Guide to Operations

BioFlo 4500
Benchtop
Fermentor/Bioreactor

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Revision H
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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

INTERNATIONAL OFFICES:

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

BELGIUM
New Brunswick Scientific NV/SA
't Veldeke 1
B-1970 Wezembeek-Oppem
België/Belgique
Tel: 32 (0)2 731 6787
Fax: 32 (0)2 731 8130
E-mail: sales@nbsnv-sa.be

FRANCE
New Brunswick Scientific SARL
3, rue des Deux-Boules
75001 Paris
France
Tel: 33 (0)1 4026 2246
Fax: 33 (0)1 4026 5423
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

UNITED KINGDOM
New Brunswick Scientific (UK) Ltd.
Edison House, 163 Dixons Hill Road
North Mymms, Hatfield, Herts. AL9 7JE
United Kingdom
Tel: 44 (0)1707 275733
Fax: 44 (0)1707 267859
E-mail: bioinfo@nbsuk.co.uk

CHINA
New Brunswick Scientific Co., Inc.
9A. Ai Bang Building
585 Ling Ling Road
Shanghai 200030, P.R. China
Tel: 86 21 6481 2658
Fax: 86 21 6481 2665
E-mail: nbschc@online.sh.cn

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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.

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Box 4005, 44 Talmadge Road
Edison, New Jersey 08818-4005

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.

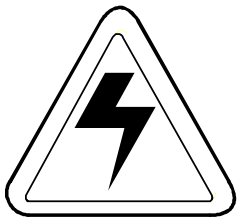
Manual Conventions

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 bold face type emphasizes key words or phrases.

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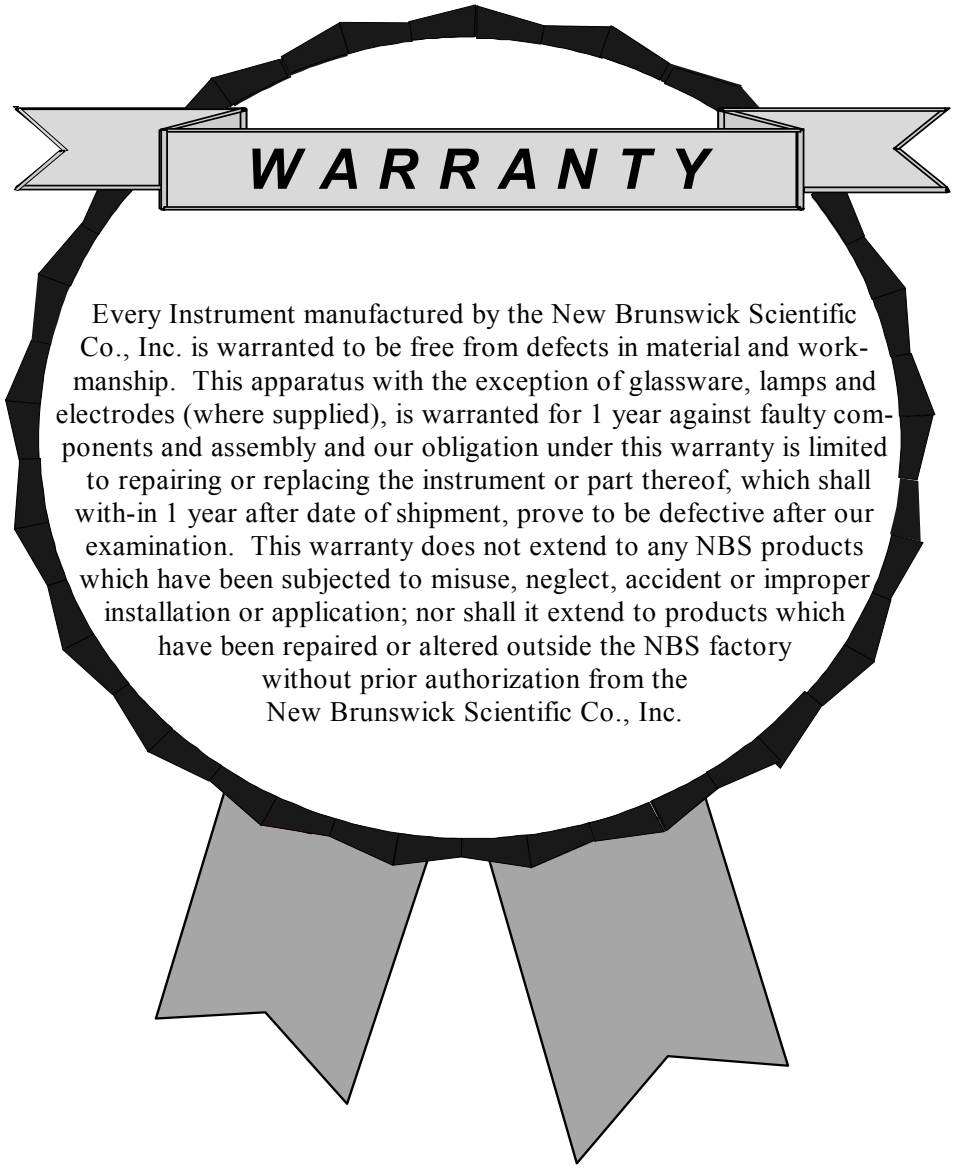
WARRANTY
Every Instrument manufactured by the New Brunswick Scientific Co., Inc. is warranted to be free from defects in material and workmanship. This apparatus with the exception of glassware, lamps and electrodes (where supplied), is warranted for 1 year against faulty components and assembly and our obligation under this warranty is limited to repairing or replacing the instrument or part thereof, which shall with-in 1 year after 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.

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FERMENTOR/BIOREACTOR

INFORMATION SHEET

On this page, record the information for your Fermentor/Bioreactor and retain this for future reference.

Model Number:

Voltage:

Serial Number:

Controller Type:

The above information can be found on the electrical specification plate on the right side panel of the console.

Purchased with the following installed options:

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CONTENTS

1 OVERVIEW

The BioFlo 4500 fermentation system is an automatically sterilizable-in-place fermentor/bioreactor. It consists of a console and a stainless steel fermentation vessel. The console connects to all required services (air, gases, water, steam, electricity, and drain). The vessel is ASME-Coded with ports and wells for the insertion all the required sensors; to provide agitation and aeration; and to permit the heating and cooling necessary for in-place sterilization of all process components and to maintain growth conditions.

In a typical fermentation run, the fermentor/bioreactor is:

- filled through the filling port on the headplate
- raised to sterilization temperature while the contents of the vessel are being agitated
- held at sterilization temperature for an operator-determined time period
- cooled to operating temperature
- maintained at fermentation temperature, pressure and sparge rate for an operator-determined period
- harvested
- shut down.

Aseptic addition of culture medium and inoculum, as well as aseptic sampling, may be accomplished by the use of the steam-sterilizable inoculation and sampling ports.

The BioFlo 4500 fermentation system is easily configured to meet the wide range of culture requirements and operation modes for batch, fed batch, continuous culture and perfusion processes. The BioFlo 4500 offers the versatility and flexibility necessary to meet the complex demands of a wide variety of processes for the culture of bacteria, fungi and yeast, as well as plant, insect, animal and mammalian cells.

The versatility of the BioFlo 4500 is derived from its state of the art ML-6100™ instrumentation. This instrumentation package may be configured as an imbedded controller with touchscreen interface, a remote stand-alone system, or can be controlled by third-party SCADA systems.

The ML-6100 allows a simple, intuitive user interface for operation and system configuration. This allows the fermentor/bioreactor to be reconfigured in minutes to meet virtually any control need. In addition, the incorporation of the ML-6100 in the BioFlo 4500 allows for real time interfacing with ancillary instrumentation.

1.1 Features

1.1.1 Vessels and Ports

- Jacketed vessel with hemispherical bottom dish
- Four removable baffles
- Four built-in cartridge heaters in vessel jacket
- Rectangular viewing window
- Combined filling & light port on headplate
- Re-sterilizable poppet-type drain/harvest valve with quick-connect fitting
- Four upper vessel wall 19mm Ingold-type ports
- Two 19 mm port in lower vessel wall, one with thermowell
- Three 25 mm ports in lower vessel wall for optional pH and DO probes

1.1.2 Piping and Instrumentation

- Automatic sterilization in place (SIP) of vessel and all process-related components
- Embedded NBS ML-6100 multi-loop process controller or third-party SCADA system
- All related process components and piping are manufactured from 316L stainless steel
- Variable speed, top-entering agitation system
- SIP exhaust filter with upstream heat exchanger and inspection glass
- SIP inlet filter
- One switched auxiliary power outlet for remote fixed speed peristaltic pump connection and control
- Thermal mass flow controller
- Three analog inputs for analyzers or other external devices
- Minimum 350 mMoles/L /hr oxygen transfer rate (OTR)
- Capable of minimum 1°C/minute temperature rise between 30° and 45°C

1.1.3 Utilities

- Connections for water, air, gases, steam and drain are provided on either side of the base

1.1.4 Optional ML-6100 Controller

- Touchscreen user interface
- Embedded or stand-alone, remote configuration
- RS422 communications port for supervisory control and data logging using NBS *BioCommand* bioprocess software
- LAN (Ethernet) port network connectivity

1.1.5 Other Options

- Choice of single or double mechanical agitator seal
- Up to three programmable peristaltic pumps
- Gas overlay
- Exhaust condenser
- Level and foam control
- High foam kit
- 19mm diaphragm septum addition ports
- Re-sterilizable poppet-type inoculation/addition valves
- Syringe/septum addition assemblies
- Re-sterilizable variable flow sample valve
- Auxiliary pump, fixed speed
- Aerosol containment system
- Steam generator for utility and clean steam
- Pre-filter/Regulator kits for air, water, steam
- Two-gas mixer for supplementation of the air stream with oxygen
- Three-gas mixer for O_2, CO_2 or N_2, and air
- Four-gas mixer for N_2, O_2, CO_2, and air
- Automatic back pressure control
- Choice of Ingold or Broadley James pH and DO sensors
- Passivation package which includes all stainless steel valves and traps
- Upgraded interior and exterior finishes
- Electropolishing

1.2 Specifications

BioFlo 4500 Fermentor/Bioreactor			
Vessel			
Design Code		The vessel conforms to the latest issue of ASME, Sect. VIII Pressure Vessel Code. It is supplied with copies of the Manufacturer's Data Report (U-3). Vessel includes the ASME-Code Stamp.	
Total Volume		20L	30L
Maximum Working Volume		15.0L	22.5L
Minimum Working Volume		5.0L	7.0L
Aspect Ratio (H:D)		1.98:1	2.03:1
Material		All surfaces in contact with the culture liquid, including the headplate and the jacket, are fabricated from type 316L stainless steel	
Finish	**Interior**	Mechanically polished to 15-20 Ra, Electropolish optional	
	Exterior	Mechanically polished to 25-30 Ra, Electropolish optional	
Geometry		Cylindrical with hemispherical bottom dish	
Dimensions	**20L**	9.48" ID X 18.81" H (24.08 cm ID X 47.48 cm H)	
	30L	10.79" ID X 22" H (27.40 cm ID X 55.88 cm H)	
Viewing Window		Rectangular, approx. 1¼" W X 8½" H (3.18 cm W X 21.6 cm H), above and below maximum working volume	
Baffles		Four removable baffles	
Pressure Rating	**Vessel**	40 PSIG (2.7216 atm = 2.756 bar), tested at 1.5 times Maximum Allowable Working Pressure (MAWP)	
	Jacket	50 PSIG (3.402 atm = 3.445 bar), tested at 1.5 times Maximum Allowable Working Pressure (MAWP)	
	Design Temp.	300°F (149°C)	
Impellers	**Type**	(2) six-blade Rushton 316L stainless steel turbine impellers mounted on the impeller shaft, removable and adjustable along the length of the shaft, are standard. Marine blade, pitched blade, medium lift basket and various other low shear axial flow impellers are optional.	
	Diameter	20L: 3¾" (9.53 cm), 30L: 4-5/16" (10.95 cm)	
	OTR	Capable of producing a minimum oxygen transfer rate (OTR) of 350 mMoles of O_2/L/hr at minimum vessel pressure of 2 PSIG (0.1360 atm = 0.1378 bar)	

BioFlo 4500 Fermentor/Bioreactor			
Ports			
Description	***Fitting/Size***	***Location***	***Notes***
Filling/Light Port	2" Tri-clamp	Headplate	Standard with high intensity light
Seven 28 mm Knuckle Radius Ports	19 mm ID	Headplate	Plugged as standard. Options: Foam/Level kit which includes tube fittings, adapters, sensor; single and double hose barb addition fittings and one-time sterilizable syringe-type addition fittings.
Exhaust Condenser Port	2" Tri-clamp	Headplate	Plugged as standard. Optional exhaust condenser and high foam kits available
Bearing Housing		Headplate	Equipped with either single or optional double mechanical seal with steam condensate lubrication
Rupture Disk	1½" Tri-clamp	Headplate	316L stainless steel, ASME coded, piped to the bottom of console to drain
Air/Gas Overlay	19 mm	Upper Side Wall	Optional, plugged as standard
Inoculation/Addition Port	Ingold Type 19 mm ID	Upper Side Wall	Plugged as standard. Re-sterilizable poppet-type inoculation/addition valve and septum port kits are optional
Sparge Port	19 mm	Upper Side Wall	Ring sparger, standard with removable fitting, ½" Tri-clamp
Thermowell	Ingold Type 19 mm	Lower Side Wall	Platinum RTD sensor, standard
Sampling Port	Ingold Type 19 mm	Lower Side Wall	Plugged as standard. Resterilizable spool-type variable flow valve optional
Spare	Ingold Type 19 mm	Lower Side Wall	Plugged as standard.
pH Port	Ingold Type 25 mm	Lower Side Wall	Plugged as standard. Optional Ingold gel or liquid-filled or Broadley James gel pH probe available
Dissolved Oxygen (DO) Port	Ingold Type 25 mm	Lower Side Wall	Plugged as standard. Optional Ingold or Broadley James polarographic O_2 probe available

…continued…

Ports			
Description	***Fitting/Size***	***Location***	***Notes***
Spare	Ingold Type 25 mm	Lower Side Wall	For insertion of redundant probe or third party sensors or samplers. *Redox or turbidity probes available as options: please inquire.*
Harvest/Drain Valve	Plunger-type NBS Valve	Bottom	Standard, equipped with 1/4" quick-connect fitting
Jacket Pressure Relief Valve	1/2" NPT	Jacket	Standard, rated at 35 PSIG
Jacket Water Out	1/2" NPT	Jacket	Standard
Jacket Water In	1/2" NPT	Jacket	Standard

Piping and Instrumentation with ML-6100 Controller		
Materials	**Process**	All process piping, valves, and associated components are Type 316L stainless steel
	Non-Process	Type 316L or Type 304 stainless steel
	Gaskets	Silicone
	O-rings	Ethylene Propylene EPDM
Temperature	**Sensor**	Platinum RTD sensor in thermowell
	Actuator	Four high watt density cartridge heaters in the bottom of the vessel (675W in 20L vessel & 850W in 30L vessel). Cooling water is admitted into the jacket through the temperature control valve and the flow control valve.
	Control Mode	PID with constants factory-set at P = 39, I = 1.3, D =0, PWM 0-100%, 2 Ch Direct, and Period 10
	Range	5°C above coolant supply temperature to a maximum of 85°C ± 0.2°C
	Display	Current value, setpoint, controller output % displayed on virtual display gauge at touchscreen
Agitation	**Speed Sensor**	Frequency 1000 Line Encoder
	Drive	1 HP, direct drive, AC, top-mounted motor. Allows OTR of 350 mMoles/L/hr
	Control Mode	Direct w/ Enable and PID with constants factory-set at P = 0.30, I = 4.0, D =0
	Range	50-1000 rpm ± 1 rpm
	Bearing Housing	Standard single or optional double mechanical seals
	Display	Current value, setpoint, controller output % displayed on virtual display gauge at touchscreen
Aeration	**Air inlet filter**	Steam-sterilizable absolute 0.2µ filter that continuously removes viable organisms, cartridge- type 316 L, stainless steel housing, Domnick Hunter. NOTE: Relative humidity must be less than 95%. Other brands can be supplied upon request

…continued…

Piping and Instrumentation with ML-6100 Controller (continued)		
Aeration (continued)	**Control mode**	Thermal Mass Flow controller monitors and controls airflow to sparger, PID: P = 0.05, I = 2, D = 0
	Range	1-50 SLPM (50:1 turndown) ± 0.5% FS or optional 0.2-10 SLPM (50:1 turndown) 0.5% FS for Four-Gas
	Display	Current value, setpoint, controller output % displayed on virtual gauge at touchscreen
Pressure	**Manual**	Back pressure regulator supplied as standard
	Automatic	Optional system with pressure transmitter that controls an air-operated valve in exhaust line. Control modes include Direct and PID with constants factory-set at P = 5.0, I = 1.0, D = 0.
Exhaust	**Heat Exchanger**	Exhaust gases are heated above dew point in stainless steel heat exchanger.
	Exhaust Air Filter	Steam-sterilizable depth filter (absolute 0.2 μ, cartridge-type filter optional), Domnick Hunter filter in stainless steel housing, standard. Other brands and depths can be supplied upon request. Relative humidity must be less than 95% for air and O_2
2-Gas Mix (Optional)	**Control Mode**	Two solenoid valves in PWM Mode. Manual control or oxygen enrichment
	Display	Current composition of gas mixture displayed on touchscreen
3-Gas Mix (Optional)	**Control Mode**	Three solenoid valves in PWM Mode for Air, CO_2, and O_2. Manual control or oxygen enrichment
	Display	Current composition of gas mixture displayed on touchscreen
4-Gas Mix (optional)	**Control Mode**	Four solenoid valves in PWM Mode for N_2, CO_2, O_2, and Air. Manual control or interactive pH-DO control
	Display	Current composition of gas mixture displayed on touchscreen
Peristaltic Pumps (Optional)		Up to three console-mounted, programmable Master Flex™ Easy Load II™ pumps available. One auxiliary, remote, fixed speed pump available for use with switched auxiliary power outlet
Foam (Optional)	**Sensor**	Conductivity probe
	Actuator	Peristaltic pump
	Control Mode	PWM. Sensitivity can be adjusted and sensor calibrated at touchscreen
High Foam (Optional)	**Sensor**	Conductivity probe
	Alarm	Airflow and agitation are shut down in case of high foam alarm indication
pH (Optional)	**Sensor**	Choice of Ingold gel or liquid-filled, or Broadley James gel pH probe available

…continued…

Piping and Instrumentation with ML-6100 Controller (continued)		
pH (continued)	**Actuator**	Two peristaltic pumps for addition of acid and base or cascade to Three- or Four-Gas Mixer
	Control Mode	Output type: PWM 0-100%, Mode: PID with Direct output action
	Range	2-12 pH
	Display	Current value, setpoint, controller output % displayed on virtual display gauge at touchscreen
DO (Optional)	**Sensor**	Choice of Ingold or Broadley James DO polarographic probe
	Actuator	Cascade control to agitation, airflow, pressure or Two-, Three-, Four-Gas Mixer
	Control Mode	Output type: PWM 0-100%, Mode: PID with Direct output action
	Range	0-100% air saturation
	Display	Current value, setpoint, controller output % displayed on virtual display gauge at touchscreen
Level (Optional)	**Sensor**	Conductivity probe
	Actuator	Peristaltic pump
	Control Mode	Output type: PWM 0-100%, Mode: On/Off with Reverse action
	Display	Current value, setpoint, controller output % displayed on virtual display gauge at touchscreen

BioFlo 4500: General Specifications			
Weight		20L	30L
	Net	300 lbs. (136 kg)	420 lbs. (191 kg)
	Gross	425 lbs. (193 kg)	545 lbs. (247 kg)
Overall Dimensions		34" W X 29½" D X 48¼" H (86 cm W X 75 cm D X 123 cm H)	
External Computer Connections		Port supplied for remote connection of interface computer and touchscreen	
Alarm		Audible alarm mounted on console and external alarm output relay contacts provided	
***BioCommand* Connections**		Port supplied for connection of *BioCommand* supervisory host computer.	
Analog Inputs		Three sets of 0-20 mA inputs for analyzers and/or other external devices	
External (Auxiliary) Pump Connection		One switched auxiliary power outlet for remote control of peristaltic pump in ON/OFF Mode	
***BioCommand* Network**		Part supplied for connection of *BioCommand* supervisory host computer through LAN (Ethernet) network connectivity	

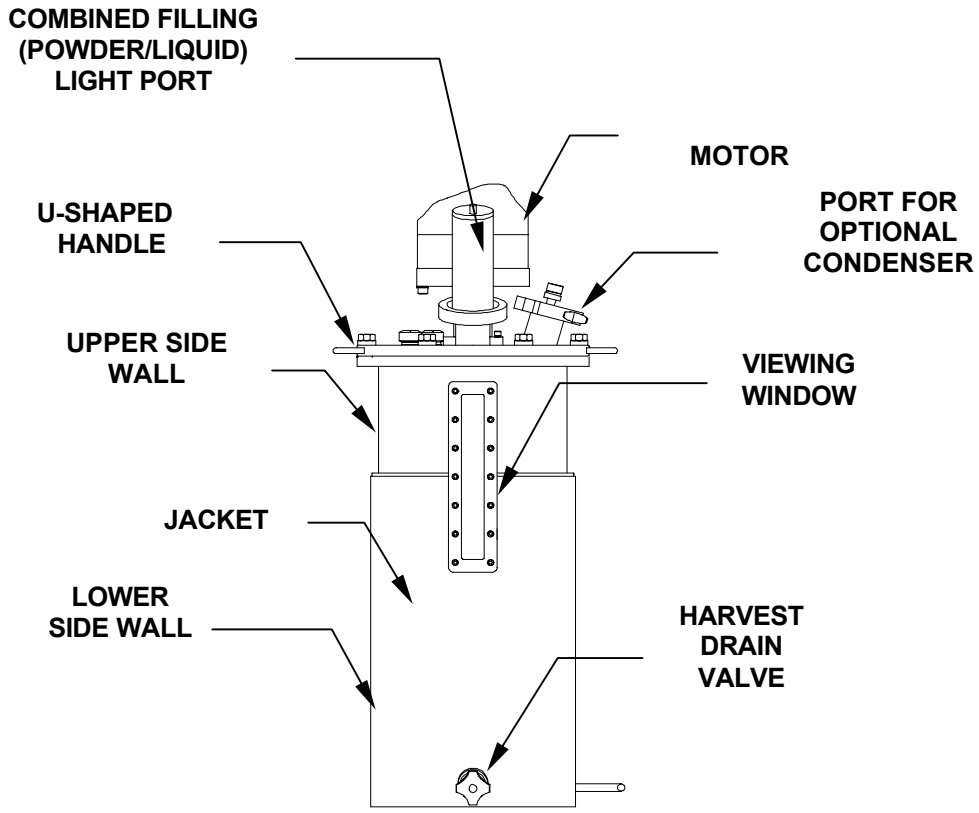
2 BioFlo 4500 Features

2.1 Vessel

The fermentor vessel is cylindrical with a hemispherical bottom dish. It is available in two sizes: 20 and 30 liters total volume. The maximum working volume in a 20L vessel is 15L. The maximum working volume in a 30L vessel is 22.5L.

The vessel conforms to the latest issue of ASME, Sect. VIII Pressure Vessel Code. It is supplied with copies of the Manufacturer's Data Report (U-3). The vessel includes the ASME-Code Stamp.

Figure 1: Vessel Front View



The bottom harvest/drain port with a plunger-type valve is located on the centerline of the vessel. The port incorporates steam lines for continuous re-sterilization. Steam and/or condensate is then passed to a steam trap and drain connection.

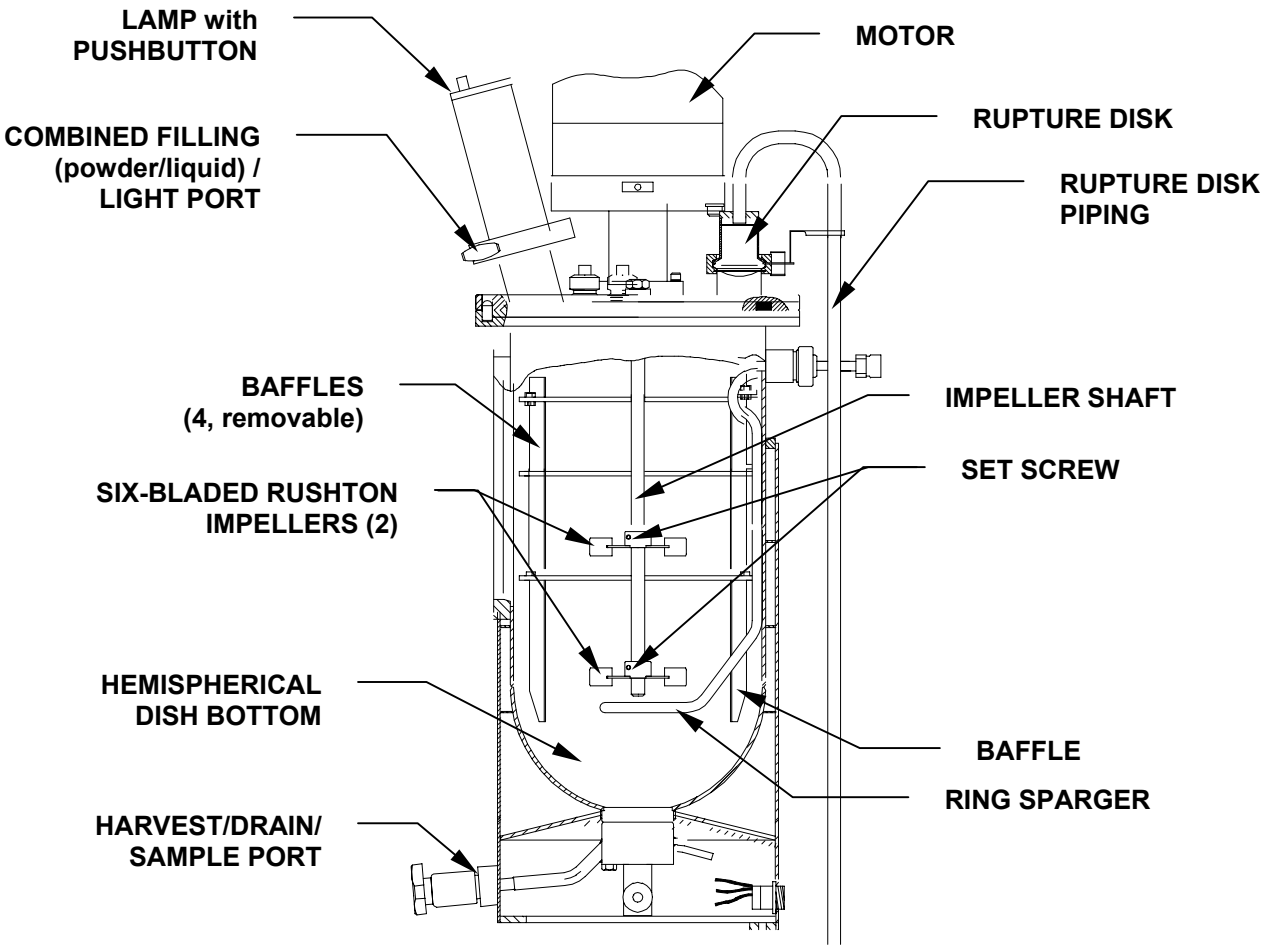
2.1.1 Viewing Window

The vessel includes a rectangular viewing window (approx. 1¼" W X 8½" H, 3.18 cm W X 21.6 cm H) for observation of the vessel interior. There is also a removable light port with a high-intensity lamp to facilitate viewing.

2.1.2 Vessel Jacket

- The vessel jacket houses ports for water circulation (not shown), and a pressure relief valve.
- There are four cartridge heaters (675W in the 20L vessel/850W in the 30L vessel) at the bottom of the jacket (not shown). These are used to heat the vessel to the required growth temperature. During initial steam sterilization of the vessel, these heaters are not used.

