Supplemental Manual

Brooks Calibration Application Tool (BCAT)

BROOKS® INSTRUMENT

Beyond Measure

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Introduction

BCAT (Brooks Calibration Application Tool) is a stand-alone desktop application designed to configure, monitor, and calibrate the GC Series mass flow controller. It supports high volume OEM use with essential functionality for setup and integration. This manual provides comprehensive instructions on installing, connecting, operating, and calibrating with BCAT.

How to Use This Manual

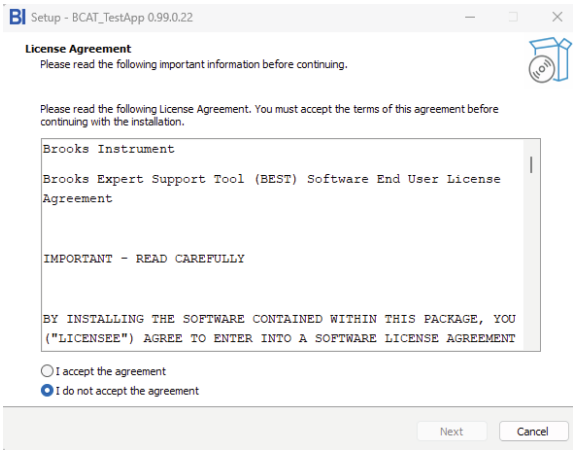
Use this manual in conjunction with the GC device installation and Operation manual (IOM).

System Requirements

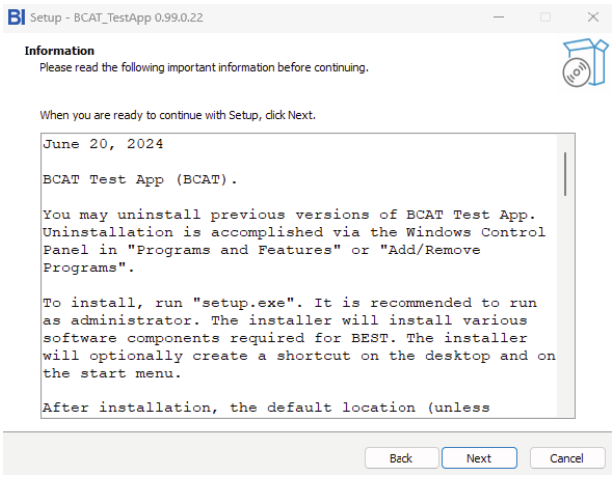
- **Operating Systems:** Windows 10 or Windows 11
- **Admin Privileges:** Not required
- **Hardware:** BCAT Adapter – 778Z024AAA or equivalent

Installation & Launch

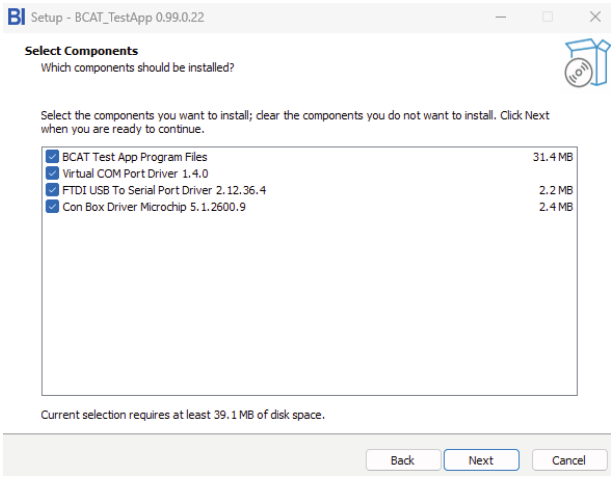
1. Download the Brooks Calibration Application Tool from the Website and save file to your hard drive.
2. Unzip the *.zip file on your local computer's hard drive.
3. Execute the setup.exe (right click on the executable and run as administrator)
4. Read and accept the license agreement and click next:



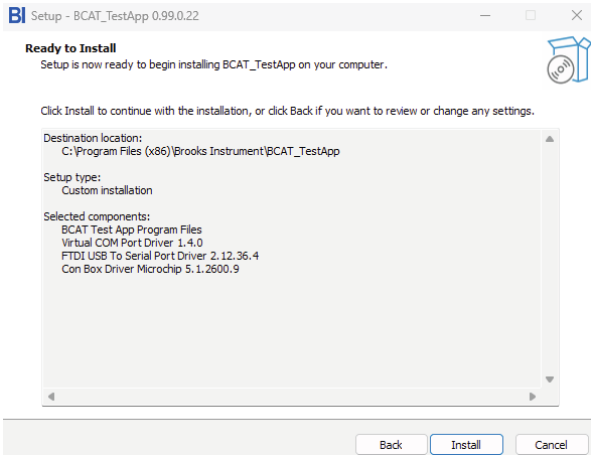
5. Read the text from the ReadMe file, then click Next:



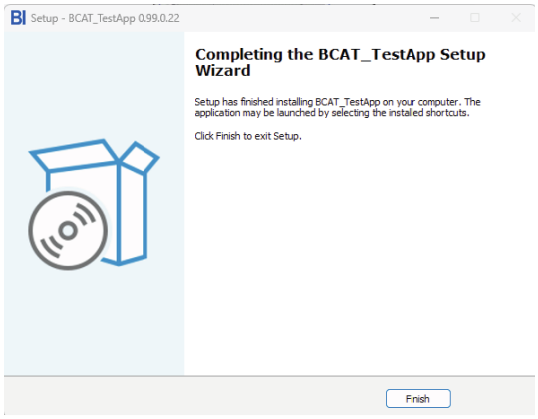
6. Select BCAT and Deselect any of the other drivers if not required.



7. Click Install



8. Click Finish to complete the installation:



9. A desktop short cut will be added to your Windows desktop. Double click it to start BCAT.

10. Launch the application.
11. On startup, the Device Connection Window will open.

License Overview

- **Free Version:** Configuration & monitoring only
- **Licensed Version:** Includes calibration & verification

System Requirements

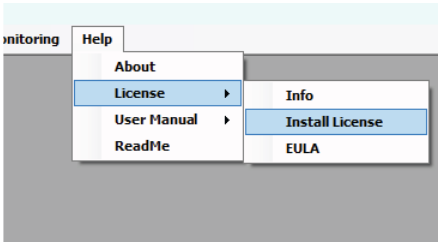
- **Per Time License** (duration configurable by Brooks) one year default
- Activated once and non-pausable
- Valid on one workstation at a time but transferable
- Can be activated offline or online

License Installation Instructions

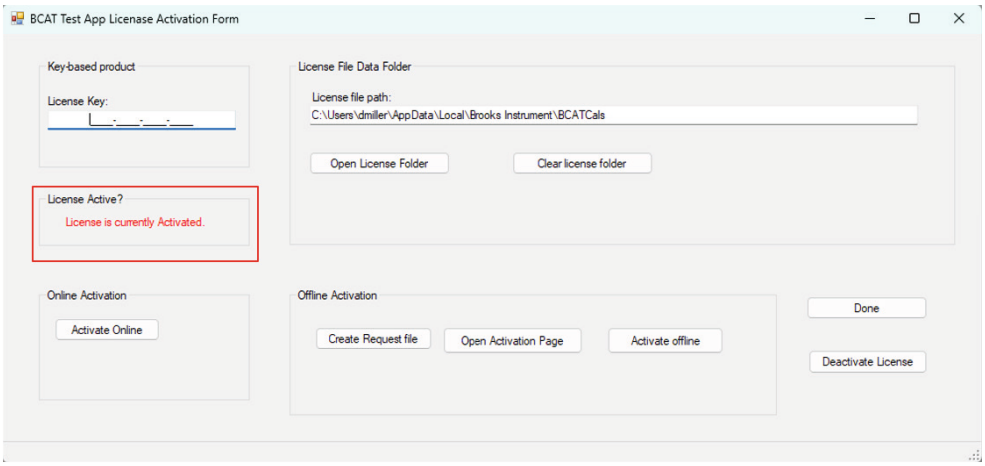
License is only required for calibration and verification features

Installing the License Online

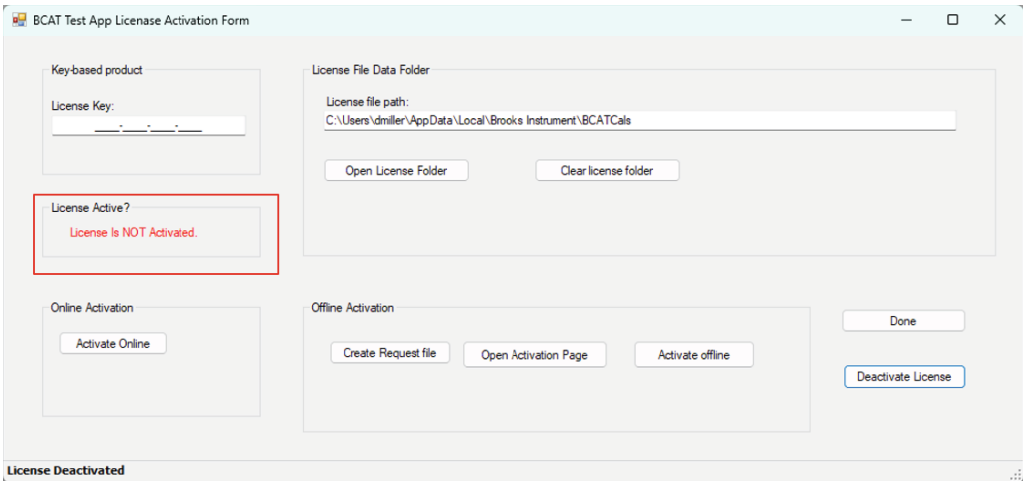
- Open the BCAT software.
- Close the Connection form, if it is open.
- Select the menu item Help->License->Install License.



