Series 3000

BLENDED GAS ON DEMAND

NOTE: Every Series 3000 is customized to the User's Needs. This manual is just one example!

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THEORY OF OPERATION

This system has been designed to dilute 100% CO_2 with air to an output concentration of 5%.

The main controls of the system are HMI (Human Machine Interface); color touch screen and PLC combined. A series of I/O modules connect to all the electro-mechanical devices.

Precision mass flow controllers (MFC) are used to control the flow rate of each gas for blending. A 40 SLPM MFC is used for air and a 2 SLPM MFC is used to control the flow of CO_2; refer to the P&ID at the end of this document. Each MFC was calibrated at 11 points by Environics, for linear and accurate flow throughout the range. The 11 point calibration curve is stored in the software of the PLC. As the system is used to blend the two gases, these look up tables are used to improve the accuracy of the blender, using the mathematical algorithm linear interpolation.

Precision mass flow meters (MFM) have been installed on the outputs of the MFCs. These electronic meters monitor the flow rate of each flow controller and the PLC mathematically calculates the actual CO_2 blend based on the metered flows. This provides an independent check on the MFC performance. Each MFM was also calibrated at 11 points by Environics

The system is built into a NEMA 4 wall mount enclosure. Fitting connections and tubing are 316 stainless steel. All wetted surfaces are oxygen compatible.

When actively mixing, the instrument will send the diluted gas through and in-line static mixer and to the input side of an internal back pressure regulator. The regulator provides a controllable output pressure, assuming the downstream process draws less flow than the S3000 delivers. The back pressure is factory set to 4 PSIG. The excess flow, not being used by the downstream process, will exhaust through the VENT port. The vented flow can be minimized by reducing the total flow to satisfy the demand as well as an output pressure setting of 4 to 8 PSIG.

A visual alarm lamp has been installed onto the top of the instrument to alert the operator of a fault condition.