Figure 2: Vessel Cross Section



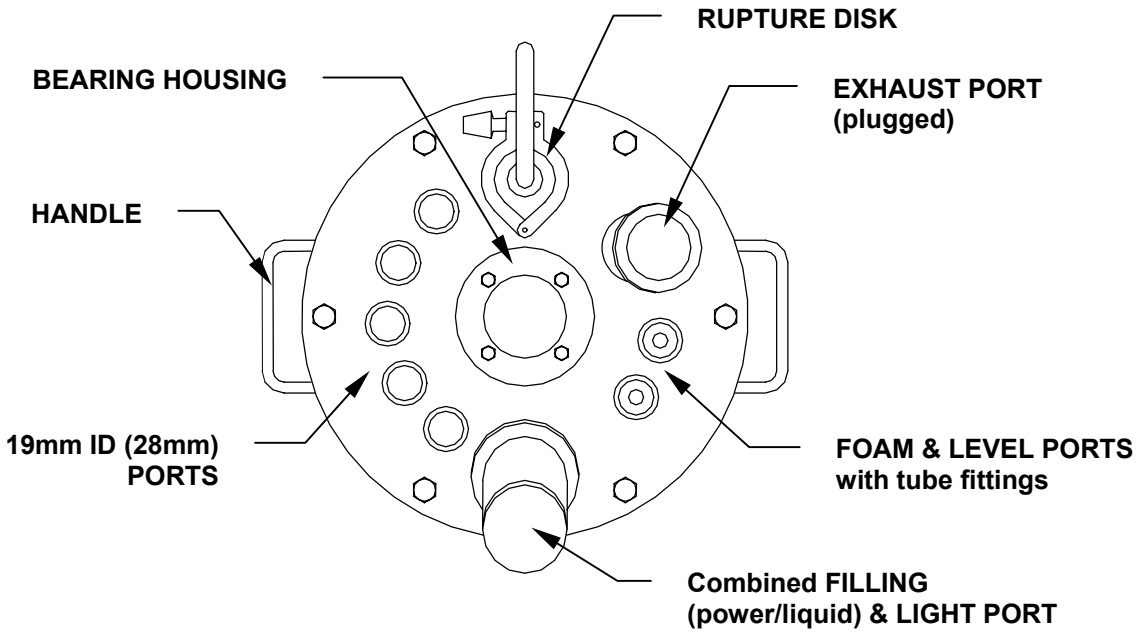
2.2 Vessel and Jacket Penetrations

2.2.1 Standard Headplate

The fermentor headplate includes a single O-ring seal. The headplate is fabricated from 316L stainless steel and includes the following ports and penetrations:

- Combined filling (powder/liquid) and light port with a high intensity lamp
- Seven 28 mm threaded ports, 19 mm ID, plugged as standard
- Exhaust condenser port, plugged as standard
- Bearing housing with single or optional double mechanical seal
- Rupture disK (stainless steel), ASME-coded, piped to the bottom of the console.
- Six ASME headplate bolts fabricated of type 304 stainless steel
- Two U-shaped handles

Figure 3: Headplate Penetrations
Top View



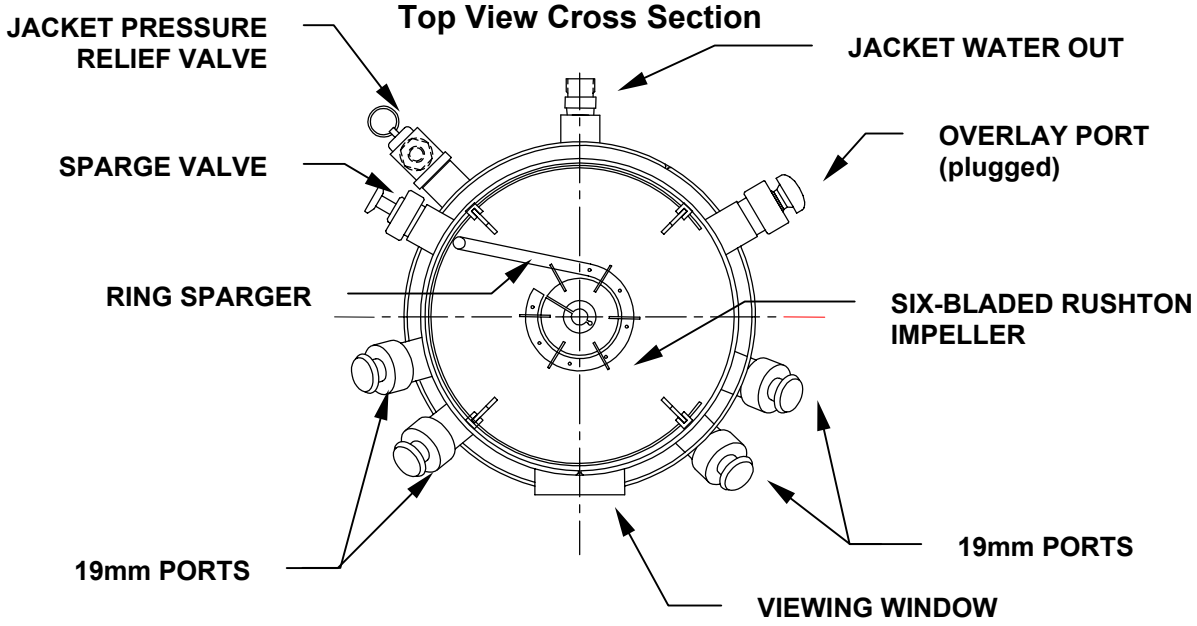
2.2.2 Optional Headplate Equipment

- High foam kit installed in exhaust condenser port or optional exhaust condenser
- Exhaust condenser installed in exhaust condenser port
- Double mechanical seal with steam condensate lubrication for bearing housing
- Syringe/septum assembly for 28 mm ports (available with 3 mm or 6.5 mm bore syringe)
- Septum cover and septum for 28 mm ports

2.2.3 Standard Vessel Upper Side Wall

- Air/Gas Overlay, plugged as standard
- Four 19 mm inoculation/addition ports, plugged as standard
- Rectangular viewing window
- Sparge port with ring sparger
- Jacket pressure relief valve
- Jacket water out
- Four removable baffles
- Two movable six-bladed Rushton impellers

Figure 4: Upper Side Wall Penetrations
Top View Cross Section



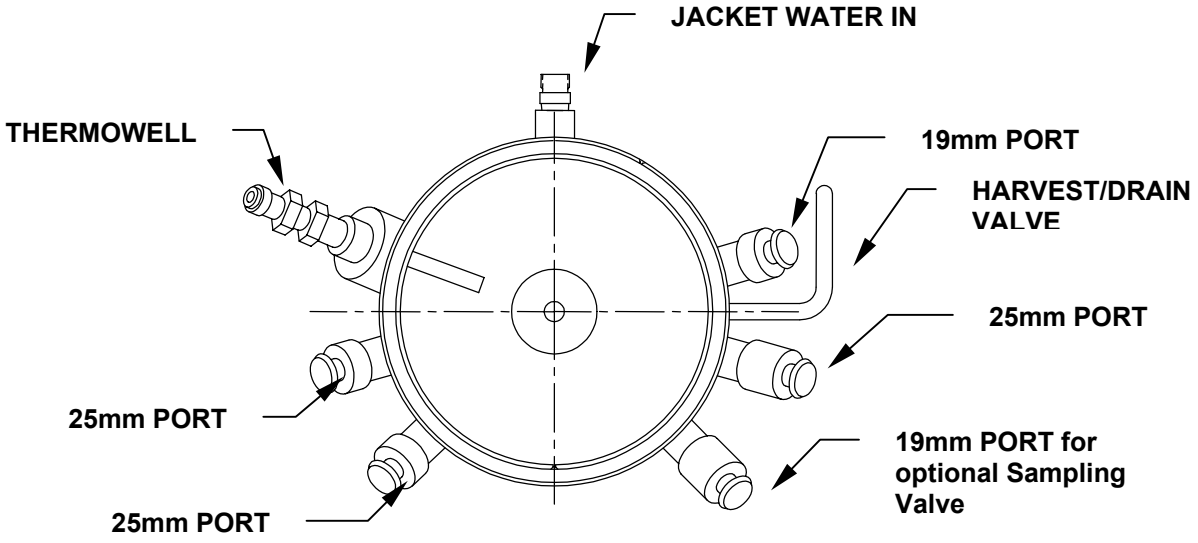
2.2.4 Optional Vessel and Vessel Upper Side Wall Equipment

- Re-sterilizable 19 mm spool-type inoculation/addition valve with ¼" quick-connect fitting
- Septum kit for 19 mm side ports
- Marine blade, pitched blade and medium lift (basket) as well as various other low shear, axial flow impellers

2.2.5 Standard Lower Side Wall

- Thermowell with platinum RTD sensor
- Two 19 mm Ingold-type ports (one for optional sampling valve), plugged as standard
- Three 25 mm Ingold-type ports, plugged as standard for spare and/or optional pH or DO sensors
- Jacket water in

Figure 5: Lower Side Wall Penetrations
Top View Cross Section



2.2.6 Optional Lower Side Wall Equipment

- Re-sterilizable, spool-type sampling valve with ¼" quick-connect fittings
- Ingold gel or liquid-filled or Broadley James gel pH probe
- Ingold or Broadley James DO polarographic probe

2.2.7 Vessel Bottom:

- Re-sterilizable, plunger-type harvest/drain valve with 1/4" quick-connect fitting.

2.3 Process Piping & Components

- All process piping, valves and associated components are of type 316L stainless steel. All other piping is of type 316L or 304 stainless steel.
- All gaskets are silicone.
- All O-rings are Ethylene Propylene EPDM.

3 INSPECTION, VERIFICATION & UNPACKING OF EQUIPMENT

3.1 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 to the carrier and to your local NBS Sales Order Department.

3.2 Packing List Verification

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

3.3 Physical Location

The surface on which you place the BioFlo 4500 Fermentor/ Bioreactor should be smooth, level and sturdy. Ensure that support structure and surface can bear the weight of the BioFlo 4500 (300 lbs/136 kg for the 20L vessel and 420 lbs/191 kg for the 30L vessel) plus vessel contents and any applicable auxiliary equipment.

Also ensure that there is enough space around the back and the front of the BioFlo 4500 for proper operation and access. The unit's overall dimensions are 34" (86 cm) W X 29½" (75 cm) D X 48¼" (123 cm) H.

3.4 Environment

The BioFlo 4500 Fermentor operates properly under the following conditions:

- Ambient temperature range 10°C–35°C
- Relative humidity up to 80% non-condensing

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4 GETTING STARTED

4.1 Positioning the Fermentor

Carefully transport the fermentor/bioreactor to the exact position in which it will be operated. Set the console on a sturdy, level surface. Ensure that there is enough space around the back and the front of the BioFlo 4500 for proper operation and maintenance and that the surface can handle the weight of the unit, including vessel contents and any auxiliary equipment.

The unit is shipped with the vessel attached and secured with three bolts that are accessible only from beneath the console platform. If you wish to remove the vessel from the console, these bolts should be removed before setting the console in place.

The console must be level for proper operation. Level the console by adjusting the height of each of the five feet on the bottom with a wrench until the console is level.

Figure 6: Level Adjustment (Shown without Vessel)

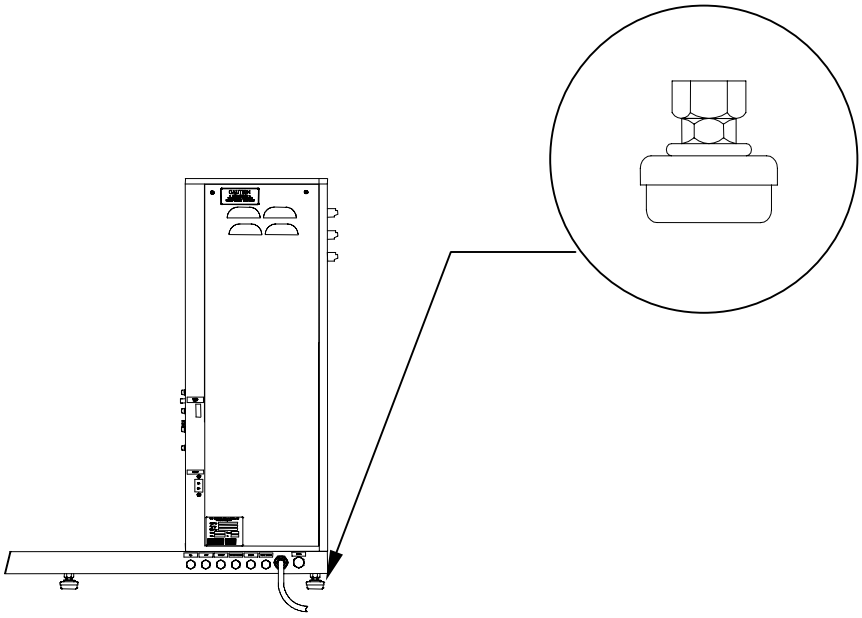
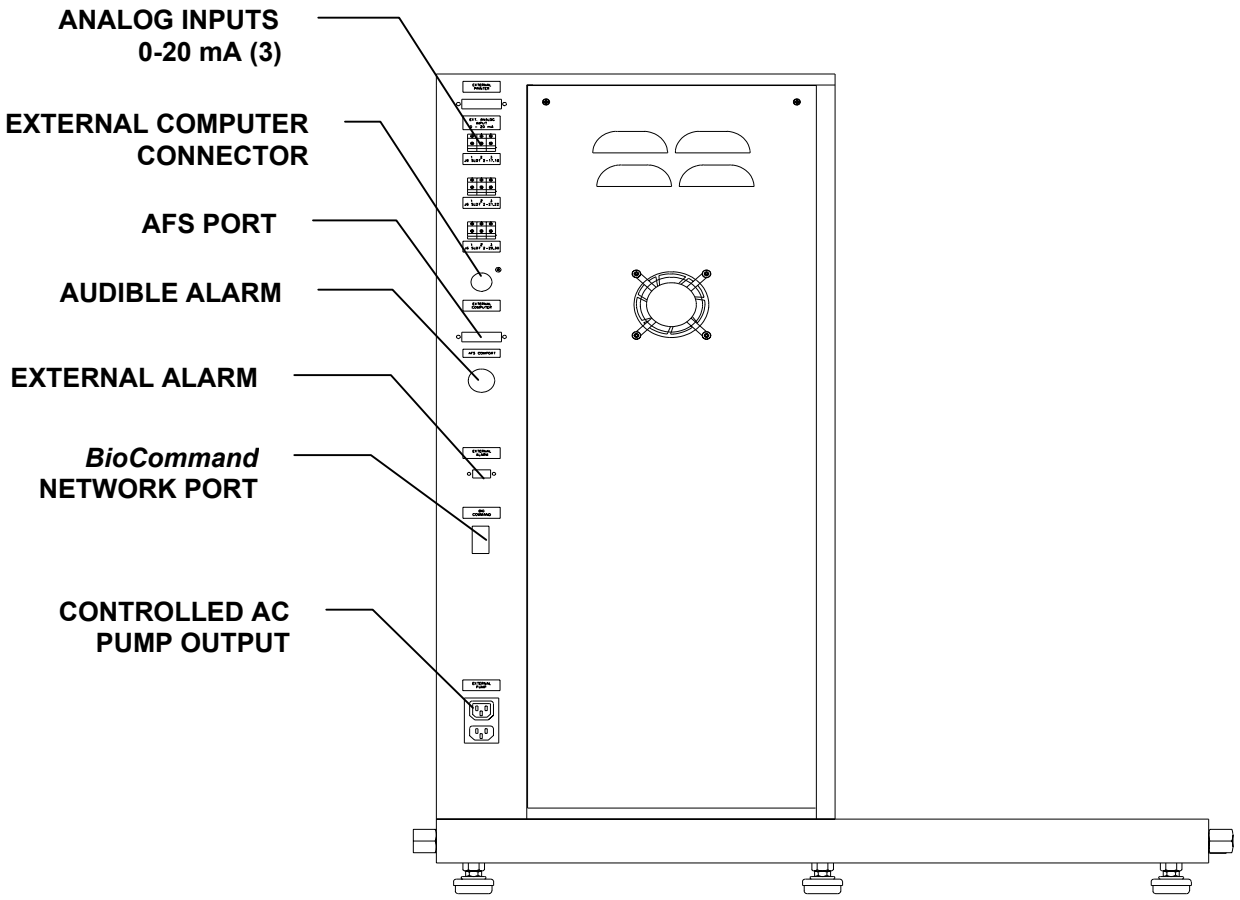


Figure 7: Console Rear Panel Connections



4.2 External Computer Set-up

NOTE:

For units shipped with the external computer option, set up your system in the following way:

1. Unpack the computer and touchscreen monitor. Save all packaging.

2. Place the computer on a sturdy, level surface in close proximity to the intended location of the fermentor.

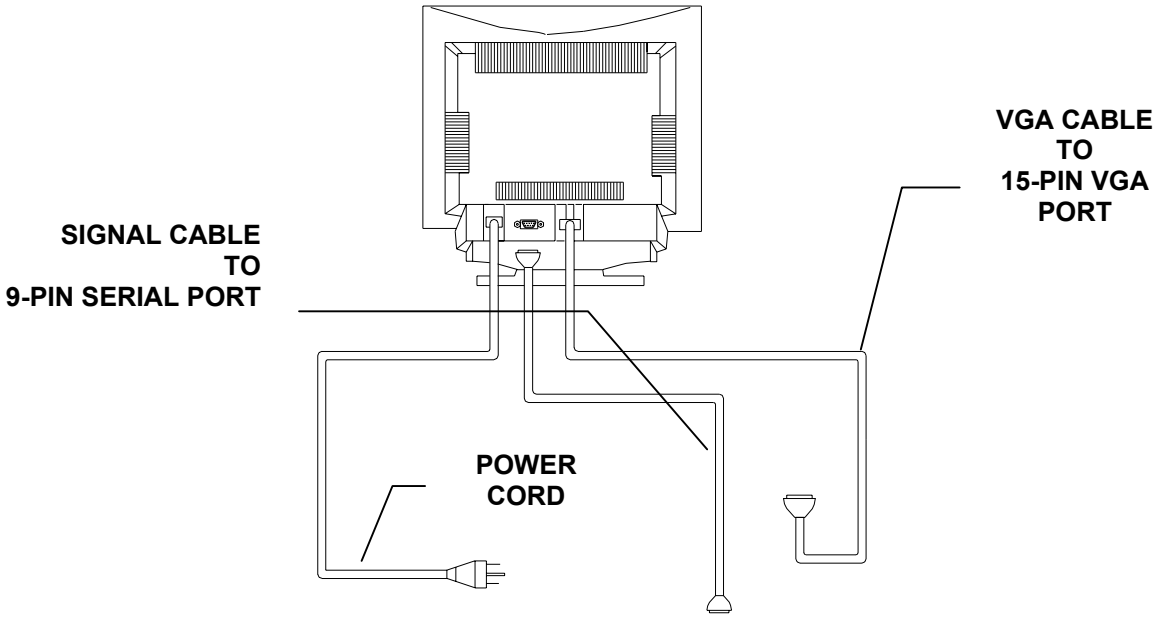
3. Place the touchscreen monitor on the top of the computer.

4. Attach the power cord to the computer

5. Connect the **VGA CABLE** to the 15-pin **VGA CONNECTOR** on the rear panel of the computer.

6. Connect one end of the **SIGNAL CABLE** to the nine-pin **CONNECTOR** on the monitor and the other end to a nine-pin **SERIAL PORT** on the computer. *(See drawing below.)*

Figure 8: Touchscreen Connections



7. Attach the power cord to the monitor.

8. Connect the 25-pin end of **EXTERNAL COMPUTER CABLE** to a suitable com port on the computer.

The electrical connections to both the computer and the touchscreen should be made after the **EXTERNAL COMPUTER CABLE** has been connected to the fermentor/bioreactor.

NOTE:

Verify that the supply voltage matches the voltage of the computer.

4.3 Computer Connections

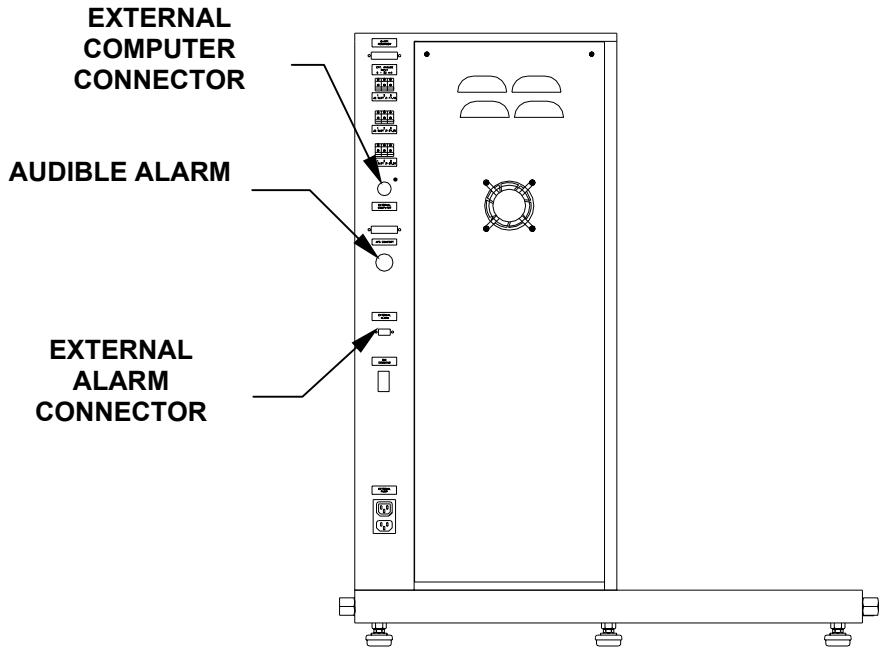
NOTE:

This section is only for units shipped with the external computer option.

The interface computer and touchscreen are connected to the fermentor/bioreactor via the supplied **EXTERNAL COMPUTER CABLE**.

To connect the **EXTERNAL COMPUTER CABLE** to the fermentor, unscrew the black **SEALING CAP** of the **EXTERNAL COMPUTER CONNECTOR** on the rear panel of the console, and connect the cable to the port. Secure the cable by hand tightening the threaded cable seal. Connect the other end of **EXTERNAL COMPUTER CABLE** to an unused **COM PORT** on the rear panel of the computer.

Figure 9: External Computer & Alarm Connections



4.4 Alarms

An audible alarm is provided with the BioFlo 4500. It is mounted on the rear panel of the console (*see drawing above)*. The alarm will sound when an alarm condition occurs.

The BioFlo 4500 also has provision to allow the connection of an external alarm device. An external alarm device is connected to the console via the nine-pin **ALARM CONNECTOR** on the rear panel (*see drawing above*). A cable must be fabricated in order to use this option. Refer to *Appendix A* of this manual for the correct pin locations on the connector.

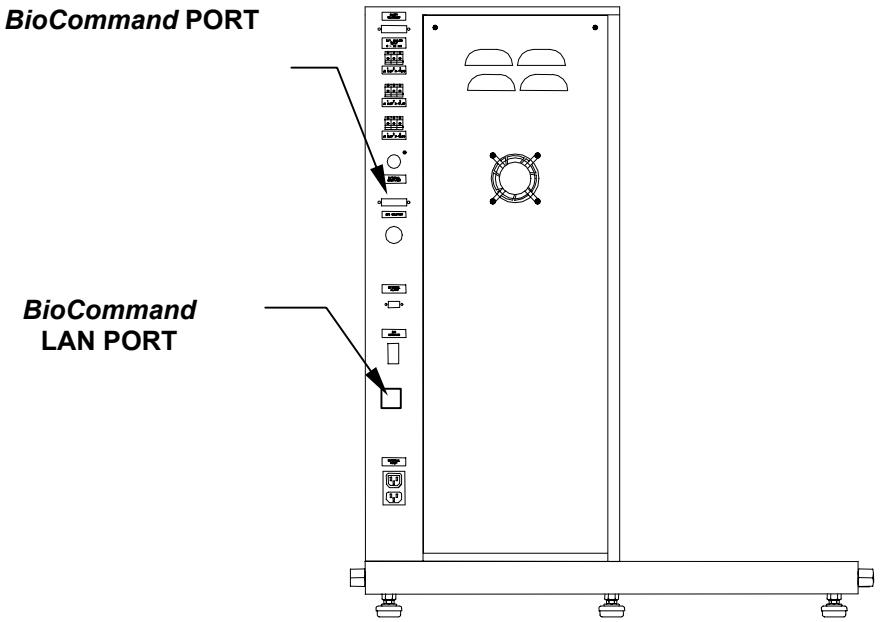
The external alarm output is made up of two alarm contacts. The contacts are normally open (NO) or normally closed (NC) relay contacts. The alarm will either close or open the relay contact, depending on which type is applied, when an alarm condition occurs. When the alarm is either disabled or acknowledged, the controller will return the relay contact to its original position.

4.5 BioCommand Connections

A 25-pin ***BIOCOMMAND* COM PORT** is provided on the rear panel to connect the BioFlo 4500 to an optional *BioCommand* interface box that allows communication to a supervisory host computer. Communications to *BioCommand* software are accomplished through an optional **RS-232 INTERFACE CABLE**.

Connect the 25-pin end of the **RS-232 INTERFACE CABLE** to the ***BIOCOMMAND* PORT**, ensure that the connection is secure, and hand tighten the thumbscrews. Refer to the *BioCommand User's Guide* for instructions on connecting the **RS-232 INTERFACE CABLE** to the *BioCommand* Interface Module.

Figure 10: *BioCommand* Connections



Additionally, some units have a ***BIOCOMMAND* LAN PORT** for communications to *BioCommand* through a local area network (LAN).

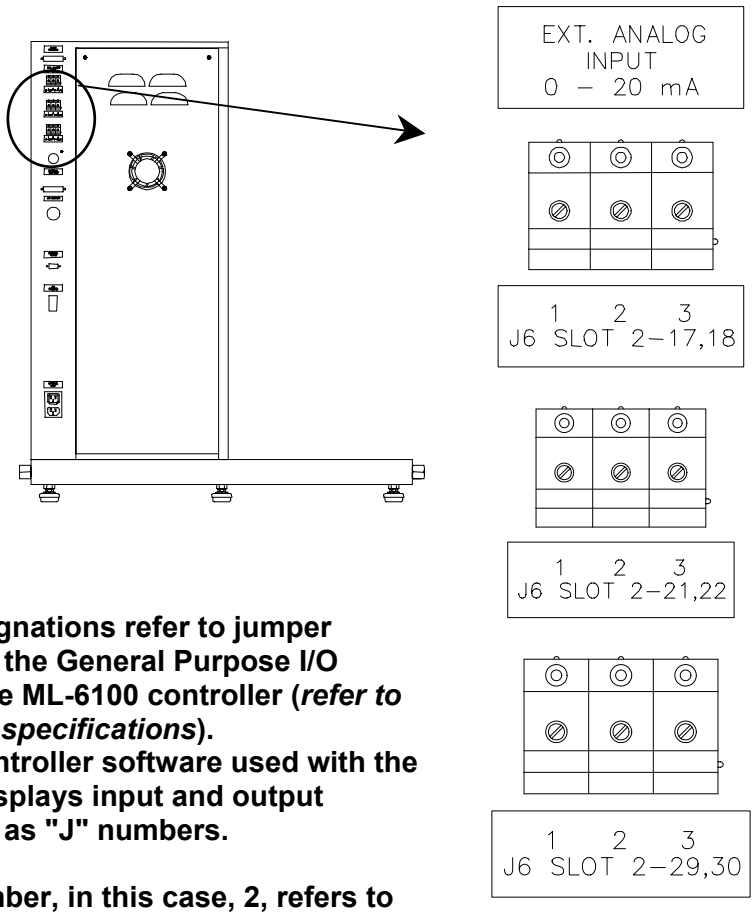
4.6 Analog Inputs

There are three sets of 0-20 mA inputs on the rear panel of the console to connect analyzers or other external devices. These inputs are connected to the controller and can be integrated into the system as control loops.

The connections to these inputs are as follows:

Pin 1	*Pin 2*	*Pin 3*
Ground	+	-

Figure 11: External Analog Inputs



NOTE:

The "J" designations refer to jumper locations on the General Purpose I/O Module of the ML-6100 controller (*refer to the ML-6100 specifications*).
The local controller software used with the controller displays input and output connections as "J" numbers.

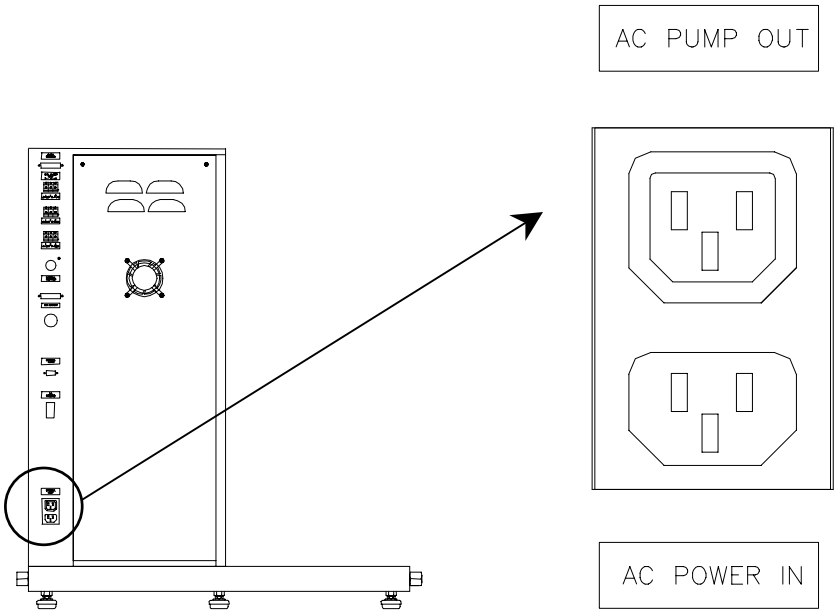
The slot number, in this case, 2, refers to installed position of the I/O module in the ML-6100 controller.

4.7 External Pump Connections

The BioFlo 4500 fermentation system is configured to operate a fourth, external pump. This fourth pump is controlled to turn on and off depending on system conditions.

The supply voltage for this pump is supplied by a line cord connected to the **AC POWER IN RECEPTACLE**. The pump is then connected to the **AC PUMP OUTPUT CONNECTOR**, which is controlled by the fermentor's internal controller.

Figure 12: External Pump Connections



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5 ASSEMBLING THE FERMENTOR/BIOREACTOR

5.1 Baffles

The four baffles inside the vessel are removable, should the process require low shear operation such as cell culture operations. The baffles are removed by lifting them from the vessel with the headplate removed. They are installed in reverse fashion.

5.2 Impellers

5.2.1 Rushton Impeller

CAUTION!
On initial set-up, prior to operation, check that all impellers are tightly fastened to the drive shaft.