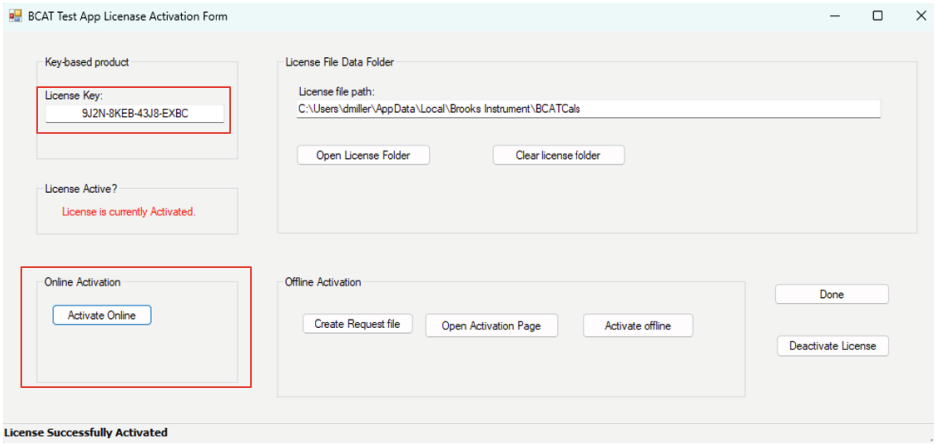
- The BCAT License Activation Form will appear:



- The License Active block will inform as to whether there is a currently installed active license.

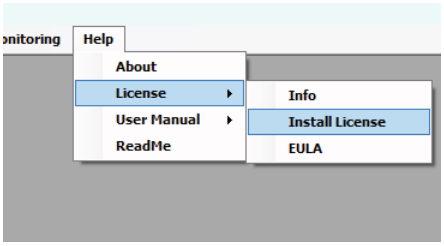


- If the license is NOT activated, it may be activated.
- Enter the license key, and click the Activate Online button. The form will show the activated status. This requires an active Internet connection.

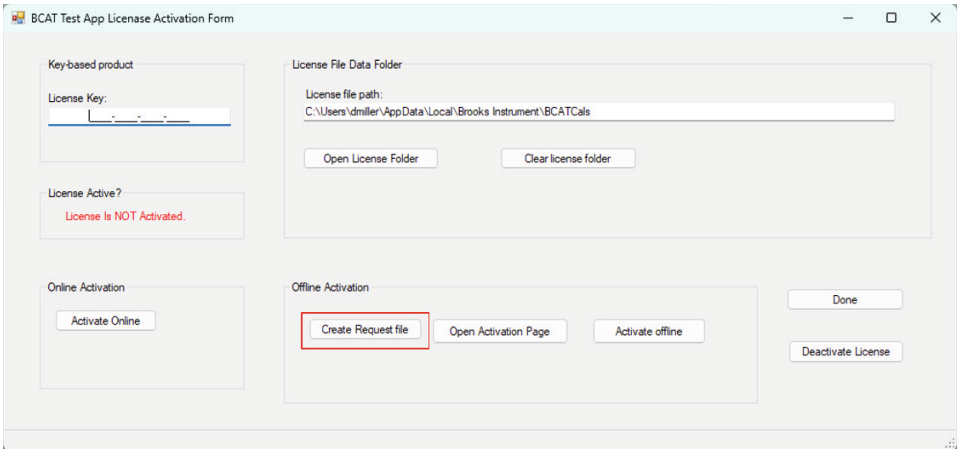


Installing a License Offline

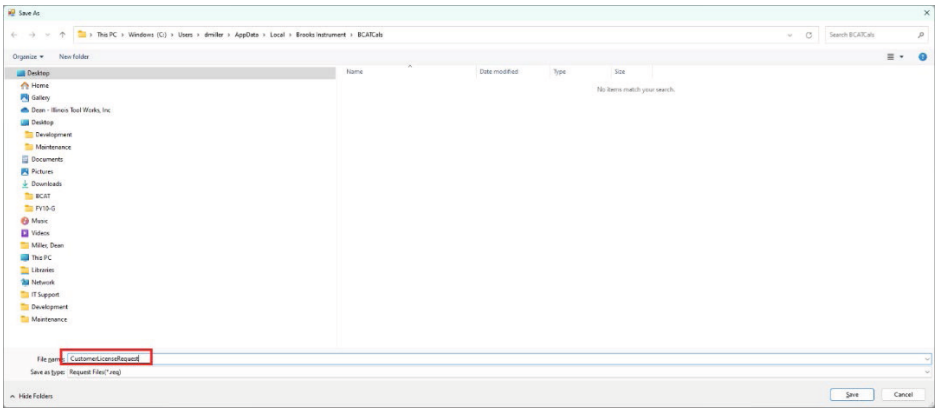
- Customers who operate in a secure environment (no Internet connection), can still install a license. The process is similar to the online process but includes a few additional steps.
- Download the BCAT installer from the Brooks Instrument. Copy the installer to a USB drive or other transferable medium.
- The customer must obtain a license key according to the same steps as above. Copy the key (text) to the USB drive.
- Take the USB drive into the secure area and insert into the computer.
- Copy the installer from the USB drive onto the local hard drive.
- Run the BCAT installer (Run as admin) to install the software on the destination computer.
- In Bcat software at the customer site, the customer opens the menu item Help>License->Install License:



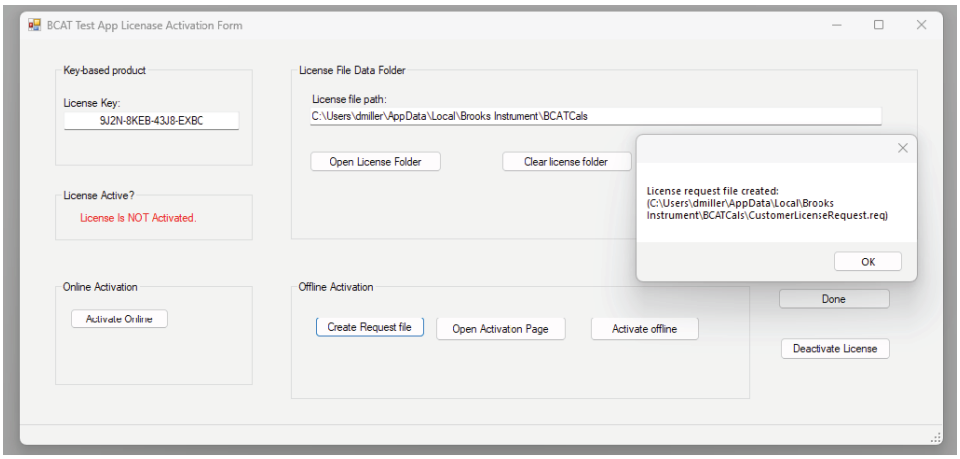
- The BCAT License Activation Form will appear, same as online activation:



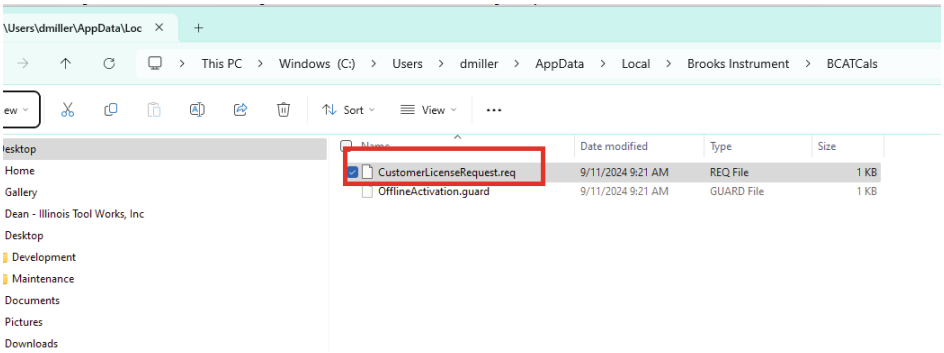
- Similar to online activation, the customer must enter the license key. However, instead of clicking the Online Activation button, the user should click the Create Request File button.
- A dialog box opens at the user's license file folder – take note of this folder location. Under File name, type a name.