SYSTEM LAYOUT

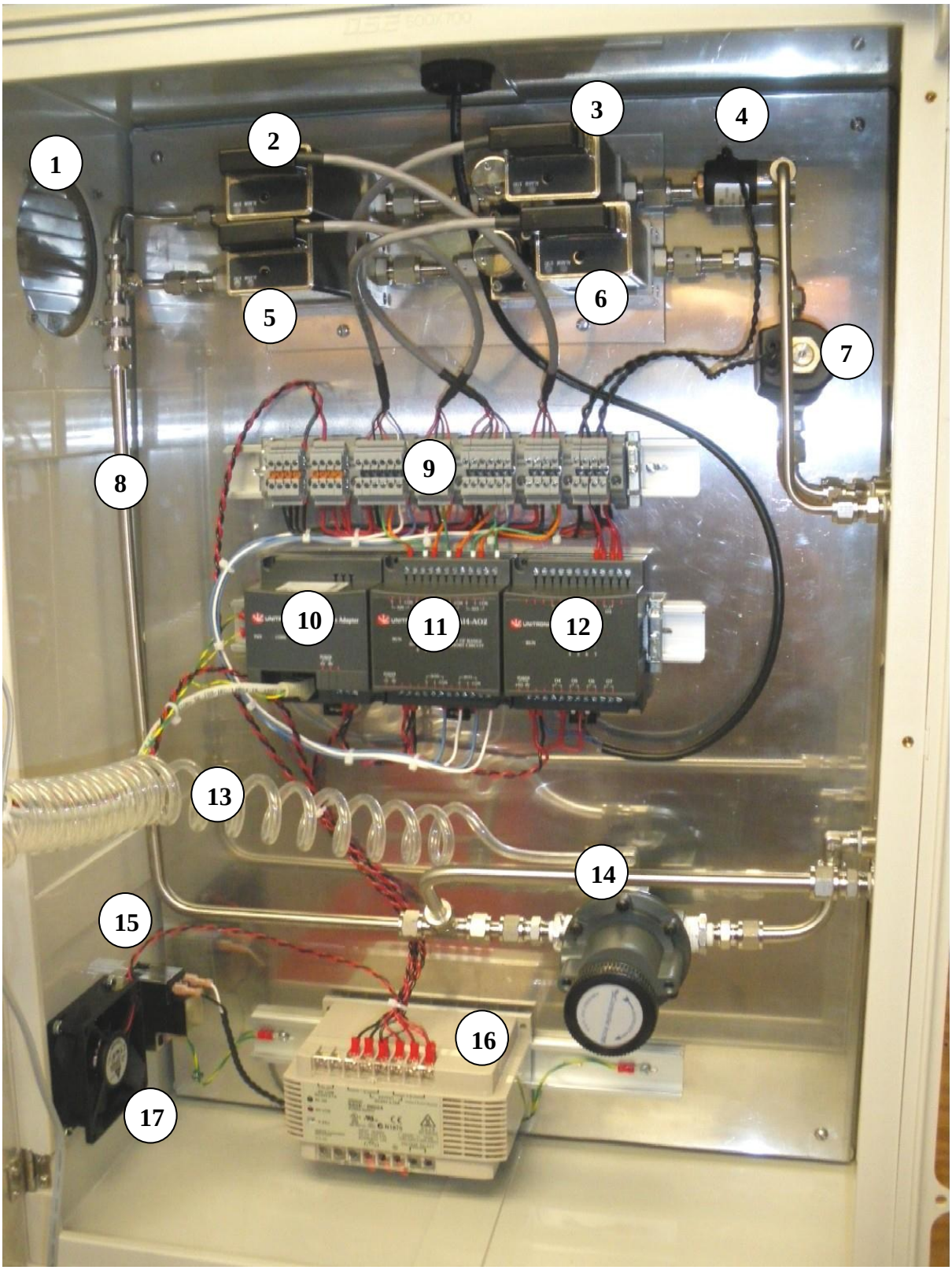


FIGURE 1: INTERNAL COMPONENTS

COMPONENT LIST

1. Louvered vent for cooling air flow, part number #GA104
2. CO_2 mass flow meter (MFM), part number MABR2-CO2-02000
3. CO_2 mass flow controller (MFC), part number MABR1-CO2-02000
4. Isolation valve for CO_2 input, part number SA01-003-02
5. Air MFM, part number MABR2-AIR-40000
6. Air MFC, part number MABR1-AIR-40000
7. Isolation valve for Air, part number SA01-017
8. In-line static mixer, part number MA06-003
9. Terminal blocks for power and signal distribution, HJ22-001-002
10. Interface module between the PLC and I/O modules, part number PLC-EXA-EXP
11. Analog module for mass flow device (MFD) signals, part number PLC-ANA-EXP
12. Relay I/O module for solenoid valves and alarm lamp, part number PLC-IO1-EXP
13. Tube connection for output pressure gauge, part number PA19-04-001-O2
14. Back pressure regulator, part number VA-BPR-3
15. Power entry module with power switch, part number GJ008
16. +24 VDC power supply, part number PJ02-11-002.
17. Cooling fan, part number BA01-003

PLC part number PLC-570-24-1
Alarm lamp part number DK07-012
Pressure gauge part number VA-G-015

QUICK START PROCEDURE

1. Make all plumbing and power connections.
2. Power the instrument on. The 3000 should be on for at least 60 minutes before proceeding to step 4.
3. Enter the blend mode and set up the required output gas concentration of CO_2 and the total flow rate for the mixture; setting the blend parameters, pages 5 and 6.
4. Start the BLEND mode, page 7.

OPERATING THE 3000

All modes of operation are accessed from the main screen shown in figure 2. This mode will be referred to throughout this manual as the standby screen. When powering on the 3000, the standby screen will appear. There are two main modes that can be accessed from the standby screen. To enter each mode, press the respective virtual button on the touch screen display. The calibrate mode allows the mass flow meters and controllers to be calibrated to an external gas flow standard. The blend mode is used to dilute CO_2 with air to the desired concentration.

FIGURE 2: STANDBY SCREEN

SETTING THE BLEND PARAMETERS

Upon pressing the BLEND button, the screen shown in figure 3 will appear. The current CO_2 concentration and total flow setting a.re displayed on the respective buttons. To change these values, press on either button. Upon pressing one of the two buttons, the virtual keypad shown in figure 4 will appear. Total flow is entered as two digits in increments of 1 LPM. So for a total flow rate of 40 LPM, simply enter 40. Once the desired flow is entered, press the enter key (↵) and the screen shown in figure 3 will reappear. Limits for total flow rate are 8 to 40 LPM. The output concentration is entered in increments of .01 percent, with an allowable range of 4.00 to 6.00 percent.

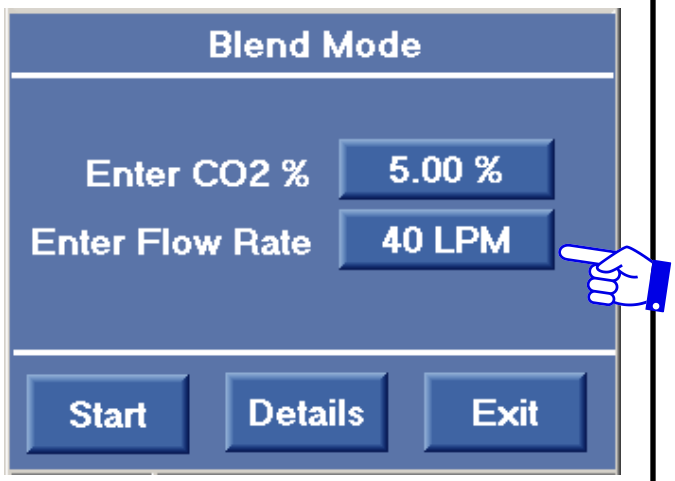


FIGURE 3: SETUP BLEND MODE

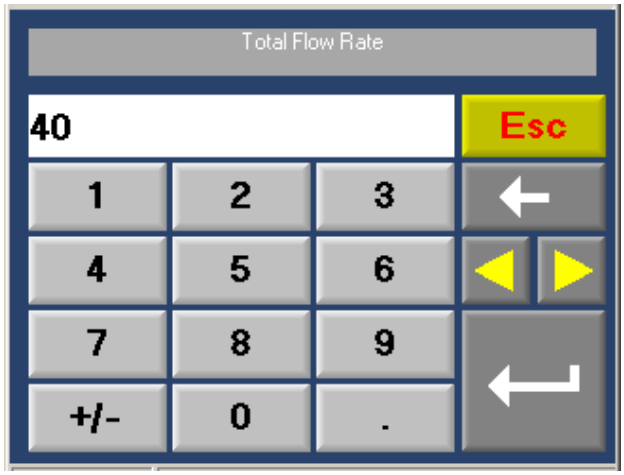


FIGURE 4: VIRTUAL KEYPAD

BLENDING WITH THE 3000

The system is now ready to start blending. Upon pressing the START button, shown in figure 5, the system will start flowing and mixing gas immediately. The pressure gauge on the front panel should rise and stabilize at the preset value very quickly, if there is flow restriction downstream. The screen shown in figure 6 will appear once the START button is pressed. There is a slight delay for the display of the Actual % CO_2; this is intentional. The actual CO_2 value is derived from the metered flow rates of each individual MFM. To stop the blend, simply press the STOP button shown in figure 6. Flow will stop immediately and the screen shown in figure 5 will reappear. While the system is blending without an alarm condition, the lamp on top of the system will be illuminated green.