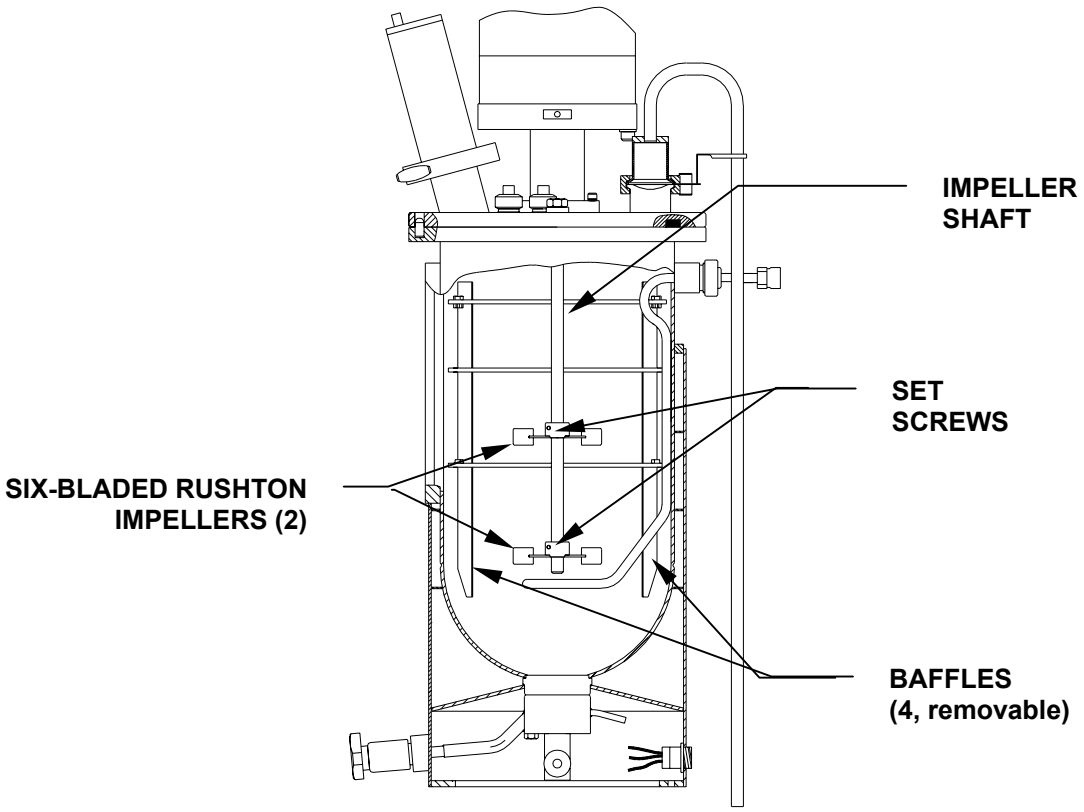
The BioFlo 4500 is equipped with two Rushton six-blade impellers as standard. The impellers' position should be verified before securing the headplate to the vessel. The impellers are adjustable along the length of the shaft and are secured to the impeller by a locking collar.

Proper positioning of the impellers on the shaft is absolutely essential in order to obtain optimal oxygen transfer rates (OTR).

The lower impeller should be positioned about one impeller diameter above the bottom of the vessel (for the 20L vessel, 3.75"/9.53 cm; and 4.31"/10.95 cm for the 30L vessel).

The upper impeller should be 1 to 1½ impeller diameters (for the 20L vessel, 3.75"-5.63"/9.53-14.30 cm and 4.31"-6.47"/10.95-16.43 cm for the 30L vessel) above the lower impeller. *(See drawing on the following page.)*

Figure 13: Vessel Cross Section



5.3 Placing the Vessel on the Console

NOTE:

With the headplate and motor in place, the vessel is very heavy. Remove the motor and headplate before moving the vessel.

The motor is removed by unscrewing the wingnuts. Unbolt the headplate and remove. Exercise caution when removing the headplate because the shaft is attached. Lift the headplate with attached shaft straight up.

The baffles may also be removed at this time. Mechanical assistance may be required to move the vessel and console.

Position the console in its permanent location then proceed to reinstall the vessel, headplate and motor.

5.4 Headplate & Motor Installation

Once the vessel is in place:

1. Position the headplate on the two locating pins on the upper vessel flange.

2. Install the 1/2" headplate bolts and secure them, using a wrench.

3. Install the high intensity lamp into the combined powder & liquid addition/ light port. The light fitting connects to the headplate flange via a Tri-clamp fitting.

4. Install the motor by positioning it onto the bearing housing.

5. Secure the motor, using the four bolts provided, connect the motor power cable to the **AGITATION MOTOR CONNECTOR** on the side of the console. Wrench tighten, but **do not overtighten**.

6. Install the speed sensor cable to its connection on the side of the console near the bearing housing on the lower side vessel wall.

7. Connect the heater cable (which exits the lower vessel wall) to the **VESSEL HEATER CONNECTOR** on the lower front of the console.

Figure 14: Motor & Bearing Housing
(shown with double mechanical seal option)

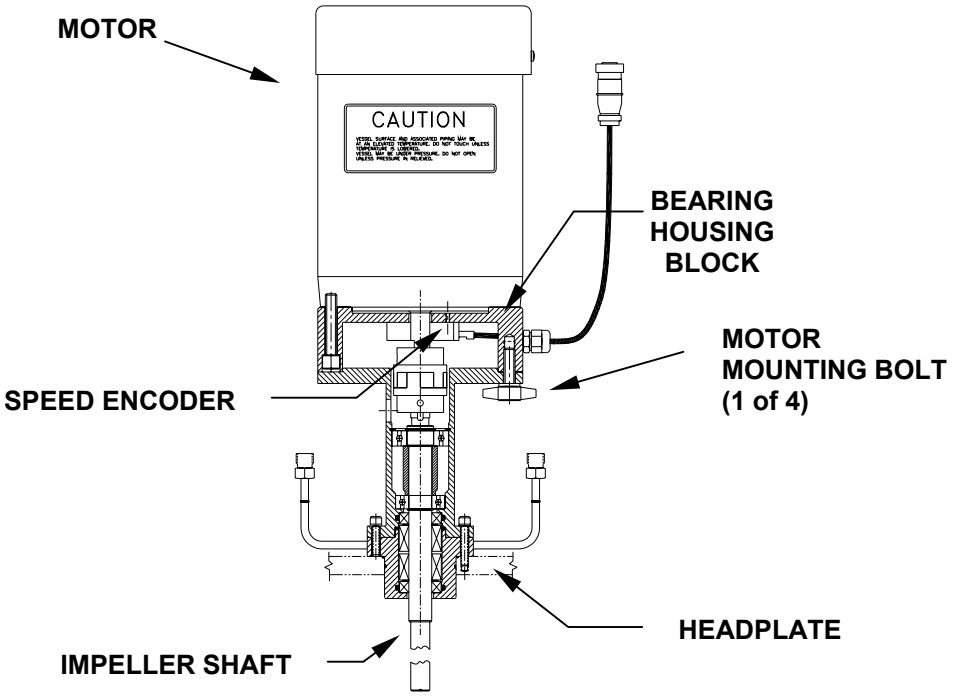
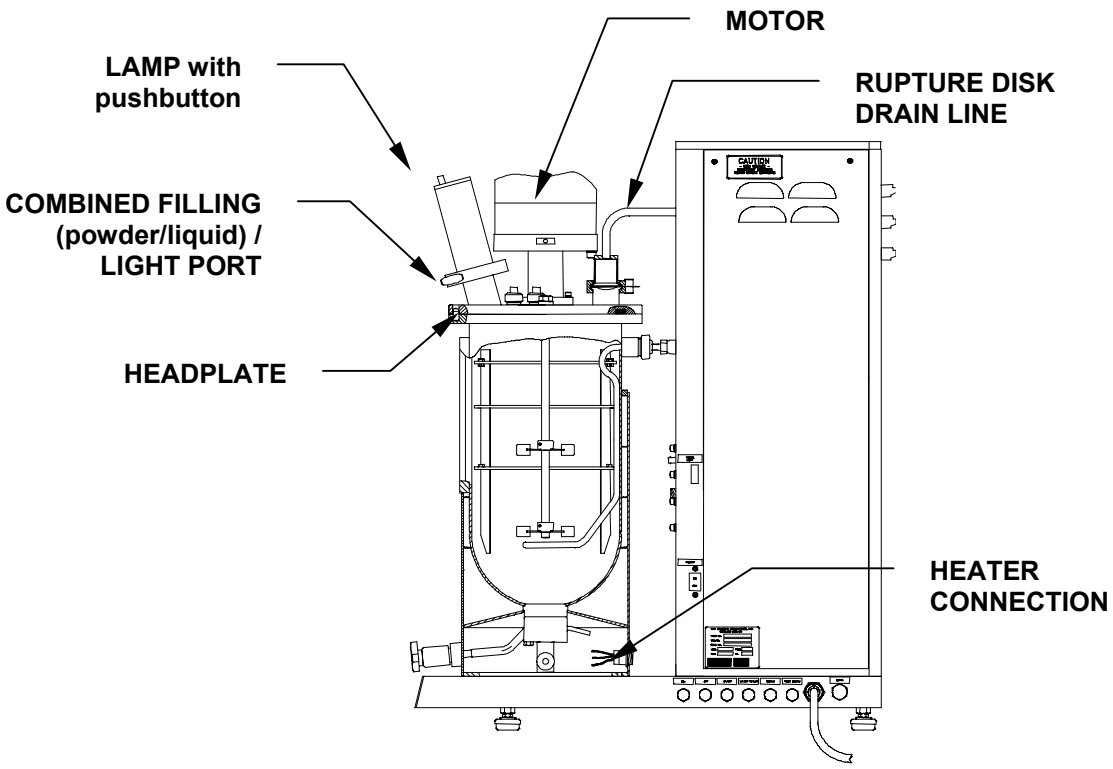


Figure 15: Headplate & Motor Installation



5.5 Service/Utility Connections

Before making service/utility connections to the BioFlo 4500, become familiar with each service connection and its location.

The following table describes each service connection. The BioFlo 4500 must be connected to regulated utilities as described in the order that they appear:

Service/Utility	*Requirement*	*Regulated*	*Connection*
Drain	Open gravity drain	--	1/2" Hose ID
Electrical	208/220/240 VAC 50/60 Hz 30 amp. Single phase	--	Hard Wire or Plug[3]
Steam(Utility)[1]	50-60 PSIG (3.3-4 bar) 40 lb/hr (18 kg/hr)	25-30 PSIG (1.67-2 bar)	1/4" FNPT
Pure Steam[1]	50-60 PSIG (3.3-4 bar) 10 lb/hr (4.5 kg/hr)	25-30 PSIG (1.67-2 bar)	1/4" FNPT
Air	30 SLPM, 30- 60 PSIG (2-4 bar)	20 PSIG (1.3 bar)	1/4" FNPT 1/8" FNPT[4]
Water	35 PSIG (2.3 bar) 2.5 gpm (9.5 L/min)	30 PSIG (2 bar)	1/4" FNPT
Water Return	Maximum backpressure	5-10 PSIG (.33-0.67 bar)	1/4" Hose ID
Optional O_2, CO_2, N_2[4]	30 SLPM, 30- 60 PSIG (2-4 bar)	20 PSIG (1.3 bar)	1/4" FNPT
Exhaust[2]	Connection to open drain or to outside environment.	--	1/4" FNPT

Notes:

1. For steam, we recommend adding the steam prefilter/regulator kit, PN M1117-2020.
2. Piping should be as short as possible and large in diameter to prevent excessive backpressure.
3. Plug not delivered as standard
4. Only if optional 2-gas, 3-gas or 4-gas mixer is installed

NOTE:

Water to the fermentor/bioreactor should be free of particulates. Passage through a 20μ filter is acceptable. If the water is laden with particulates, a water prefilter/regulator kit, PN M1117-2040, is recommended.

NOTE:

If the water return line is to be connected so that water is returned to a chiller or cooling tower, then the maximum allowable back pressure in this line is 10 PSIG (0.67 bar) with unit in rapid cooling.

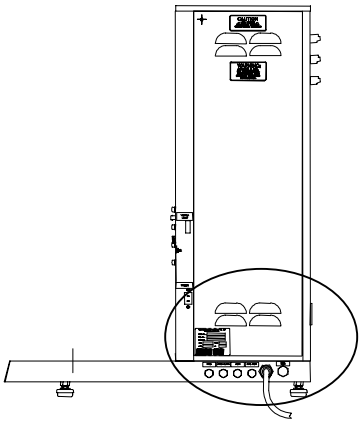
NOTE:

Utility steam to the fermentor/bioreactor should be free of particulates. If the utility steam is laden with particulates, a steam prefilter/regulator kit PN M1117-2020 is recommended.

NOTE:

Air to the fermentor/bioreactor should be free of particulates and oil. If the air is laden with particulates and/or oil, an air prefilter/regulator kit PN M1117-2020 is recommended.

Figure 16: Service Connections



For gas connections, see Figure 17 on the following page.

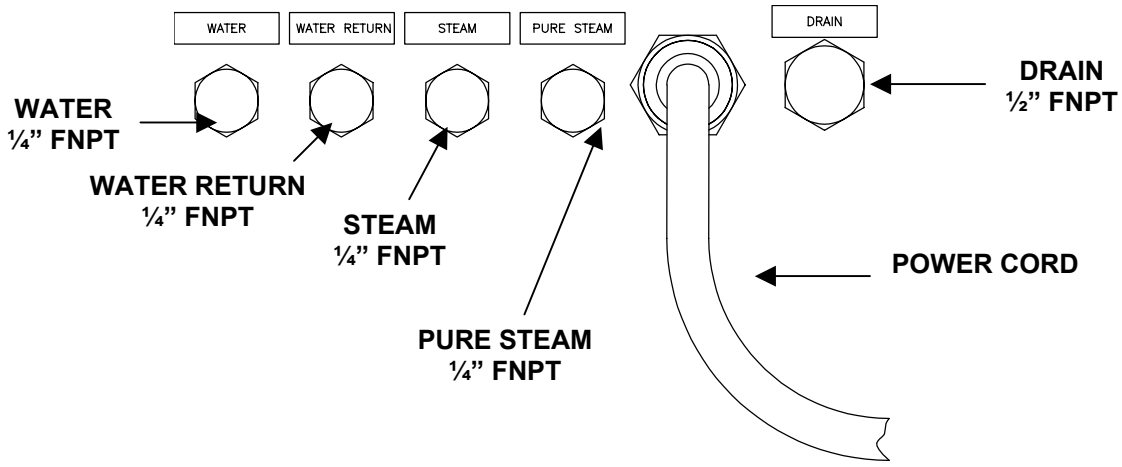
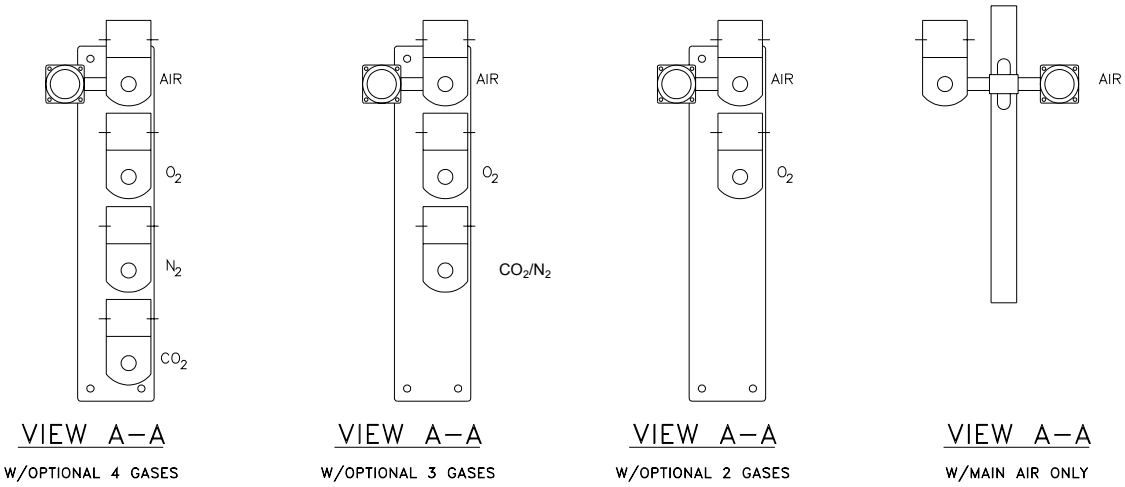
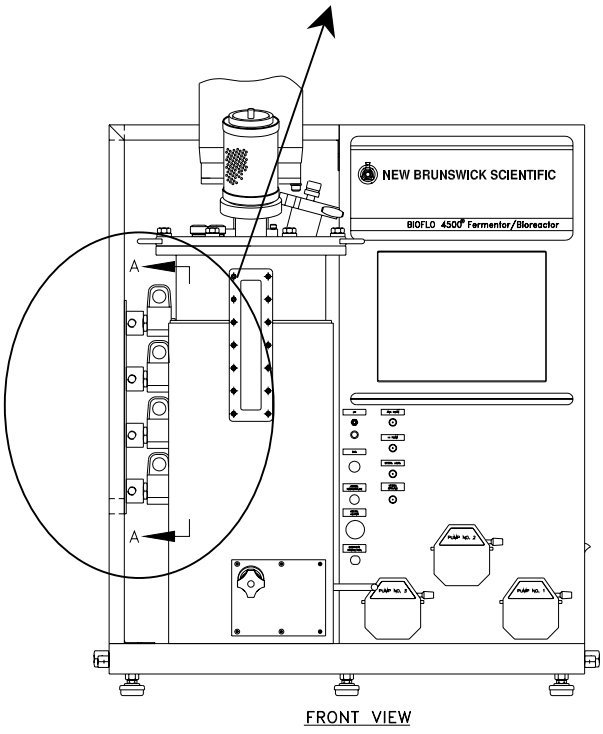


Figure 17: Gas Connections





CAUTION!

Power fluctuations varying more than 10% from the nameplate rating can result in severe damage to the fermentor/bioreactor electronics.

5.5.1 Steam Supplies

If it is known that the steam supply is dirty or contains large particles, it is recommended that a steam prefilter be installed in the steam line leading to the unit. Such a prefilter should consist of a bronze or stainless steel filter body rated for maximum available inlet pressure and temperature.

The filter element may be any of the following: glass or nylon fiber wound on a stainless steel support screen, sintered metal, or graphite. Flow capacity must equal or exceed the maximum steam flow requirement of the unit.

A steam pressure regulator and filter kit is available as an option. When used, install the filter in the vertical position with valves on the inlet and the outlet side. Steam traps should be connected on the filter drain and downstream of the discharge valve.

If the steam supply line to the unit is of considerable length, it is recommended that a drip leg with a steam trap be installed in the steam line as close as possible to the steam service connection. This will prevent steam condensate from collecting in the line.

5.5.2 Pure Steam

Pure steam or clean steam is required for the sterilization of process components which are in direct contact with the process, such as the inlet filter, the sparger line, the re-sterilizable valves and for steam condensate production in case of a double mechanical seal. Pure steam can be made available to the BioFlo 4500 either from a house supply or from a small, dedicated clean steam generator.

5.5.3 Utility Steam

Utility steam or house steam is required for initial sterilization of the vessel contents. Steam enters the jacket and heats the vessel contents indirectly to the desired sterilization temperature.

5.5.4 Exhaust

The Exhaust connection may be run to an open floor drain if the gases exiting from the fermentor/bioreactor are not harmful and have no significant odor. Piping should be as short as possible and large in diameter to prevent excessive backpressure. If local codes allow, the line may be run directly from the building.

If it is necessary to clean the gases before exhausting them to the atmosphere, the line can be run to a filter or scrubber. If the gases are piped away, a drip leg (larger in size so that a slight reservoir is formed) should be put in the line because the gases leaving a fermentor/bioreactor are moisture-laden. A drain valve should be put in the drip leg and it should be opened periodically to allow the condensate to drain. Refer to your local NBS parts distributor or sales office for special containment and gas treatment devices.

5.5.5 Electrical

The BioFlo 4500 is shipped with a line cord that does not include a plug. A suitable plug must be attached or the fermentor may be hardwired directly to a circuit breaker. Before making connections, verify that the supply voltage matches the specified voltage and power requirements on the electrical specification plate, located on the side panel of the fermentor console.

CAUTION!
Before making electrical connections, verify that the supply voltage matches the voltage and power requirements on the electrical specification plate.

CAUTION!
Power fluctuations varying more than 10% from the nameplate rating can result in severe damage to the fermentor/bioreactor electronics.

Because power fluctuations greater than 10% from the nameplate rating of your BioFlo 4500 can result in severe damage to the electronics of the unit, it is recommended that an appropriately rated, high quality voltage stabilizer be installed on the line to protect the electronic components.

5.5.6 Drain

The drain encompasses all waste streams which are considered to have been in contact with the process and are therefore referred to as *contaminated*. Refer to your local NBS parts distributor or sales office for containment and waste treatment devices.

5.5.7 Water & Water Return

Water to the fermentor/bioreactor is used for temperature control (heated in the jacket by the electrical cartridge heaters) for rapid cooling after sterilization, for cooling the vessel contents during growth, and for cooling the condenser, if installed. The water return allows the reuse of the water. Alternatively, a closed loop water system including a chiller can be set up. Refer to your local NBS parts distributor or sales office for chillers.

5.6 Prefilter & Regulator Kits (Optional)

Optional prefilter and regulator kits are available for installation on your BioFlo 4500 system:

Optional Kit	NBS Part Number
Steam Prefilter/Regulator Kit	M1117-2020
Water Prefilter/Regulator Kit	M1117-2040
Water Regulator	M1176-0060
Air Prefilter Kit	M1117-2030
Air Prefilter/Regulator Kit	M1230-3030
Air Regulator (Only) 0-125 PSI	P0220-4080

6 PREPARATION

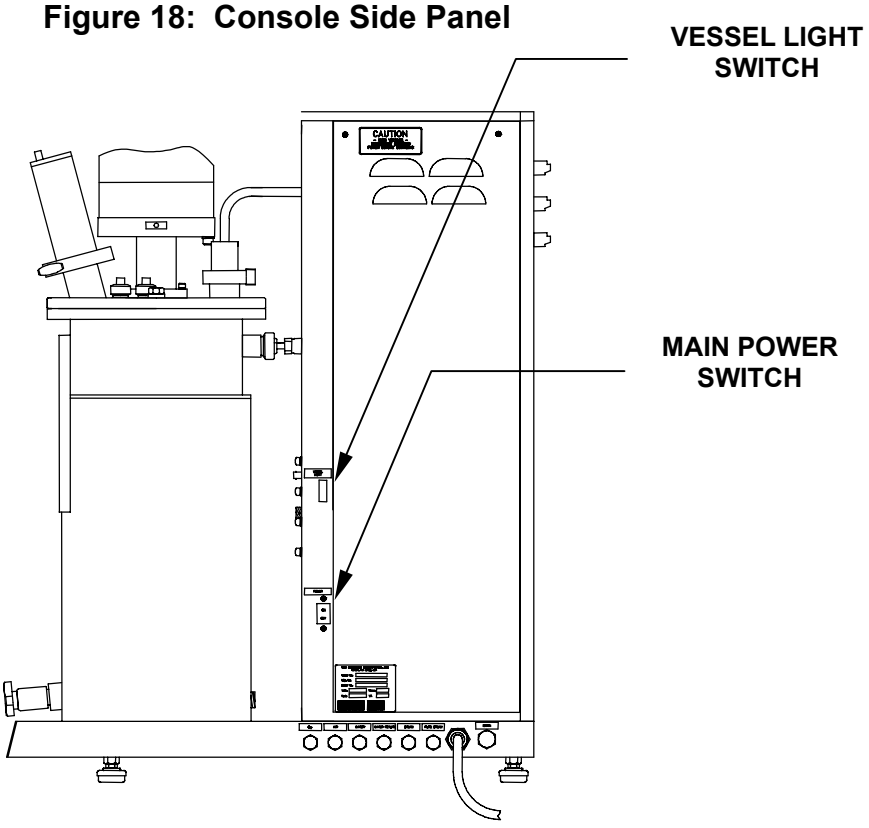
NOTE:

Sections 6.1 through 6.3 refer to the use of the BioFlo 4500 *with the ML-6100 controller only.* If you are not using the ML-6100 controller, skip ahead to Section 6.4.

6.1 Initial Preparation

1. Turn the power on by setting main power switch (on the side of the console) to the **ON** position.

Figure 18: Console Side Panel



2. Adjust both utility and pure steam pressure at source to 25-30 PSIG.

3. Adjust water pressure regulator at source to 30 PSIG.

4. Adjust **AIR PRESSURE REGULATOR** to read 20 PSIG on gauge.

5. For units with manual pressure control, adjust the **VESSEL PRESSURE** to read 18-20 PSIG on the pressure gauge.

6.2 Water Priming

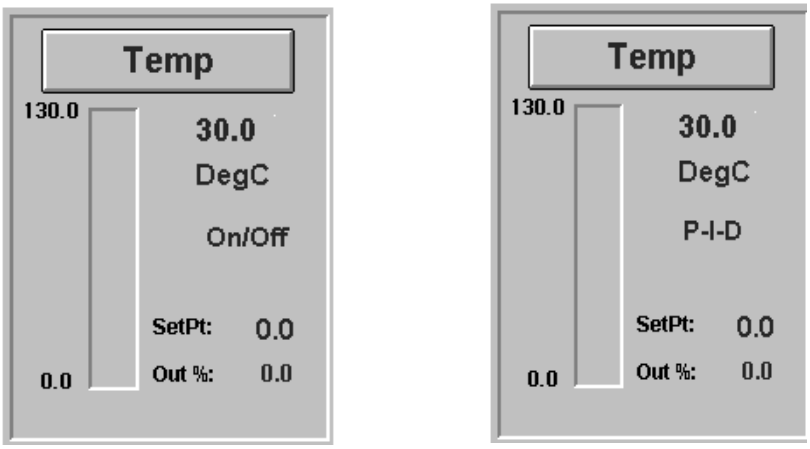
The water system must be primed before proceeding with any temperature control adjustments. Once the system has been primed, it is not necessary to repeat these procedures unless the system is drained.

To prime the system:

1. Measure out 2-3 cc (ml) of mineral oil or glycerin, and insert it into the **THERMOWELL** using an eyedropper or transfer pipette

2. Verify that the **RTD TEMPERATURE PROBE** is connected to the console, insert the probe into the **THERMOWELL** and secure it.

3. Verify that the temperature control loop in the display is set to **ON/OFF** or **PID** control mode. The words **ON-OFF** or **P-I-D** will appear in the temperature control loop's **DISPLAY GAUGE** on the touchscreen.



4. Set the operating setpoint of the temperature control loop to 10°C below the indicated temperature.

5. Observe the water return line. The vessel jacket is primed when a steady stream of water runs out of the line. If the line is not exposed, wait approximately two minutes.

6.3 Calibrating the Touchscreen

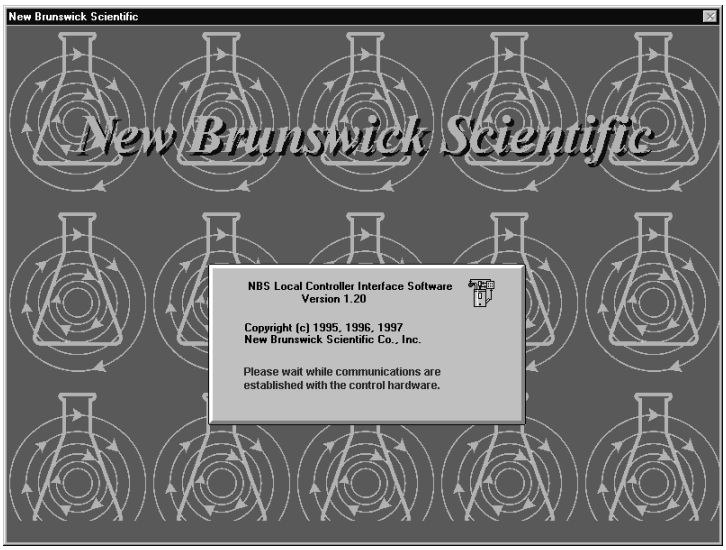
The touchscreen monitor should be calibrated to the operator. To calibrate the touchscreen:

1. For units equipped with an external computer, press the **MAIN POWER SWITCH** on both the computer and the touchscreen monitor.

NOTE:

For units with internal computer and touchscreen, the touchscreen is activated when the unit is turned on.

2. The **START-UP** screen will appear on the monitor. The message "*Please wait while communications are established with the control hardware*" will be in a window in the middle of the display.

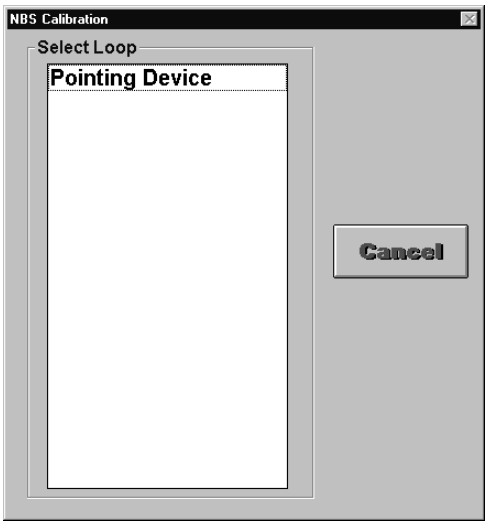


3. Within a few seconds, the start up message will disappear, and the **START-UP** or **GAUGE SCREEN** (see Figure 36) will appear blank.

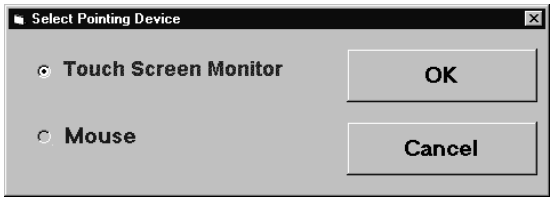
NOTE:

If the controller has been configured prior to or after initial start-up, the GAUGE SCREEN will not appear blank after the start-up message disappears. The control loop display gauges from the last configuration entered will appear on the GAUGE SCREEN (see Figure 36).

4. Press the **CAL. BUTTON** located on in the upper portion of the touchscreen. The **CALIBRATION SELECTION WINDOW** will appear.



5. Select the pointing device loop in the **SELECT LOOP TEXT BOX** by pressing on **POINTING DEVICE**. The **SELECT POINTING DEVICE DIALOG** will appear.



