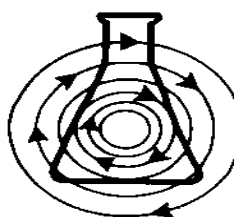




# Guide to Operations

## 16-Channel Gas Sequencer

MANUAL NO: M1154-0059  
Revision B  
June 14, 2006



**NEW BRUNSWICK SCIENTIFIC CO., INC.**

BOX 4005 • 44 TALMADGE ROAD • EDISON, NJ 08818-4005

Telephone: 1-732-287-1200 • 1-800-631-5417

Fax: 732-287-4222 • Telex: 4753012 NBSCO

Internet: <http://www.nbsc.com> • E-mail: [bioinfo@nbsc.com](mailto:bioinfo@nbsc.com)

---



---

## INTERNATIONAL OFFICES:

### **BELGIUM**

New Brunswick Scientific NV-SA  
Stationsstraat 180/4  
3110 Rotselaar  
België/Belgique  
Tel: 32 (0)16 56 28 31  
Fax: 32 (0)16 57 27 53  
E-mail: sales@nbsnv-sa.be

### **CHINA**

New Brunswick Scientific Co., Inc.  
A903, 904 Yin Hai Building  
No. 250, Cao Xi Road  
Shanghai 200235, P.R. China  
Tel: 86 21 6484 5955 or 5966  
Fax: 86 21 6484 5933  
E-mail: nbschc@online.sh.cn

### **FRANCE**

New Brunswick Scientific SARL  
12-14, Rond Point des Champs Elysées  
75008 Paris  
France  
Tel: 33 (0)1 5353 1511  
Fax: 33 (0)1 5353 1557  
E-mail: sales@nbssarl.fr

### **GERMANY**

New Brunswick Scientific GmbH  
In Der Au 14  
D-72622 Nürtingen  
Deutschland  
Tel: 49 (0)7022 932490  
Fax: 49 (0)7022 32486  
E-mail: sales@nbsgmbh.de

### **THE NETHERLANDS**

New Brunswick Scientific BV  
Kerkenbos 1101, 6546 BC Nijmegen  
P.O Box 6826, 6503 GH Nijmegen  
Nederland  
Tel: 31 (0)24 3717 600  
Fax: 31 (0)24 3717 640  
E-mail: sales@nbsbv.nl

### **UNITED KINGDOM**

New Brunswick Scientific (UK) Ltd.  
17 Alban Park  
St. Albans, Herts. AL4 0JJ  
United Kingdom  
Tel: 44 (0)1727 853855 or 0800 581331  
Fax: 44 (0)1727 835666  
E-mail: bioinfo@nbsuk.co.uk  
Web: www.nbsuk.co.uk

**CAUTION!**

This equipment *must* be operated as described in this manual. If operational guidelines are not followed, equipment damage and personal injury *can* occur.

Please read the entire User's Guide before attempting to use this unit.

Do not use this equipment in a hazardous atmosphere or with hazardous materials for which the equipment was not designed.

New Brunswick Scientific Co., Inc. (NBS) is not responsible for any damage to this equipment that may result from the use of an accessory not manufactured by NBS.

## Copyright Notice

New Brunswick Scientific Company, Inc.  
Box 4005 44 Talmadge Road  
Edison, New Jersey 08818-4005

© Copyright 2006 New Brunswick Scientific Co., Inc.

All Rights Reserved.

Reproduction, adaptation, or translation without prior written permission from New Brunswick Scientific is prohibited.

## Disclaimer Notice

New Brunswick Scientific Co., Inc. reserves the right to change information in this document without notice. Updates to information in this document reflect our commitment to continuing product development and improvement.

## Manual Conventions



### NOTE:

Notes contain essential information that deserves special attention.



### CAUTION!

*Caution* messages appear before procedures which, if caution is not observed, could result in damage to the equipment.



### WARNING!

*Warning* messages alert you to specific procedures or practices which, if not followed correctly, could result in serious personal injury.

### Bold

Text in boldface type emphasizes key words or phrases.



This particular *Warning* message, whether found in the manual or on the unit, means **HOT SURFACE**—and therefore represents a potential danger to touch.



### CRUSH WARNING!

*Crush Warning* messages alert you to specific procedures or practices regarding heavy objects which, if not followed correctly, could result in serious personal injury .



## WARRANTY

Every Instrument manufactured by the New Brunswick Scientific Co., Inc. is warranted to be free from defects in material and workmanship. This apparatus, with the exception of glassware, lamps and electrodes (where supplied), is warranted for 1 year against faulty components and assembly and our obligation under this warranty is limited to repairing or replacing the instrument or part thereof, which shall within 1 year following date of shipment prove to be defective after our examination. This warranty does not extend to any NBS products which have been subjected to misuse, neglect, accident or improper installation or application; nor shall it extend to products which have been repaired or altered outside the NBS factory without prior authorization from the New Brunswick Scientific Co., Inc.

---

## TABLE OF CONTENTS

<b>1</b>	<b>OVERVIEW</b>	<b>9</b>
1.1	Specifications	10
<b>2</b>	<b>INSPECTION &amp; VERIFICATION</b>	<b>11</b>
2.1	Inspection of Boxes	11
2.2	Packing List Verification	11
2.3	Unpacking	11
2.4	Inspection of Equipment	11
<b>3</b>	<b>FEATURES</b>	<b>12</b>
<b>4</b>	<b>GETTING STARTED</b>	<b>15</b>
4.1	Physical Location	15
4.2	Environment	16
4.3	Electrical Connections	16
4.4	4-20 mA Output	16
4.5	Using NBS Process Controllers	18
<b>5</b>	<b>OPERATION</b>	<b>20</b>
5.1	Starting Up	20
5.2	Valve Sequencing	20
<b>6</b>	<b>EXHAUST GAS ANALYSIS SYSTEM WITH <i>AFS-BIOCOMMAND</i></b>	<b>21</b>
6.1	AFS-BioCommand Control Diagrams	21
<b>7</b>	<b>PREVENTIVE MAINTENANCE</b>	<b>24</b>
7.1	Cleaning	24