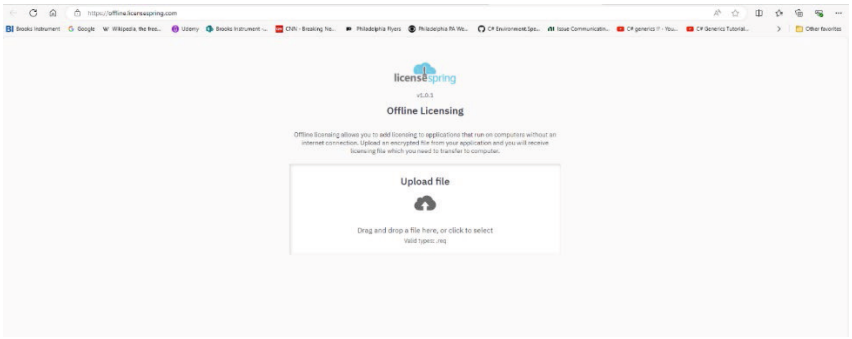
- Click Save button. A confirmation message will appear.



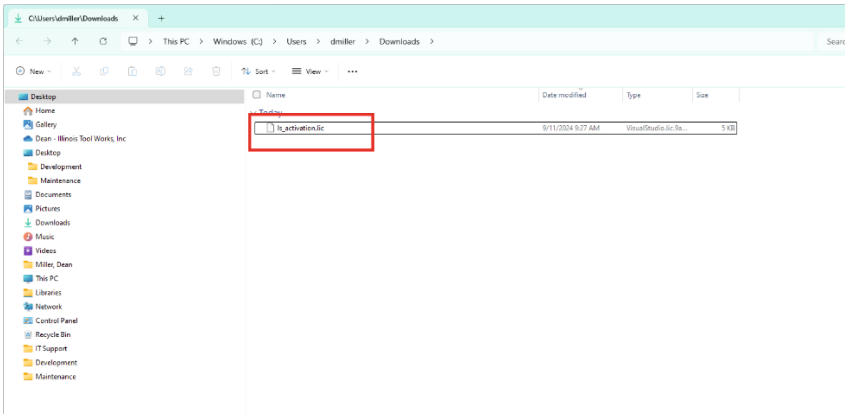
- User may open the License Folder (click the Open License Folder button), to verify the file is present:



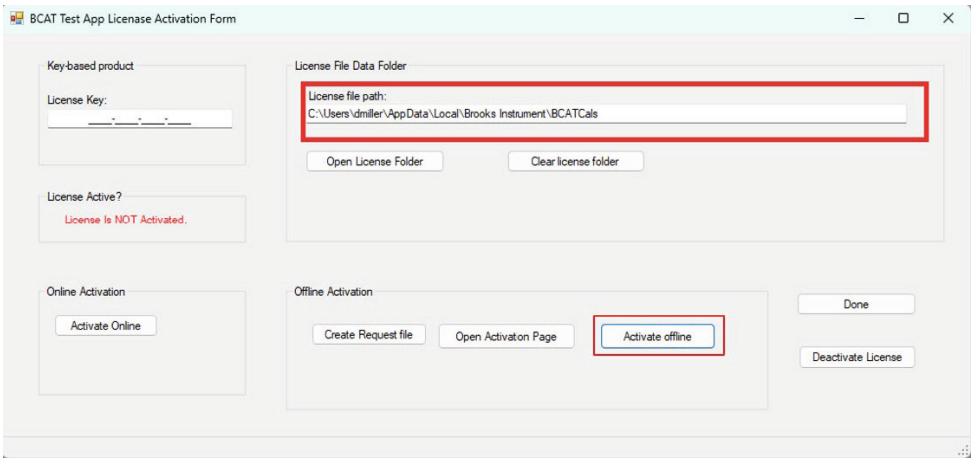
- On the computer without Internet access, the user will need to locate the license request file created in the previous step. This file must be copied to the USB drive.
- Take the USB drive to any computer with Internet access.
- Open the page https://offline.LicenseSpring.com/ in a browser. This can also be opened by clicking on the Open Activation page in Bcat at a computer with Internet access.
- Copy or drag the license request file from the USB drive onto this web page:



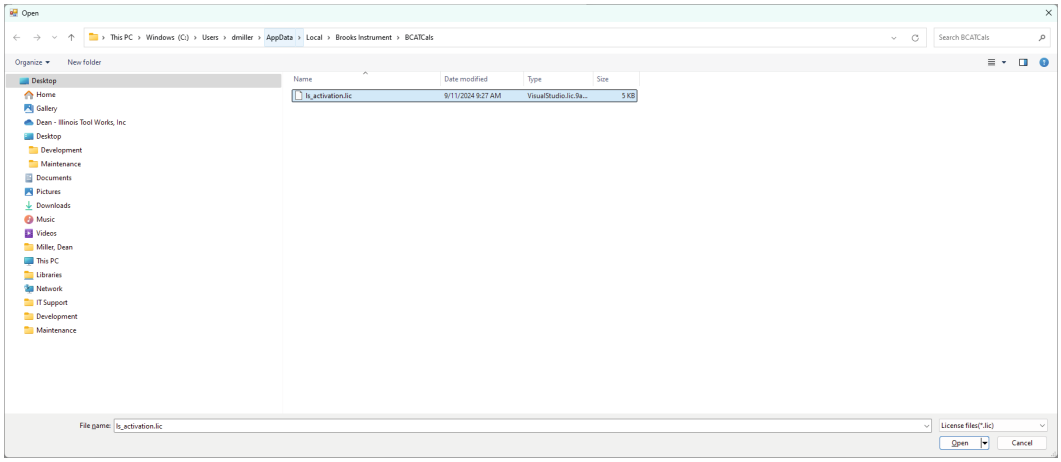
- A new license file will be created in the user's browser downloads folder.



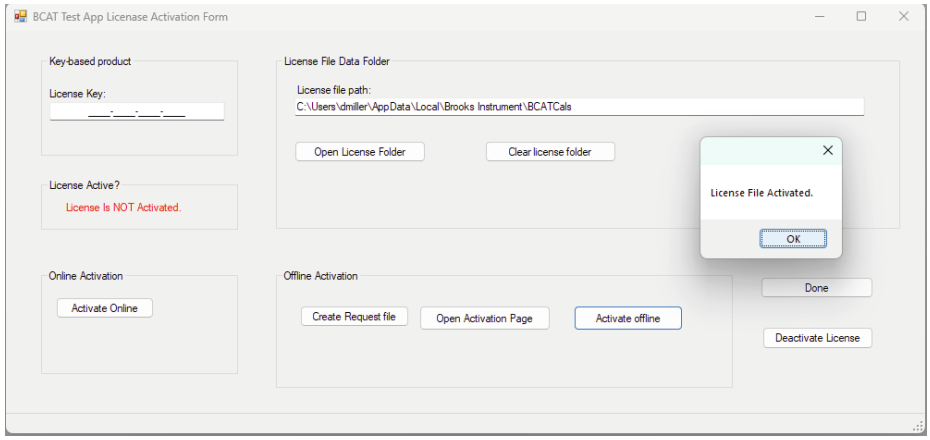
- This file must be copied back to USB drive.
- Take the USB drive back into the secure area and insert into the destination computer.
- Copy the new license file onto the Bcat license folder on the user's computer without Internet access. The license file path can be found in the BCAT License Activation window or by clicking the Open License Folder button (your folder may be different).



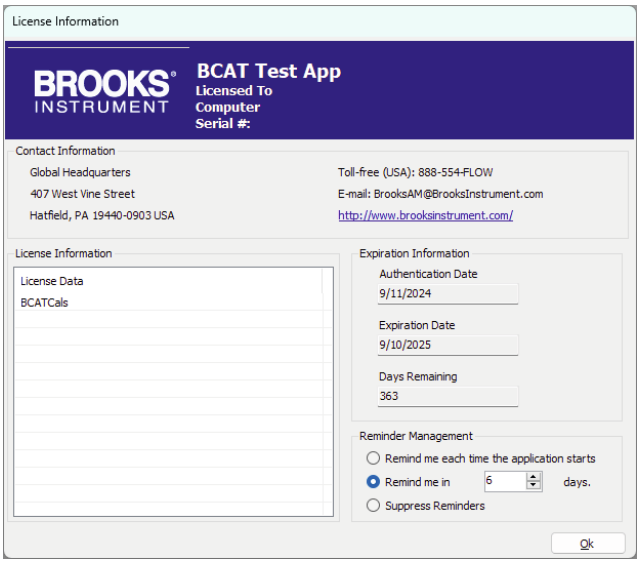
- Next, click Activate offline button. In the file open dialog, select the license file and click Open.