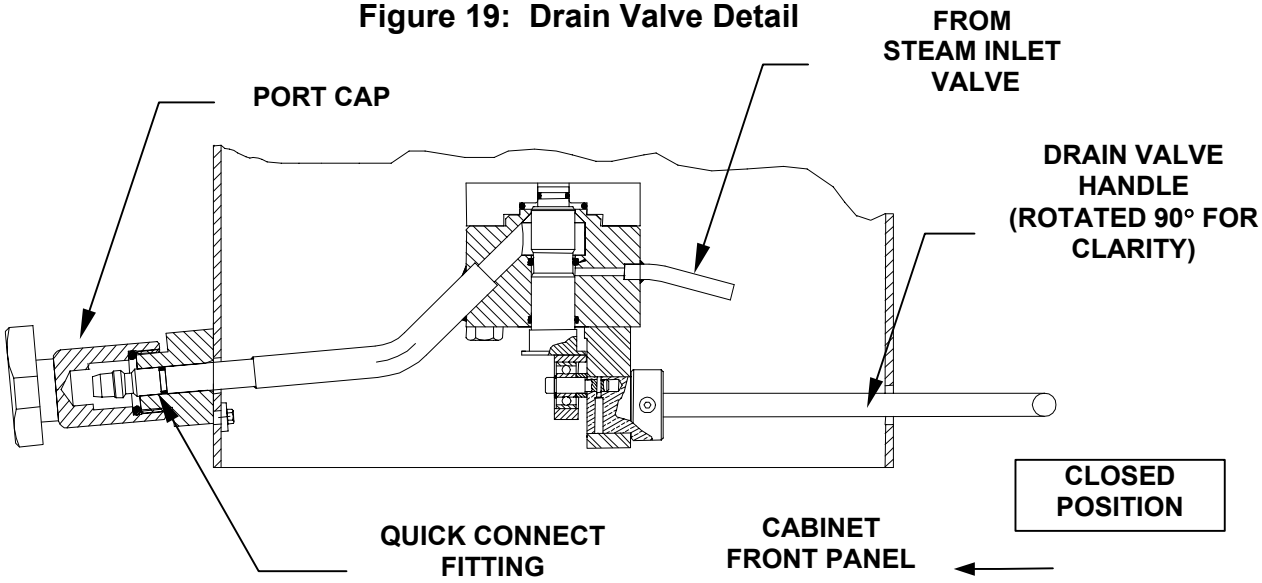
6. Verify that the touchscreen monitor is highlighted and press **OK**.

7. Follow the onscreen directions to touch the monitor in two locations and press **OK** to exit the touchscreen calibration utility.

6.4 Harvest/Drain Valve

The BioFlo 4500 is equipped with a manually-operated, re-sterilizable, plunger-type drain valve *(see drawing below)*. The bottom drain port with valve is located on the centerline of the vessel, and is equipped with a ¼" quick-connect fitting for aseptic transfer of culture broth. The quick-connect fitting is housed inside a port steam cap that allows for re-sterilization after use. A steam valve allows cleaning or re-sterilization of the valve while the harvest/drain valve is closed.

Figure 19: Drain Valve Detail



To harvest/drain the vessel aseptically, the valve must be sterilized prior to use. It is a good habit to resterilize the valve immediately after each use so that is ready for subsequent use.

To sterilize the valve:

1. Ensure sure that the stainless steel port steam cap is in place.
2. Open the **STEAM INLET VALVE**.
3. Allow steam to pass through the valve for about 15 minutes.
4. Close the **STEAM INLET VALVE**.
5. Allow the valve to cool thoroughly before using.

To harvest/drain the vessel aseptically, choose one of the following two methods:

6.4.1 Asceptic Harvest/Drain Method A

1. Prepare an appropriate harvest vessel fitted with tubing (and a fitting that allows easy connection to the quick-connect). Sterilize if required.

NOTE:

Refer to your local NBS parts distributor or sales office for re-sterilizable quick-connect options.

2. Reduce the vessel pressure to 0 PSIG using the **BACKPRESSURE REGULATOR** located in the upper left rear corner of the open piping frame (manual pressure control), or set the setpoint to "O" in the **PRESSURE DISPLAY GAUGE** on the touchscreen.

3. Assuming the port was previously sterilized, carefully remove the port steam cap and aseptically attach a harvest vessel using silicone or Tygon type tubing.

4. To open the drain, rotate the drain valve handle as far as it will allow so it is facing the front of the vessel. When the valve is open, the word **OPEN** is visible on the end of the handle.

5. Draining of the liquid may be accomplished by gravity, a peristaltic pump, or by using the vessel pressure to drive out the liquid from inside the vessel.

6. After draining the vessel, close the drain valve by rotating the drain valve 180°. In the closed position, the handle should be facing the front panel console and the word **CLOSE** is visible on the end the handle.

7. Break the harvest vessel connection by removing the connecting tubing from the quick-connect fitting.

8. Put the stainless steel port steam cap back on the port and re-sterilize the port.

6.4.2 Asceptic Harvest/Drain Method B

1. Prepare an appropriate harvest vessel fitted with tubing and a quick-connect fitting. Sterilize if appropriate.

NOTE:

Refer to your local NBS parts distributor or sales office for quick-connect options.

2. Autoclave harvest vessel and quick-connect fitting in the closed position (121ºC, 30 minutes minimum, depending on vessel).

3. Remove steam port cap from the harvest/drain port and connect the quick-connect fitting from the harvest vessel to the harvest/drain port.

4. Ensure sure that the stainless steel port steam cap is in place.

5. Open the **STEAM INLET VALVE**. Allow steam to pass through the valve for about 15 minutes.

6. Close the **STEAM INLET VALVE**. Allow the valve to cool thoroughly before using.

7. Reduce the vessel pressure to 0 PSIG using the **BACK PRESSURE REGULATOR** located in the upper left rear corner of the open piping frame (manual pressure control) or set the setpoint to "O" in the **PRESSURE DISPLAY GAUGE** on the touchscreen.

8. Open the valve on the sterile quick-connect.

9. To open the drain, rotate the drain valve handle as far as it will allow so it is facing the front of the vessel. When the valve is open, the word **OPEN** is visible on the end of the handle.

10. Draining of the liquid may be accomplished by gravity, a peristaltic pump or by using the vessel pressure to drive out the liquid from inside the vessel.

11. After draining the vessel, close the drain valve by rotating the drain valve 180°.

12. In the closed position, the handle should be facing the front panel console and the word **CLOSE** is visible on the end the handle. Open the valve on the sterile quick-connect.

13. Close the valve on the quick-connect fitting. Detach the sterile quick-connect from the harvest/drain port.

14. Put the stainless steel port steam cap back on the port. Re-sterilize the port.

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7 STARTING THE SYSTEM

NOTE:

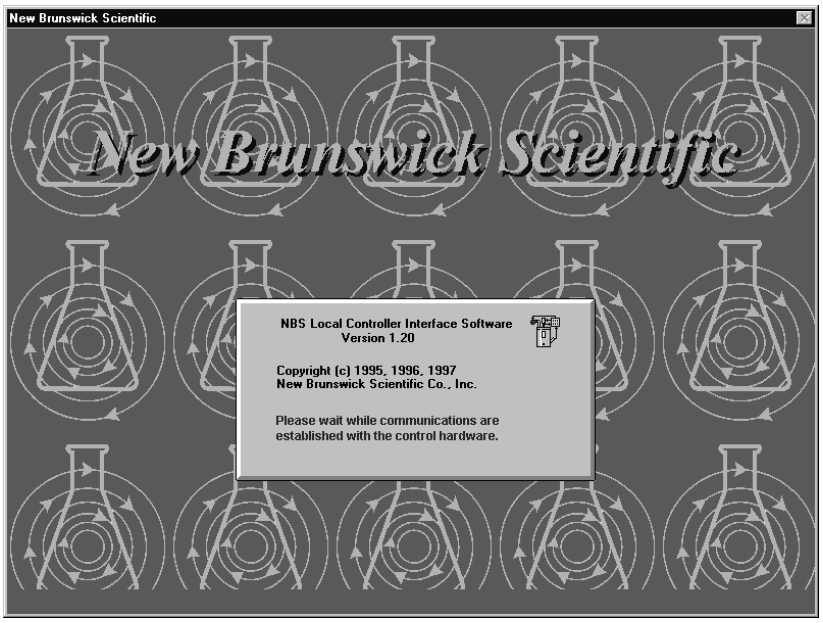
The following paragraphs refer to the use of the BioFlo 4500 *equipped with the ML-6100 controller only*.

7.1 Start-Up

Do the following to start the BioFlo 4500 fermentation system:

- Press the **MAIN POWER SWITCH** on the fermentor/bioreactor. Turn on the computer and touchscreen monitor if applicable to your system. If your system includes an external computer, the BioFlo 4500 will not communicate with it if it is not turned on.

- The **START-UP SCREEN** will appear. The message "*Please wait while communications are established with the control hardware*" will be in a window in the middle of the display.



- Within a few seconds, the start up message will disappear, and the **START-UP** or **GAUGE SCREEN** will appear blank.

NOTE:

If the controller has been configured prior to or after initial start-up, the GAUGE SCREEN will not appear blank after the start message disappears. The control loop display gauges of the last configuration entered will appear on the GAUGE SCREEN.

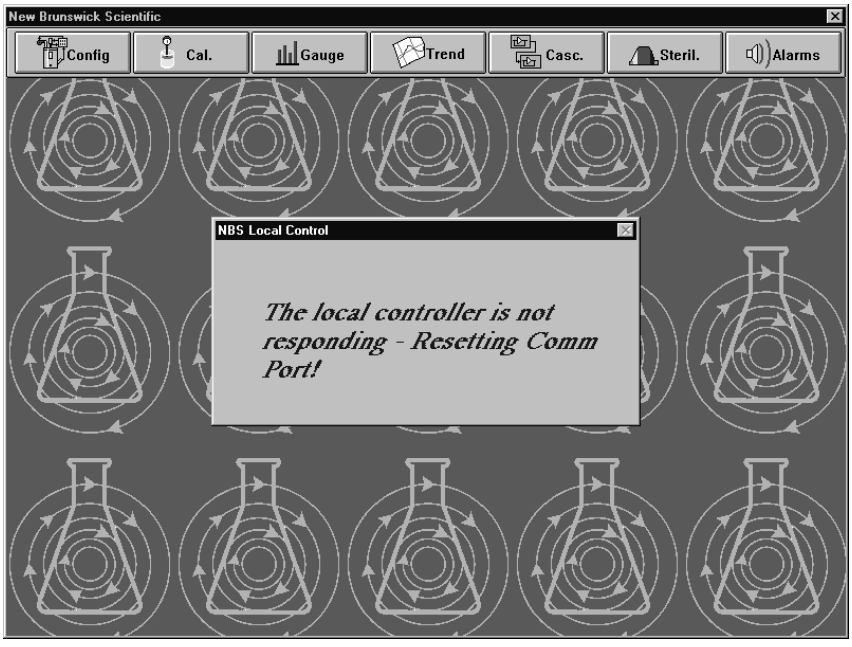
This condition will not occur if the controller cannot communicate with the software, if the controller configuration has been deleted, or if there is no current controller configuration.

All BioFlo 4500 fermentor/bioreactors are pre-configured at the factory for all standard process parameters and any factory-installed options (for example: automatic backpressure control).

NOTE:

This original factory-established configuration is saved as a Read-Only file on the controller. If changes are made to the configuration and retention of the configuration is required, save the configuration using a new, unique file name.

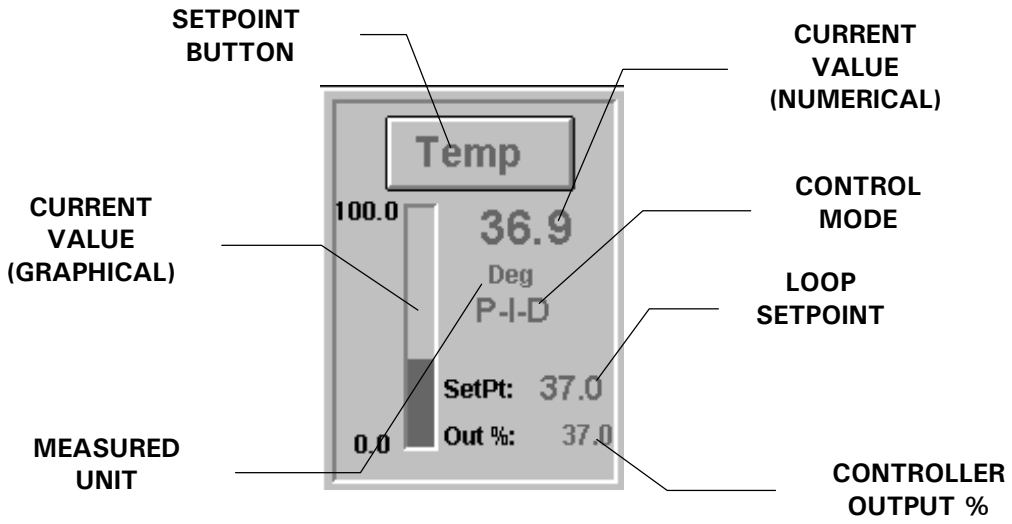
- If the message "Local Controller is not responding - Resetting Comm Port!" appears, refer to Section 35, *Troubleshooting*.



7.2 Display Gauge

The **GAUGE SCREEN** shows virtual **DISPLAY GAUGES** for each configured loop. Each gauge displays current values for that control loop. When a control loop is added, a display gauge automatically appears on the **GAUGE SCREEN**. The following is an example of a typical display gauge:

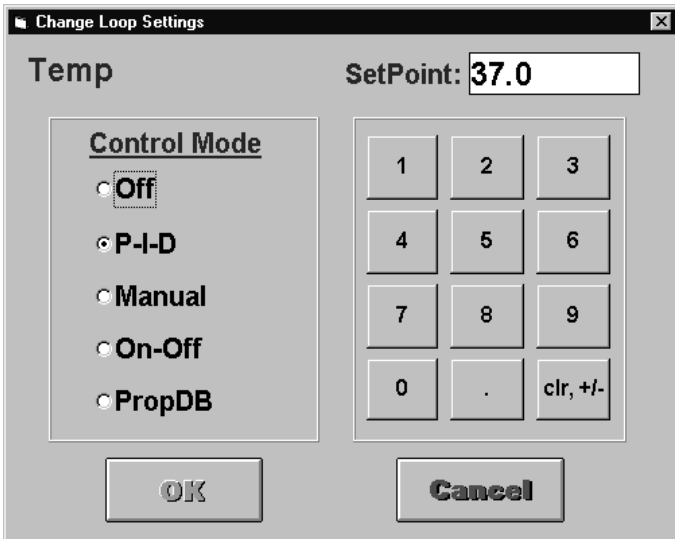
Figure 20: Display Gauge



SETPOINT BUTTON	Displays the given loop name and, when selected, gives the user access to the Change Loop Settings Window
CURRENT VALUE	Displays the current value of the loop as a numerical value and a bar graph.
CONTROL MODE	The selected method of control for the loop. If the loop is cascaded, the name of the control loop that is driving the cascade will appear in this area.
LOOP SETPOINT	The setpoint value of the loop.
MEASURED UNIT	The unit of measurement of current output and setpoint.
CONTROLLER OUTPUT %	The value of loop output as a percentage of full-scale controller output.

To change the loop settings (setpoint and control mode) of a process loop from a **DISPLAY GAUGE**:

- Press the **SETPOINT BUTTON**. The **CHANGE LOOP SETTINGS WINDOW** will appear.



- To change the control mode, press the one you want to select.

NOTE:

If you are unfamiliar with control modes, see Section 9, *ML-6100 Control Loop Operations*.

- Press the values you wish to use. If a negative sign is desired, press the **clr, + /- BUTTON** before entering a number value.

- Press **OK** to accept the loop setting changes. The new values you entered will be displayed in the gauge within a few seconds after returning to the **GAUGE SCREEN**.

8 ML-6100 CONTROLLER CONFIGURATION

NOTE:

The following procedures refer *only* to the use of the BioFlo 4500 *equipped with the ML-6100 controller*.

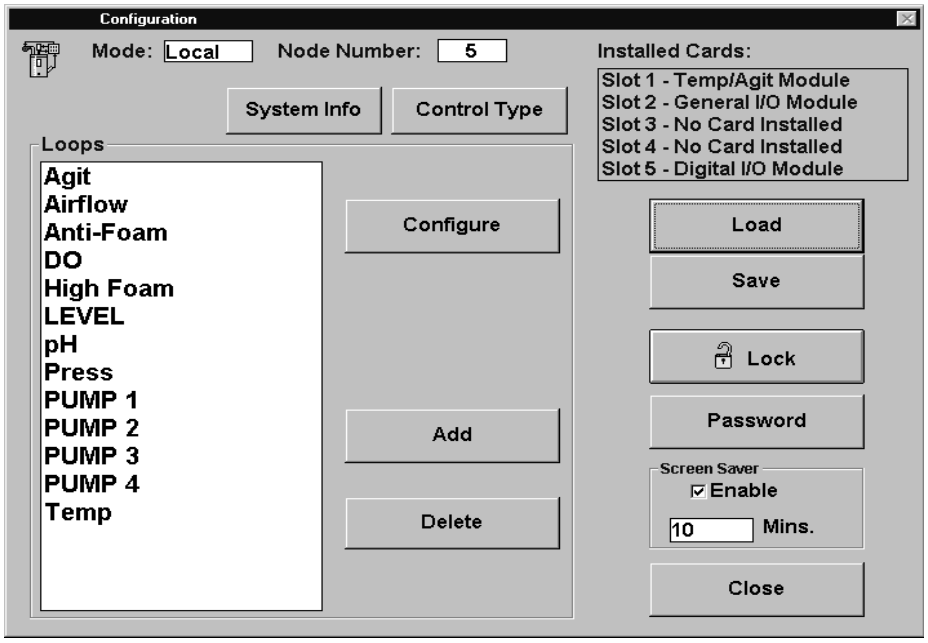
The ML-6100 controller of the BioFlo 4500 was configured prior to shipment. However, user adjustments may be required for certain processes.

Configuring the controller includes specifying for each controlled parameter its display, input, output and control characteristics. It also includes identifying the terminals used to connect the input from the loop sensor (probe, tachometer, etc.), and the output to the loop actuator(s) (pump, valves, etc.). Finally, if the controller will be used with supervisory software or as part of a networked control system, it must be assigned communications-related parameters.

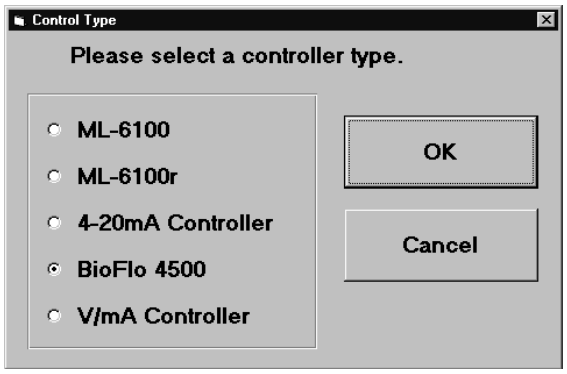
8.1 Configuring The Controller

To configure the controller, press the **CONFIG BUTTON** in the upper left-hand corner of the **GAUGE SCREEN**.

The **MAIN CONFIGURATION SCREEN** will appear (*see sample screen on following page*).



Press the **CONTROL TYPE BUTTON**, the **CONTROL TYPE DIALOG BOX** will appear.

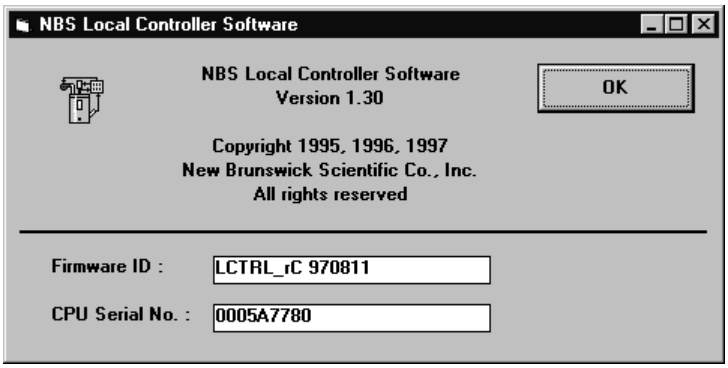


Verify that the BioFlo 4500 is the selected controller type. Press **OK**.

A message will appear, asking if you want to change the control type. If you do, press the **YES BUTTON**. If not, press the **NO BUTTON**.

8.2 System Information

To view system information specific to your controller, press the **SYSTEM INFO BUTTON**. This will display a screen containing the Firmware ID, the serial number of the CPU on the Digital I/O Module, and the version of the NBS local software installed.

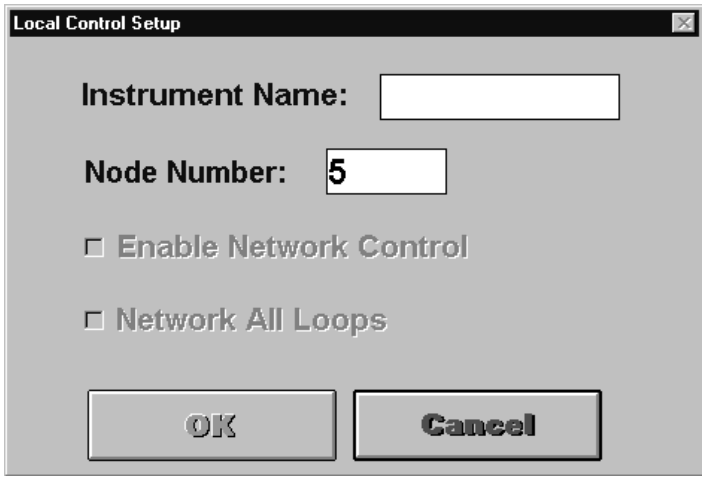


To return to the **MAIN CONFIGURATION SCREEN**, press **OK**.

8.3 Control Mode Selection and Node Number

The ML-6100 controller can be assigned a **NAME**, a **NODE NUMBER** (Multidrop Address or Unit ID) and a **CONTROL MODE**. To set or change any of these components:

- From the **MAIN CONFIGURATION SCREEN**, press the **MODE** or **NODE NUMBER** text boxes. Touching either box will display the **LOCAL CONTROL SETUP WINDOW**.



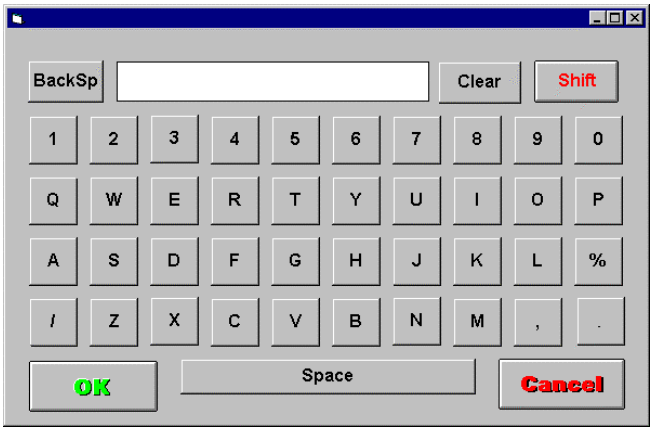
- The **LOCAL CONTROL SETUP WINDOW** will appear. The default value for the **INSTRUMENT NAME** is blank. If you wish to change it, press the text box.

- A **RENAME MODE DIALOG BOX** will appear. To clear the text out of the text box, press CLEAR. The **INSTRUMENT NAME** can be blank.

- If you wish to leave the **INSTRUMENT NAME** blank, press OK. This will return you to the **LOCAL CONTROL SETUP WINDOW** where you can also change the **NODE NUMBER**.

- If you wish to give the controller a name, press on the text box and a keyboard will appear. Enter the name of the controller using the onscreen keyboard and press **OK**.

- Press **OK** in the **LOCAL CONTROL SETUP** window to accept the name change.



NOTE:

Text is entered on the onscreen keyboard by pressing a letter, number or character button.

To change letter case and characters, press the shift button. When the word SHIFT appears in black, lower case letters appear on the buttons. When SHIFT is written in red, uppercase letters and a different character set appear on the buttons.

To clear the text box, press the CLEAR BUTTON. To accept the text in the text box, press OK. To cancel, press CANCEL.

For the controller to work in conjunction with *BioCommand s*upervisory software, AFS Mode must be selected and the **NODE NUMBER** must be set to an even number between 0 and 30. The first 10 loops in the BioFlo 4500 will appear at the selected **NODE NUMBER**. Any additional loops will appear at the next odd number (node number plus one). **Do not** use odd node numbers in AFS mode; they will not be recognized.

The default operating mode for the controller is **LOCAL**. Verify that the word **LOCAL** is in the mode text box of the **CONFIGURATION SCREEN**, and that the **ENABLE NETWORK CONTROL** and **NETWORK ALL LOOPS** modes are disabled.

NOTE:

If optional *BioCommand* supervisory software is used for multiple fermentor/bioreactors, each fermentor/bioreactor and any auxiliary equipment must have a unique node or multi-drop number.

- Press **OK** to return to the MAIN CONFIGURATION SCREEN. If you have changed the control name, you will notice that the new name appears before the word configuration in the menu bar.

- Press **CLOSE** to return to the **GAUGE SCREEN**.

8.4 Passwording and Locking

The ML-6100 controller is equipped with two levels of security. The first level is used to protect against unauthorized tampering with basic operations functions such as process loop setpoint changes. The second level of security is designed to safeguard the configuration of the controller and the process loops.

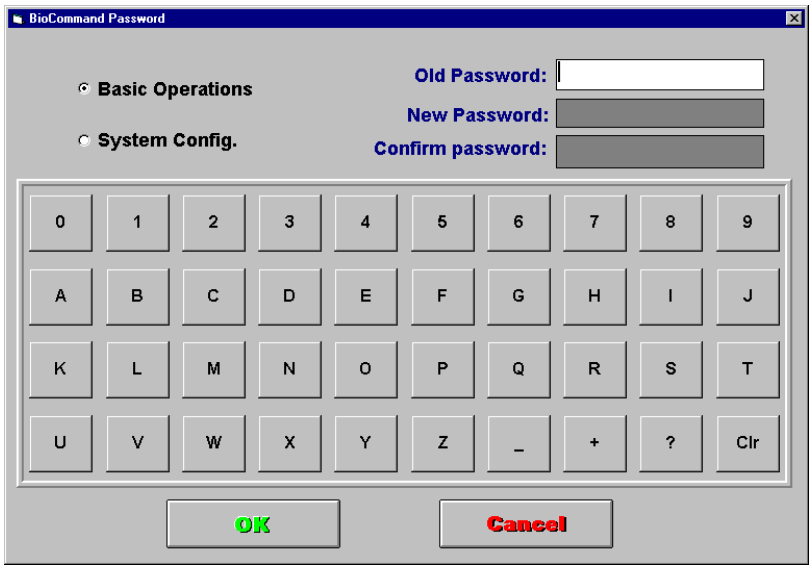
The Controller Interface Software accepts a different password for each level of security. They are the following:

- **BASIC OPERATIONS** — This password is used for basic operator functions such as changing loop setpoints via the **LOCKING** feature.

- **SYSTEM CONFIGURATION** — Used to protect the configurations of the controller, loops,alarms,as well as loading from disks. May also be used to access the **LOCKING** feature.

The default value of the **SYSTEM CONFIGURATION PASSWORD** is **NBS**, and the **BASIC OPERATIONS PASSWORD** is set to blank.

To change either password, press the **PASSWORD BUTTON** in the **MAIN CONFIGURATION SCREEN**. The **PASSWORD DIALOG BOX** will appear, with the default selection being the **BASIC OPERATIONS PASSWORD**.



It is recommended that the system configuration *always* be passworded to prevent inadvertent configuration changes.

NOTE:

Text is entered into the keyboard by pressing a letter, number or character button. To clear the text box, press the CLEAR BUTTON. To accept the text in the text box, press OK. To cancel, press CANCEL.

If you wish to change the **SYSTEM CONFIGURATION PASSWORD**, select it by touching the white circle next to it.

To change either password:

1. Choose the password you wish to change, and press the selection.
2. Enter the old password by pressing the text area and typing in the old password on the keyboard.
3. Touch the new password text area.
4. Touch the **CONFIRM PASSWORD** text area, then type in the new password utilizing the onscreen keyboard.
5. Press **OK** on the onscreen keyboard after completing all three fields.

As an added security feature, a controller lock is included. The controller lock prevents changes to loop setpoints from the **GAUGE SCREEN**. Once the **LOCK** is activated, process loop settings cannot be modified until the **LOCK** is removed. To **LOCK** the controller:

1. From the **GAUGE SCREEN**, press the **CONFIG BUTTON**. The **MAIN CONFIGURATION SCREEN** will appear.

2. Press the **LOCK BUTTON**.

3. You will be prompted to enter the **BASIC OPERATIONS PASSWORD**. Enter the password and press **OK**. If the **BASIC OPERATIONS PASSWORD** has been set to a blank value, the prompt will not appear.

4. The lock icon on the **LOCK BUTTON** will change from unlocked to locked (compare sample button above, which is unlocked, to sample button below, which is locked). To exit the **MAIN CONFIGURATION SCREEN**, press **CLOSE**.

The controller is now locked. If an attempt is made to change a loop setpoint or control mode while the controller is locked, the following message will appear:

Press **OK** and perform the following steps to unlock the controller:

1. From the **GAUGE SCREEN**, press the **CONFIG BUTTON**. The **MAIN CONFIGURATION SCREEN** will appear.

2. Press the **LOCK BUTTON**.

3. You will be prompted to enter the **BASIC OPERATIONS PASSWORD**. Enter the password and press OK. If the **BASIC OPERATIONS PASSWORD** has been set a blank value, you will not be prompted for it.