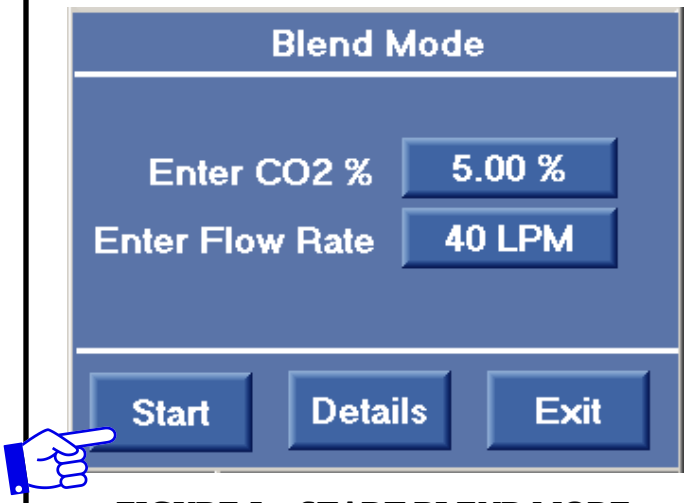


FIGURE 5: START BLEND MODE

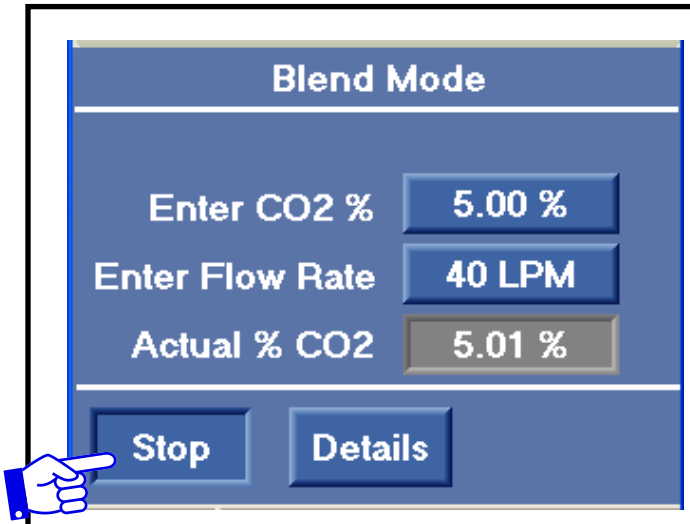


FIGURE 6: BLEND MODE RUNNING

While the system is flowing gas, either the total flow rate and/or the desired output concentration of CO2 can be adjusted by following the directions explained on page 5; setting the blend parameters. Pressing the details button will bring up the screen shown in figure 7. The details screen is used to adjust the error for alarming and as a tool to view the individual flow rates of each gas. Pressing the exit key will cause the display to revert back to screen shown in figure 6. All the values shown in the gray depressed blocks are read only and cannot be changed.

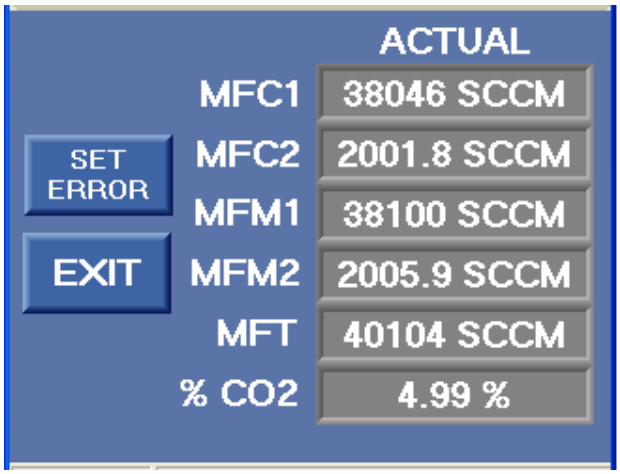


FIGURE 7: DETAILS SCREEN

Pressing the SET ERROR button, within the details screen, will cause the screen in figure 8 to appear. This value is used by the software to compare to the calculated error. If the calculated error is greater than the value in this screen, the alarm lamp will turn from green to red and an out of tolerance message will appear in the main blend mode screen shown in figure 6; see the section titled alarms in the blend mode for more information. To change the alarm value, press the button shown in figure 8.

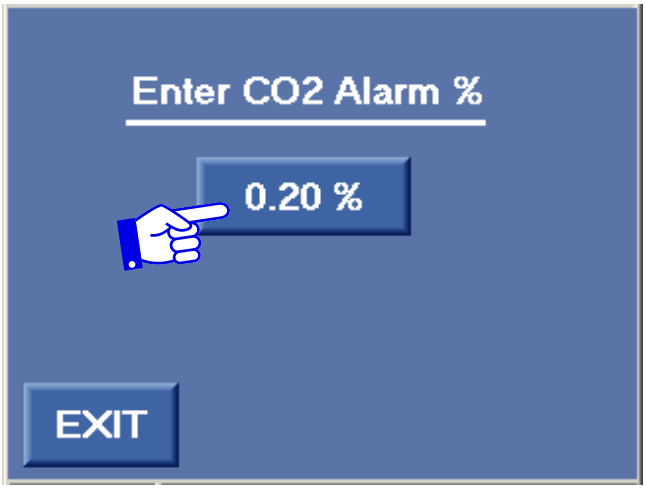


FIGURE 8: ACCESSING THE ALARM VALUE

Pressing the button shown in figure 8 will cause the virtual keypad in figure 9 to appear. The factory default for the alarm is .2%, but it can be adjusted from zero to .50% in .01% increments. This setting is an absolute value. If the value is set for .2%, the alarm will turn on if the actual concentration calculated from the flow meter feedbacks is outside the range of 4.8% to 5.2%. Simply enter the error value and press the enter key.