- A message will appear confirming that the license file was activated:

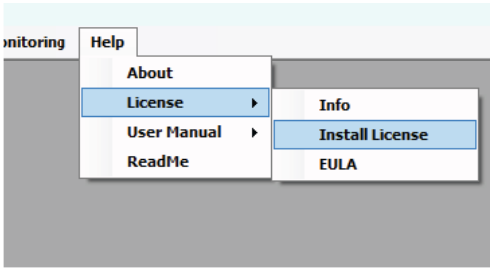


- Click OK to acknowledge, and the License Active? Text block will show “License is currently active”. Close the License Activation Window.
- User may also check the that the license activated by going to the Help->License>Info menu:

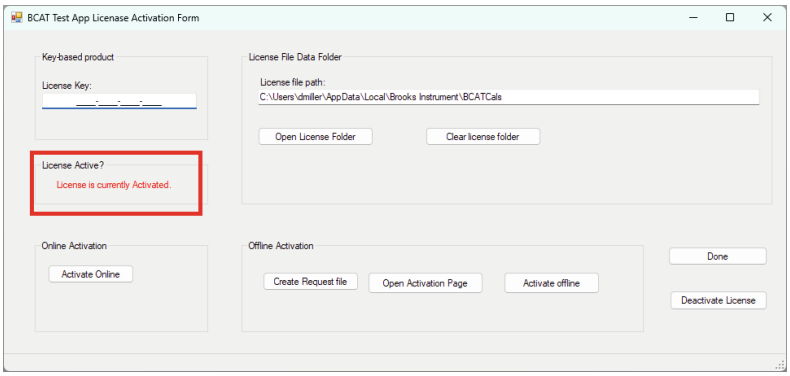


Deactivating a License

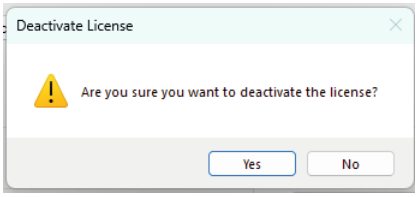
- In BCAT software, open the menu item Help->License->Install License.



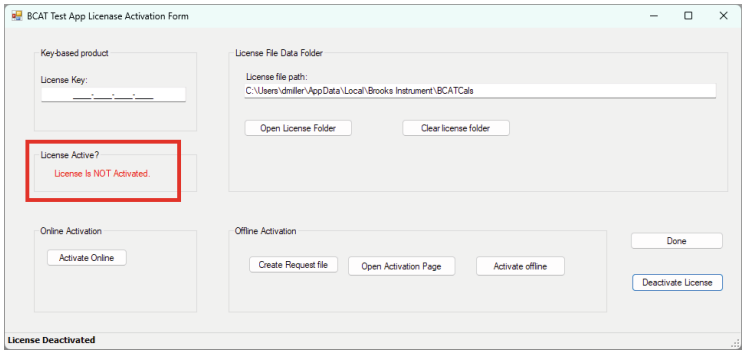
- The BCAT License Activation Form will appear:



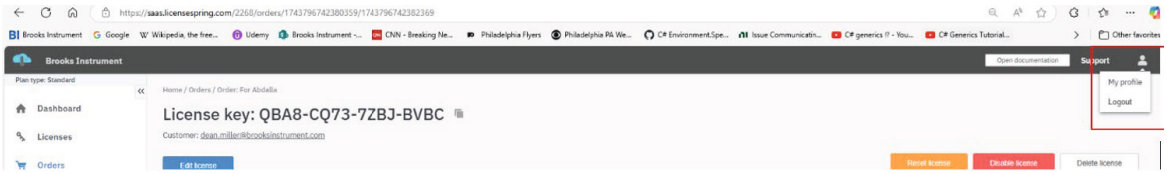
- If the message “License is currently Activated” appears, then it may be deactivated.
- Click Deactivate License and confirm:



- The License Activation form now shows the License is no longer activated:



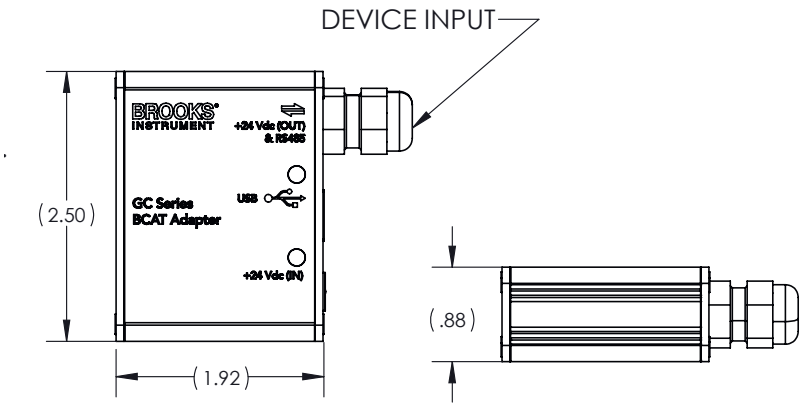
- When finished, always remember to log off the LicenseSpring website:

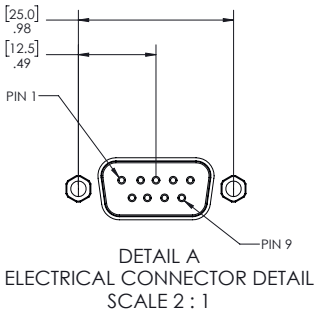


Transferring a License

- A license may be transferred from one computer to another. Simply deactivate the license on one computer. Then, activate the license on the other.

Cable Connection Diagram





Pin	Connection
1	N/C
2	N/C
3	RS-485 (-)
4	0-5 Vdc, Setpoint
5	RS-485 (+)
6	0-5 Vdc, Output
7	V+
8	GND
9	GND

Device Communication

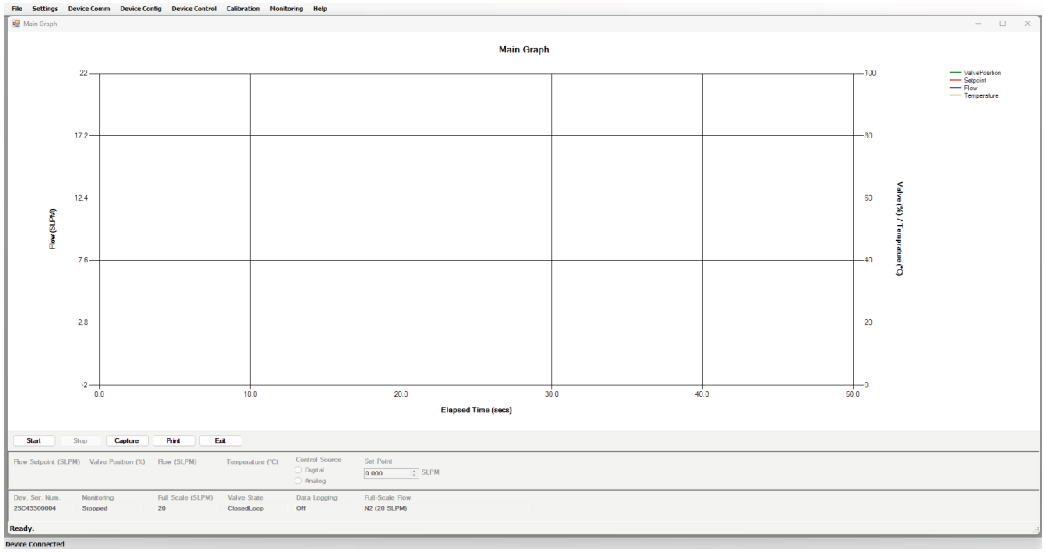
- Protocol: **Modbus RTU over RS-485**
- Use COM port via BCAT Adapter – 778Z024AAA
- No diagnostic port available

Connecting to a Device

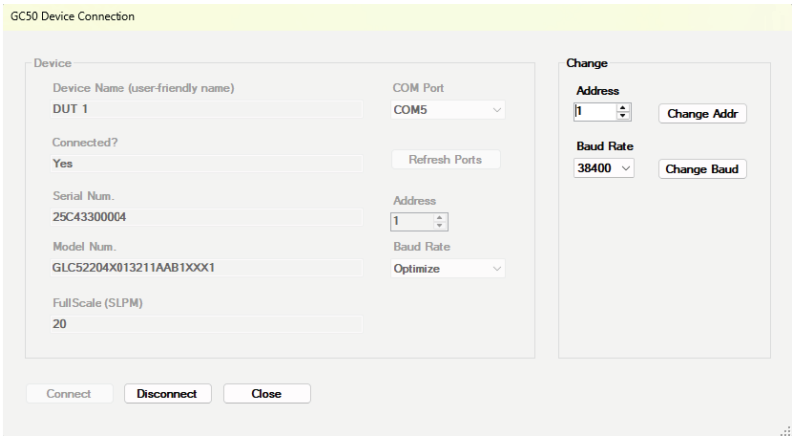
1. Select COM port and Address
2. Choose baud rate:
   - Optimize (default)
   - 4800, 9600, 19200, 38400
3. Press Connect

On Successful Connection

- Graph will appear and with “Ready” in bottom left



- “Device Connected” will be listed in the main BCAT App in the bottom left
- Following details will be populated under Device Comm > Connection



