for its paired colors. One filament has red/green, one red/blue, one black/green, and one black/blue. The red/green and black/blue are the sample side filaments, and the ones which typically deteriorate first. Remove the 8 wires from the bridge terminal by loosening the retaining setscrews with a small blade screwdriver. Measure the resistance across the filament leads using an ohmeter, making sure the correct pair of colored wires is tested together for each filament. An infinite reading is an indication that the filament is open, or burned out. If any of the filaments has a significantly different resistance than the others (which should be in the ranges mentioned above), it should be replaced. Replacement filaments, o-rings, and TCD blocks with four new filaments are available from SRI. In addition to the standard filaments, optional gold-plated filaments for improved corrosion resistance are also available.

SRI TCD detector replacement parts

<table>
<thead>
<tr>
<th>Description</th>
<th>Part Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Standard TCD filament with rubber O-ring gasket</td>
<td>8670-9120</td>
</tr>
<tr>
<td>High temperature TCD filament with copper gasket</td>
<td>8690-9123</td>
</tr>
</tbody>
</table>

(filament part #s are also listed on the top of the TCD oven in your SRI GC)
Replacing the TCD Filaments

SRI TCD detectors are made to last a long time without ever replacing the filaments. However, any TCD filaments that fail the diagnostic ohmeter test mentioned previously will have to be replaced. While they share the same outer assembly, there are a few differences between the high temperature TCD detector block and the standard TCD block. Both designs are discussed. All filaments are fragile; handle them with care. Have colored ink pens, electrical tape, whatever you will use for color coding close at hand before you begin. It is best to go slowly, color-coding then replacing each filament one at a time. **IF YOU MIX UP THE FILAMENT LEADS, YOUR TCD WILL NOT WORK!**

A. Standard TCD detector block access

1. With a small blade screwdriver, free the filament leads from the bridge terminal by loosening the setscrews.

2. Remove the detector assembly cover by unscrewing the thumbscrew then sliding the cover off toward the right-hand edge of the GC; gently remove the white insulation to reveal the detector block.

3. Disconnect the detector block gas inlets and outlets. The reference gas inlet is disconnected at the polishing filter immediately behind the column oven. The reference gas outlet is disconnected inside the column oven. Disconnect the sample gas inlet at the fitting on the column. The detector block sample gas inlet tubing has a copper sheath for identification. The sample gas outlet is usually routed out the right side of the column oven.

---

Exploded view of the standard TCD detector assembly

- Outer TCD detector assembly case permanently mounted to column oven wall
- Insulated padding
- Outer TCD detector assembly case cover is removable for access to inner metal clamshell case and heater wrap
- Filament leads to bridge electronics
- Inner clamshell case is heat-wrapped with thermostatted electrical heating element and protects TCD detector block
- 2 hex-head screws secure inner clamshell
- Carrier gas in from polishing filter, and back to injector
- Sample gas in from analytical column, and out to next detector or vent
- Column oven
4. Cut the fiberglass tape wrapped around the detector block and peel it off. Unwrap and remove the heater rope from the detector block (it is probably affixed to the thermocouple wires with more fiberglass tape).

5. Disconnect the thermocouple by loosening the small philips head screw which holds it on the detector block clamshell. Next, remove the clamshell by unscrewing the two small philips head screws that hold its halves together. Gently remove the white insulation to reveal the detector block.

6. The TCD filaments are secured in the detector block by two plates, each of which is held in place with three hexagonal head screws. Holding the detector block with one hand, use an Allen wrench to unscrew and remove the hexagonal head screws from one of the filament securing plates. Then, slide the filament securing plate off the filaments and leads. Set it securely aside.

7. Once the securing plate is removed, the filament and rubber O-ring that seals it can be gently pulled out of the detector block cell. When replacing a filament, its rubber O-ring should also be replaced. Check the lip of the detector block cell for fragments of the old O-ring and if any are present, remove them as they will interfere with proper sealing of the cell. If you’re replacing one reference or sample filament, replace the other at the same time. If you didn’t have fun disassembling the TCD detector block, replace all the filaments while you have it open. It’s a good idea to remove then replace one plate and corresponding pair of filaments at a time to avoid mixing up their connections.

8. To install a new filament, color-code it the same as the filament you are replacing, then slide it, leads first, through the appropriate hole in the filament securing plate. An existing or replacement filament should occupy the other hole. Place a new rubber O-ring against the rim of the detector block cell which will accept the new filament. Place filament securing plate and filaments against the detector block with the filaments inside the detector block cells. Replace and tighten the 3 hex-head screws. Repeat this process on other side to replace the corresponding filament.

9. Reverse your steps for TCD detector reassembly. Steps 7-10 of the high temperature TCD detector block access instructions detail reassembly of the inner clamshell and outer detector housing.
Replacing the TCD Filaments continued

B. High temperature TCD detector block access

The high temperature TCD assembly is the same as the standard: outer housing around an inner clamshell case. The high temp detector block uses gland nuts and copper gaskets to secure the four filaments in its two cells. Instead of the heater rope, it employs a heating cartridge, which is inside the inner clamshell case with the detector block.

1. With a small blade screwdriver, disconnect the filament leads from the bridge terminal by loosening the setscrews.

2. Remove the detector housing by unscrewing the thumbscrew then sliding the housing cover off toward the right-hand edge of the GC. Gently remove the white insulation to reveal the detector block.

3. Disconnect the detector block gas inlets and outlets. The reference gas inlet is disconnected at the polishing filter immediately behind the column oven. The reference gas outlet is disconnected inside the column oven. Disconnect the sample gas inlet at the fitting on the column. The detector block sample gas inlet tubing has a copper sheath for identification. The sample gas outlet is usually routed out the right side of the column oven. Once these three fittings are loosened and the detector block tubing freed, gently pull the detector block away from the housing.
Replacing the TCD Filaments continued

(High temperature TCD detector block access continued)

4. Open the inner clamshell case by unscrewing the two small philips head screws that hold the two halves together. Gently remove the white insulation to access the detector block.

5. The filaments are held in place by gland nuts; loosen these nuts to remove the filaments and copper gaskets. Color-code the new filament the same as the one you are replacing (you can use colored marker pens, electrical tape, etc.) before completely removing the old one. Slide the gland nut off the existing filament, toward the ends of the filament leads.

6. Put the new filament’s leads through the gland nut. Slide the gland nut up the filament’s leads until it rests against the base of the filament. Place the copper gasket against the rim of the detector block cell opening. Carefully insert the filament and gland nut together into the cell opening. Tighten the gland nut to secure the filament in the cell.

7. When you’re finished replacing filaments, place the re-assembled detector block inside the inner clamshell with the insulation and heater cartridge. Make sure the gas inlet and outlet tubes are running through the cut-outs in the clamshell. Secure the clamshell with its two screws.

8. Reconnect the TCD detector gas inlets and outlets.

9. Replace the inner clamshell and its insulation inside the detector housing that is permanently mounted on the column oven wall. Replace the housing cover and secure with its thumbscrew.

10. Reconnect the filament leads to the bridge current terminal block. Use the color guide labels on the terminal block to insert the color-coded leads into the appropriate terminal.