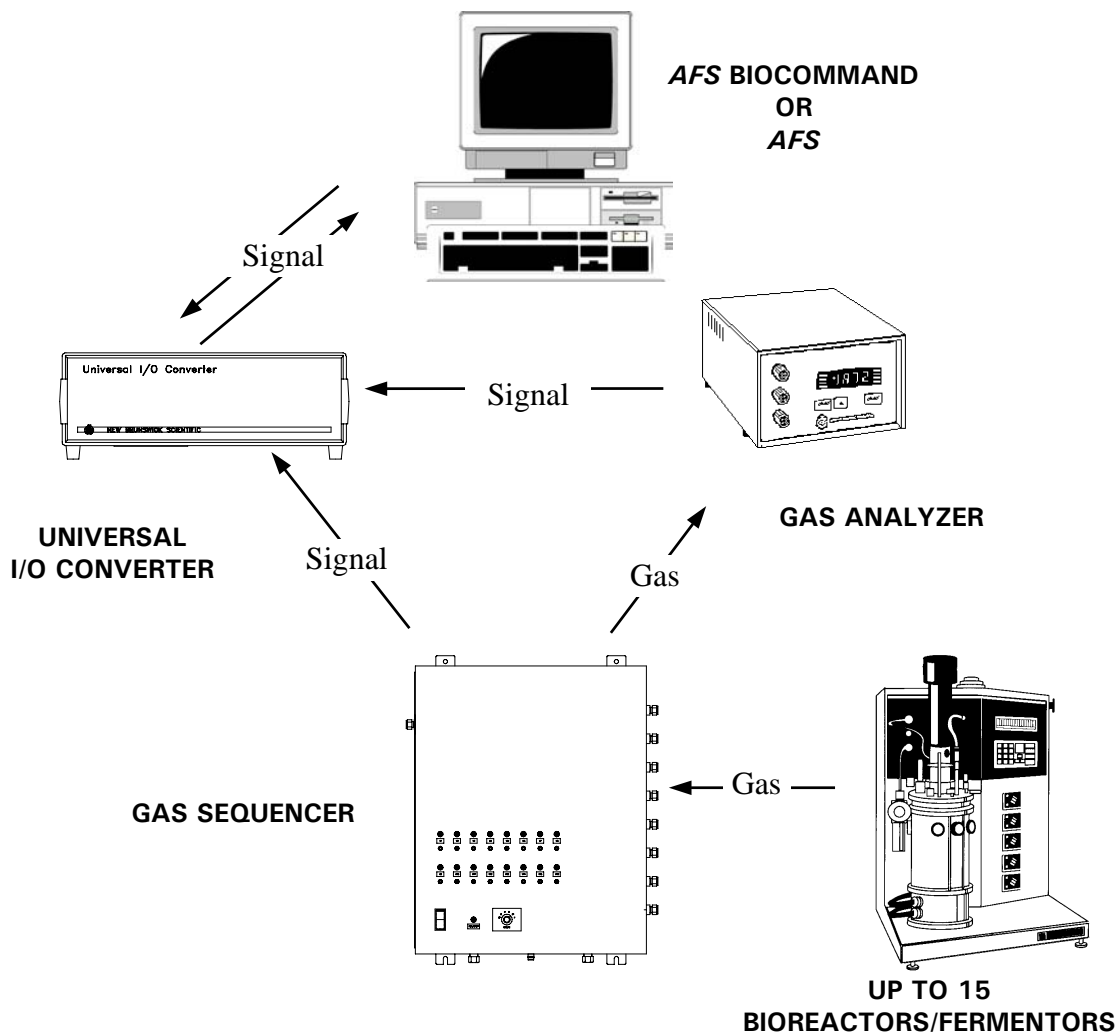
7.2	Fuse Replacement	24
8	REPLACEMENT PARTS	25
9	DRAWINGS & TABLES	26
9.1	Control Schematic	26
9.2	List of Drawings	28
9.3	List of Tables	28
10	INDEX	29



# 1 OVERVIEW

The NBS Gas Sequencer samples gases in sequential order from fermentors and/or bioreactors and then sends these sampled gases to a gas analyzer during a process. The Gas Sequencer is designed to be used as part of a loop in conjunction with the following equipment:

**Figure 1: Typical Equipment Set-up**



There are 16-Channels on the Gas Sequencer which can be turned on and off sequentially. A maximum of 15 fermentors or bioreactors can be connected to the unit. The 16th channel is used for a reference gas stream (zero gas stream). The user-selected sequencing time range for each channel or valve is 2 to 7 minutes.

## 1.1 Specifications

<b>Gas Sequencer</b>		
<b>Output Signal</b>	<b>Valve No.</b>	<b>Output (<math>\pm 0.1</math>mA)</b>
	All Off	4.0
	1	5.0
	2	6.0
	3	7.0
	4	8.0
	5	9.0
	6	10.0
	7	11.0
	8	12.0
	9	13.0
	10	14.0
	11	15.0
	12	16.0
	13	17.0
	14	18.0
	15	19.0
16	20.0	
<b>Compression Fittings</b>	18 unions, 3/8" OD, 316 Stainless Steel	
<b>Sequencing Time</b>	2 to 7 minutes, user-selected	
<b>Dimensions</b>	24 $\frac{1}{4}$ inches L x 13 $\frac{3}{8}$ inches W x 30 $\frac{5}{16}$ inches H 61.6 cm L x 34 cm W x 77 cm H	
<b>Electrical</b>	85-264 VAC 50/60 Hz, 0.2 A	

---

## 2 INSPECTION & VERIFICATION

### 2.1 *Inspection of Boxes*

After you have received your order from New Brunswick Scientific, inspect the boxes carefully for any damage that may have occurred during shipping. Report any damage immediately to the carrier and to your local NBS Sales Order Department.

### 2.2 *Packing List Verification*

Verify against your NBS packing list that you have received the correct materials.

### 2.3 *Unpacking*

Save all packing materials and the User's Guide. If any part of your order was damaged during shipping, is missing pieces, or fails to operate, please fill out the *Customer Satisfaction Form 6300* and return it by fax or mail.