4. The lock icon on the **LOCK BUTTON** will change from locked to unlocked. To exit the **MAIN CONFIGURATION SCREEN**, press **CLOSE**.

8.5 Screensaver Option

The screensaver feature allows the user to enable or disable the screensaver when using the fermentor. By default, the screensaver option is disabled. If you wish to have a screensaver when using the controller, you must enable the screensaver as follows:

1. Press the CONFIG BUTTON in the GAUGE SCREEN.

2. In the **MAIN CONFIGURATION SCREEN**, press in the **ENABLE** box in the screensaver window.

3. Select the time interval after which you wish the screensaver to activate.

4. Press CLOSE to enable your selection

5. To disable a screensaver, repeat the previous steps, pressing the **ENABLE** box to remove the "**X**" then pressing **CLOSE** to enable your selection.

9 ML-6100 CONTROL LOOP OPERATIONS

NOTE:

The following procedures refer *only* to the use of the BioFlo 4500 *equipped with the ML-6100 controller*.

9.1 Adding a New Loop to the Display

Adding a new signal input (feedback signal) and control output (control signal) will require that the controller be "configured" for the new loop through the touchscreen interface.

Users of *BioCommand* Supervisory Software should note that only the first ten control loops of the controller communicate with *BioCommand*. For example, if your application requires 16 control loops on the controller, only the first ten configured control loops will be available in *BioCommand*. This limitation is within NBS digital protocols, and does not limit the capacity of the controller to accommodate its full complement of 16 control loops.

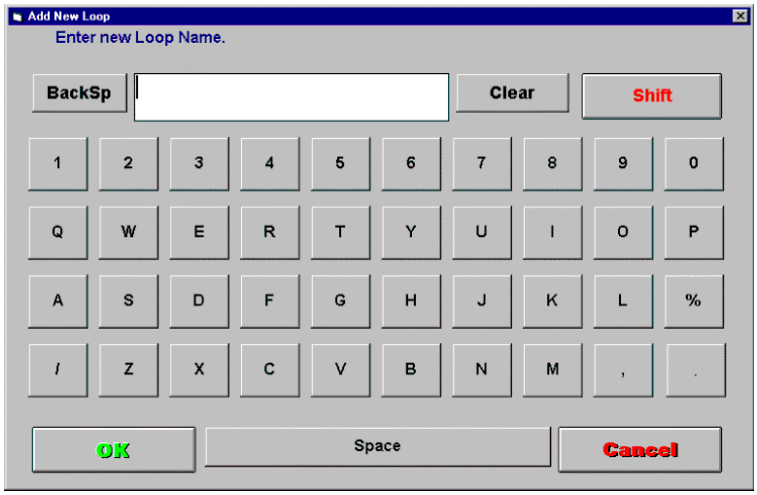
To add a new loop to the display:

1. Select the **CONFIG BUTTON** in the **GAUGE SCREEN**. A **MAIN CONFIGURATION SCREEN** box will appear.

2. Select ADD. You will be prompted for the **SYSTEM CONFIGURATION PASSWORD**.

3. Enter the configuration password and press **OK**. The default **SYSTEM CONFIGURATION PASSWORD** is **NBS**. If the **SYSTEM CONFIGURATION PASSWORD** was set to blank, you will not be prompted for a password.

4. The **ADD NEW LOOP PROMPT** will appear.



5. Enter the loop name you wish to add in the space provided using the onscreen keyboard.

6. If you wish to change the name before pressing **OK**, press the **CLEAR BUTTON**. This will clear the content of the loop name. Press **OK** to accept the loop name.

7. The **LOOP CONFIGURATION SCREEN** will appear. You may proceed to the next section (section 9.2) to finish configuring the loop.

8. If you cancel the **LOOP CONFIGURATION SCREEN**, the loop will not be added. To add the loop, press **OK**.

9. To leave the **MAIN CONFIGURATION SCREEN** press the **CLOSE BUTTON**. A **DISPLAY GAUGE** will appear in the **GAUGE SCREEN** with the loop name that was just added.

9.2 Configuring Control Loops

Configuring each control loop consists of specifying its controller output, input, and display characteristics, and identifying the terminals used to connect the input from the loop sensor, and the output to the loop actuator.

To configure a new control loop or to modify a previously configured control loop:

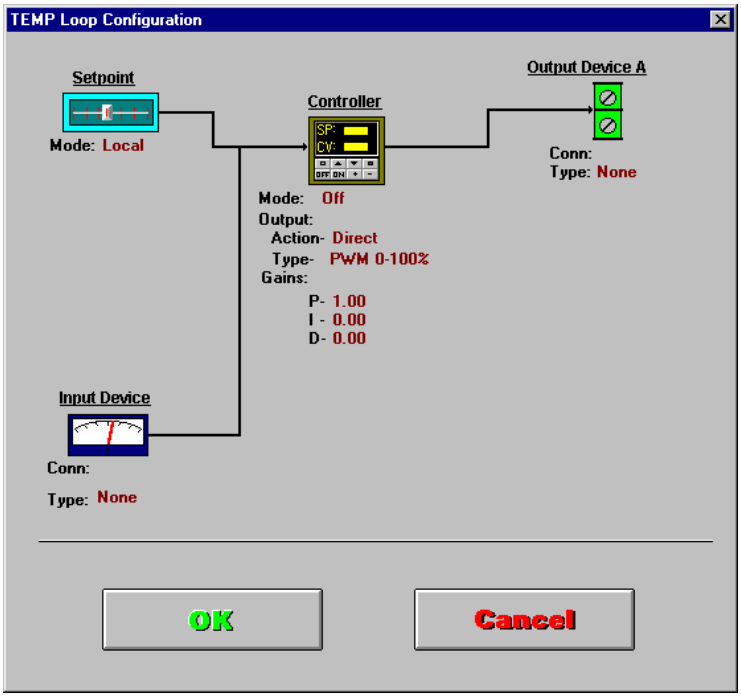
1. Press the **CONFIG BUTTON** in the **GAUGE SCREEN**.

2. The **MAIN CONFIGURATION SCREEN** will appear.

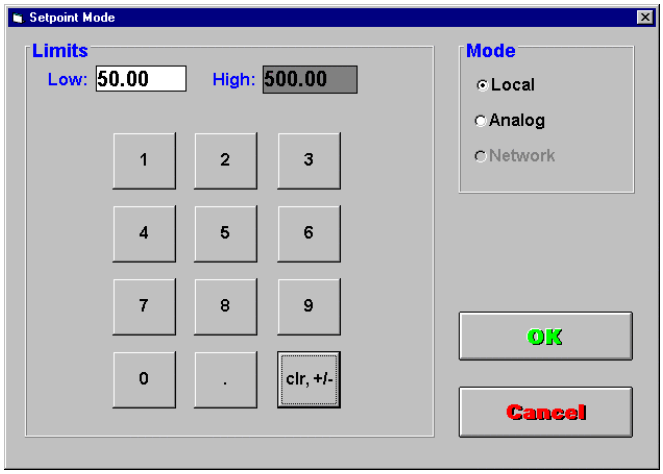
3. In the **LOOPS WINDOW**, touch the loop that you wish to configure.

4. After selecting the loop, touch the **CONFIGURE BUTTON**.

5. The **LOOP CONFIGURATION SCREEN** will appear.



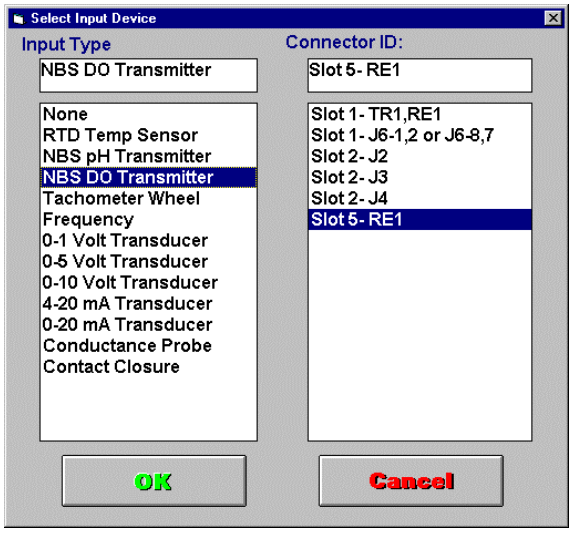
6. To select upper and lower limits for the loop display gauge and setpoint, touch the **SETPOINT ICON**. The **LOOP SETPOINT MODE SCREEN** will appear.



7. Select either **LOCAL** or **ANALOG** for the **LOOP CONTROL MODE**. **LOCAL** will allow the ML-6100 controller to directly control the input signal of the control loop. **ANALOG** will allow an analog 4-20 mA signal from an external PLC or controller to be input to the controller, thus setting the controller in "slave" mode for the control loop.

8. To set the limits of the control loop, touch the **LOW** text box, then enter the desired values using the onscreen keypad. Press **OK** to accept the settings. Do the same to set the high limit in the **HIGH** text box.

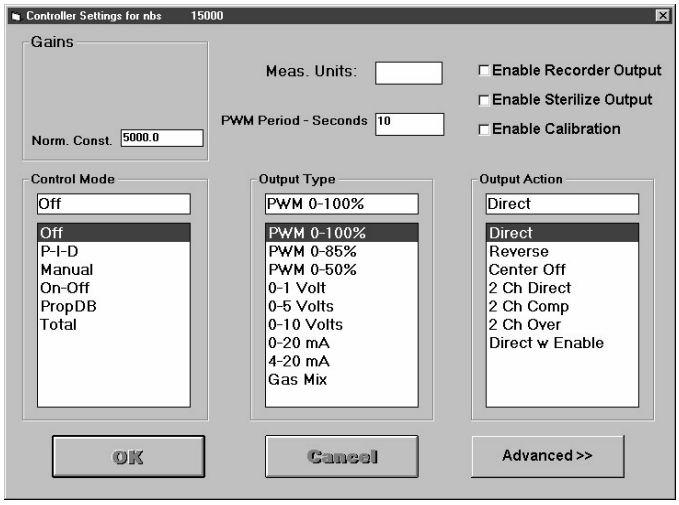
9. To configure the input device, press the **INPUT DEVICE ICON**. The **SELECT INPUT DEVICE SCREEN** will appear.



10. Select the **INPUT TYPE** and **CONNECTOR ID** by pressing on the selections you wish to use. The **CONNECTOR ID WINDOW** will only display available inputs. If an input is already allocated to another device, it will not be displayed.

11. Touch **OK** to accept your selections.

12. Select the **CONTROLLER ICON** to set the controller characteristics for this loop, i.e., how it will respond to differences between setpoint and current value. The **CONTROLLER SETTINGS SCREEN** will appear.



13. Enter the unit of measure for this loop in the **MEAS. UNITS BOX**.

14. Enter **NORM CONST**, the range of values for this parameter. For example, if you are configuring an agitation loop with a range of 0 to 1000 rpm, enter 1000. The **NORM CONST** compensates for differences in **PID** values resulting from different measuring units.

NOTE:

If 0 is entered for NORM CONST, an error message appears. To clear the message, press OK. The NORM CONST will assume the default value of 100. Touch the text box to change to any other non-zero value.

15. Select the **CONTROL MODE** for this loop. The **CONTROL MODE** determines the method used by the controller to calculate an output signal:

OFF	No controller output signal is generated.
PID	Controller output is the sum of Proportional, Integral, and Derivative error components. Enter P, I and D values.
MANUAL	Controller output is set by user between 0 and 100% of maximum output.
ON-OFF	Controller output toggles between fully on and fully off, as required to maintain setpoint.
PropDB	Output is proportional to error when error is greater than the deadband, otherwise it is zero. Enter a P constant and a deadband value.
TOTAL	Controller output is as described in manual mode. However, the controller records an accumulation of output over time and displays it as the current loop value.

16. Select the **OUTPUT TYPE**. Refer to the output device manufacturer's specifications. The selections and related user actions are as follows:

PWM 0-100%	A Pulse Width Modulated output signal switches between On and Off . The duration of the On state ranges between 0 and 100% of the period. The electrical characteristic of the PWM output signal depends on the Digital I/O Terminal Panel used. Enter a period between 1 and 600 seconds.

PWM 0-85%	Same as **PWM 0-100%**, except the duration of the on state ranges between 0 and 85% of the period. Enter a period between 1 and 600 seconds.
PWM 0-50%	Same as **PWM 0-100%**, except the duration of the On state ranges between 0 to 50% of the period. Enter a period between 1 and 600 seconds.
0-1 Volt	Analog output varies between 0 and 1 volt
0-5 Volts	Analog output varies between 0 and 5 volts
0-10 Volts	Analog output varies between 0 and 10 volts
0-20 mA	Analog output varies between 0 and 20 mA
4-20 mA	Analog output varies between 4 and 20 mA
GAS MIX	Varies addition gas mix ratios while maintaining a constant flow rate. Refer to the *Controlling & Mixing Addition Gases* section of this manual for details.

NOTE:

For Frequency and Tachometer Wheel inputs, the integral will not run if the feedback signal is zero. To compensate for this, set the PROPORTIONAL CONSTANT to a non-zero value.

17. Select the **OUTPUT ACTION**. Refer to the output device manufacturer's specifications. The choices are:

DIRECT	Varies linearly *from minimum* at 0% controller output *to maximum* at 100% controller output.
REVERSE	Varies linearly *from maximum* at 0% controller output *to minimum* at 100% controller output.
CENTER OFF	Varies linearly *from minimum* at 100% controller output *to maximum* at +100% controller output.
2 CH DIRECT	• **OUTPUT A** varies linearly *from minimum* at 0% controller output *to maximum* at 100% controller output. • **OUTPUT B** varies linearly *from maximum* at -100% controller output *to minimum* at 0% controller output.

2 CH COMP

- **OUTPUT A** varies linearly from *minimum* (Complementary) at 100% controller output, to *maximum* at +100% controller output.
- **OUTPUT B** varies linearly from *maximum* at -100% controller output to *minimum* at 100% controller output.

This action allows two actuators with a continuous transition between them.

2 CH OVER

- **OUTPUT A** varies linearly from *minimum* (Overlap) at -25% controller output, to *maximum* at 100% controller output.
- **OUTPUT B** varies linearly from *maximum* at -100% controller output to *minimum* at +25% controller output.

This action allows an overlap control transition between two actuators.

DIRECT w/ ENABLE

Same controller action **DIRECT**, with an additional digital controller output which is **OFF** when either controller output or setpoint is zero, **ON** when both setpoint and controller output are not zero. This function is used to actuate the shutdown features of mass flow controllers, motor controllers, etc.

18. Select **ENABLE AUTO STERILIZE** only if this loop (typically, temperature) will control the sterilization cycle.

19. If you wish to calibrate the control loop through the controller, select **ENABLE CALIBRATION**. If this box is not checked, the control loop will not be visible in the **SELECT CALIBRATION SCREEN**. Refer to the *Calibration* section of this manual for detailed instructions on loop calibration. The BioFlo4500 is configured at the factory to display the following loops on the **SELECT CALIBRATION SCREEN**:

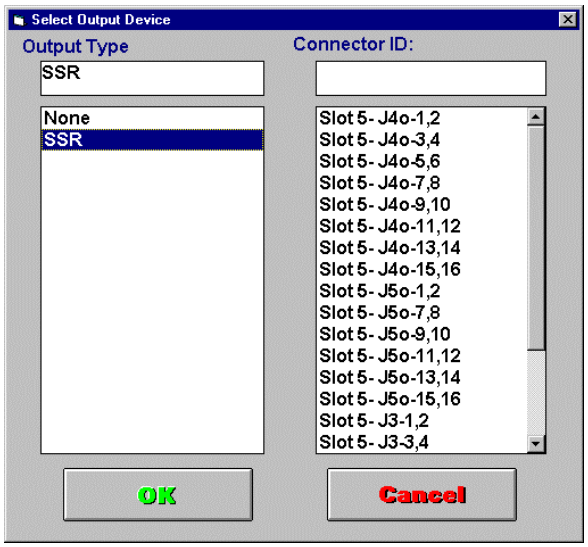
    The factory settings for the select calibration screen are:

    - Pointing Device
    - pH
    - DO
    - Pump 1
    - Pump 2
    - Pump 3
    - Aux Pump
    - Hi Foam
    - Anti Foam

20. The **ADVANCED SETTINGS BUTTON** is used for conditioning the controller's input and output signals. For more information on the advanced settings screen, refer to *Appendix I.* Press the button to access the **ADVANCED SETTINGS SCREEN**. Make the desired selections and press **OK** to accept them. The software will return to **CONTROLLER SETTINGS SCREEN**.

21. Press **OK** to accept the controller setup and return to the **LOOP CONFIGURATION WINDOW**.

22. To configure the **OUTPUT DEVICE**, press the **OUTPUT DEVICE ICON** in the **LOOP CONFIGURATION SCREEN**. The **SELECT OUTPUT DEVICE SCREEN** will appear.



23. Choose the **OUTPUT TYPE**. Refer to the output device manufacturer's specifications. The **CONNECTOR ID WINDOW** will indicate which terminals are used to connect the output device. The **CONNECTOR ID WINDOW** will only display available outputs. If an output is already allocated to another device, it will not be displayed. Press **OK** to accept your selections.

NOTE:

If the ENABLE AUTO STERILIZE option was selected in the CONTROLLER SETTINGS SCREEN, it must be configured as an OUTPUT DEVICE before exiting the LOOP CONFIGURATION SCREEN.

The Sterilization function will be enabled only if it was assigned an OUTPUT TYPE and CONNECTOR ID. Please refer to the Automatic Sterilization section of this manual for detailed instructions.

24. The **SYSTEM CONFIGURATION PASSWORD** prompt will appear. Enter the password using the onscreen keyboard, then press **OK**. If the **SYSTEM CONFIGURATION PASSWORD** is set to blanks, the prompt will not appear.

25. To exit the **CONFIGURATION SCREEN**, press the **CLOSE** button. Any changes made to the loop configuration will be seen on the corresponding display gauge on the **GAUGE SCREEN**.

9.3 Deleting Loops

A control loop may be deleted from the controller configuration:

1. Select the **CONFIG BUTTON** in the **GAUGE SCREEN**. The configuration screen will appear.

2. Select a control loop from the loops list and press the **DELETE BUTTON**. You will be prompted to enter the **SYSTEM CONFIGURATION PASSWORD**. If the **SYSTEM CONFIGURATION PASSWORD** was set to blanks, you will not be prompted for a password.

3. To delete the control loop, enter the password and press **OK**. To cancel this operation press **CANCEL**. A message will appear asking you if you want to delete this loop. If you want to delete it, answer **YES**. Answer **NO** if you wish to cancel the operation.

4. Control will return to the CONFIGURATION SCREEN. Press **CLOSE** to return to the **GAUGE SCREEN**. The display gauge for the deleted control loop will be removed.

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10 ML-6100 TEMPERATURE CONTROL SYSTEM

NOTE:

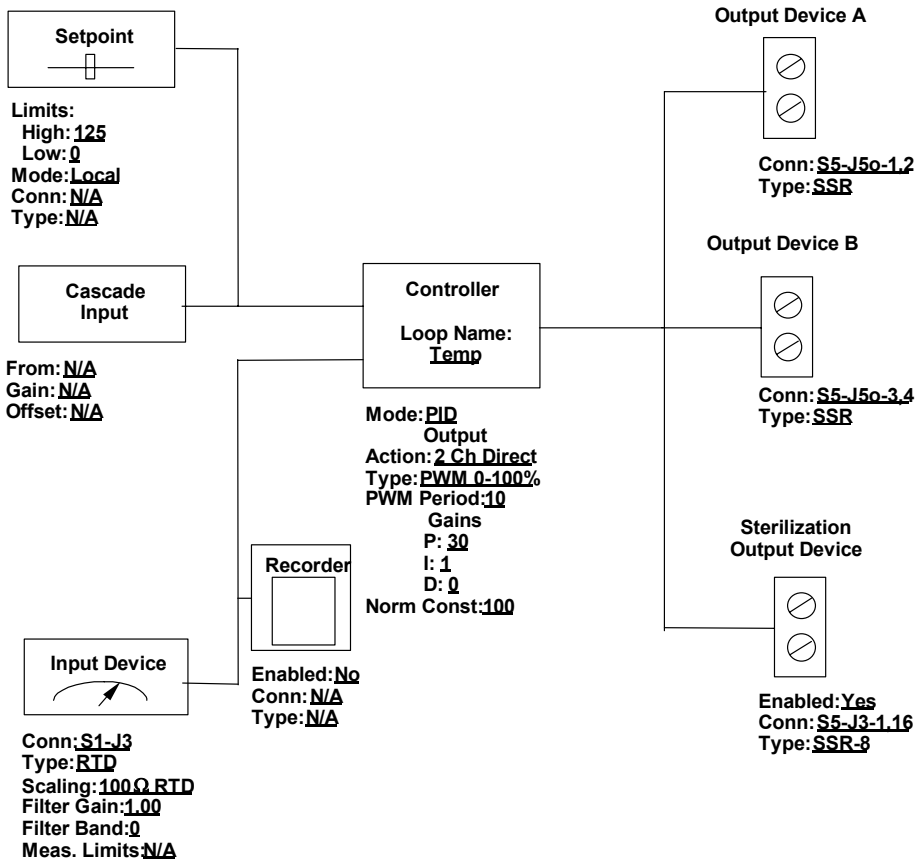
The following procedures refer *only* to the use of the BioFlo 4500 *equipped with the ML-6100 controller*.

There are four high watt density cartridge heaters at the bottom of the vessel. Water is heated by the cartridge heaters in the jacket, where heat is transferred through to the media in the inner vessel. Cooling water is admitted to the jacket through the temperature control valve and the flow control valve.

Vessel temperature control during the growth cycle is controlled from 5°C above the coolant supply temperature to a maximum of 85°C. An RTD temperature sensor and thermowell are provided as standard. The RTD probe provides the signal for a PID loop capable of holding the vessel temperature to within ±0.2°C. Temperature control and setpoints are controlled at the touchscreen interface of the ML-6100 if applicable.

The temperature control loop is configured as shown on the following page.

Figure 21: Temperature Control Loop Configuration



11 ML-6100 AGITATION CONTROL SYSTEM

NOTE:

The following procedures refer *only* to the use of the BioFlo 4500 *equipped with the ML-6100 controller*.

The top-entering agitation system incorporates a 1 HP direct drive on a 20- or 30- liter vessel, capable of agitation speeds from 50 to 1000 RPM. The speed is regulated electronically to compensate automatically for normal voltage fluctuations and changes in viscosity. A 1000-line frequency encoder is used to sense vessel agitation speed and to provide feedback for precise control.

Adjustable variable speed control is provided and utilizes feedback to hold RPM constant within ±1 RPM of the set value.

Two six-bladed, stainless steel, Rushton turbine impellers are mounted on the impeller shaft. as standard. Impellers are removable and adjustable along the length of the shaft. The impellers are sized to be capable of producing a minimum oxygen transfer rate of 350 mMoles of oxygen per liter per hour at minimum vessel pressure of 2 PSIG.

The agitation system is turned on when the main power switch (located on the side panel of the console) is turned on. Setpoints and control modes may then be entered at the touchscreen interface of the ML-6100. Agitation is accomplished by means of a motor rotating the shaft with impellers. Shaft revolution (speed) is indicated on the display gauge of the agitation control loop. Power for the motor operation is controlled by the main power switch (located on the side panel of the console). Agitation operating mode and setpoints are user- defined at the interface touchscreen monitor.

CAUTION!
The Agitator should be used whenever the fermentor is in the sterilize or temperature control mode.

A speed of 150-200 RPM is recommended during operation of the sterilization or temperature control mode. Agitation improves heat transfer between the liquid in the vessel and water or steam in the vessel jacket.

NOTE:

Agitation is not required during sterilization if the vessel is sterilized empty.

11.1 Operation

To operate the agitation control system:

1. Ensure that the main power switch is **ON** and that there is power to the fermentor.

2. Set the agitation control loop on the touchscreen to **PID** control.

NOTE:

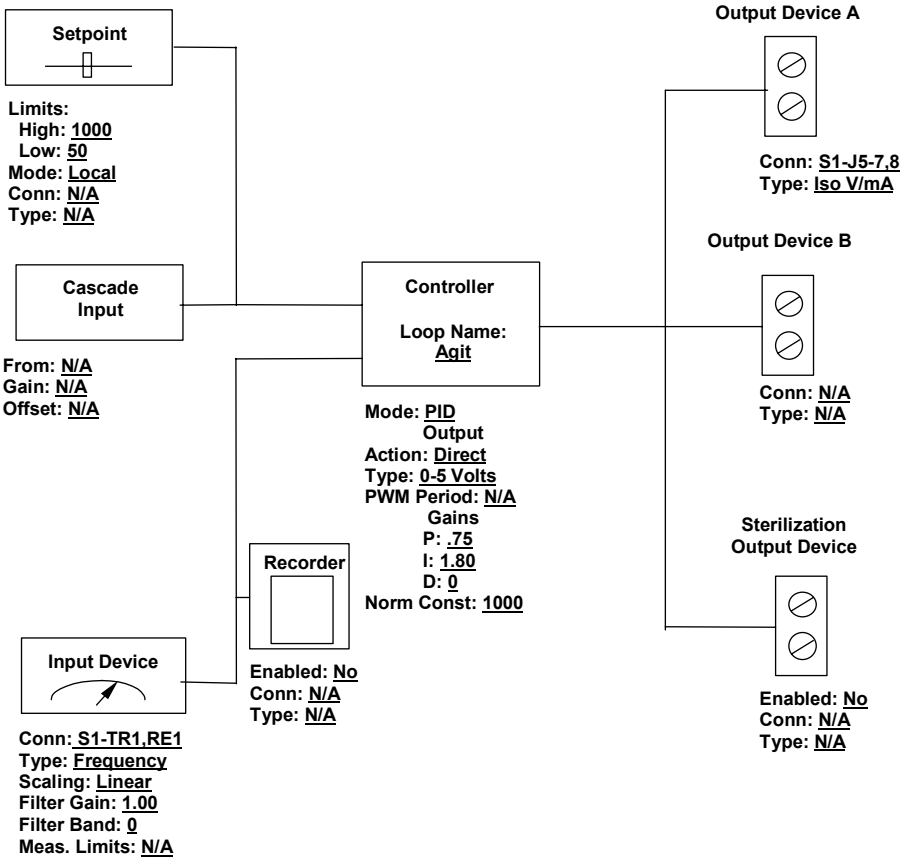
Optional Marine Blade, Pitched Blade or Medium Lift (Basket) impellers may be installed for all culture applications.

NOTE:

If the agitation control loop is cascaded from the DO control loop, the DO control loop may provide the setpoint for the Agitation control loop.

The factory settings for the agitation control loop are as shown on the following page.

Figure 22: Agitation Control Loop Configuration



11.2 Double Mechanical Seal (Optional)

If the fermentor has the double mechanical seal option, the stream pressure between the seals must be set prior to operation of the agitation system. The pressure should be set 2-3 PSI greater than the vessel pressure.

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12 ML-6100 AIR CONTROL SYSTEM

NOTE:

The following procedures refer *only* to the use of the BioFlo 4500 *equipped with the ML-6100 controller*.

The Filter elements used must be changed periodically to maintain proper filter operation. Because many operating and environmental variations exist between fermentations, a periodic check of the filter condition is required to determine when replacement is necessary. Initially, the filter element should be examined on a monthly basis and changed when:

- The filter is found to have deteriorated from repeated sterilizations.
- Oil or media is observed on the element.

Installed in the inlet sparge air line is a steam-sterilizable 0.2µ absolute filter that continuously removes viable organisms (relative humidity must be less than 95%). The filter is a cartridge type filter and is mounted in a 316L stainless steel housing. Domnick Hunter or other brand name filters can be supplied upon request.

All piping, valves and fittings in the air system are fabricated of 316L stainless steel.

All necessary valves, steam traps, check valves are provided for in-situ sterilization of the air inlet system.

SPARGE AIR PRESSURE is regulated by a **PRESSURE REGULATOR** and indicated on the air pressure gauge. Air is introduced at the bottom of the vessel through a ring sparger. The sparger can be removed for cleaning or for replacement with other types of spargers.

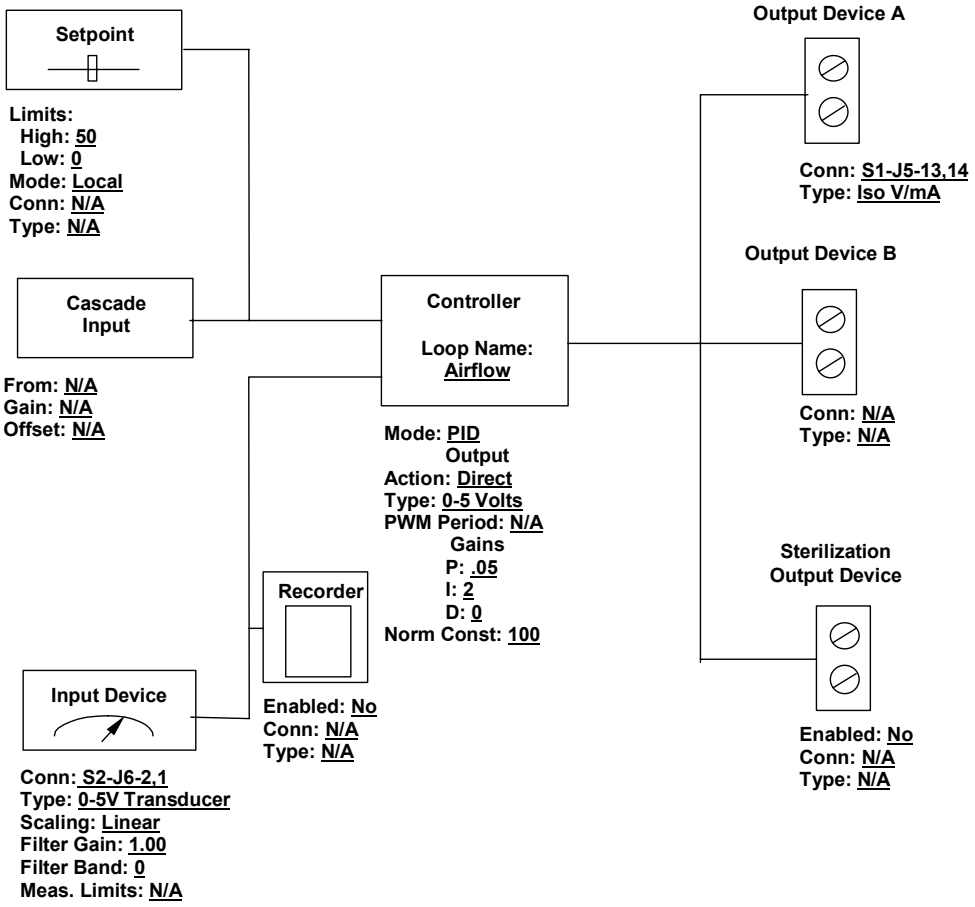
INLET GAS FLOW RATE is adjustable from 1 to 50 SLPM (50:1) by a control valve. Flow is monitored and controlled via a thermal mass flow controller device and displayed on the touchscreen display. The thermal mass flow controller, which can provide other flow rates, can be supplied as an option: 0.2-10 SLPM (50:1) for all culture applications.