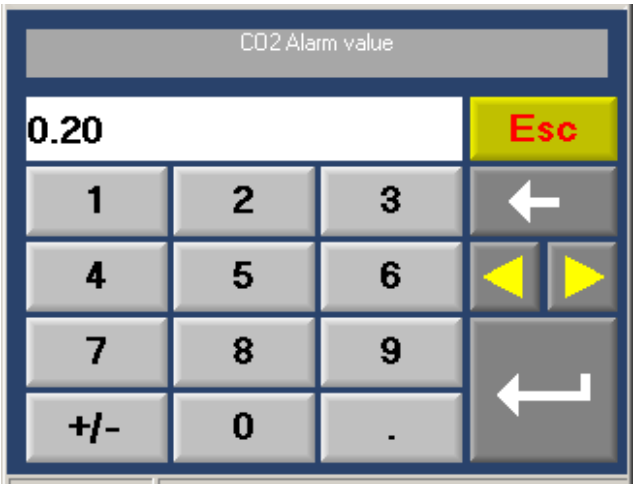


FIGURE 9: ENTERING THE ALARM VALUE

ALARMS IN THE BLEND MODE

While the blend mode is running, the software is constantly calculating the actual mixture based on the flow meter outputs. The actual concentration is interpreted based on these flow values. The software is also calculating the error based on the set point value made in the main blend mode screen; figures 5 and 6. When the calculated error exceeds the setting made in the screen shown in figure 8, alarm lamp will illuminate red and the message shown in figure 10 will appear on the screen. The alarm does not latch. If the alarm condition somehow corrects itself, the lamp will turn back to green and the message displayed in figure 10 will disappear from the screen. The system will continue to flow while the alarm condition occurs, this gives the operator the opportunity to use the details screen to evaluate the problem.

When the START button in the blend mode is pressed, the alarm check is delayed for 15 seconds, allowing enough time for the system to stabilize. Also, after new data is entered for total flow rate, output concentration, or the alarm value itself, the system suspends the alarm check for 10 seconds after the enter key of the virtual keypad is pressed.

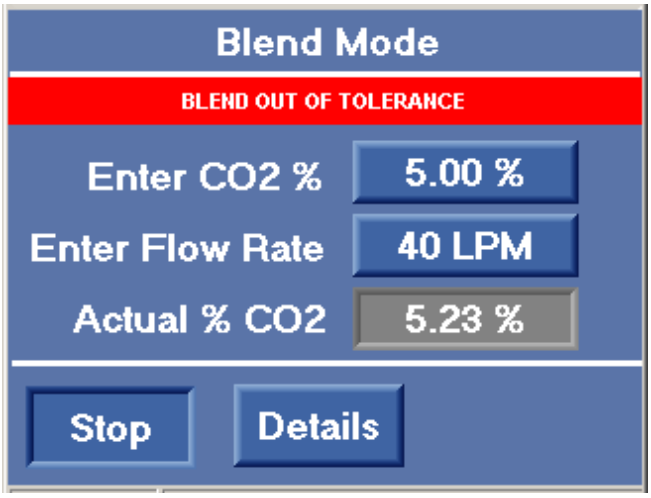


FIGURE 10: ALARM MESSAGE

CALIBRATING THE MASS FLOW DEVICES

Each mass flow device has an 11-point calibration curve stored in the memory of the PLC. When used in the blend mode, the PLC uses this calibration curve as a look up table, applying linear interpolation to improve the accuracy of the flow devices. The factory calibration setup is shown in figure 11 below. Important, for the calibration of this S3000, a standard temperature of $90^{O}F$ was used. This was necessary in order to get an actual flow measurement that was slightly above the full scale flow rate of the MFCs. This allows the instrument to be used up to the full 40 LPM flow rate. **IMPORTANT:** before taking flow readings, cap the output port and take readings from the vent port.