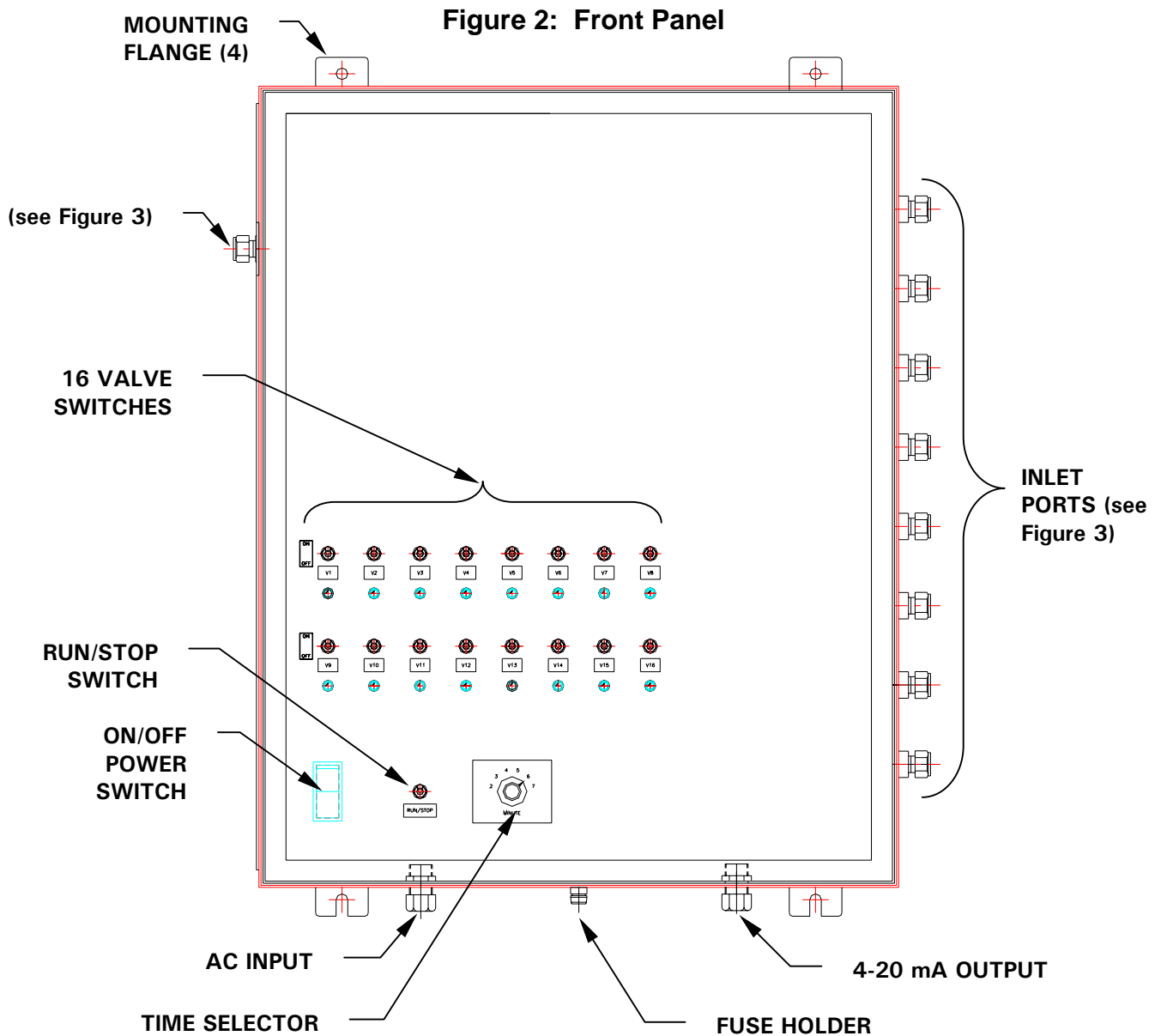
### 2.4 *Inspection of Equipment*

Verify that you have received the following:

- Gas Sequencer (M1154-2396)**
- Gas Sequencer User's Guide**

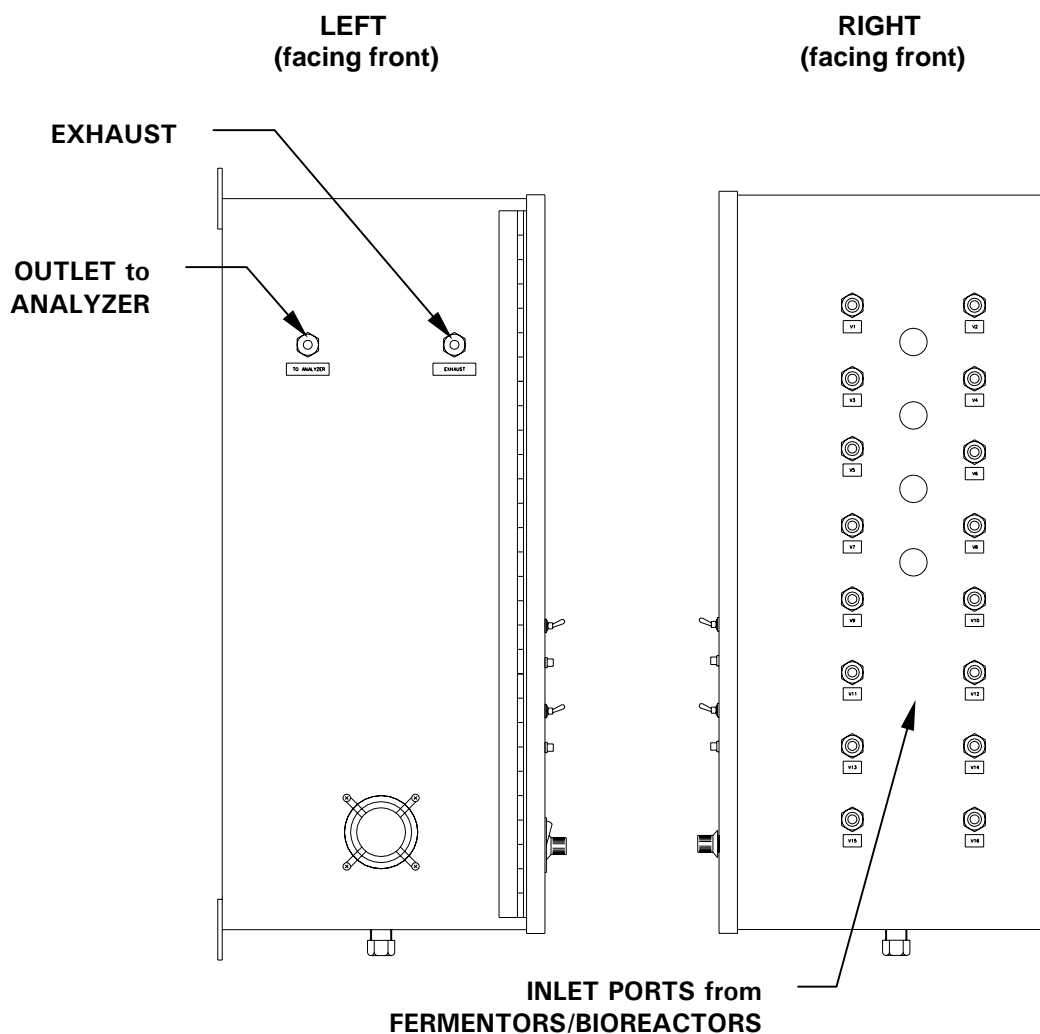
# 3 FEATURES

The 16 compression fittings on the right hand side of the Gas Sequencer are inlets you're your fermentors or bioreactors, and/or an alternate (zero) gas stream.