File Menu

Exit: Close connection and exit app

Settings Menu

Graph Options:

- **Display options:** Flow Setpoint, Flow, Valve Drive, Temp
- **Axis settings:** Manual or Auto Scale
- Sample period & decimal display
  - Set to 0 for maximum sample rate

Data Logging: Edit data log path, output file type = csv

Device Comm Menu

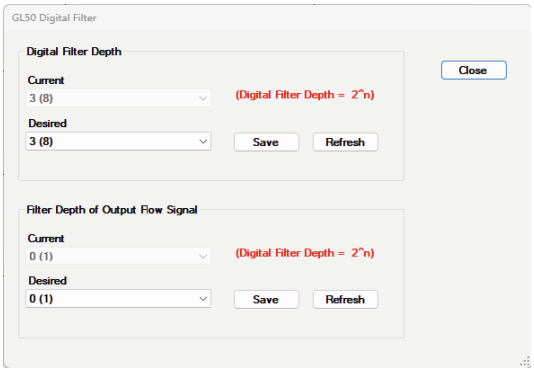
Connection: COM port settings
Terminal: Brooks access only

Device Config Menu

Device Info: Serial Number, Model Number, Firmware Rev, FS Flow
Model Code: Read-only breakdown
Protocol Settings:

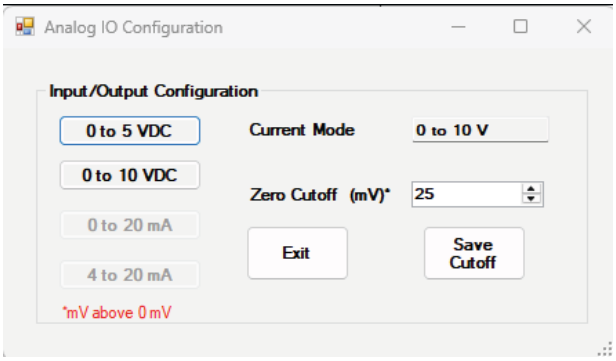
- **Address:** 1-247 (except 157)
- **Baud Rates:** 4800–38400

Filter Settings: Average samples: 0–512



Analog I/O

Modes: 0–5 V, 0–10 V, 0–20 mA, 4–20

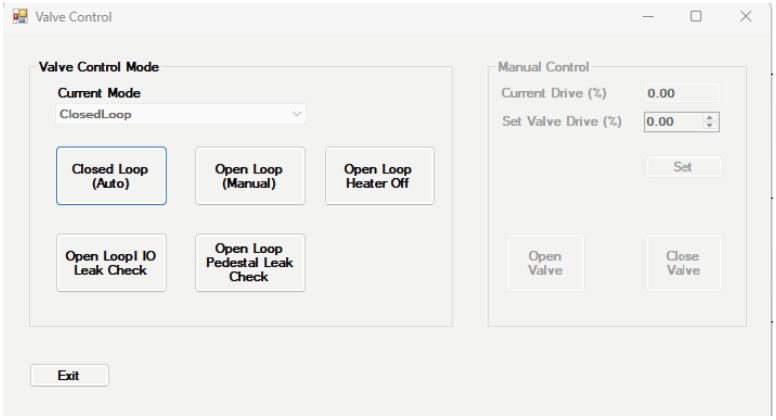


- Device cannot be switched between Voltage and Current analog
- Zero Cutoff can be adjusted.

Device Control Menu

Valve Control: Can be used for troubleshooting and diagnosing the device

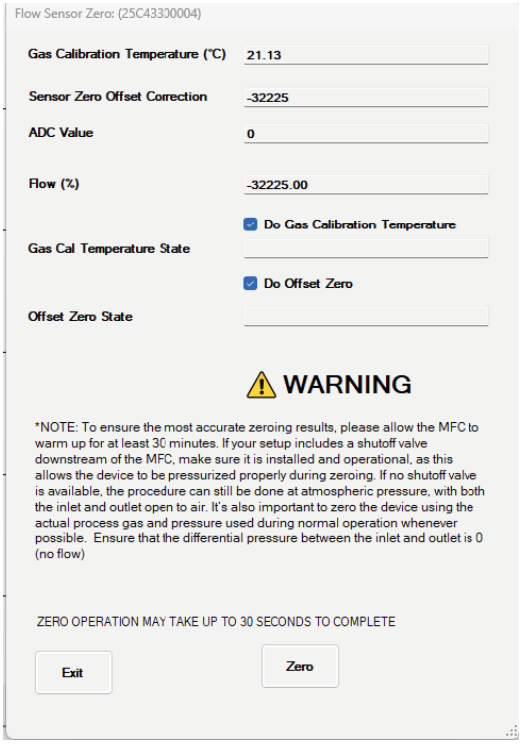
- Closed Loop (Auto)
- Open Loop (Manual)
  - Set Valve Position (0–100%)
  - Open/Close valve
- Open Loop Heater Off (service)
- Open Loop I/O Leak Check (service)
- Open Loop Pedestal Leak Check (service)
- Exit prompt to return to Auto



Calibration Menu

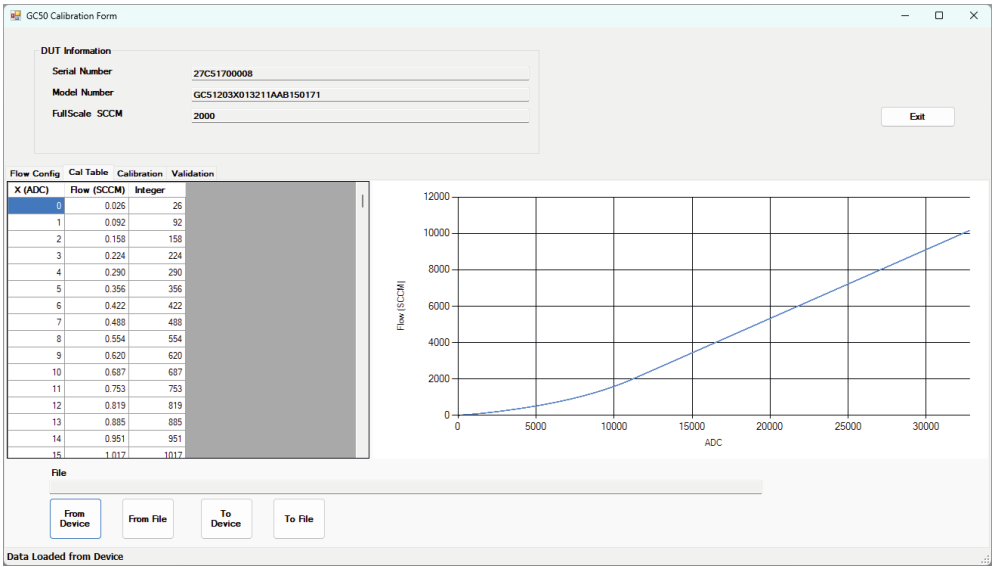
Sensor Zero (License Not Required)

- Read the warning notice on the window.
- With gas filled in the sensor and no inlet to outlet gas flow, click the Zero button.



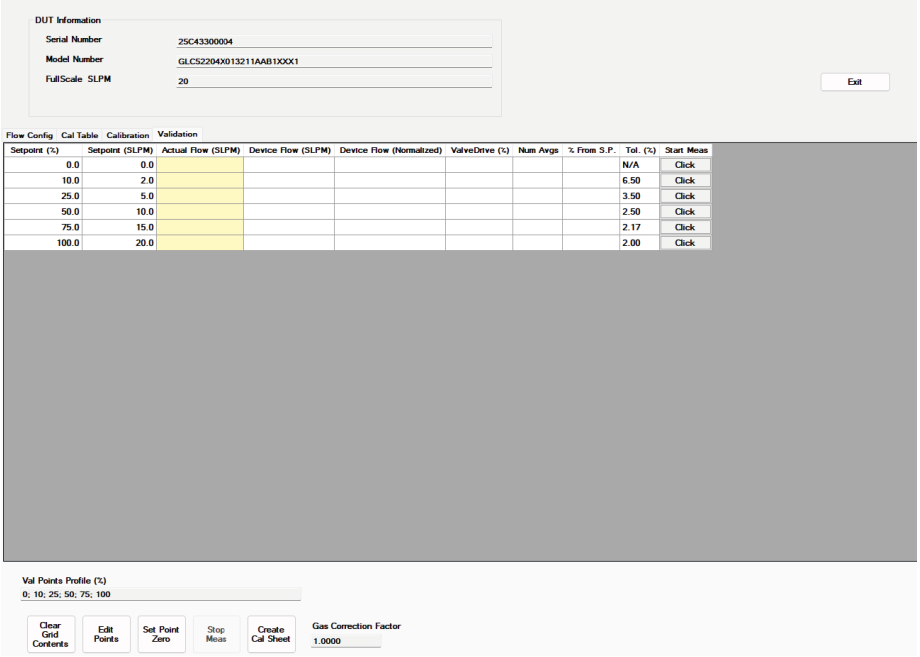
Calibration (License Required)

- Flow Config Tab:
  - Gas selection & properties
  - Heater Drive (read only)
  - Correction Factors
    - See section “Using the Gas Correction Factor”
  - Amplification Factors
    - Set to 32 for N2/Air, 128 for H2/He
    - Contact Brooks Tech Service for custom amplification factors
  - Adjustable Full-scale Flow (SCCM only)
  - Save to Page button to commit changes to Page 0
  - Sensor Zero - opens the Sensor Zero Window shown above.
- Cal Table Tab:
  - Load/save calibration tables to/from device/file
  - View 2D Graph of calibration table



Validation (As Found Initial Accuracy Check)

Objective: Determine if the MFC is within specification (ex: before calibration).