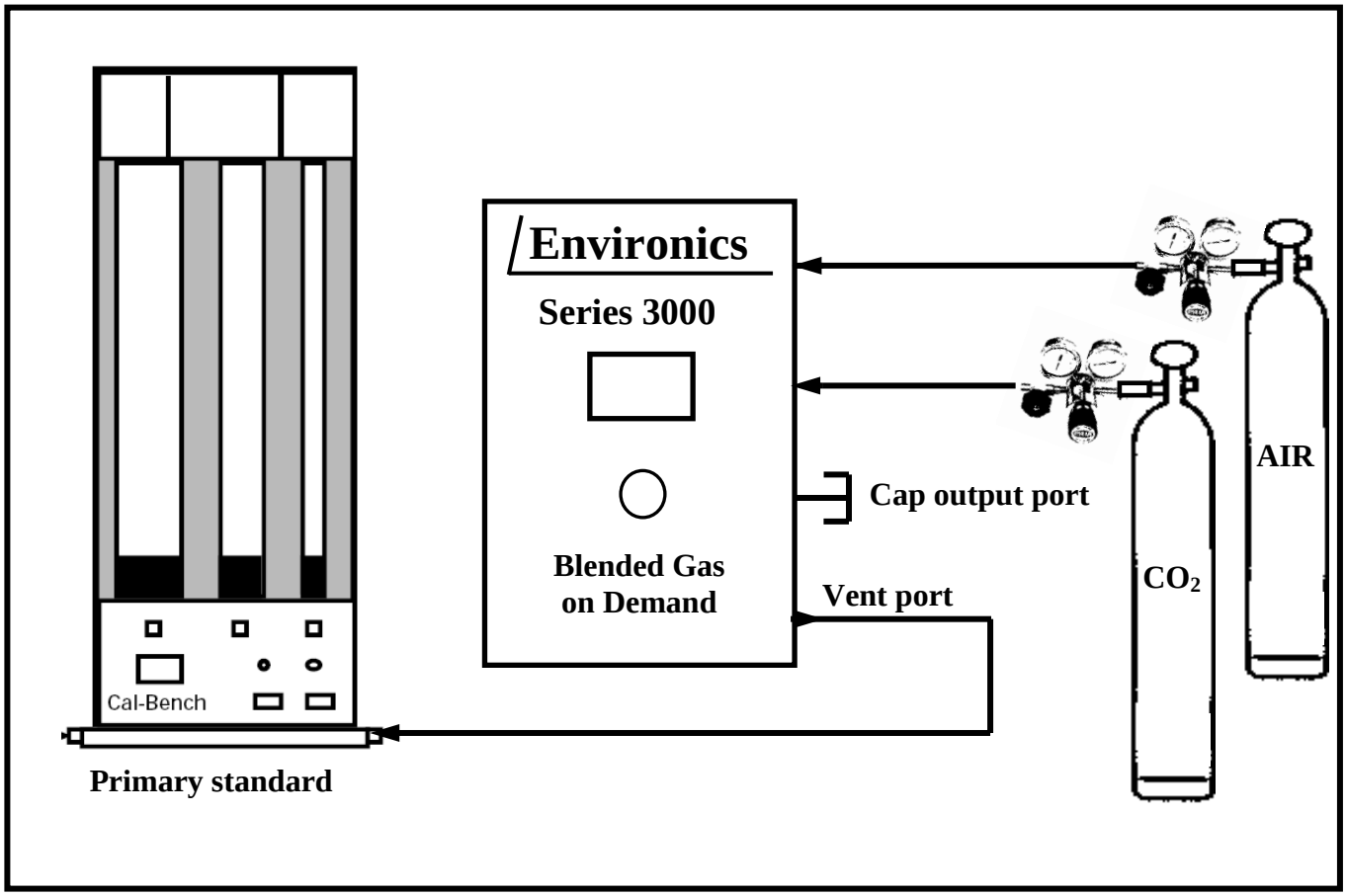


FIGURE 11: CALIBRATION SETUP

1. From the standby screen shown in figure 2 on page 5, press the CALIBRATE button. The screen shown in figure 12 will appear. At this point in the procedure, It is important not to press the CALIBRATE button shown on this screen. This button toggles the instrument between calibrate mode and verify mode. Verify mode is used to verify the flow accuracy once the instrument has been calibrated. The fact that the word calibrate is shown on the face of this button indicates that the system is in the calibrate mode.

2. Select the device set to calibrate by pressing the respective full scale flow rate button for each device. The screen shown in figure 13 will appear. The values shown in the depressed fields are read only values and cannot be changed.

3. Use the up or down arrow keys to change the desired calibration point. As the arrow buttons are pressed, both the percentage and set point values change, as shown in figure 14 on page 13. Pressing the exit button will bring back the main calibration screen shown in figure 12.

FIGURE 12: MAIN CALIBRATION SCREEN

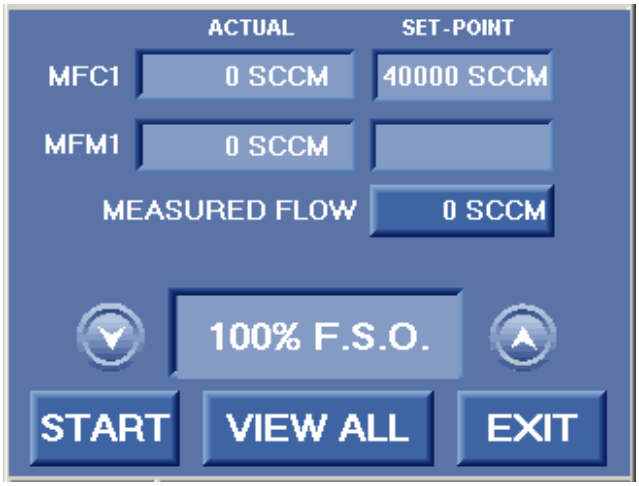


FIGURE 13: CALIBRATION MODE

4. Environics calibrates from high to low, starting the MFC at 100% and allowing the MFC to flow for several minutes; which insures stability. Once the desired set-point is selected, press the START button on the bottom of the display. Gas will start to flow immediately as the PLC provides the displayed percentage of 5 VDC to the MFC. The screen shown in figure 15 will appear after pressing the START button. The feedback voltages of the MFC and the MFM are converted to a flow rate and displayed.