The port on the upper left side panel of the cabinet is an outlet port which is connected to a gas analyzer. The port on the upper right side panel of the cabinet is used for exhaust. The exhaust port is used to bypass the analyzer so that the sample is as fresh as possible when each solenoid valve is turned on and the gas stream is sent to the analyzer. Depending on the gases sampled, the exhaust gases may or may not need connected to a room vent.

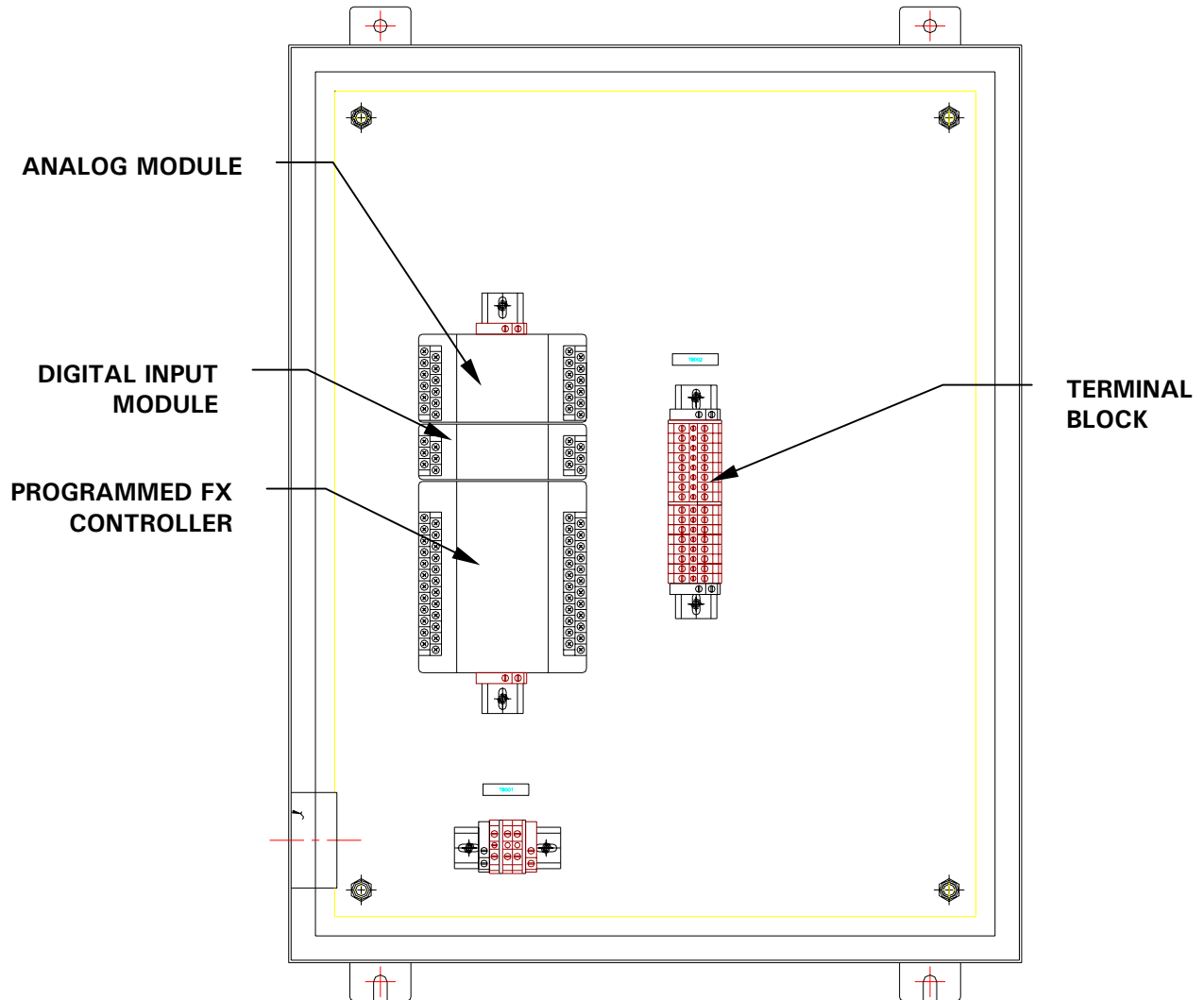
**Figure 3: Side Panels**



The interior of the Gas Sequencer cabinet consists of an analog module, a digital input module, a programmed FX controller, a terminal block, process piping, and sixteen solenoid valves.

The analog module produces a 4-20 mA signal which is used for identifying each valve in its open (ON) condition. See Section 1.1, *Specifications*, for the output signal of each valve.

**Figure 4: Cabinet Interior**



## 4 GETTING STARTED

### 4.1 Physical Location

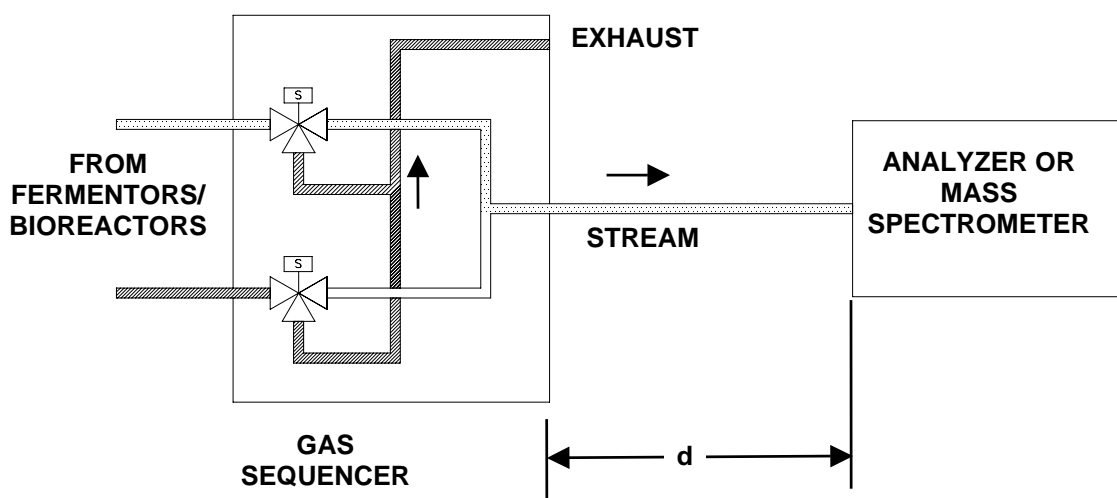


#### **WARNING!**

Never attempt to lift or move the Gas Sequencer by yourself. It should be lifted or moved by at least two people.