NOTE:

For units with 4-gas control, please see the section on Four-Gas Control for the configuration of valves and loops to provide the correct flow rate and display of gas data.

The factory settings for the airflow control loop are as follows:

Figure 23: Airflow Control Loop Configuration



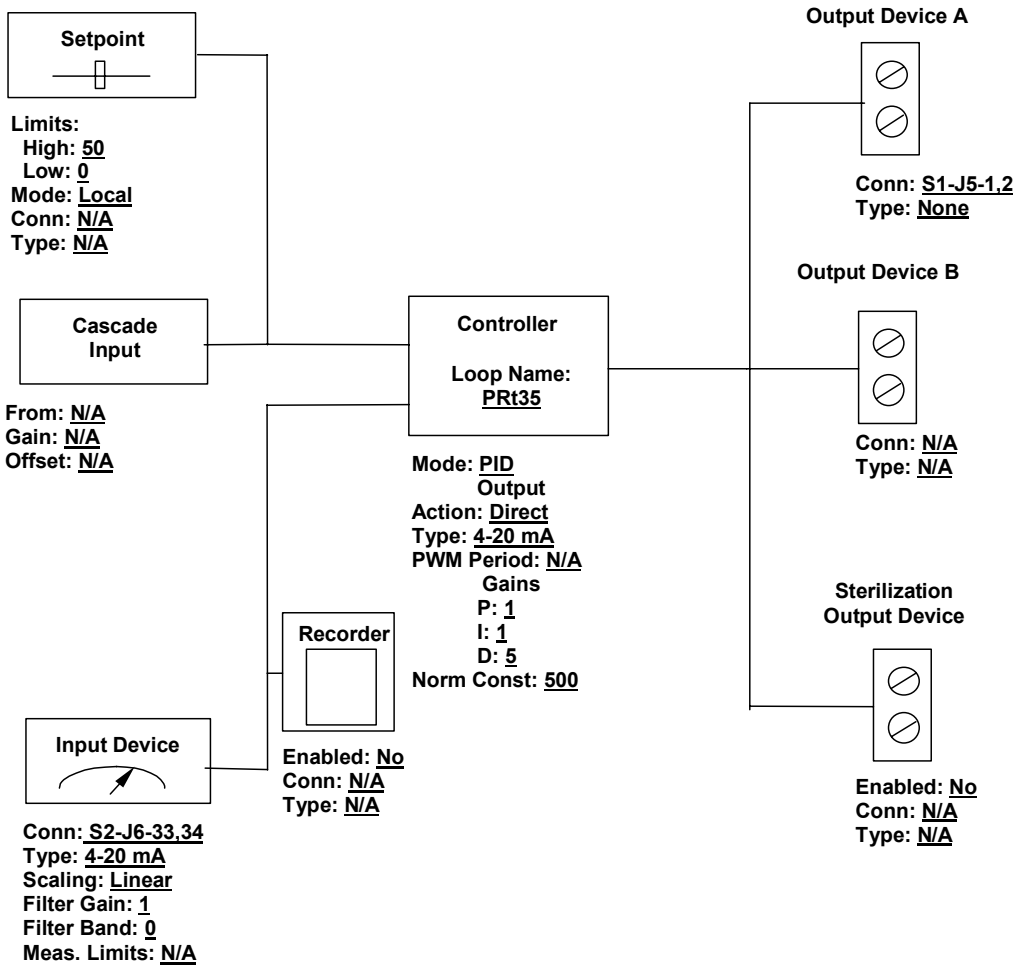
12.1 Vessel Pressure

MANUAL PRESSURE CONTROL: Manual pressure regulation is achieved with an in-line pressure gauge and a backpressure valve. The regulating valve is adjusted manually to produce the required vessel pressure as indicated on the gauge.

AUTOMATIC PRESSURE CONTROL (OPTIONAL): Automatic pressure control is obtained with an in-line pressure sensor and an air-operated backpressure regulating valve. The pressure sensor sends a signal to the controller that displays the system pressure and controls the output to the valve. The controller sends a 4-20 mA signal that is converted to pressure by a current-to-pressure (I to P) device. Changes to vessel pressure are made at the touchscreen.

The pressure control loop is configured as follows:

Figure 24: Pressure Control Loop Configuration



12.2 Exhaust Gas Treatment

12.2.1 Exhaust Air (Gas) Filters:

The exiting air is filtered by a cartridge type 316L filter (supplied with the system). Each filter element is located in its own in-line stainless steel housing. The filter is sterilized during the last phase of vessel sterilization by steam passed through the filter.

The exhaust filter is heated to raise the exhaust gas above its dew point. The heater upstream of the exhaust filter has a valve associated with it. This is located on the exposed piping side of the rear panel and clearly labeled as the **EXHAUST STEAM HEATER VALVE**. It must be fully open during operation of the fermentor, and is only closed when the filter housing needs to be cleaned due to a foam-over.

A safety-relief, blowout, stainless steel rupture disc is mounted on the headplate of the fermentor vessel. This protects the vessel from accidental over-pressure. Exhaust gas enters the exhaust line through a stainless steel connection mounted on the fermentor headplate. The gas then enters a stainless steel heat exchanger that heats the exhaust gas above its dew point. Next the gas enters a steam-sterilizable, depth (optional 0.2µ absolute) filter which is installed to continuously remove viable organisms. Finally, the gas enters the vessel pressure regulator and then exits to the atmosphere. The vessel pressure is regulated by a manually operated pressure regulator. The exhaust line is fabricated of stainless steel. A pressure gauge mounted on the piping skid is provided to indicate vessel pressure.

12.3 Operation of Sparge System

To operate the Sparger Air System:

- Ensure that connections of air into and out of the fermentor are tight. Also check the **INLET FILTER CARTRIDGE** as described above.

- Adjust the airflow rate and the vessel pressure manually or at the touchscreen (if appropriate) in the airflow control loop. Make sure that another loop is not attempting to control air (gas) flow.

13 ML-6100 TWO-, THREE- & FOUR-GAS CONTROL

NOTE:

The following procedures refer *only* to the use of the BioFlo 4500 *equipped with the ML-6100 controller*.

The optional gas mixing modules are activated when the **GAS MIX CONTROLLER OUTPUT TYPE** is selected on a specific loop. With the **GAS MIX CONTROLLER OUTPUT TYPE** selected, the controller mixes combinations of air, oxygen, nitrogen and carbon dioxide as required to control DO and pH. A constant flow rate is maintained during this process. The composition of the gas mixture is determined by the duty cycle of the solenoid valves that control the flow of the respective gases. The time required to cycle once through all four valves is called the Pulse Width Modulation (PWM) Period. It is typically set to 10 seconds, but the time period can be made shorter for smoother control, or longer for extended valve life.

WARNING!
We highly recommend that you clean the gas lines & air inlet line prior to use with oxygen, in order to remove any combustible oils that may be present.

Special Note for Four-Gas Applications:

In systems equipped with four-gas control, two thermal mass flow controllers have been provided. When fermentation is the primary task, the controller rated for larger flow (1 to 50 SLPM) should be used, while for a cell culture application, where four-gas control is essential, a controller rated for smaller flow (0.2 to 10 SLPM) has been supplied. Two flow controllers are needed to give adequate control at the different flow rates required.

Each flow controller has been equipped with a blocking valve located just before the flow meter. To choose the appropriate flow meter, simply open the valve that corresponds to the flow meter of choice.

The ML-6100 controller has been set up with two loops. **GAS1** is set up to control the large flow controller, and **GAS2** controls the smaller flow controller. Change the control mode for the required loop to either **ON** or **P-I-D**, and change the control mode for the non-required meter to **OFF**.

The loop called **AIRFLOW** in Section on the *Air System* is the **GAS1** loop in four-gas applications. It is configured exactly the same way.

The **GAS2** loop is very similar, but there are changes in the Input Device and Output Device. The PID values also differ loop to loop. For more specific details about four-gas control, see Section 13.5 below.

WARNING!
Gases used in 2-, 3- and 4-gas mixing must be oil-free, must be particulate-free, and must meet 85% relative humidity requirements.

13.1 Setting Up the Two-, Three- or Four-Gas Mixer Option

Typically, the two-gas mixer is used to supplement the air stream with pure oxygen to meet the huge oxygen requirements of high density cell cultures. The three-gas mixer is often used to mix Air, O_2, and CO_2 or N_2 to provide the appropriate conditions for interactive pH & DO, central to feed batch mode. With the built-in four-gas controller, N_2, O_2, CO_2, and air are mixed to provide interactive control of pH and DO in batch or perfusion modes.

With the Gas Mix controller output type selected, the controller mixes combinations of air, oxygen, nitrogen and carbon dioxide as required to control DO and pH. A constant gas flow rate is maintained during this process. The composition of the gas mixture is determined by the duty cycle of the solenoid valves which control the flow of the respective gases. The time required to cycle once through all four valves is called the Pulse Width Modulation Period or PWM Period. It is typically set to 10 seconds, but the time period can be made shorter for smoother control, or longer for extended valve life.

The gas mix control mode is determined by the controller output action and the presence of a cascade input to the loop:

Control Mode	*Cascade Input*	*Output Action*	*Gases Mixed*	*Application*
2-Gas	No	Direct	Air and O_2	Oxygen enrichment
2-Gas	Yes	2 Ch Comp	Air and O_2	Cascade-driven oxygen enrichment
3-Gas	No	Center Off	Air, N_2 and O_2	Bi-directional DO Control
3-Gas	Yes	Direct	Air, O_2, and CO_2	Oxygen enrichment w/ CO_2 addition for pH control
4-Gas	Yes	Center Off	Air, N_2, O_2, and CO_2	Bi-directional DO Control w/ CO_2 addition for pH control

The configuration of a control loop for gas mixing is completed by selecting the output device type as SSR4 and the output device connector ID.

SSR4 is a set of four dedicated solid state relays (SSRs) which must be chosen for this operation. For the gas mix to work appropriately, the relay pairs must be connected to the gas solenoid valves. The correct order for connecting the solenoid valves is as follows:

Gas Solenoid Valve	*Output Device Conn: S5-Txo-1,8*	*Output Device Conn: S5-Txo-9,16*
CO_2	1,2	9,10
Nitrogen	3,4	11,12
Oxygen	5,6	13,14
Air	7,8	15,16

SSR	*Gas*
1	CO_2
2	Nitrogen
3	Oxygen
4	Air

The controller causes the valves to pulse open for different fractions of a user-specified time to obtain different mixing ratios. A constant and continuous flow is maintained for all mixtures.

13.2 Oxygen Enrichment

13.2.1 Set-Up Summary

Control Loop	*Cascade Input*	*Output Action*	*Controller Output Type*	*Device Control Type*
DO	None	Direct	0-5 Volts	None
Agitation	DO	-	-	-
Gas Flow	DO	-	-	-
Oxygen	DO	Direct	Gas Mix	SSR4

13.2.2 Set-Up Procedure

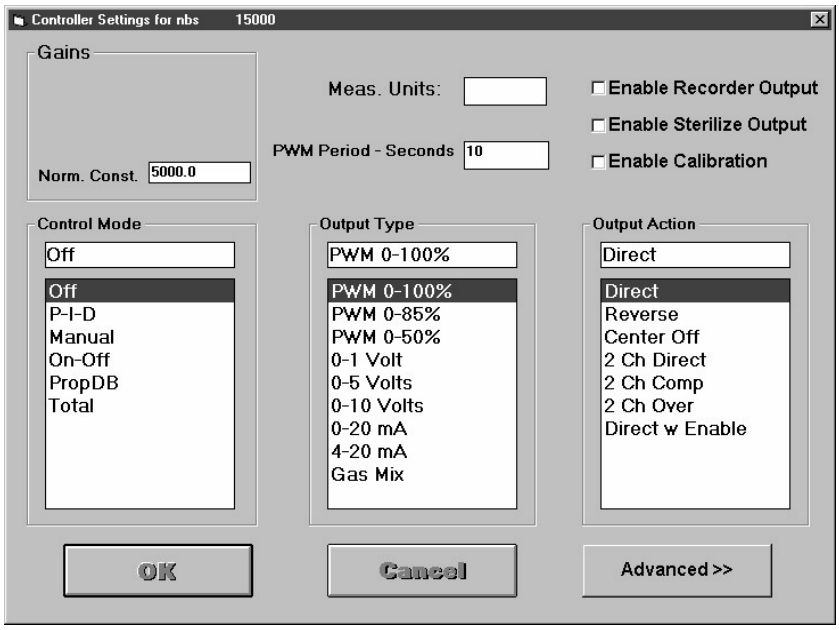
To set up the existing DO control loop for oxygen enrichment:

1. From the **GAUGE SCREEN**, press the **CONFIG. BUTTON**. The **MAIN CONFIGURATION SCREEN** will appear.

2. Select the DO control loop and press **CONFIGURE**. The **LOOP CONFIGURATION SCREEN** will appear.

3. Touch the **CONTROLLER ICON** on the **LOOP CONFIGURATION SCREEN**.

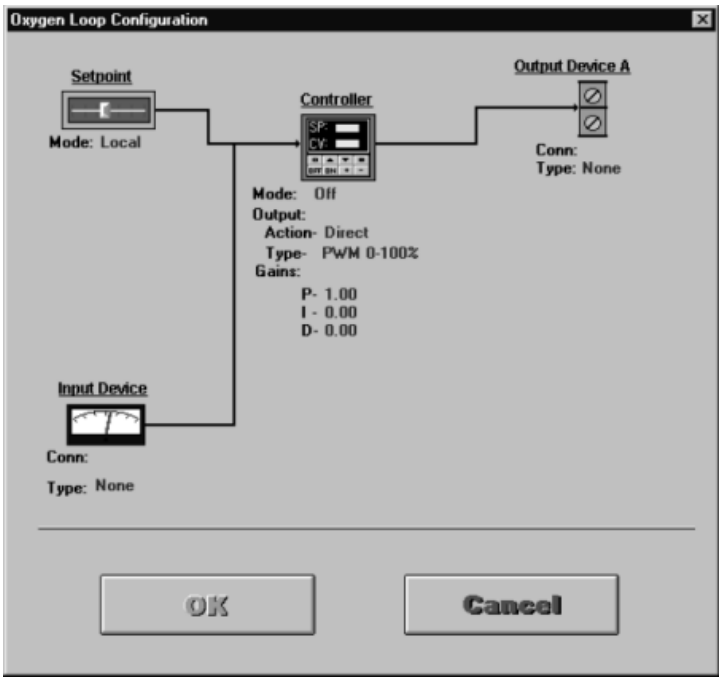
4. The **CONTROLLER SETTINGS SCREEN** will appear.



5. For the **OUTPUT TYPE**, select any type other than **GAS MIX,** and for the **OUTPUT ACTION**, select **DIRECT**.

6. The Press **OK** to accept these settings, and return to the **LOOP CONFIGURATION SCREEN**.

7. In the **LOOP CONFIGURATION SCREEN**, verify the **OUTPUT TYPE** for the **OUTPUT DEVICE**. If it is **NONE**, press **OK** to accept the changes to the controller settings and return to the **MAIN CONFIGURATION SCREEN**. If it is not, touch the **OUTPUT DEVICE ICON**. The select **OUTPUT DEVICE SCREEN** will appear. Select **NONE** as the **OUTPUT TYPE**.



8. Press **OK** to accept these settings and return to the **LOOP CONFIGURATION SCREEN**.

9. Press **OK** to exit the **LOOP CONFIGURATION SCREEN**.

10. A message will appear, press **YES** to accept changes to the DO loop, **NO** to decline.

11. Exit the **MAIN CONFIGURATION SCREEN** by pressing the **CLOSE BUTTON**.

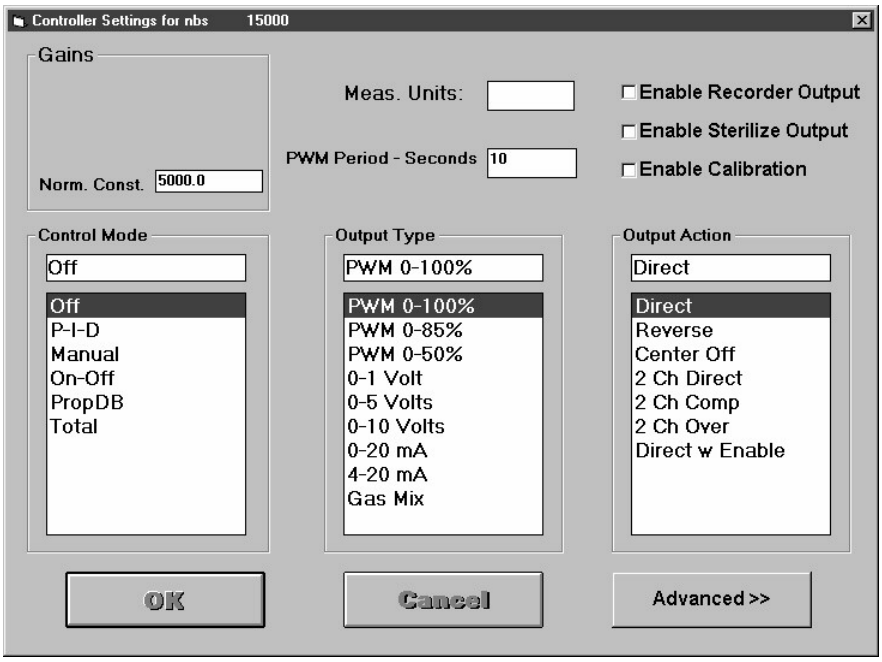
For this application, the oxygen control loop must have a cascade input from the DO control loop. If there is no oxygen control loop, it must be added to the controller configuration. Perform the following to setup the oxygen control loop for oxygen enrichment:

12. From the **GAUGE SCREEN**, press the **CONFIG. BUTTON**. The **MAIN CONFIGURATION SCREEN** will appear.

13. Select the Oxygen control loop and press **CONFIGURE**. The **LOOP CONFIGURATION SCREEN** will appear.

14. Touch the **CONTROLLER ICON** on the **LOOP CONFIGURATION SCREEN**.

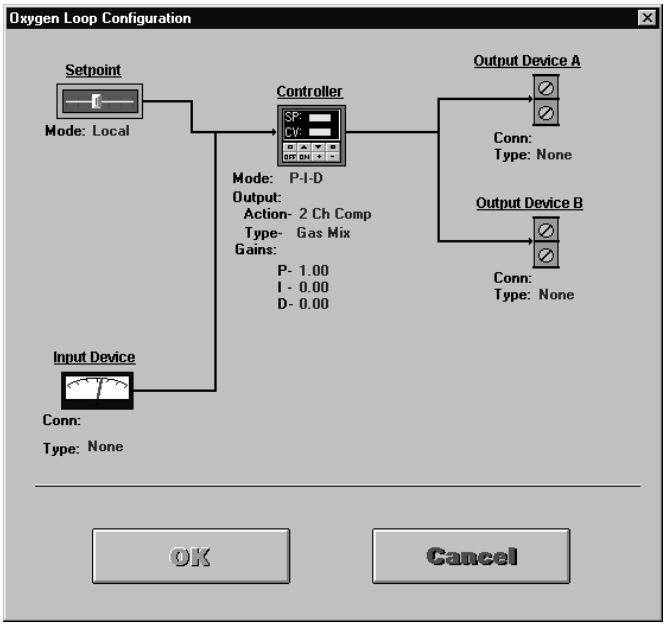
15. The **CONTROLLER SETTINGS SCREEN** will appear.



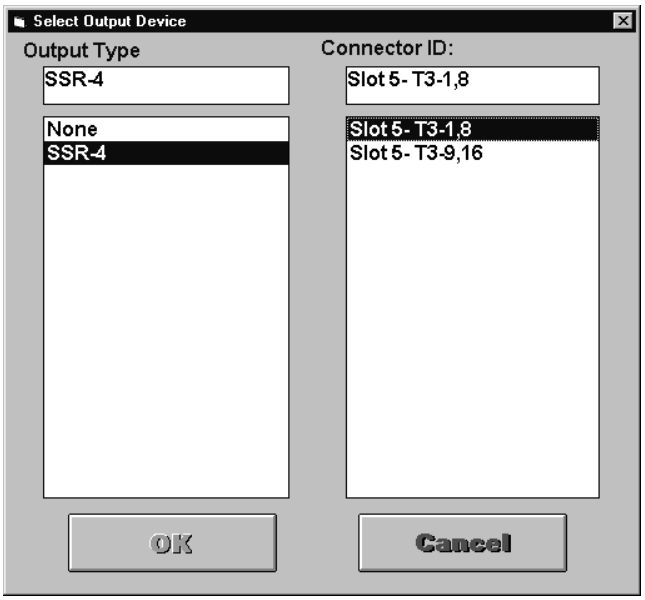
16. For the **OUTPUT TYPE**, select **GAS MIX,** and for the **OUTPUT ACTION**, select **2 Ch Comp**.

17. Enter the **PWM PERIOD** in seconds (the default value is 10 seconds) by pressing on the text box and entering in the time using the keyboard.

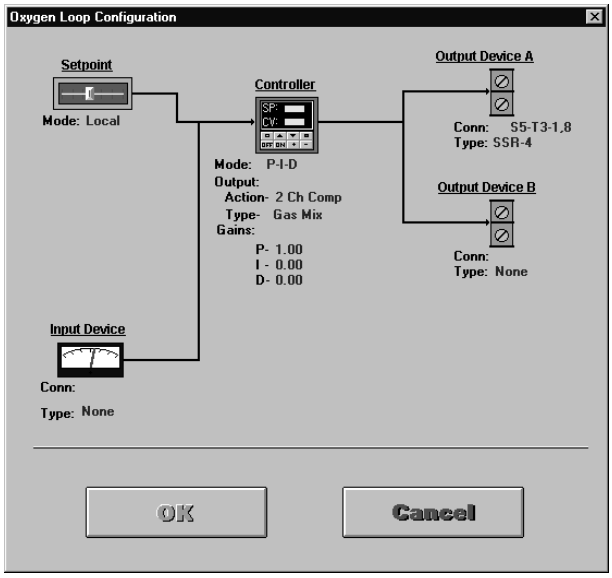
18. Press **OK** to accept these settings.



19. In the **LOOP CONFIGURATION SCREEN**, touch the **OUTPUT DEVICE "A" ICON**. The **SELECT OUTPUT DEVICE SCREEN** will appear.
20. Select **SSR-4** as the **OUTPUT TYPE** and choose the corresponding **CONNECTOR ID** (the group of four SSRs that the gas solenoid valves will be connected to).



21. Press **OK** to accept these settings, and return to the **LOOP CONFIGURATION SCREEN**.

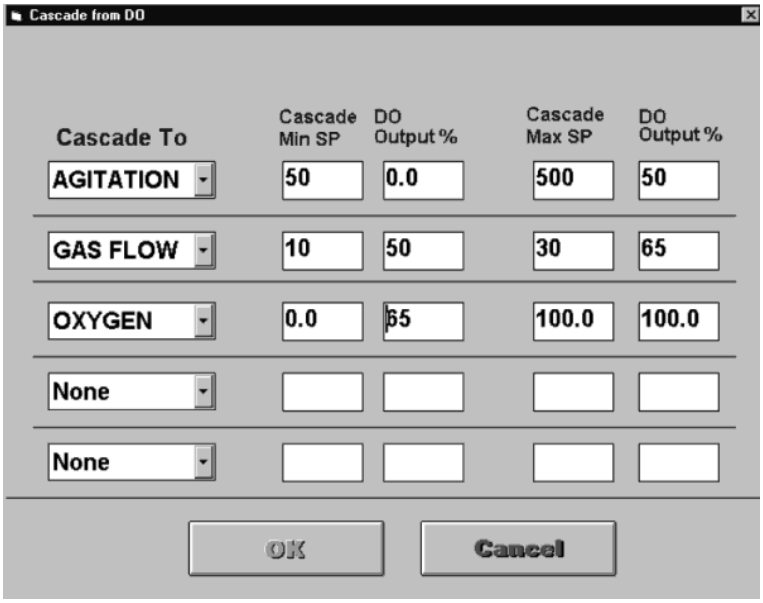


22. Verify that **OUTPUT TYPE** for the **OUTPUT DEVICE B** is **NONE**, and Press **OK** to exit the **LOOP CONFIGURATION SCREEN**.

23. A message will appear, press **YES** to accept changes to the Oxygen control loop, **NO** to decline.

24. Exit the **MAIN CONFIGURATION SCREEN** by pressing the **CLOSE BUTTON**.

Refer to the Cascade Control section of this manual for general instructions on cascades. A typical oxygen enrichment cascade is shown below:



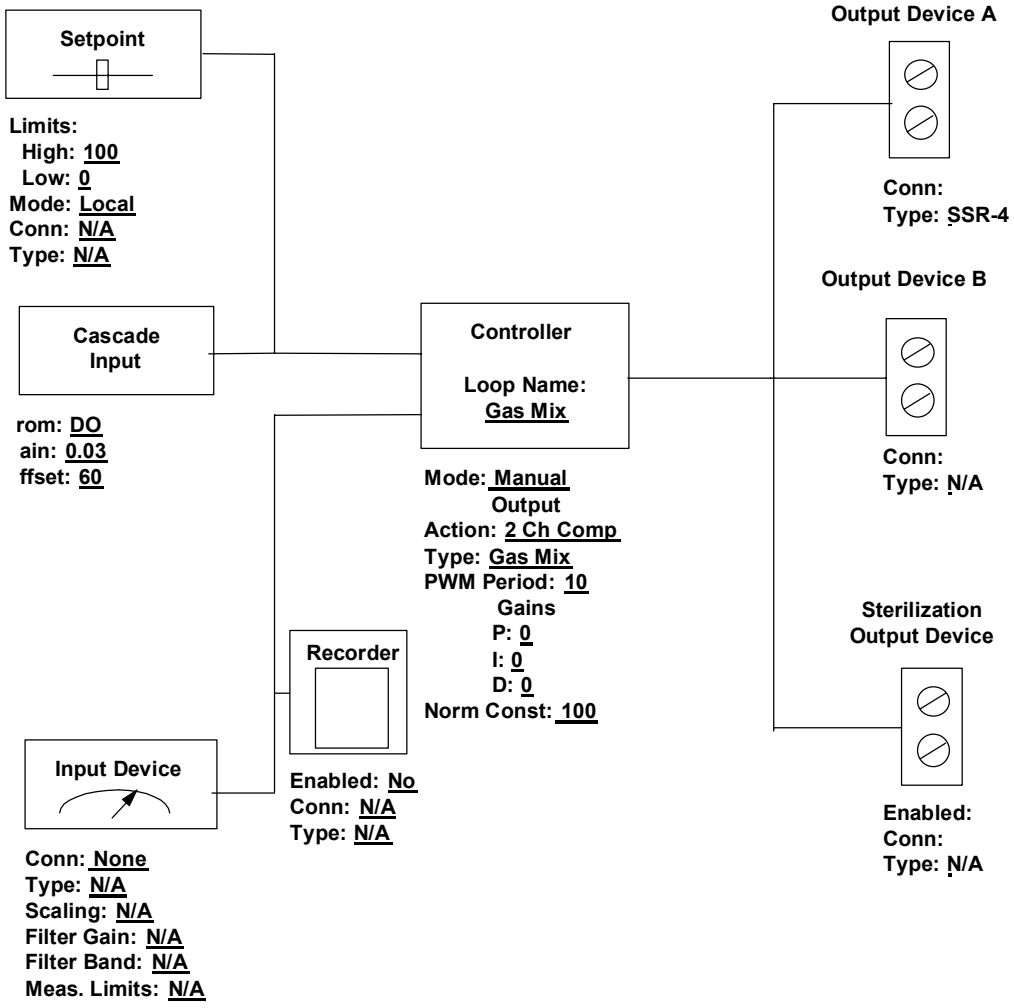
This set-up responds to culture DO demand with changes in agitation for DO loop outputs between 0 and 50%, then with gas flow for DO loop outputs between 50 and 65%, and finally with oxygen enrichment for DO output greater than 65%.

These transition percentages and agitation and gas flow values are examples only, not recommendations. They may be inappropriate for some fermentors.

The control mode of the oxygen control loop display gauge in the **GAUGE SCREEN** will now display **2-GAS**.

Following is a diagram of this cascade-driven oxygen enrichment configuration.