5. After a few minutes, take a measurement on a flow standard.

6. Press the measured flow button shown in figure 15 and the virtual keypad shown in figure 16 will appear.

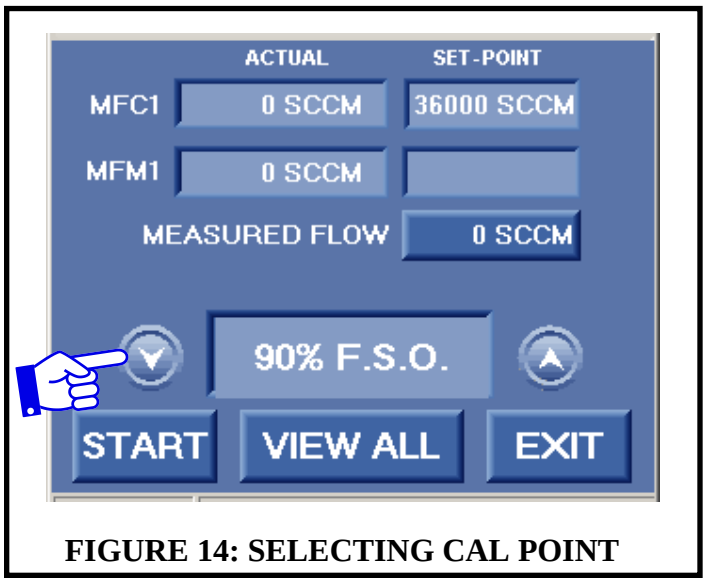


FIGURE 14: SELECTING CAL POINT

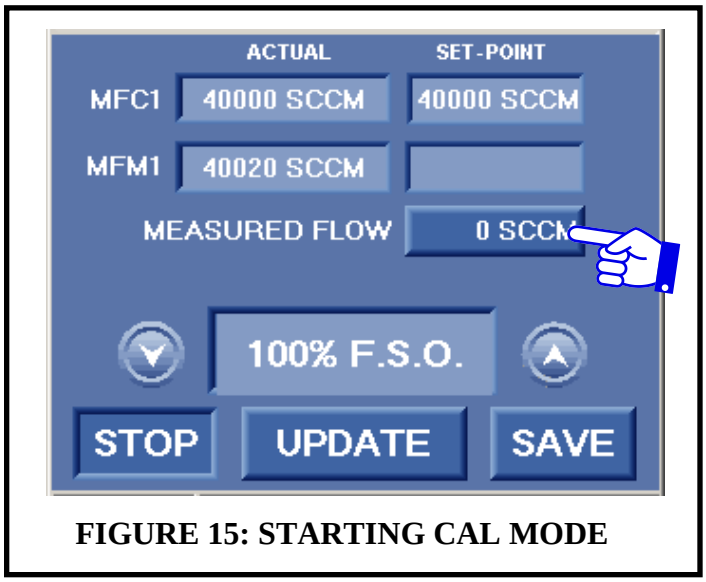


FIGURE 15: STARTING CAL MODE

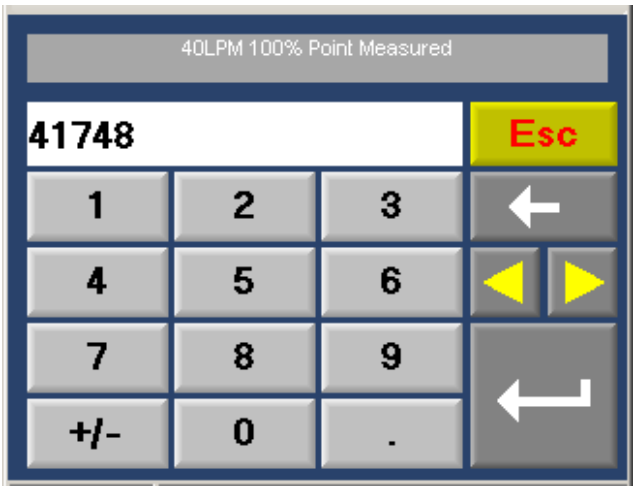


FIGURE 16: ENTERING FLOW DATA

7. Using the numeric keys of the virtual keypad, enter the flow rate measured on the flow standard and press the enter key. The number entered will now appear in the center of the measured flow button shown in figure 17.

8. Press the save key once the data has been entered. The data saved message shown in figure 17 will briefly appear indicating a successful save.

9. Using the up or down arrow key, select the next point and press the UPDATE button.

10. Repeat steps 5-9 for all eleven calibration points. Perform these steps for both sets of flow devices. The screens shown in this procedure are for the 40 LPM set.

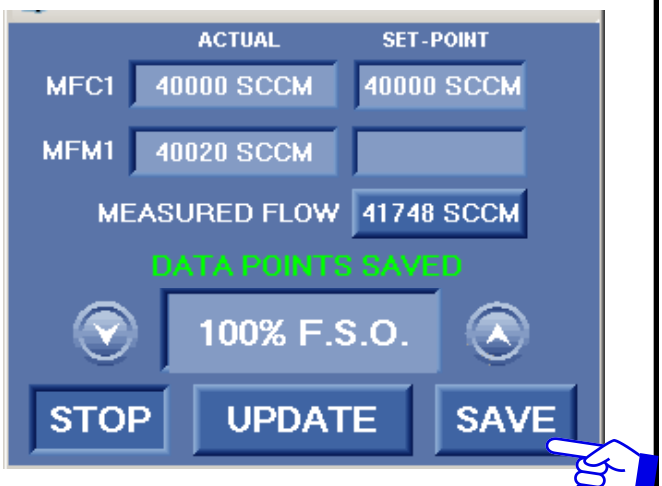


FIGURE 17: SAVING FLOW DATA

11. Press the stop key and the screen shown in figure 14 will reappear .

12. Press the VIEW ALL button. One of the two data tables shown in figure 18 will appear. This table shows all eleven points of calibration data that were previously entered and saved while calibrating. The first column shows the percentage point. The second column lists the set point. The third column lists the actual flow meter reading captured when the SAVE button was pressed in step 8 above, for each individual calibration point. The forth and final column list the measured flow reading entered by the calibration technician in steps 6 and 7.