The 16-Channel Gas Sequencer is designed to be wall or rack-mounted. Select a location that will allow for gas lines to be run to and from the unit, while providing the shortest distance (d) between the unit and the gas analyzer/mass spectrometer. This distance (d) is critical for accurate and meaningful readings of your gas samples.

**Figure 5: Location**



Do not attempt to lift or carry the unit yourself. Two or more people are required to lift or move the unit.

Before mounting the Gas Sequencer, ensure that the wall or rack is sturdy and stable enough to support the unit.

## 4.2 Environment

The sequencer is designed to operate optimally in the following ambient conditions:

- 5 - 35°C
- 20 to 90% Relative Humidity, non-condensing

## 4.3 Electrical Connections

**Before making electrical connections**, verify that the power source voltage matches the voltage listed on the unit's electrical specification plate (located on the unit's side panel), and make sure that the ON/OFF switch is in the OFF position.

After verifying the above, plug the power cord (provided) securely into the AC power input connector (*see Figure 2*), and connect the power cord to a suitable, grounded receptacle.

## 4.4 4-20 mA Output

Each valve is associated with a unique analog current signal while it is open to a gas analyzer.

**Table 1: Valve Analog Current Signals**

Valve No.	Signal (mA)
All Off	4.0
1	5.0
2	6.0
3	7.0
4	8.0
5	9.0
6	10.0
7	11.0
8	12.0
9	13.0
10	14.0
11	15.0
12	16.0
13	17.0
14	18.0
15	19.0
16	20.0



This signal, which is used for identifying the open valve, is available at the output terminals of the analog module located inside the sequencer's cabinet (*see Figure 4*). The signal enables data processing equipment to link the gas stream currently exiting the Gas Sequencer with its source. This signal must be brought out to the external equipment via electrical connection.

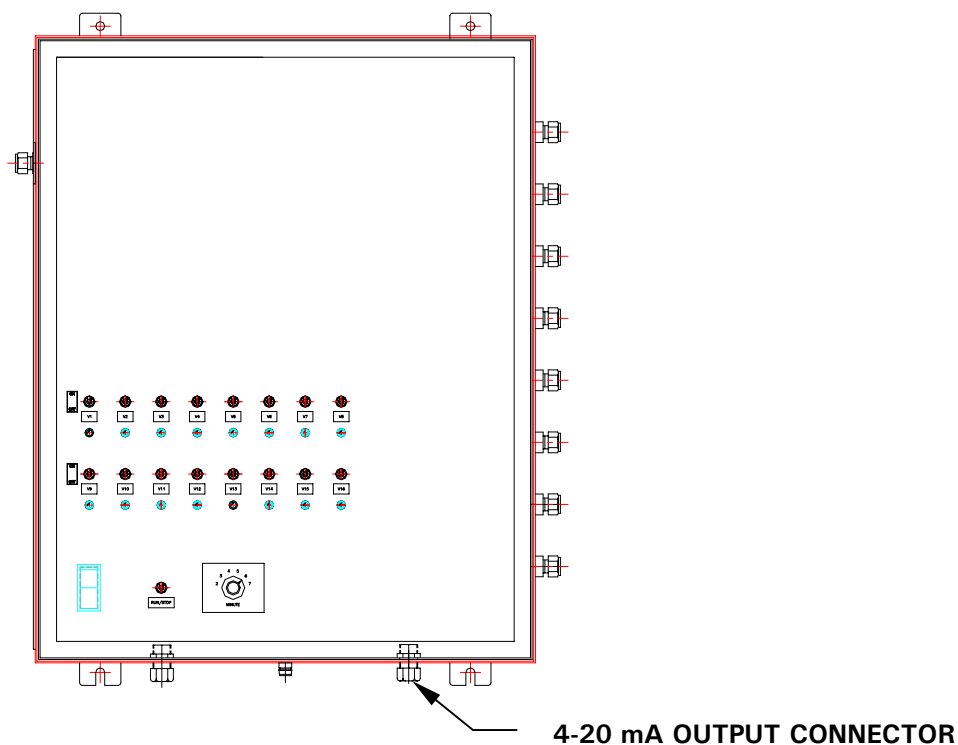
**WARNING!**

The following procedure should only be performed by a qualified technician.

To do so:

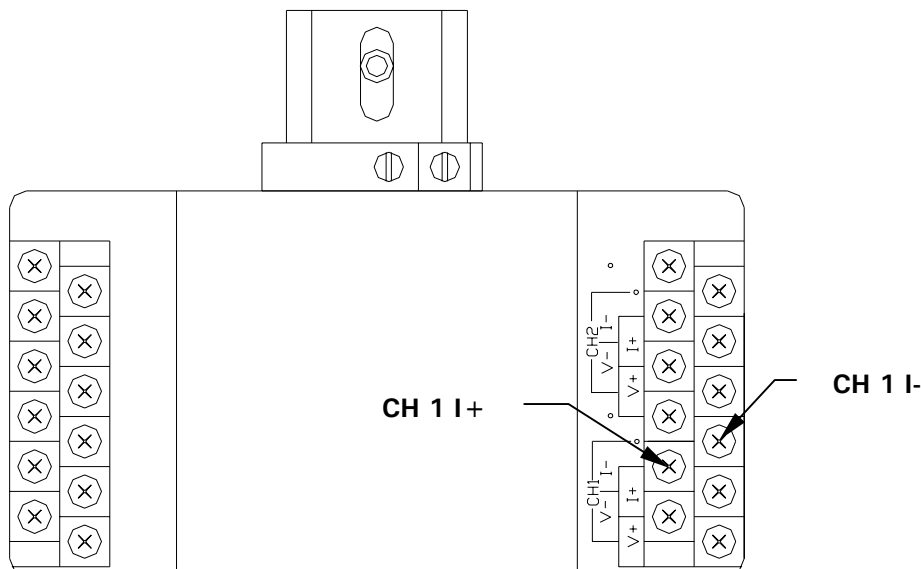
1. Ensure that the power switch is in the OFF position. Disconnect the power cord from the power supply.
2. Select two lengths of hookup wire that allow connection to the external recording/signal conditioning device and sequencer.
3. Open the cabinet door.
4. From the bottom panel, feed the two lengths of wire through the 4-20 mA Output connector (*see Figure 6*):

**Figure 6: 4-20 mA Output Connector**



- Using a screwdriver, connect one of the wires to the **CH1 I+** terminal (see Figure 7) and the other to the **CH 1 I-** terminal. Label both wires at the other ends.