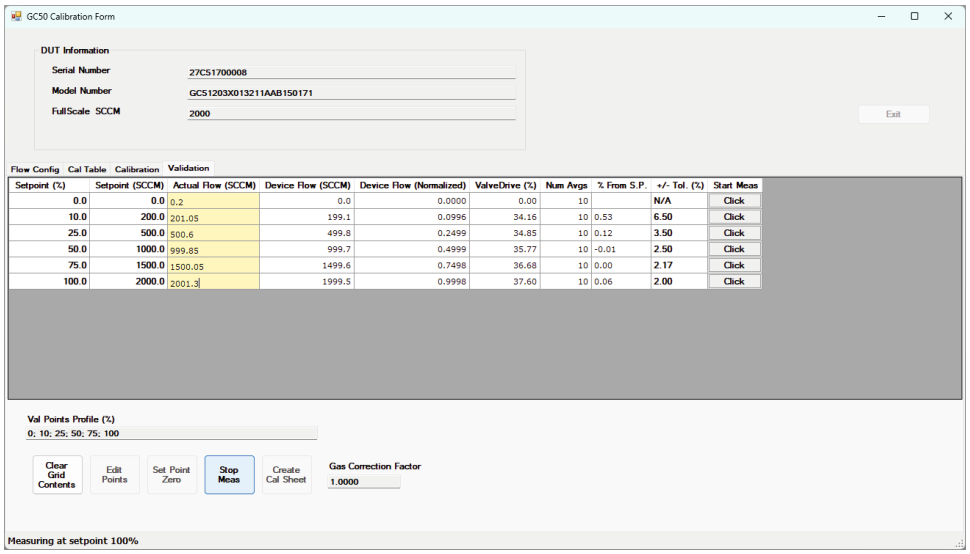


1. Ensure the device and measurement equipment are sufficiently warmed up.
2. Select the Validation Tab
   - Launch the calibration software and navigate to the Validation section.
3. Verify Setup
   - Confirm the flow reference standard is connected and thermally stabilized
4. Set Flow Setpoint
   - At each setpoint, click the “Click” button to send a flow setpoint to the device.
   - Recommended test points: 10%, 25%, 50%, 75%, 100% of full scale.

5. Wait for Stabilization
   - After sending the setpoint, wait for the system to stabilize.
   - The “Num Avgs” counter in red will increment—wait until it reaches 10.
   - Also, it is recommended to wait until the Device Flow (Normalized) column turns from red to black.
   - Do not record a flow value until stabilization is complete.
6. Record Measured Flow
   - Manually record the reading from the external flow reference standard in the cell under the Actual Flow column (yellow column).
   - Repeat for all test points (each row in the Validation tab Grid).
   - At the end, click “Stop Meas” and “Set Point Zero”.
7. Evaluate Accuracy
   - Compare the measured flow against the setpoint.
     - If supported by the system, percent error will be calculated automatically.
     - Manual method:

$$\text{Percent Error} = \left(\frac{\text{Measured Flow} - \text{Setpoint}}{\text{Full Scale}} \right) \times 100$$

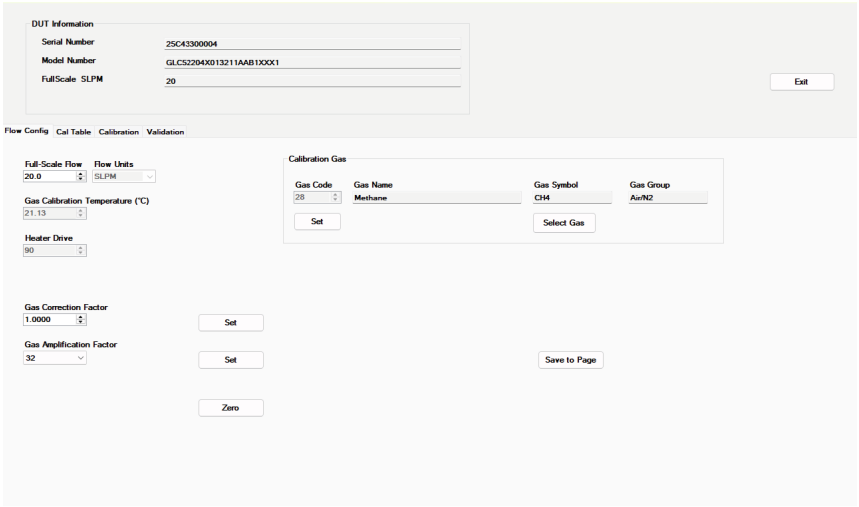
   - If all readings are within specification, proceed to “As Left” step (Part 3).
   - If any point is out of spec (or if you just want to recalibrate), continue to Part 2: Calibration.
8. Stop Measurement & Zero
   - Click “Stop Meas” and “Set Point Zero” to halt flow.
9. Save Validation Data
   - Click “Save” to export the As Found results as a PDF or Excel report.



Calibration

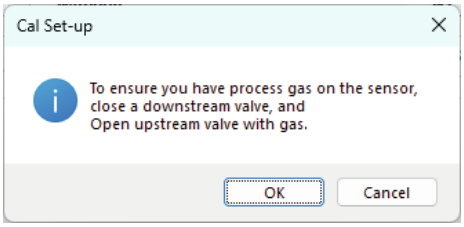
Objective: Adjust internal calibration factors to bring the device into spec (ex: If As Found Fails)

Characterizes the response of the device to a known flow measurement standard and adjusts the device's internal correction factors to match the standard.

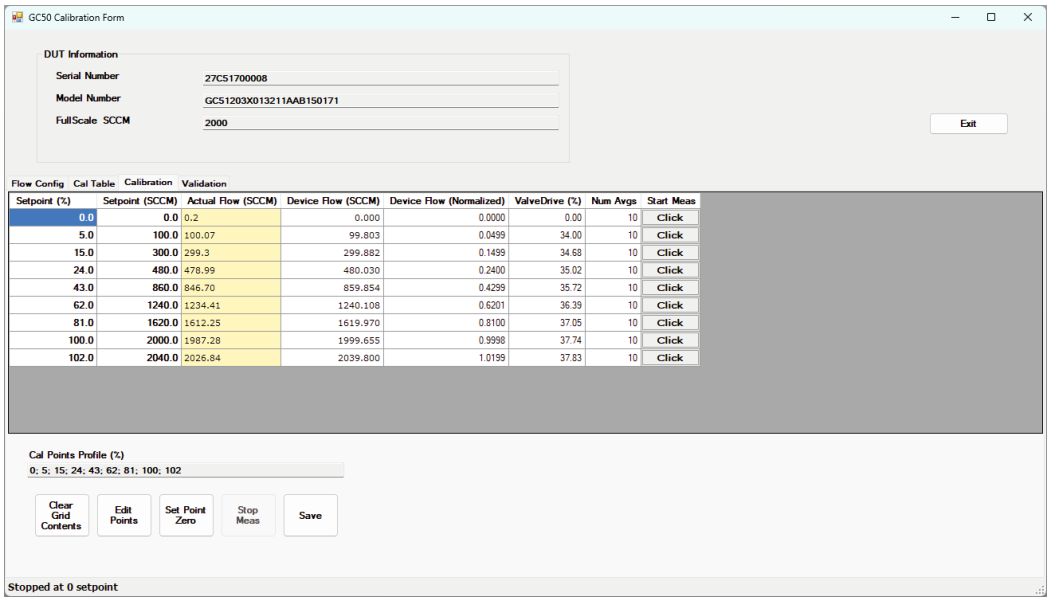


1. Open Flow Config Tab
2. Select Calibration Gas by clicking the Select Gas button.
   - Use the Select Gas table and "Set" button to assign the correct gas.
3. If desired, adjust the Full-Scale Flow value.
4. Apply Gas Correction Factor
   - Prior to calibration, always set the Gas Correction Factor 1.0000. If you do not, the software will remind you. The factor can be readjusted after the calibration, if desired. More on this later.
5. Set Amplification Factor
   - Use the amplification value provided in the GC user manual, depending on the selected gas, typically. Then click the Set button next to the Gas Amplification Factor.
6. Equalize Device Differential Pressure
   - Close a shutoff valve downstream from the GC device.
   - Under Device Control menu, click the Valve Control menu, to open the Valve Control Window.
   - Click on Open Loop Manual.
   - Click on Open Valve.
   - Open a shutoff valve upstream from the GC device.
   - Allow gas to fill the MFC
   - Wait for 0 pressure differential (upstream pressure = downstream pressure) and gas no flow.
   - Click on Close Valve in the Valve Control Window.
   - Click on Closed Loop (Auto).
   - Close the Valve Control Window.