13. If needed, each individual MFM OUT point and MEASURED point can be modified. Press the cell in the data table and the virtual keypad will appear. The data tables shown contain Environics factory calibration data.

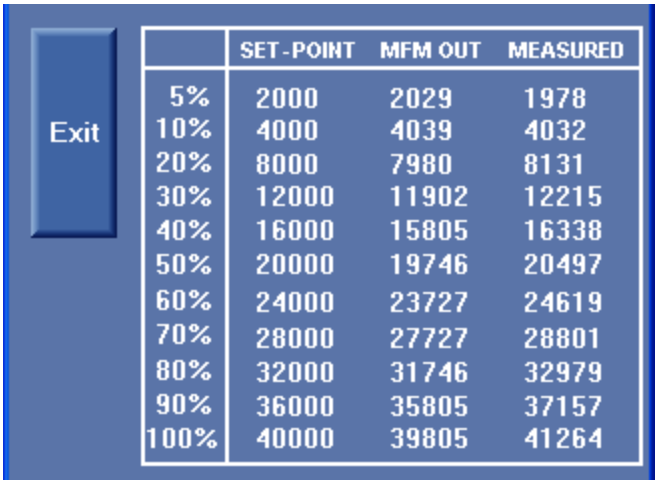


FIGURE 18: CALIBRATION TABLES

Once the calibration is complete, a verification of the system accuracy can be performed. In this mode, the system uses the flow data that was previously entered and applies linear interpolation to correct the flow command to the MFC and the reading of the flow meter. To verify the flow calibration, perform the following steps.

1. From the main calibration screen shown in figure 12, press the calibrate button. The word on the face of the button will change from Calibrate to Verify, as shown in figure 19.

2. Select the device set to verify by pressing the button showing the full scale flow rate; The screen shown in figure 20 will appear.

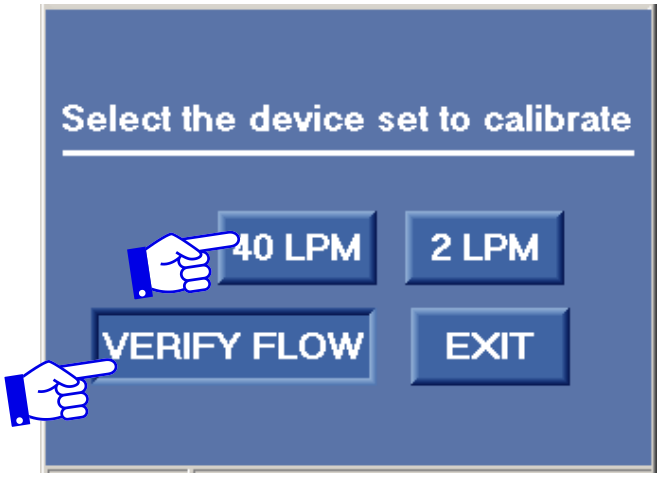


FIGURE 19: SELECT TO VERIFY FLOW

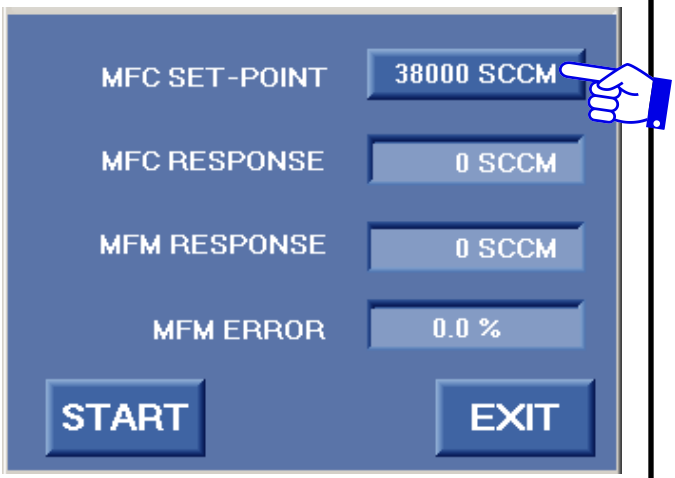


FIGURE 20: VERIFY FLOW SCREEN

3. Press the MFC Set-point button shown in figure 20. The virtual keypad will appear.

4. Enter a flow rate to verify between 8000 SCCM and 40000 SCCM for MFC1 and 400 SCCM to 2000 SCCM for MFC2 and press the enter key.

5. Press the START button shown in figure 20. Gas will start to flow immediately; see figure 21. The response flows of the MFC and MFM are displayed, along with the calculated error between what is commanded to the flow controller and what is read by the flow meter.

6. Using the flow standard. Measure the actual flow rate being delivered by the instrument.

7. If desired, change the set-point to another flow rate as described in steps 3 and 4. This can be done without stopping flow.