**Figure 7: Analog Module Detail**



- Close the cabinet door and secure it.
- Observe polarity when connecting the external devices.
- Reconnect the power cord and, when ready, turn the power switch ON.

#### 4.5 Using NBS Process Controllers

The Gas Sequencer is designed for use as a switching device to aid in the recording of data between a gas analyzer and one or more fermentor(s)/bioreactor(s). When used properly, they form a powerful system for displaying, graphing, and recording exhaust gas components. Component values can be incorporated into control schemes to automatically adjust process parameters as specified by the user.

To utilize any digital software, analog electrical current signals from the Gas Sequencer and gas analyzer must first be converted to a digital signal. The NBS Universal I/O Converter or controller convert up to ten 4-20 ma current signals to a digital signal which is compatible with *AFS-BioCommand* (based on Windows®) or its predecessor, *AFS* (based on DOS).

Whatever controlling software is used, it must be programmed to associate the currently open valve with the current readings from the gas analyzer. Further, a delay between opening of the valve and reading of the gas analyzer should be included in the program to ensure that residual gas from the previous source has been fully purged from the lines.

The minimum required delay, typically about 1 to 4 minutes, will depend on the gas flow rate, the distance between the sequencer and the analyzer (regarding the volume to be purged). The greater the distance, the greater the volume that has to be purged. This varies among installations and applications, and may be determined by trial.

# 5 OPERATION

## 5.1 Starting Up

Before turning the unit on, verify that all connections to and from the unit are secure and, if you have not done so previously, verify that the voltage of your power supply matches the voltage marked on the electrical specification plate on the control cabinet's side panel.

After making the above-mentioned checks, press the power switch to turn the unit ON.

## 5.2 Valve Sequencing

1. Turn the valve switches ON for all the valves desired to be sequenced during the process.
2. Select the time that each valve will be open by adjusting the time selector to the appropriate position. Cycle times may be set from 2 to 7 minutes.
3. Set the Run/Stop switch to the RUN position to start the valve sequencing cycle. The selected valves will open and close sequentially.
4. To cease the valve sequencing cycle, set the Run/Stop switch to the STOP position.

### NOTE:

**If the valve or time settings must be changed during a process, the Run/Stop switch must be set to the STOP position before adjusting the valve switches or the time selector.**

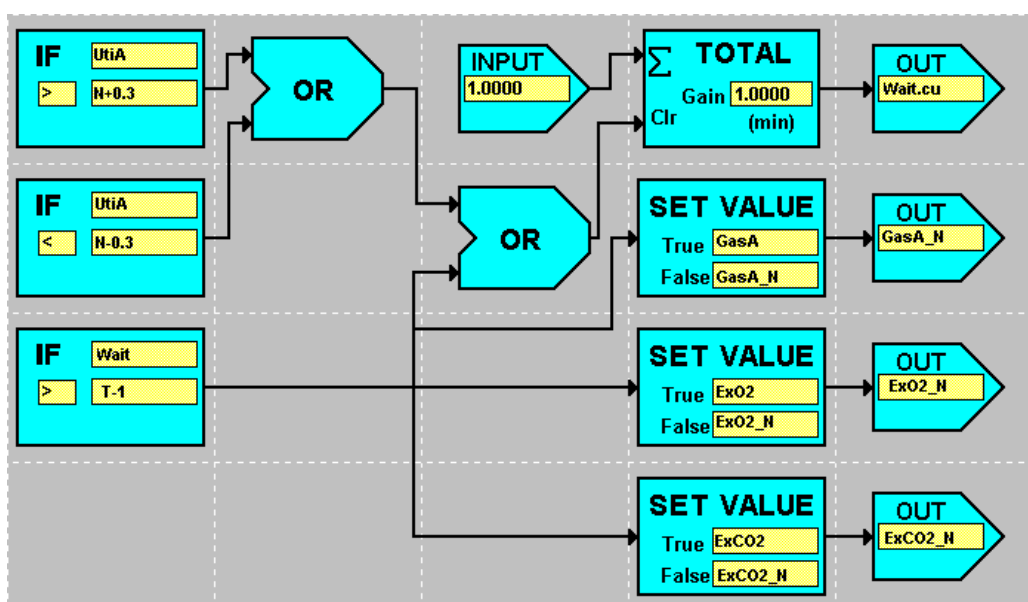
**When the Run/Stop switch is set to STOP, the unit will remain idle and the output current signal of the last valve opened will be held constant. To restart the valve sequencing cycle after changes have been made, set Run/Stop switch to the RUN position. This will reset the valve sequencing cycle starting with the first valve selected in the process.**

## 6 EXHAUST GAS ANALYSIS SYSTEM WITH *AFS-BIOCOMMAND*

### 6.1 AFS-BioCommand Control Diagrams

An example of an *AFS-BioCommand* (Windows® -based) Control Diagram is shown below. This Control Diagram assumes that the I/O Converter or controller has been scaled to provide a valve-identifying output as described..

Figure 8: *AFS-BioCommand* Control Diagram



#### NOTE:

**T = valve on time selected (2 to 7 minutes) and N = unit number (1 to 15).**

The following information should be helpful to those who already have a general understanding of *BioCommand* control diagrams. Others should refer to the *AFS-BioCommand* User's Guide to learn how to create, read and activate Control Diagrams.

In the sample program shown in Figure 8 above, a minute timer starts running when the "Nth" valve opens to the gas analyzer. It reads the gas analyzer values only after the minute timer indicates that this particular valve is within one minute of closing. This delay allows time for the lines to purge.

The timer is cleared to zero when the valve closes. Additional diagrams would, in a similar fashion, associate other gas analyzer readings with the opening of other valves.