7. Create New Gas Page
   - Save configuration to a new page by clicking the “Save to Page” button. Confirm the overwrite warning.
   - After a few moments, confirm the prompt that the device’s differential pressure has been equalized.



   - Again, wait for differential pressure to stabilize.
   - The software will show the message “Page Creation Successful”.
8. Calibrate
   - Open a shutoff valve downstream from the GC device.
   - Open a shutoff valve upstream from the GC device.
   - Navigate to the Calibration tab.
   - Repeat the same flow validation steps outlined in Part 1 for each test point in the Calibration Tab grid.
   - When finished, click “Stop Meas”, “Set Point Zero”, and “Save”. Wait a few minutes for the response of “Final Cal saved to device”. Internal factors will be adjusted and saved to the device to align measured flow with setpoints.



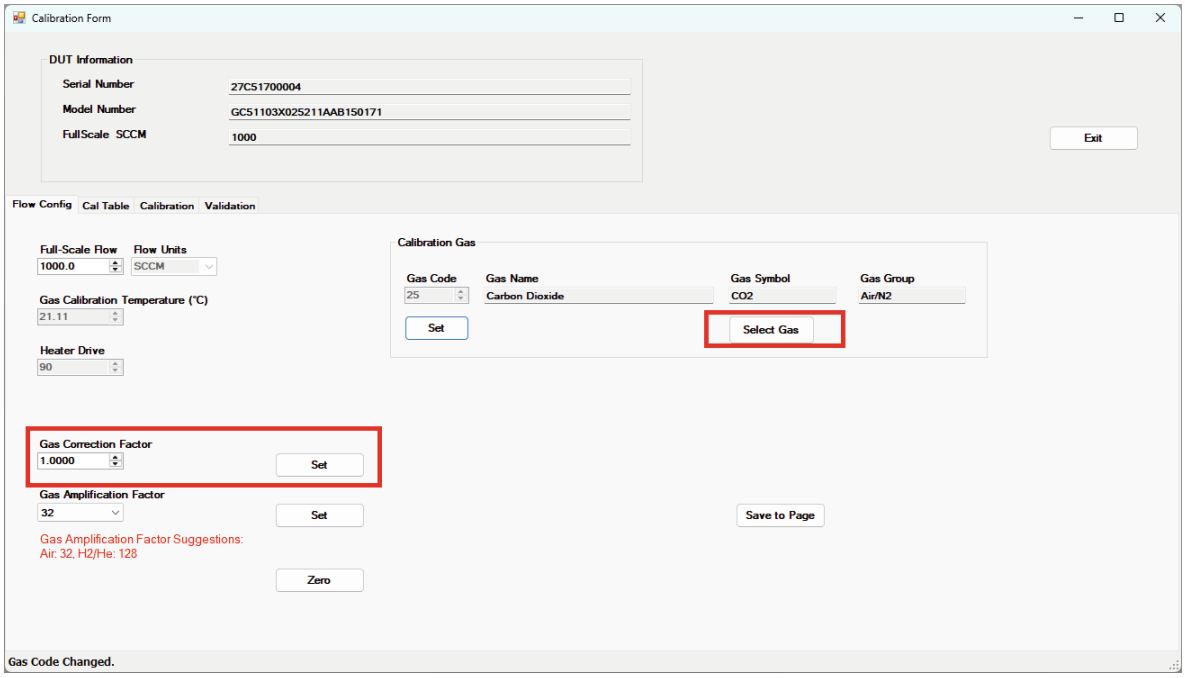
Using the Gas Correction Factor

The Gas Correction Factor allows the controlled flow to be scaled, such as for a process gas that is different from the calibrated conditions.

The factor is a ratio, relative to the calibration of the device. The user may set the factor to a known value for their process gas compared to calibration gas. Or, the user may set a custom factor, based on their own conditions.

To see the device's current factor after calibration, open the Calibration window and click on the Flow Config tab. The current factor is show in the Gas Correction Factor numeric control. This is the ratio of the device's ordered condition/gas compared to the calibrated gas/condition.

To set the factor after calibration, open the calibration Window and click on the Flow Config tab. Change the Gas Correction Factor numeric control, and click the Set button to the left of it.



To see factors for common gasses, click on the Select Gas button under the Calibration Gas text block. A table of standard gasses and their correction factors will be displayed. Choose the row that contains your device's calibration gas (CalGas column) and the process gas you wish to use (Name column). The factor column will contain your factor. Close this window with table. NOTE: you will need to enter the reciprocal of this factor and then click the Set button.

Select Gas Window: (27C51700004)

Code	Name	Symbol	Factor	CalGas
4	Argon	Ar	1.000	Air
8	Air	Air	1.000	Air
9	Carbon Monoxide	CO	1.000	Air
13	Nitrogen	N2	0.996	Air
15	Oxygen	O2	1.000	Air
25	Carbon Dioxide	CO2	1.000	CO2
27	Nitrous Oxide	N2O	0.980	CO2
28	Methane	CH4	1.030	Air
89	Propane	C3H8	0.298	Air

You may also select a custom factor if your gas combination is not shown or if you have other conditions.

Validation (As Left Confirm Calibration Success)

Objective: Verify device accuracy post-calibration.

1. Return to Validation Tab
   - Repeat the full validation sequence described in Part 1.
2. Save Final Report
   - Save the “As Left” report as a PDF or Excel.
   - This serves as proof of calibration accuracy and completion.

Completion Criteria

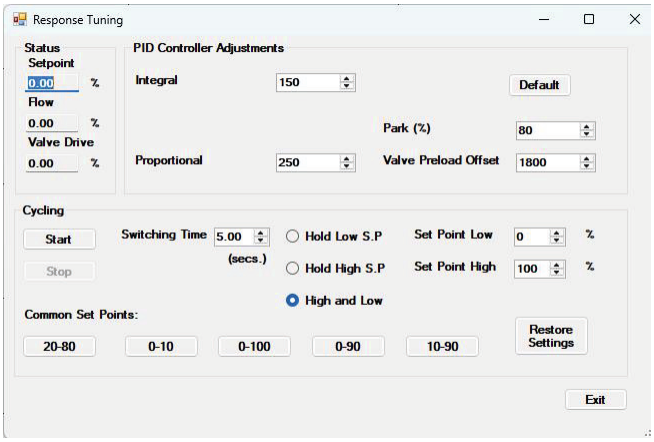
- All As Left points are within allowable tolerance.
- Validation and calibration data are saved and archived.
- MFC is ready for deployment in applications.

Response Tuning:

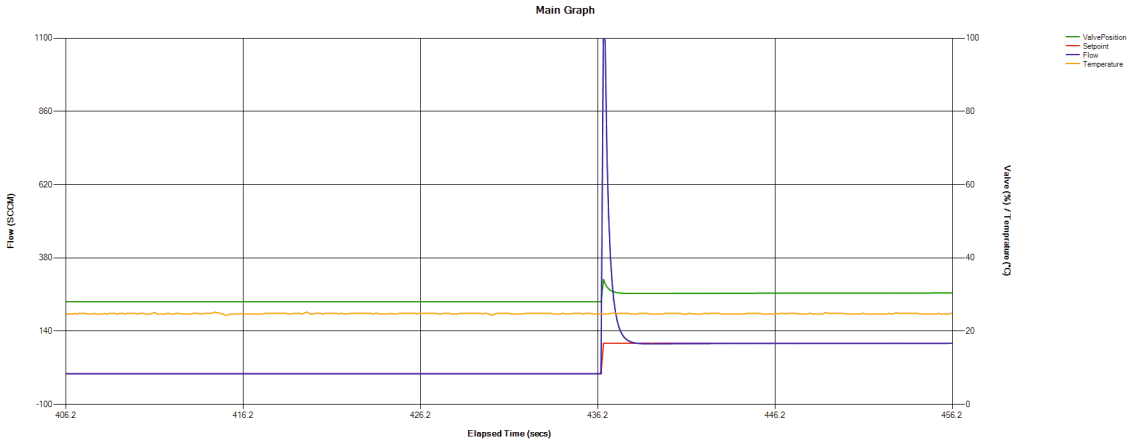
The purpose of response tuning is to minimizes overshoot, undershoot, dead time, and oscillations while ensuring smooth, responsive performance.

This section includes instructions for tuning the response of a GC Series Device using P and I parameters, preload, and related settings. It covers accessing the tuning interface, initial setup, adjustments, and validation. Note that tuning may vary by device (e.g., GC series or conventional PID modes) and process conditions like gas type, pressure, or flow range. Responsiveness and noise can also be influenced by filter parameters, adjust them if needed after PID tuning.