8. Repeat steps 6 and 7 for as many flow rates as necessary.

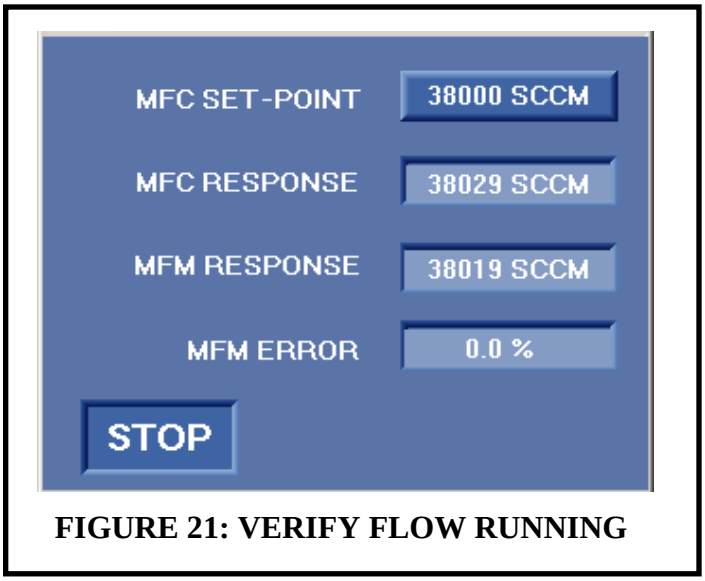
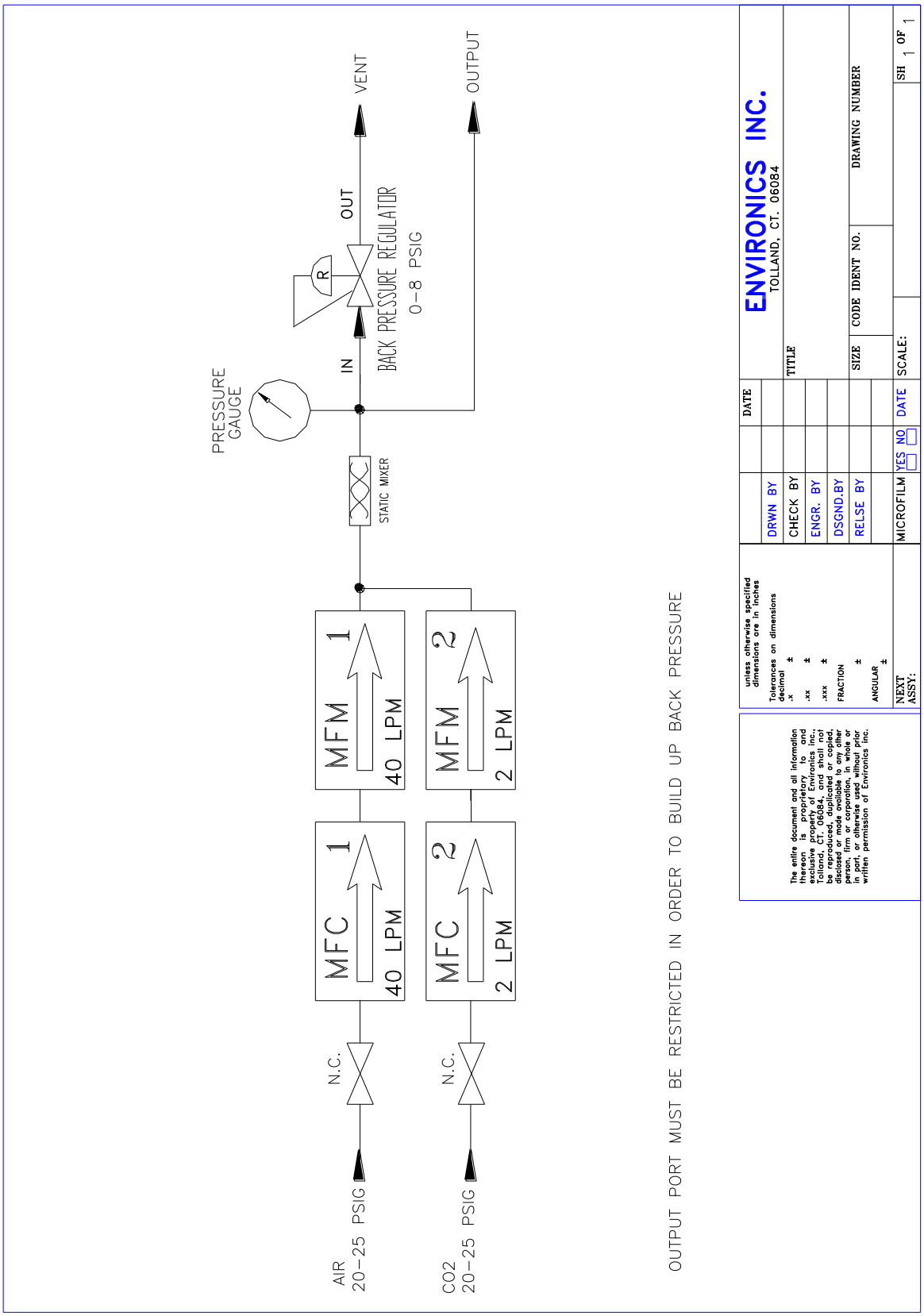


FIGURE 21: VERIFY FLOW RUNNING

P&ID


AIR
20-25 PSIG
CO2
20-25 PSIG
N.C.
N.C.
MFC 1
40 LPM
MFC 2
2 LPM
MFM 1
40 LPM
MFM 2
2 LPM
STATIC MIXER
PRESSURE GAUGE
IN
OUT
R
BACK PRESSURE REGULATOR
0-8 PSIG
VENT
OUTPUT
OUTPUT PORT MUST BE RESTRICTED IN ORDER TO BUILD UP BACK PRESSURE
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