- One Control diagram similar to the sample is required for each fermentor or bioreactor connected to the Sequencer.
- This diagram works for three exhaust gas components: CO<sub>2</sub>, O<sub>2</sub> and “GasA”. It should be modified as appropriate for other applications.
- The letter **N** symbolizes a digit between 1 and 8 which represents the one valve that is open to the gas analyzer. A different digit **N** must be used in each diagram. One diagram is required for each fermentor or bioreactor.
- The letter **T** symbolizes a digit between 2 and 15 and should be the same as the number of minutes of valve open time selected at the Gas Sequencer.
- **UtiA** is the name assigned in the Universal I/O converter or controller to the scaled value of the valve-identifying signal. When valve 1 is open, the value of UtiA is 1; when valve 2 is open, UtiA is 2; and so on. The program allows a margin of error of  $\pm 0.3$  in the value of UtiA as reported by the Universal I/O Converter or controller.
- **Wait** is the number of minutes that the valve has been open during the current cycle.
- **ExCO2, ExO2, and GasA** are names assigned by the user during configuration of the Universal I/O Converter or controller for exhaust gas analyzer values of Carbon Dioxide, Oxygen and one other component.
- The control diagram assigns the names **ExCO2\_1, ExO2\_1, GasA\_1** to the three components of exhaust gas readings *obtained T-1 minutes after valve 1 opens*. Similarly, a second Diagram (not shown) must be used to assign the names **ExCO2\_2, ExO2\_2, GasA\_2** to exhaust gas components from valve 2. One additional diagram is needed for each additional gas source attached to the sequencer.
- The values of **ExCO2\_1, ExO2\_1, GasA\_1** for fermentor 1, and corresponding values for additional fermentors, can be displayed in *BioCommand* screens and graphs, and used to automatically adjust process setpoints. Exhaust gas values are automatically included in the process data log.

 **NOTE:**

The Universal I/O Converter or controller must be calibrated to accept the corresponding input signals from the Gas Sequencer, and these signals must be scaled to the following output values:

**Table 2: Valve Input and Output Signals**

<b>Valve No.</b>	<b>Signal (mA)</b>	<b>Output</b>
All Off	4.0	0.0
1	5.0	1.0
2	6.0	2.0
3	7.0	3.0
4	8.0	4.0
5	9.0	5.0
6	10.0	6.0
7	11.0	7.0
8	12.0	8.0
9	13.0	9.0
10	14.0	10.0
11	15.0	11.0
12	16.0	12.0
13	17.0	13.0
14	18.0	14.0
15	19.0	15.0
16	20.0	16.0

## 7 PREVENTIVE MAINTENANCE

Preventive maintenance keeps the equipment in proper working condition. When performed periodically, maintenance results in a longer life of the equipment and reduces time lost due to equipment failure.



### **WARNING!**

**Always turn the power switch OFF and disconnect the power cord before performing any adjustments or maintenance on the Gas Sequencer.**

### **7.1 Cleaning**

The painted exterior surfaces can normally be cleaned with a damp cloth and, if necessary, with standard household or laboratory cleaners.

Never use abrasive or corrosive compounds to clean this instrument, as they may damage the unit and void the warranty.

### **7.2 Fuse Replacement**

The Gas Sequencer's electrical fuse is located in the fuse holder on the bottom panel of the unit.

If the fuse is suspect, first verify that the power switch is in the OFF position and that the power cord is disconnected from the power supply. To inspect the fuse, turn the cap of fuse holder counterclockwise until the fuse pops out. If the fuse appears to be blown, replace it with exactly the same kind of fuse (*see Section **Error! Reference source not found.***). Place the new fuse in the fuse holder and replace the cap. Turn the cap clockwise to secure it.



## 8 REPLACEMENT PARTS

When ordering replacement parts, accessory parts or requesting service information, please provide the Model Number, Manufacturing Part Number and Serial Number of the Gas Sequencer. This information is on the electrical specification plate, located on the side panel of the Gas Sequencer.

**Table 3: Replacement Parts**

<b>Part Description</b>	<b>NBS Part Number</b>
Fuse 0.5A 250V MDL	P0380-3070
Circuit Breaker/Power Switch	P0400-4240
Programmed FX Controller	M1154-7006
Digital Input Module	P0620-5600
Analog Module	P0620-5470
Toggle Switch, 250V 5A	P0400-0240
Rotary Switch	P0400-1460
Round Dial Knob	H-132