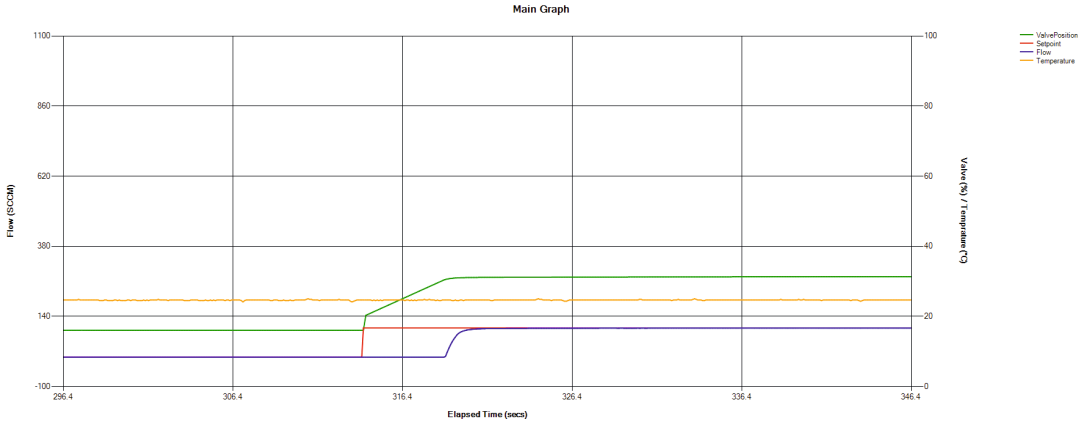
1. Accessing the Response Tuning Interface
   - In the menu, navigate to Calibration > Response Tuning.
   - This opens a graph window and the Response Tuning dialog. Move the dialog out of the way or to another monitor if available.
   - Select desired cycling parameters:
   - Cycle switching time.
   - High, low, and hold setpoints (SP) and setpoints modes.
   - Click start.



2. Preload (Pedestal/Valve Preload Offset) Adjustment
    - Start with the factory-provided or calibration-specific preload value (device-dependent).
    - Adjust preload to balance dead time and overshoot
    - Goal: Minimal but visible dead time at low setpoints (0–10%).
    - Valve current trace: Snaps up smoothly in a square-like response (not a gradual ramp).
    - Flow trace: Rises without large overshoot or undershoot.
    - If preload is too high: Overshoot exceeds specifications; valve may drive down to compensate. Lower the value until responses at both high/low SP are within spec.

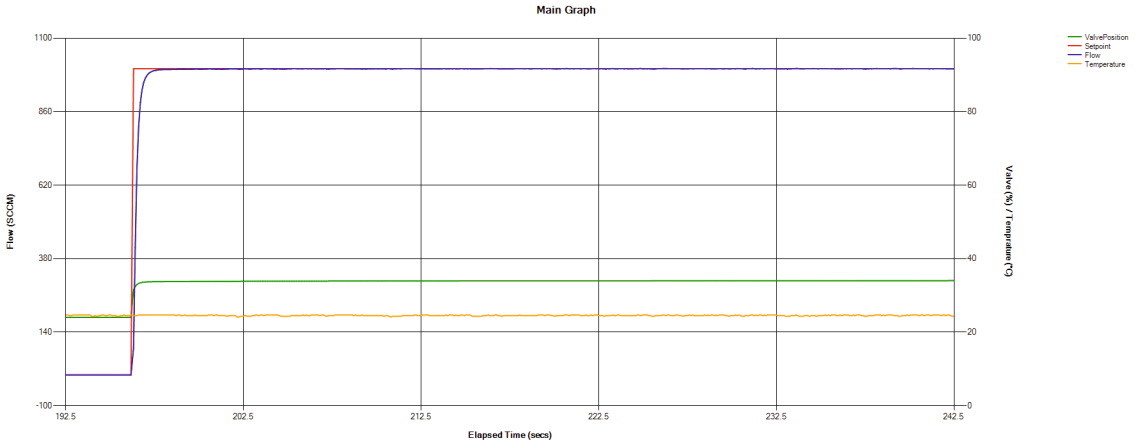


    - If preload is too low: Long dead time and sluggish response. Increase gradually.



    - Proper preload example: A slight lag between the response and SP curve; any remaining overshoot is typically due to P/I gains, not preload.
    - Test with cycling between high/low setpoints and refine until both directions meet acceptance.
3. Proportional (P) Gain
    - Initial guideline: Set to 1.0–1.5 × I gain
    - Function: Provides immediate response to error.
    - Refine to reduce overshoot while keeping response fast.
    - Validate across small (0–10%) and large (0–100%) step tests.

4. Integral (I) Gain
    - Start with factory or low value
    - Function: Slowly accumulates the error and adjusts the valve to bring the flow to the setpoint
    - Too high: If rate of change of flow too high or excessive overshoot not due to preload then lower
    - Too low: If rate of change of flow is too low then raise
5. Validation and Final Checks
    - Perform step tests at multiple setpoints, cycling between high/low setpoints, until desired performance is achieved
    - Acceptance criteria:
    - Dead time: Minimal (small visible pause is okay; no excessive lag).
    - Traces: Valve and flow are smooth, no oscillations or instability.
    - Overall: Fast response with minimal error and overshoot across conditions.

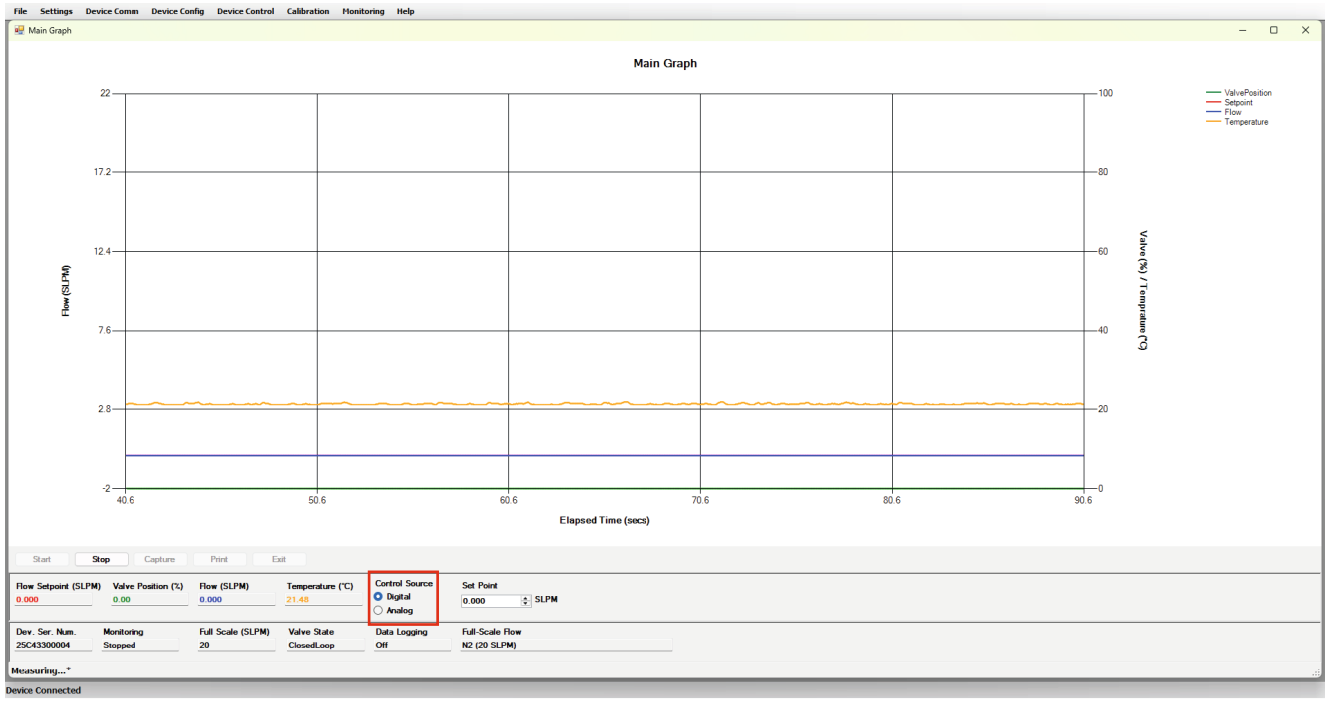


- If process conditions change (e.g., gas type, pressure), retune preload and gains as needed.
- Re-check filter parameters if noise or responsiveness issues persist post-tuning.

Monitoring Menu

Graph:

- 2D Time Graph: Flow Setpoint, Flow, Valve Drive, Temp
- Digital control allows the software to control the setpoint. Analog control is via the voltage or current on the analog input pins of the 9-pin connector
- Controls: Start, Stop, Capture, Print, Exit



Help Menu

- **About:** Version info
- **License Info:** Info, install, end user license agreement (EULA)
- **User Manual:** Opens this document
- **Read Me:** Opens a readme text file with last-minute updates

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Beyond Measure