Figure 25: Oxygen Enrichment Control Configuration



13.3 Two-Gas

13.3.1 Control Action

In two gas mixing, air and oxygen mix for control of Dissolved Oxygen (DO) whenever demand exceeds the oxygen transfer rate obtainable with air alone, as indicated by the DO loop output. The controller maintains a constant and continuous gas flow.

13.3.2 Control Procedure

To configure a two-gas mix:

1. Clear any existing cascade ***to*** the DO control loop. The DO gauge indicates which loops, if any, are cascaded to the DO loop. It is not necessary to clear cascades ***from*** the DO loop as displayed on the DO cascade screen.

2. From the **GAUGE SCREEN**, press the **CONFIG. BUTTON**. The **MAIN CONFIGURATION SCREEN** will appear.

3. Select the DO control loop and press **CONFIGURE**. The **LOOP CONFIGURATION SCREEN** will appear.

4. Touch the **CONTROLLER ICON** on the **LOOP CONFIGURATION SCREEN**. The **CONTROLLER SETTINGS SCREEN** will appear.

5. For the **OUTPUT TYPE**, select **GAS MIX,** and for the **OUTPUT ACTION**, select **DIRECT**.

6. Enter the **PWM PERIOD** in seconds (the default value is 10 seconds) by pressing on the text box and entering in the time using the keyboard. The **PWM PERIOD** is the time required to cycle once through all of the gas solenoid valves.

7. Press **OK** to accept these settings, and return to the **LOOP CONFIGURATION SCREEN**.

8. In the **LOOP CONFIGURATION SCREEN**, touch the **OUTPUT DEVICE ICON**. The **SELECT OUTPUT DEVICE SCREEN** will appear.

9. Select **SSR-4** as the **OUTPUT TYPE** and choose the corresponding **CONNECTOR ID** (the group of four SSRs that the gas solenoid valves will be connected to).
10. Press **OK** to accept these settings, and return to the **LOOP CONFIGURATION SCREEN**.

11. Press **OK** to exit the **LOOP CONFIGURATION SCREEN**.

12. A message will appear. Press **YES** to accept changes to the DO loop, **NO** to decline.

13. Exit the **MAIN CONFIGURATION SCREEN** by pressing the **CLOSE BUTTON**. The control mode of the DO control loop display gauge in the **GAUGE SCREEN** will now display **2-GAS**.

13.4 Three-Gas

13.4.1 Control Action

Air, O_2, and CO_2 or N_2 are blended in response to culture oxygen demand, as indicted by the DO loop output. The controller determines the gas mixture, and ensures a constant and continuous gas flow.

13.4.2 Control Procedure

To configure a three-gas mix:

1. Clear any cascade input that may be connected to the DO control loop.

2. From the **GAUGE SCREEN**, press the **CONFIG. BUTTON**. The **MAIN CONFIGURATION SCREEN** will appear.

3. Select the DO control loop and press **CONFIGURE**. The **LOOP CONFIGURATION SCREEN** will appear.

4. Touch the **CONTROLLER ICON** on the **LOOP CONFIGURATION SCREEN**. The **CONTROLLER SETTINGS SCREEN** will appear.

5. For the **OUTPUT TYPE**, select **GAS MIX,** and for the **OUTPUT ACTION**, select **CENTER OFF**.

6. Enter the **PWM PERIOD** in seconds (the default value is 10 seconds) by pressing on the text box and entering in the time using the keyboard. The **PWM PERIOD** is the time in which the controller will cycle through each of the solenoid valves connected to the SSRs.

7. Press **OK** to accept these settings, and to return to the **LOOP CONFIGURATION SCREEN**.

8. In the **LOOP CONFIGURATION SCREEN**, touch the **OUTPUT DEVICE ICON**. The **SELECT OUTPUT DEVICE SCREEN** will appear.

9. Select **SSR-4** as the **OUTPUT TYPE** and choose the corresponding **CONNECTOR ID** (the group of four SSRs that the gas solenoid valves will be connected to).

10. Press **OK** to accept these settings, and return to the **LOOP CONFIGURATION SCREEN**.

11. Press **OK** to exit the **LOOP CONFIGURATION SCREEN**.

12. A message will appear. Press **YES** to accept changes to the DO control loop, **NO** to decline.

13. Exit the **MAIN CONFIGURATION SCREEN** by pressing the **CLOSE BUTTON**. The control mode of the DO control loop display gauge in the **GAUGE SCREEN** will now display **3-Gas**.

13.5 Four-Gas

13.5.1 Control Action

Air, oxygen, nitrogen, and carbon dioxide are mixed in response to pH and DO culture demand as indicated by pH and DO loop outputs. The controller determines the gas ratios, and ensures a constant and continuous gas flow at all ratios.

13.5.2 Control Procedure

To configure a four-gas mix:

1. Set up a cascade in which the output of the pH control loop is input to the DO loop. The specific setpoint and output values in the cascade do not matter. The Gas Mix algorithm alone determines the gas mix ratios.

2. From the **GAUGE SCREEN**, press the **CONFIG. BUTTON**. The **MAIN CONFIGURATION SCREEN** will appear.

3. Select the DO control loop and press **CONFIGURE**. The **LOOP CONFIGURATION SCREEN** will appear.

4. Touch the **CONTROLLER ICON** in the **LOOP CONFIGURATION SCREEN**. The **CONTROLLER SETTINGS SCREEN** will appear.

5. For the **OUTPUT TYPE**, select **GAS MIX,** and for the **OUTPUT ACTION**, select **CENTER OFF**.

6. Enter the **PWM PERIOD** in seconds (the default value is 10 seconds) by pressing on the text box and entering in the time using the keyboard. The **PWM PERIOD** is the time that controller will cycle through each of the connected SSRs.

7. Press **OK** to accept these settings, and to return to the **LOOP CONFIGURATION SCREEN**.

8. In the **CONTROLLER SETTINGS SCREEN**, touch the **OUTPUT DEVICE ICON**. The **SELECT OUTPUT DEVICE SCREEN** will appear.

9. Select **SSR-4** as the **OUTPUT TYPE** and choose the corresponding **CONNECTOR ID** (the group of four SSRs that the gas solenoid valves will be connected to).

10. Press **OK** to accept these settings and return to the **LOOP CONFIGURATION SCREEN**.

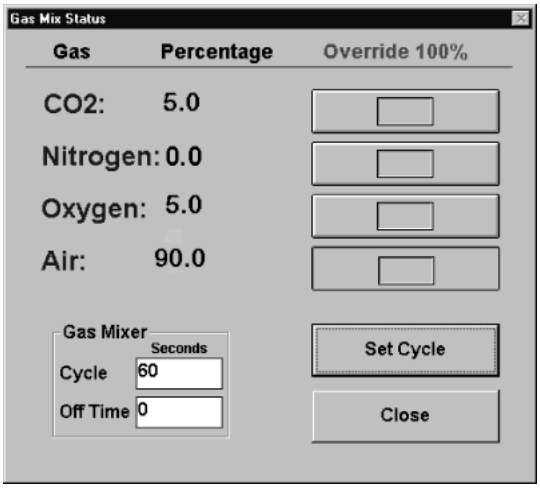
11. Press **OK** to exit the **LOOP CONFIGURATION SCREEN**. A message will appear, press **YES** to accept changes to the DO loop, **NO** to decline.

12. Exit the **MAIN CONFIGURATION SCREEN** by pressing the **CLOSE BUTTON**. The control mode of the DO loop display gauge in the **GAUGE SCREEN** will now display **4-GAS**.

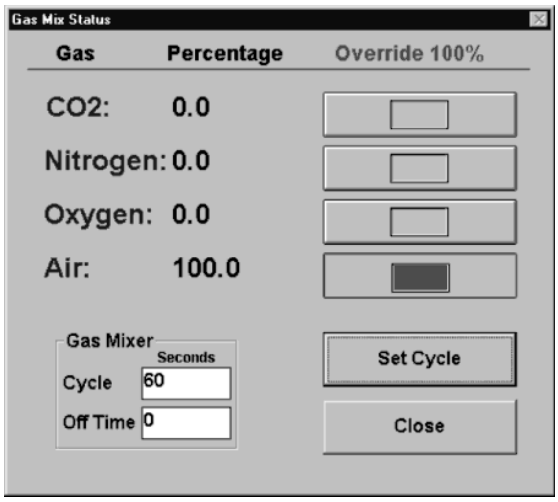
13.6 Viewing Gas Mix Status

To view the current status of a gas mix:

- In the **GAUGE SCREEN**, press **4-Gas** in the DO loop display gauge.
- The **GAS MIX STATUS WINDOW** will appear.



- The current composition of the gas mixture is displayed in the percentage column. To override the gas mix controller, press the appropriate override button to force the selected gas to 100%.



- To set the gas mix cycle, press the area inside the Cycle text box. Enter the desired time that you wish to mix gases in seconds.

- To set the time that the gas mix will be off, press the area inside the Off Time text box.

- Once the Cycle time and Off Time have been entered, press the **SET CYCLE BUTTON** to start the gas mix cycle.

NOTE:

The gas mix cycle time is used to ensure proper operation of the gas mix impeller. The exact settings are process dependent and must be empirically established for each process.

- To exit this window, press the **CLOSE BUTTON**.

14 ML-6100 PUMP CONTROL

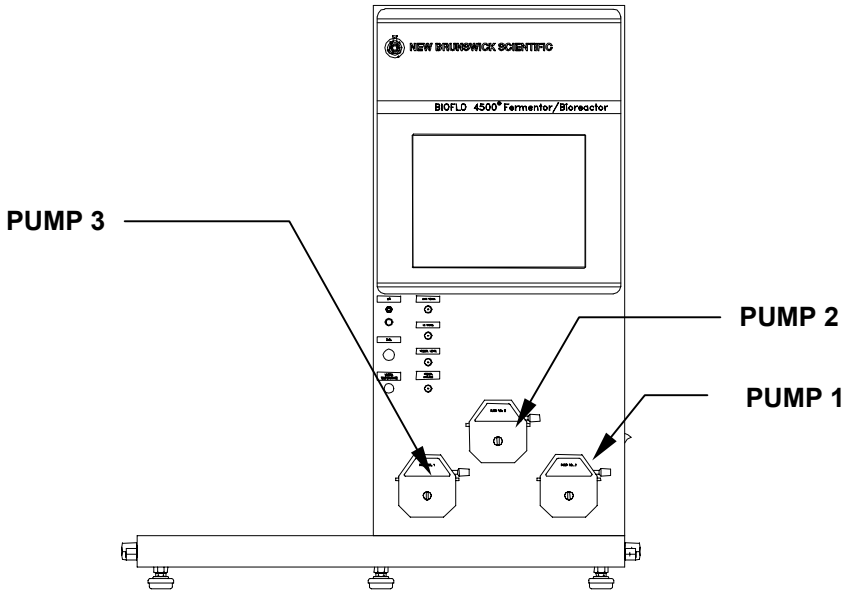
NOTE:

The following procedures refer *only* to the use of the BioFlo 4500 *equipped with the ML-6100 controller*.

The BioFlo 4500 is designed to accommodate up to four optional peristaltic pumps for nutrient addition, pH control, foam control, or other processes. Three of these pumps are mounted on the piping front panel of the fermentor console. Each of these pumps is labeled from one to three.

The fourth pump is a user-supplied auxiliary pump that is connected to the **AC PUMP OUTPUT RECEPTACLE**, on the rear panel of the console. The receptacle is controlled by the ML-6100 controller and its control action is on/off. The supply voltage for the fourth pump is connected to the console by a power cord at the **PUMP AC POWER IN RECEPTACLE**, located beneath the **AC PUMP OUTPUT RECEPTACLE**.

Figure 26: Pump Configuration (with Piping Removed)



Unless otherwise specified, the pumps will be factory-configured for the following usage:

Pump 1	*Pump 2*	*Pump 3*	*Pump 4 (Aux. Pump)*
Base Addition	not assigned	Antifoam Addition	not assigned

Refer to each subsystem section for pump operation. Each pump control loop configuration can be changed to meet process requirements. For example, Pump 4 instead of Pump 3 can be assigned or re-assigned for antifoam addition.

14.1 Pump Capacity

The following chart lists pumping capacities for the pumps that are available:

Masterflex L/S™ Tubing	***Flow Rate ml/rev***	***Discharge Pressure* Continuous PSIG (bar)***	***Discharge Pressure* Intermittent PSIG (bar)***
L/S 13	0.06	25 (1.7)	40 (2.7)
L/S 14	0.21	25 (1.7)	40 (2.7)
L/S 16	0.80	25 (1.7)	40 (2.7)
L/S 25	1.70	20 (1.4)	35 (2.4)
L/S 17	2.80	15 (1.0)	20 (1.4)
L/S 18	3.80	15 (1.0)	15 (1.4)

* As tested with Noprene, Pharmed, and Tygon Tubing.
Values will be lower for silicone and C-Flex Tubing.

14.2 Tubing Selection

Outside diameter Inch (mm)	***5/32 (3.9)***	***3/16 (4.8)***	***¼ (6.4)***
Tubing Cross Sections	***TM L/S 13***	***TM L/S 14***	***TM L/S 16***
Inside Diameter inch (mm)	1/32 (0.8)	1/16 (1.6)	1/16 (3.1)
Hose Barb Size inch (mm)	1/16 (1.6)	1/16 (1.6)	1/8 (3.2)
Flow Range ml/minute with 6 to 600 rpm drive	0.36-36	01.3-130	4.8-480
Maximum Continuous Pressure	20 psig (1.4 bar)	20 psig (1.4 bar)	20 psig (1.4 bar)
Maximum Intermittent Pressure	40 psig (2.7 bar)	40 psig (2.7 bar)	40 psig (2. bar)
Maximum Vacuum	26 in. Hg (660 mm Hg)	26 in. Hg (660 mm Hg)	26 in. Hg (660 mm Hg)
Suction Lift	29 ft. H_2O (8.8 m H_2O)	29 ft. H_2O (8.8 m H_2O)	29 ft. H_2O (8.8 m H_2O)

Tubing Cross Sections	*L/S 25*	*L/S 17*	*L/S 18*
Inside Diameter inch (mm)	0.19 (4.8)	0.25 (6.4)	0.31 (7.9)
Hose Barb Size inch (mm)	3/16 (4.8)	1/4 (6.4)	3/8 (9.5)
Flow Range ml/min with 6 to 600 rpm drive	1.7-10.0	2.8-17.0	3.8-23.0
Maximum Continuous Pressure	20 psig (1.4 bar)	20 psig (1.4 bar)	20 psig (1.4 bar)
Maximum Intermittent Pressure	35 psig (2.4 bar)	35 psig (2.4 bar)	35 psig (2.4 bar)
Maximum Vacuum	26 in. Hg (660 mm Hg)	20 in. Hg (510 mm Hg)	20 in. Hg (510 mm Hg)
Suction Lift	29 ft. H_2O (8.8 m H_2O)	22 ft. H_2O (6.7 m H_2O)	22 ft. H_2O (6.7 m H_2O)

Tubing Part Numbers	*L/S 13*	*L/S 14*	*L/S 16*	*L/S 25*	*L/S 17*	*L/S 18*
NBS Silicone*	P0740-2331	P0740-2325	P0740-2405	P0740-2505	P0740-2540	P0740-2646
Silicone (Peroxide)	96400-13	96400-14	96400-16	96400-25	96400-17	96400-18
Silicone (Platinum)	96410-13	96410-14	96410-16	96410-25	96410-17	96410-18
Tygon Lab (R-3603)	6409-13	6409-14	6409-16	6409-25	6409-17	6409-18
Tygon LFL	6429-13	6429-14	6429-16	6429-25	6429-17	6429-18
Tygon Fuel (F-4040-A)	6401-13	6401-14	6401-16	6401-25	6401-17	6401-18
Tygon Food (B-44-4X)	6419-13	6419-14	6419-16	6419-25	6419-17	6419-18

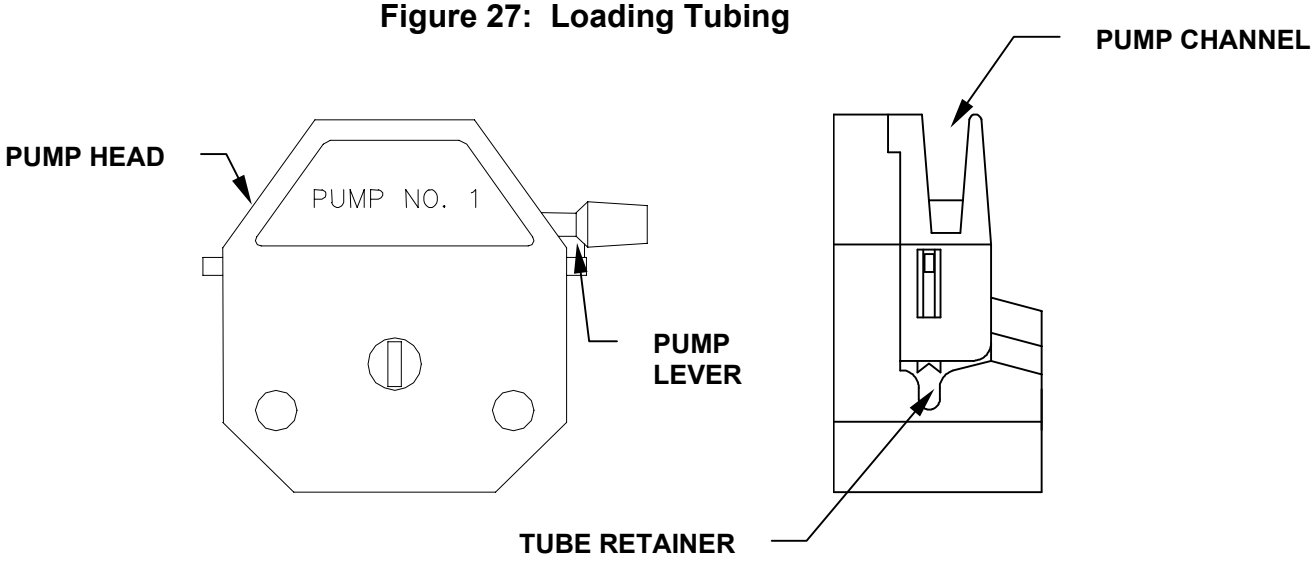
* Can only be ordered through NBS, the remaining are Masterflex part numbers

14.3 Loading Tubing into Pump Head

Before you insert the tubing into the **PUMP CHANNEL**, verify that the **PUMP LEVER** and the **TUBING RETAINERS** are in the open position. With reference to the drawing on the following page, follow these steps to properly load tubing into the **PUMP HEAD**:

- To open the **PUMP HEAD**, flip the black **PUMP LEVER** to the left.

Figure 27: Loading Tubing



- On the right (outlet) side of the **PUMP HEAD**, press the black **TUBING RETAINER** inward and up until **TUBING RETAINER** is in the up position (retracted).
- On the left (inlet) side of the **PUMP HEAD**, press the black **TUBING RETAINER** inward and up until **TUBING RETAINER** is in the up position (retracted).
- Guide tubing into, and through the **PUMP CHANNEL**.
- Flip the black **PUMP LEVER** on the **PUMP HEAD** to the right side and verify that the lever locks into place.
- On the right (outlet) side of the **PUMP HEAD**, press the black **TUBING RETAINER** inward and down until the **RETAINER** pinches the tubing.
- On the left (inlet) side of the **PUMP HEAD**, press the black **TUBING RETAINER** inward and down until the **RETAINER** pinches tubing.

14.4 Pump Calibration

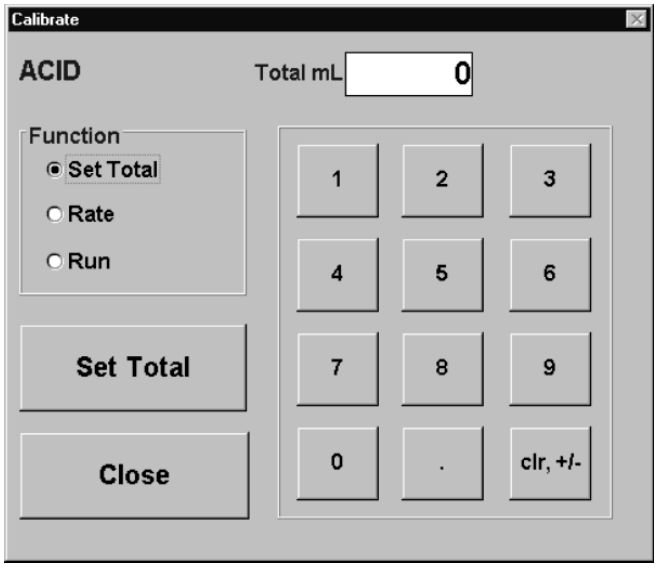
NOTE:

The following procedures refer *only* to the use of the BioFlo 4500 *equipped with the ML-6100 controller*.

The four pump control loops can be used to calibrate each pump. To do so, the control mode and output action of each loop must be changed to **TOTAL** and **DIRECT**. When a loop is configured with a control mode of **TOTAL**, the display gauge displays the sum of its output since last reset. This control mode is typically used to monitor accumulated totals of pump or other actuators. Calibrating this type of loop consists of running the pump or other actuator for a known period of time, and measuring the accumulated total in volume, mass, etc.

To calibrate a total control loop:

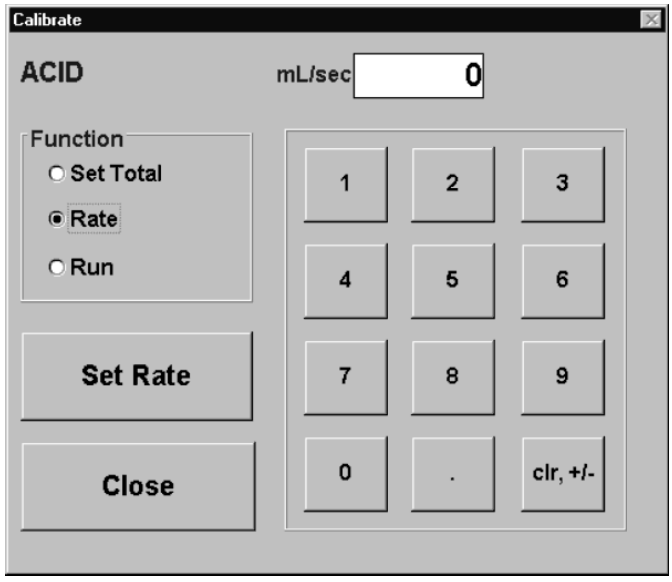
- In the **GAUGE SCREEN**, set the loop setpoint from the display gauge to zero.
- From the **GAUGE SCREEN**, select the **CAL BUTTON**. The **CALIBRATION SELECTION WINDOW** will appear.
- Select the control loop you wish to calibrate by pressing on it. A **CALIBRATION SCREEN** will appear.



- In the function window, press the **SET TOTAL FUNCTION**. Enter 0 using the onscreen keypad and press the **SET TOTAL BUTTON**.

If the pump or actuator used has been calibrated, and its flow or transfer rate is known:

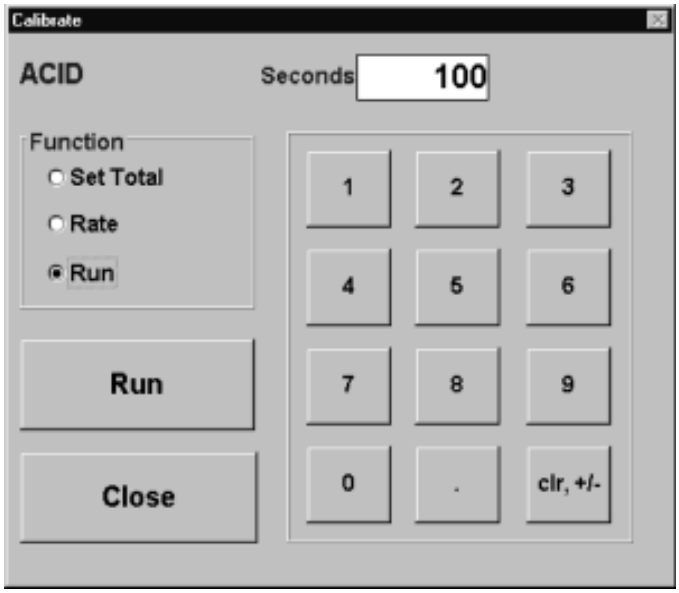
- In the function window, select the **RATE FUNCTION**. The **SET TOTAL BUTTON** will change to a **SET RATE BUTTON**.



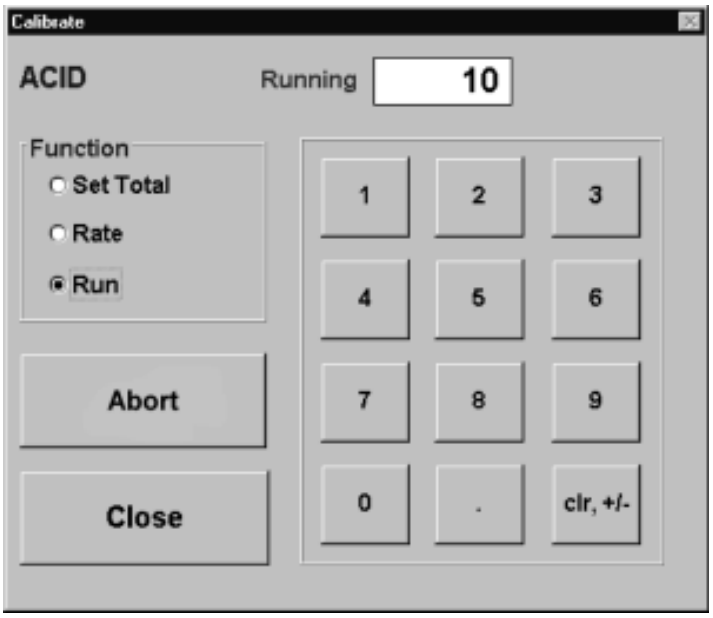
- Enter the rate.
- Press the **CLOSE BUTTON**.

If the pump or actuator flow or transfer rate is not known, perform the following:

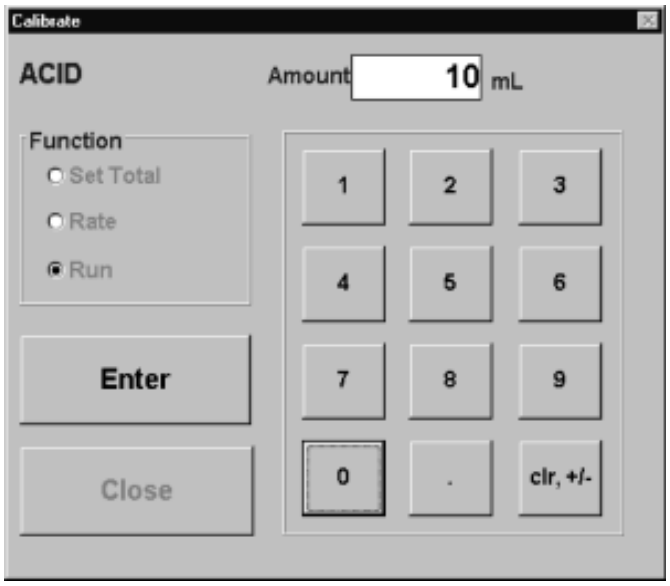
- In the function window, select the **RUN FUNCTION**. The **SET TOTAL BUTTON** changes to a **RUN** button.
- Enter the amount of time, in seconds, you want the pump or actuator to run.



- Press the **RUN BUTTON**. As the pump or actuator begins to operate, the **SECONDS** text box will begin to count down from the number of seconds entered to zero, and the **RUN BUTTON** changes to an **ABORT BUTTON**. To stop the calibration, press the **ABORT BUTTON** (see sample screen below).



- After the **RUN FUNCTION** has counted down to zero, the **ABORT** button changes to an **ENTER BUTTON**. Using the onscreen keypad, enter the amount of product transferred during the time the pump or actuator was running and press **ENTER**. The controller will automatically calculate the rate.



- Press the **CLOSE BUTTON** to exit this calibration screen.

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15 ML-6100 FOAM CONTROL

NOTE:

The following procedures refer *only* to the use of the BioFlo 4500 *equipped with the ML-6100 controller*.

Aeration and agitation may cause foaming before inoculation and during fermentation. This unit may be supplied with the following optional system for control of the foam:

15.1 Chemical Foam Control System with Peristaltic Pump

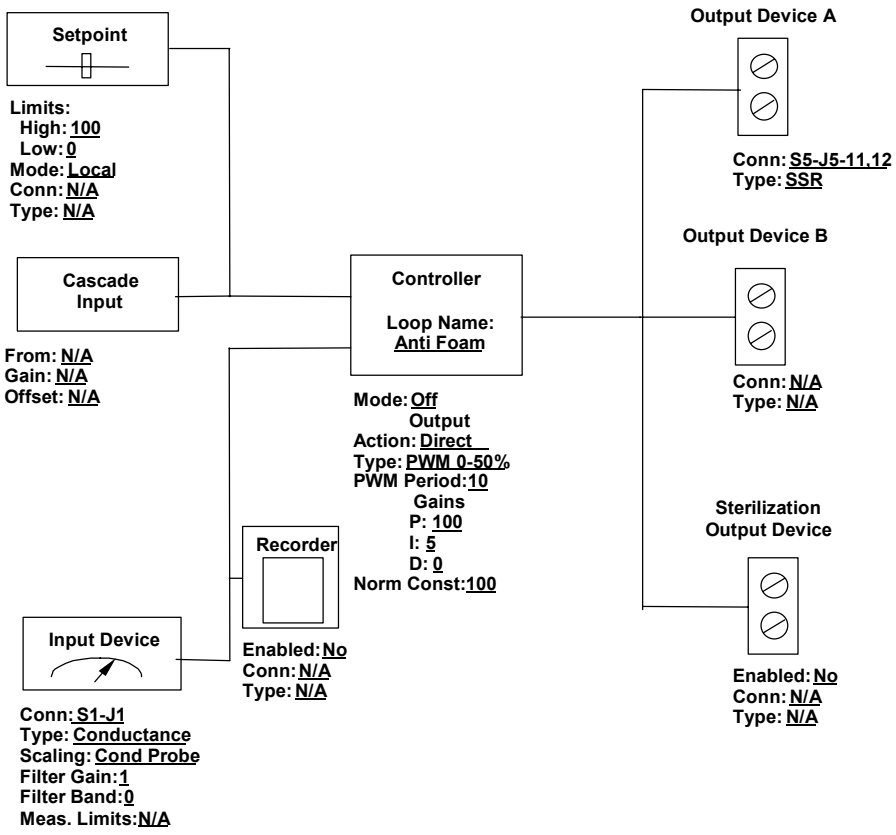
In order to control foam, a foam/level control system and an optional pump is required. A conductivity-type foam sensing probe is installed through a 6 mm OD tube which enters through a fitting and adapter in a 19 mm ID port in the headplate. Contact with foam activates a peristaltic pump, which is connected aseptically to an appropriate port on the vessel by tubing, and introduces a chemical defoaming agent into the fermentor.