# 9 DRAWINGS & TABLES

## 9.1 Control Schematic

Figure 9: Control Schematic

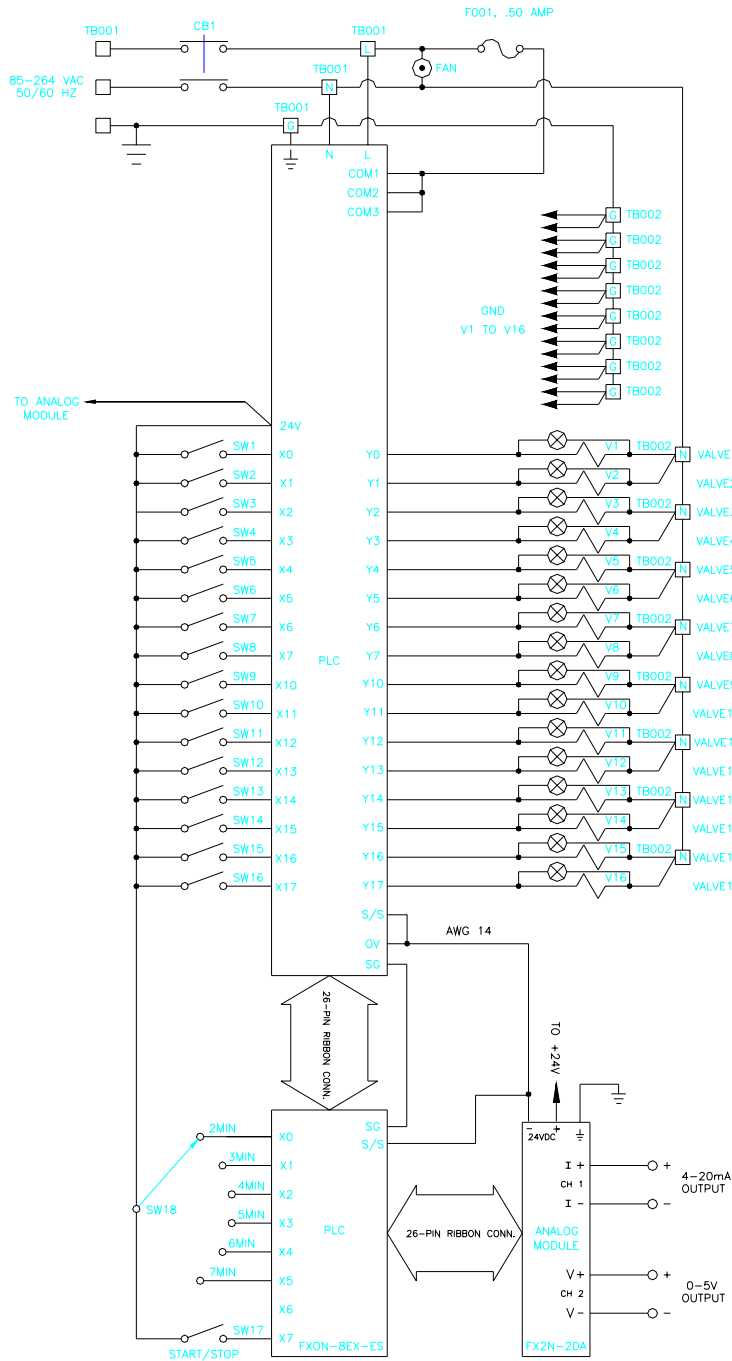
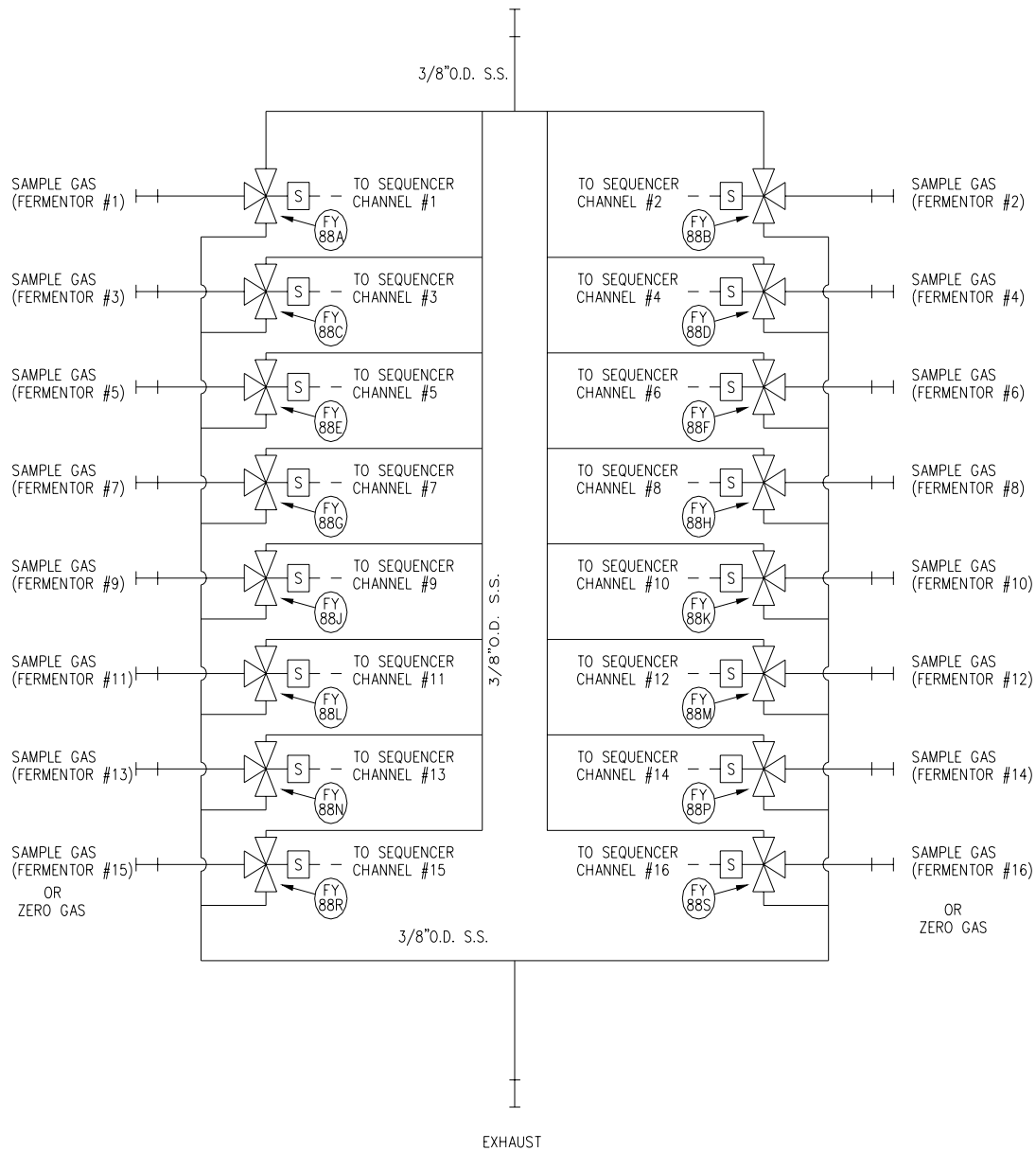


Figure 10: Piping &amp; Instrumentation Diagram



## 9.2 List of Drawings

<b>Figure</b>	<b>Description</b>	<b>Page</b>
1	Typical Equipment Set-up	9
2	Front Panel	12
3	Side Panels	13
4	Cabinet Interior	14
5	Location	15
6	Conduit Connector	17
7	Analog Module Detail	18
8	<i>AFS-BioCommand</i> Control Diagram	21
9	Control Schematic	26
10	Piping & Instrumentation Diagram	27

## 9.3 List of Tables

<b>Table</b>	<b>Description</b>	<b>Page</b>
1	Valve Analog Input Signals	16
2	Valve Input & Output Signals	23
3	Replacement Parts	25

# 10 INDEX

## A

Analog Module, 14, 16, 17  
Connections, 16, 17

## C

### CAUTION

Symbol for, 5  
Control Diagrams, 21, 22  
Control Schematic, 26  
Copyright Notice, 5

## D

Disclaimer Notice, 5

## E

Electrical  
Connections, 16  
Specification Plate, 16, 25  
Environment, 16  
Equipment  
Inspection of, 11  
Unpacking Of, 11  
Exhaust Gas Analysis System  
*AFS BioCommand*, 21  
Exhaust Port, 13

## F

Features, 12  
Fuse Replacement, 24

## I

Inspection  
Of Boxes, 11  
International Offices  
List of, 3

## M

Maintenance  
Cleaning, 24  
Fuse Replacement, 24  
Preventive, 24

Manual Conventions, 5

## N

### NOTE

Symbol for, 5

## O

Output Signal, 16, 17, 19  
Overview, 9

## P

Piping and Instrumentation Diagram, 27  
Power Switch, 20, 24  
Process Control, 19

## R

Replacement Parts  
Descriptions, 25  
Part Numbers, 25  
Run/Stop Switch, 20

## S

Specifications, 10

## T

Turning The Unit On, 20

## U

Universal I/O Converter, 19

## V

Valve Sequence, 20

## W

### WARNING

Symbol for, 5  
Warranty, 6