The control circuit includes a sensitivity adjustment to keep minor splashing from causing spurious operation. Control in PWM mode allows for addition and mixing time, as desired. (The customer provides sterile antifoam in a suitable container for this system. A steam-sterilizable port or a septum port can be provided in the upper wall of the vessel for antifoam addition.)

The BioFlo 4500 is preconfigured to include a base and antifoam control loop. The pump 3 loop is configured for the antifoam agent.

The typical settings for a foam control loop are as follows:

Figure 28: Foam Control Loop Configuration



15.2 Setup of Foam Probe

Attach the **FOAM PROBE LEAD** to **FOAM PROBE** and plug other end into **FOAM PROBE JACK** on the **CONSOLE**. Adjust the foam probe to the desired level and tighten the lock nut sufficiently to firmly hold the probe. Do not over-tighten the lock nut. (This lock nut has Teflon ferrules that will extrude if over-tightened; the nut will then cut through the Teflon sleeve on the probe thus activating the system.)

In order for the foam probe to function, the **FOAM PROBE GROUND CABLE** must be connected to the ground connection on the console and its clip must be clipped to the vessel.

NOTE:

When positioning the foam probe ensure that the probe does not contact any vessel parts. The probe should be placed as far as possible from any metal surfaces, otherwise false readings can occur.

NOTE:

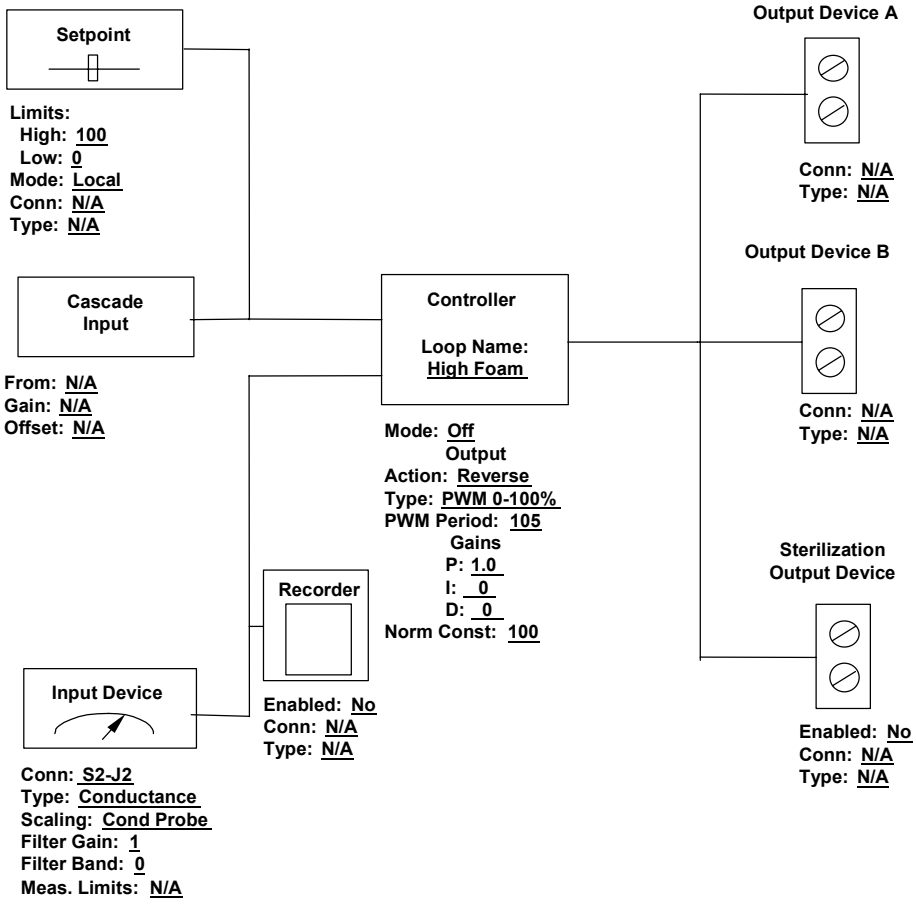
It is recommended to set up and adjust the foam probe before the sterilization cycle. The height of the probe may be adjusted after sterilization by loosening the ferrule and holding a swab of cotton that has been soaked with a suitable anti-bacterial solution around the probe. Applications of antifoaming agents are at the discretion of the user. This agent should be miscible with water and thermally stable at sterilization temperatures (121°C-130°C) in order to sterilize it.

15.3 High Foam Safety System

A separate foam probe may be supplied as an option to provide a check on the normal antifoam control system(s). This option involves a separate foam probe which should be adjusted at a higher level than the normal foam control probe. This device allows for the stopping of airflow and agitation (or any other loop) should a high foam condition occur. The same precautions for adjusting and care of the regular foam probe apply in this case.

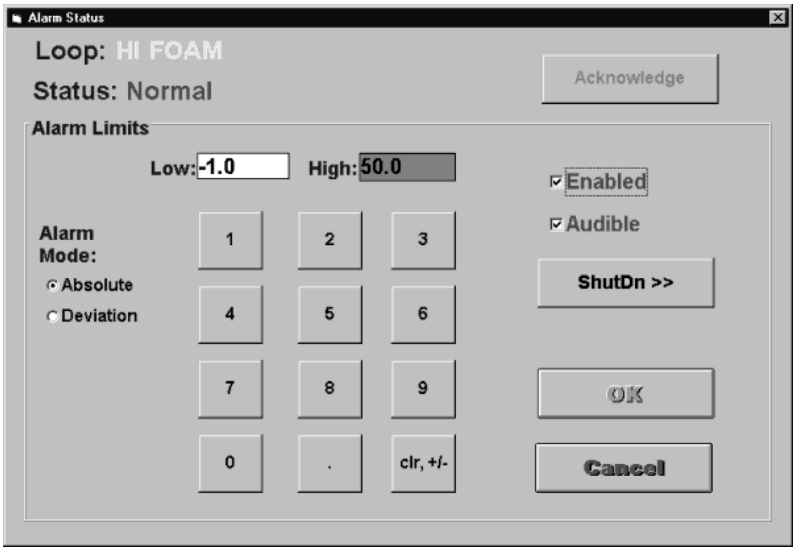
The ML-6100 may be configured to include a high foam control loop. The typical settings for this loop are as follows:

Figure 29: High Foam Control Loop Configuration

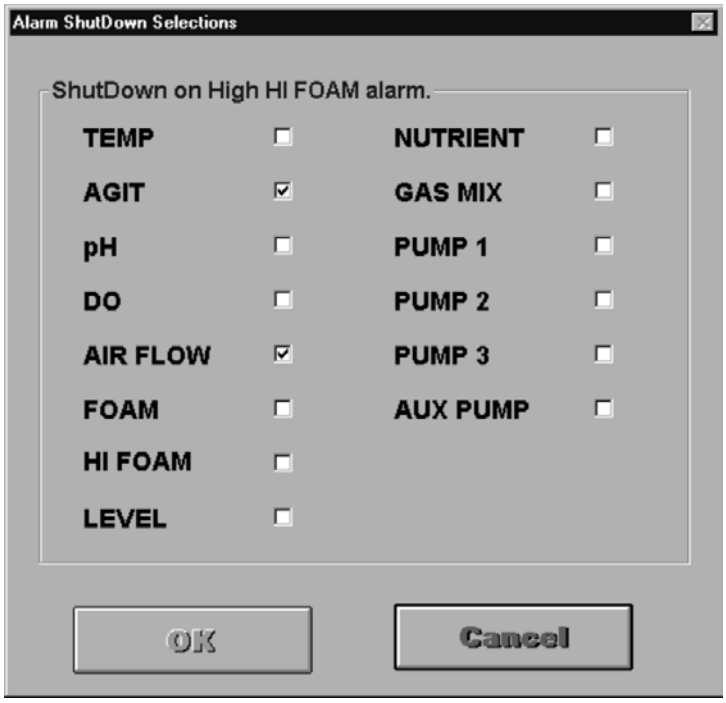


In order for the high foam probe to function, the **HIGH FOAM PROBE GROUND CABLE** must be connected to the ground connection on the console and its clip must be clipped to the vessel.

It is recommended that the high foam control loop be configured to trigger an alarm (both audible and visual) when the current value of control loop reaches the parameters below. The parameters for this alarm can be set on the **ALARM SETUP SCREEN**.



When an alarm condition occurs, the loop can also be configured to shut down the any number of loops. To do so, press the boxes near the name of each loop to be shut down. A check will appear in the box to indicate that the loop was selected. For detailed instructions on the operations of alarms, refer to the *Alarms* section of this manual.



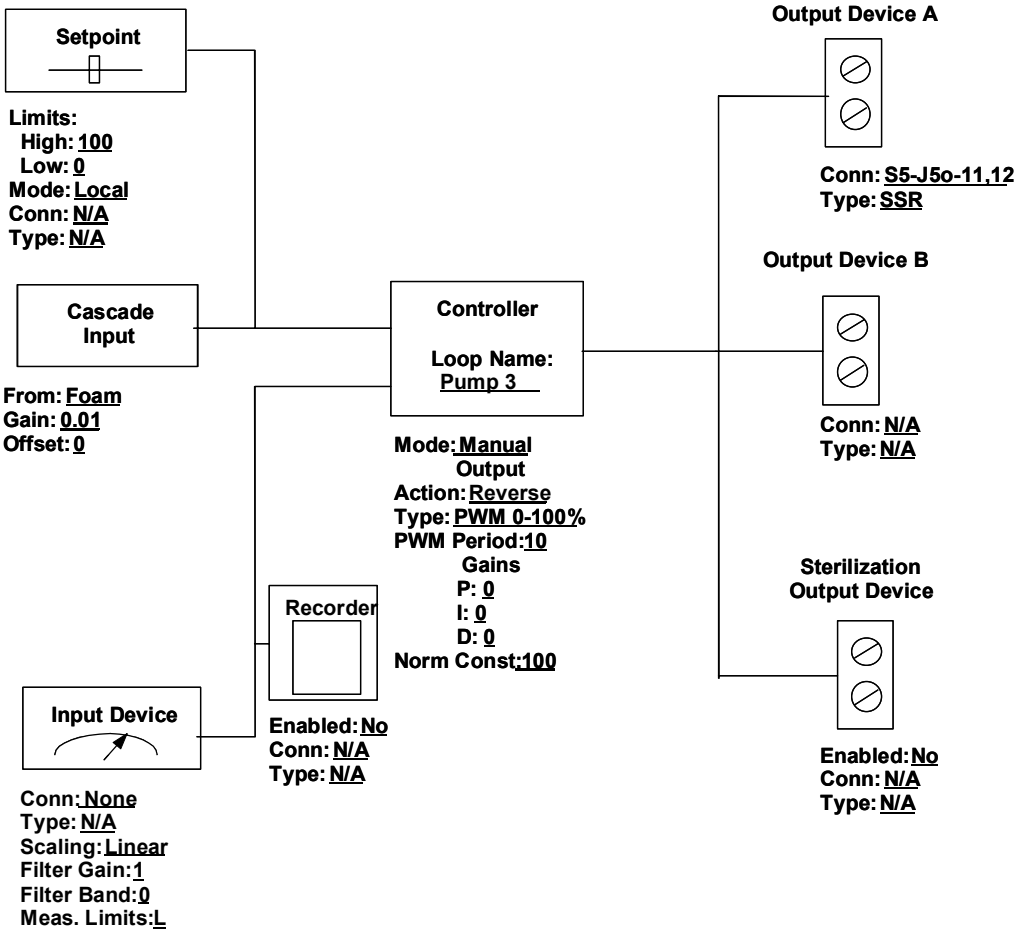
NOTE:

When positioning the high foam probe ensure that the probe does not contact any vessel parts. The probe should be placed as far as possible from any metal surfaces, otherwise false readings can occur.

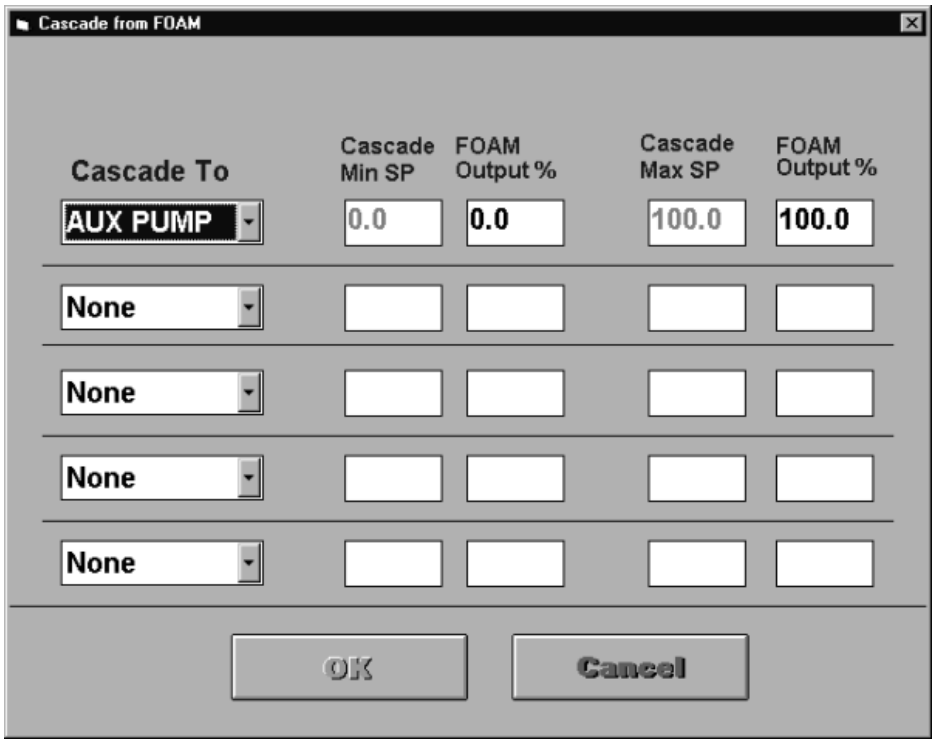
15.4 Pump 3 – Antifoam Setup

An auxiliary pump control loop can be configured to be the addition pump for the antifoam agent. This loop configuration can be changed so that another pump can be assigned to this task if required. Typical settings for this loop are as follows:

Figure 30: Auxiliary Pump Control Loop Configuration (for Antifoam Addition)



The foam control loop should be cascaded to the auxiliary pump control loop. This means that the controller output of the foam control loop is used as the input for this loop. The pump rate is determined by the PWM period. The foam loop is factory set at Pump 3. The cascade control scheme is as follows:

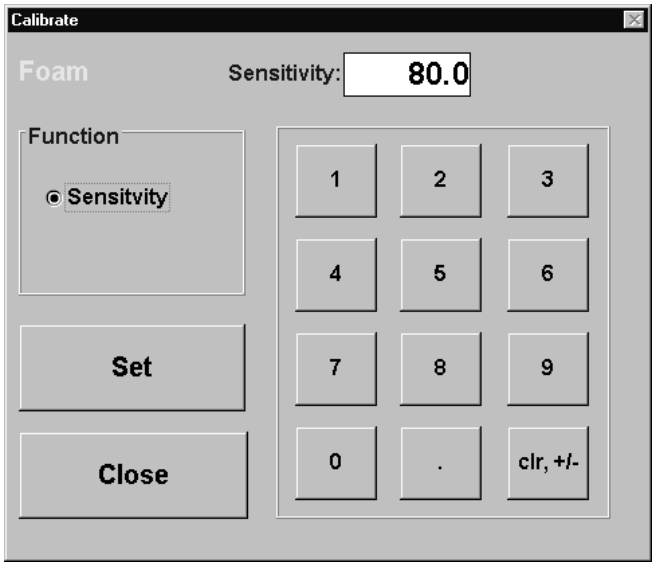


15.5 Conductance Probe Calibration

To calibrate control loops with the input device selected as **CONDUCTANCE PROBE**:

- From the **GAUGE SCREEN**, press the **CAL BUTTON**. The **CALIBRATION SELECTION WINDOW** will appear.

- Select the control loop you wish to calibrate by pressing it. A **CALIBRATION SCREEN** will appear.



- Enter the percentage of sensitivity in the text box using the onscreen keypad, then press the SET BUTTON. The foam, high foam level probes are set for the following sensitivity percentages:

Foam	*High Foam*	*Level*
80.0	80.0	60.0

NOTE:

A sensitivity of 100% will read full-scale when there is no contact with the media, and a sensitivity of 0% will not register a reading when the probe is immersed in the media.

15.6 Conductance Probe Grounding

In order for any of the conductance probes to function, the ground cable must be connected to the ground connection on the console and its clip must be clipped to the vessel.

16 ML-6100 pH CONTROL

NOTE:

The following paragraphs *only* refer to the use of the BioFlo 4500 *equipped with the ML-6100 controller*.

During the growth cycle, control of the pH may be required. The BioFlo 4500 is pre-configured at the factory to include a pH control loop. The pH control system is optional.

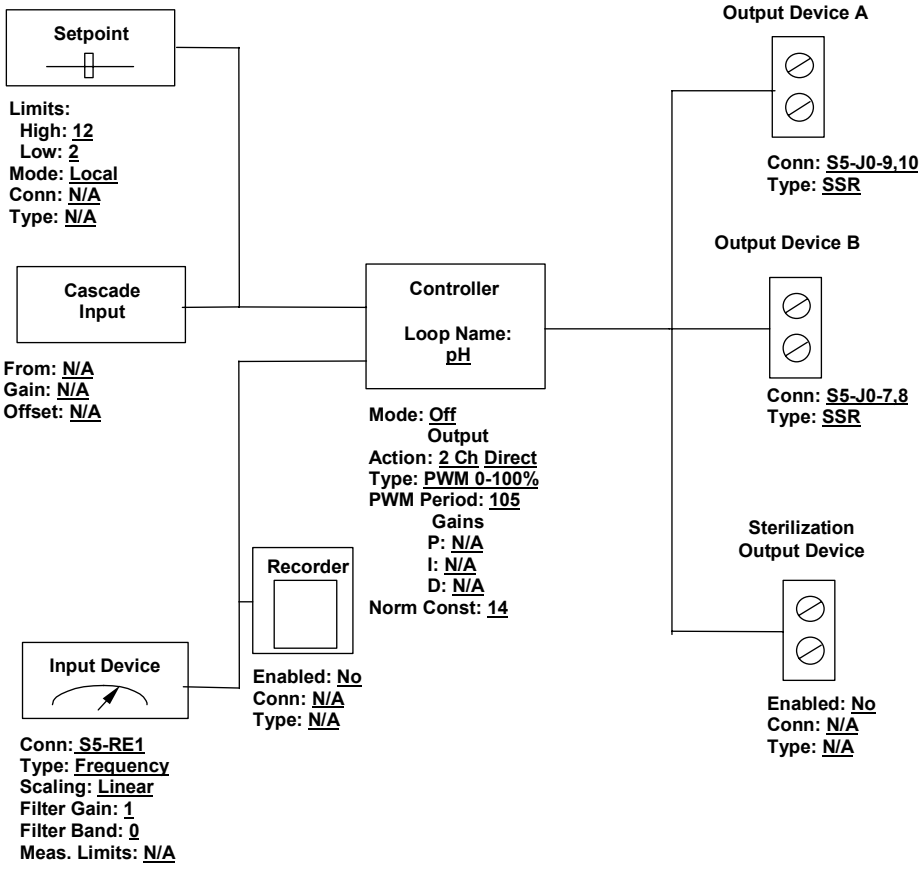
A pH probe is provided for side mounting in a 25 mm Ingold type penetration in the lower side-wall of the fermentor vessel subsequent to filling the vessel. The electrode assembly is steam-sterilizable-in-place at the same time the media and vessel are sterilized. The pH probe is connected via a probe cable to the pH connector on the front panel of the console. The pH probe generates a mV signal that is amplified and conditioned near the probe to become the input to the controller that monitors the pH. When the pH exceeds the desired value (as preset) an addition of acid is introduced automatically into the vessel; when pH is too low an addition of base is introduced automatically into the vessel. In the PWM mode of control a timed addition can be used to permit sufficient time for the acid or base to be properly mixed with the fermentation broth prior to a subsequent addition.

The pH value is also continuously displayed on the touchscreen. Two peristaltic addition pumps are required; one for acid addition and one for base addition. The BioFlo 4500 should be set for pump 1 and pump 2 to perform the task of acid and bas addition. Sterile acid and base reagent and their containers are also required. Optional 19 mm re-sterilizable addition ports with quick fit connections with appropriate valving and traps installed in the upper sidewall of the vessel may be used for introduction of the acid and base to the fermentor vessel. Alternatively, optional hose barb ports or septum ports located in the headplate or upper sidewall may be used for introduction of acid and base.

Operation, maintenance and troubleshooting of pH probe are described in corresponding manuals which accompany this manual.

Typical settings for the pH control loop are as follows:

Figure 31: pH Control Loop Configuration



16.1 Calibration of pH Probe

Inspect the probe for possible shipping damage. If damage is observed or parts are missing, notify your local NBS Service Department immediately.

16.1.1 Liquid-Filled Probes

Check the level of the reference electrolyte as described in the manufacturer's instructions. It should be about 1 cm below the filling orifices that are closed with rubber "T" stoppers. To add reference electrolyte, take the filling pipette (P0740-4820) and fill to 1cm below the orifices with Viscolyte B (P0860-0130) electrolyte.

NOTE:

The two chambers are filled with the same reference electrolyte. During normal operations the two rubber stoppers are removed. Liquid-filled probes should then be assembled into the housing and pressurized. *Refer to the pH probe manual supplied with the probe.*

16.1.2 Gel-Filled Probes

Refer to manufacturer's instructions when using gel-filled probes. These probes do not require pressurizable housings.

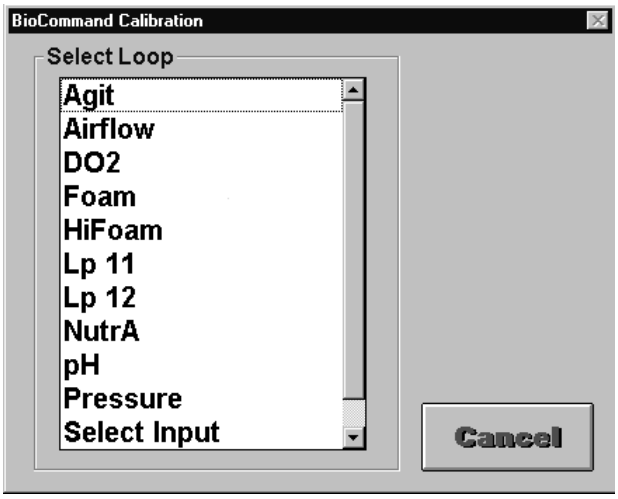
16.1.3 Calibration

A two-point calibration of the pH probe is performed with buffer solutions of known pH. Optimum results will be achieved if the buffer solutions are at the expected growth temperature.

Calibrate the pH probe before sterilizing vessel. Ensure that the calibration buffers are at the correct temperature. Calibrate the pH probe as follows:

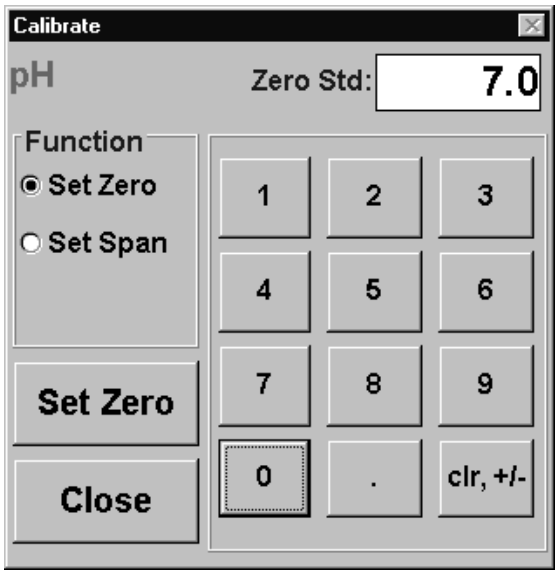
- Connect the pH cable with the probe attached to the coaxial connection on the console.

- In the **GAUGE SCREEN** of the touchscreen, press the **CAL**. **BUTTON**. The **CALIBRATION SELECTION WINDOW** will appear.



- Select the pH control loop from the list by pressing on **pH**.

- To set a "zero", ensure that the **SET ZERO** function is selected, then use the onscreen keypad to enter the appropriate value into the **ZERO STD** text box. Use the clr, **+/- BUTTON** to clear any unwanted information from the text box.



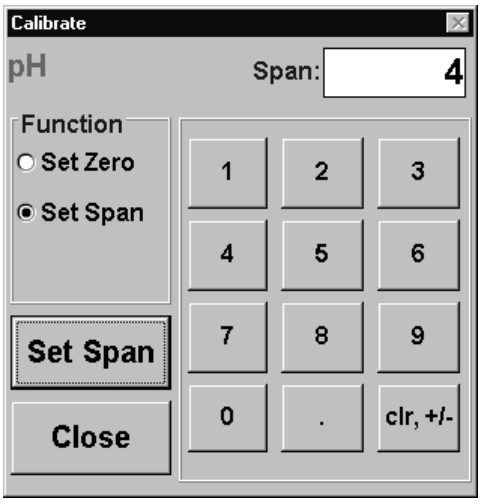
- Immerse the pH probe into an external buffer solution with a nominal pH of 7.00. Enter 7.00. Once the reading has stabilized, press the **SET ZERO BUTTON**.

- Immerse pH probe into a second buffer solution with a nominal pH of 4.00 or 10.00.

NOTE:

A pH buffer should be selected that will linearize the equipment in the range of the specific process. For example, if a process is run at a pH of 8.00, then a buffer of pH 10.00 should be used to attain optimal performance of the system. If the process is run at pH 5.5 than a buffer of pH 4.0 should be chosen for calibration.

- To set span, ensure that the SET SPAN FUNCTION is selected, then enter the appropriate value into the **SPAN** text box. Use the **Clr, +/- BUTTON** to clear any unwanted information from the text box. Once the reading has stabilized. Press the **SET SPAN BUTTON**. The value entered will then become the span value.



- After sterilization, recheck the pH probe calibration by sampling the vessel contents and measuring its pH. One may compensate for any small change by adjusting the "zero" setting to the measured value.

- Press CLOSE to exit this window.

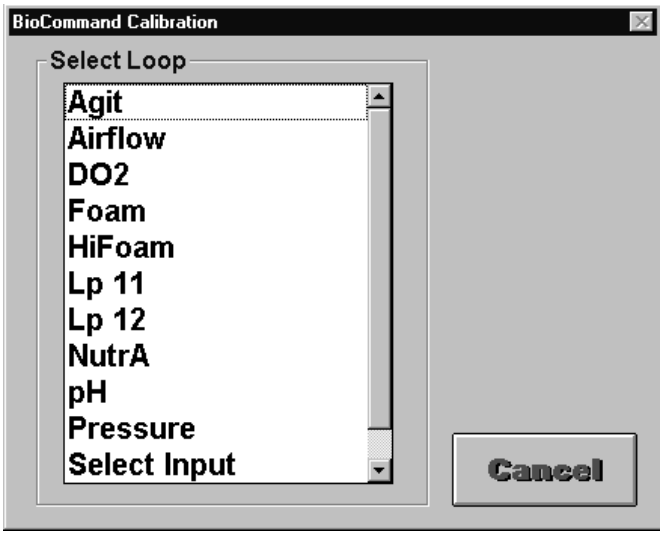
16.1.4 Recalibration After Sterilization

To recalibrate a pH probe after sterilization:

- Aseptically sample the culture medium. Refer to the *Sampling Valves* section of this manual for detailed instructions.

- Using an external pH meter, check the pH of the sample.

- In the **GAUGE SCREEN** of the touchscreen, press the **CAL. BUTTON**. The **CALIBRATION SELECTION WINDOW** will appear.



- Select the pH control loop from the list by pressing on pH.

- At the CALIBRATE WINDOW, ensure that the **SET ZERO** function is selected, and use the onscreen keyboard to enter the measured pH value into the **ZERO STD** text box. Use the Clr, +/- **BUTTON** to clear any unwanted information from the text box. Press the set **ZERO BUTTON**.

- Press **CLOSE** to exit this window.

16.2 Setting Up a Cascade from pH to Pumps

On the BioFlo 4500, the installed pumps are numbered 1 through 3. A fourth auxiliary pump may also be utilized. This is accomplished by connecting an auxiliary pump with the electrical receptacle provided on the rear panel of the console.

When setting up a pump for a particular function, pumps may be set up individually and controlled individually or cascaded from an appropriate control function such as the control of pH. For example, for the control of pH using an acid feed and a base feed, the pumps that control acid and base feed can be cascaded from pH.

In this example, **PUMP 1** will function as a base feed and **PUMP 2** will function as the acid feed pump from pH.

NOTE:

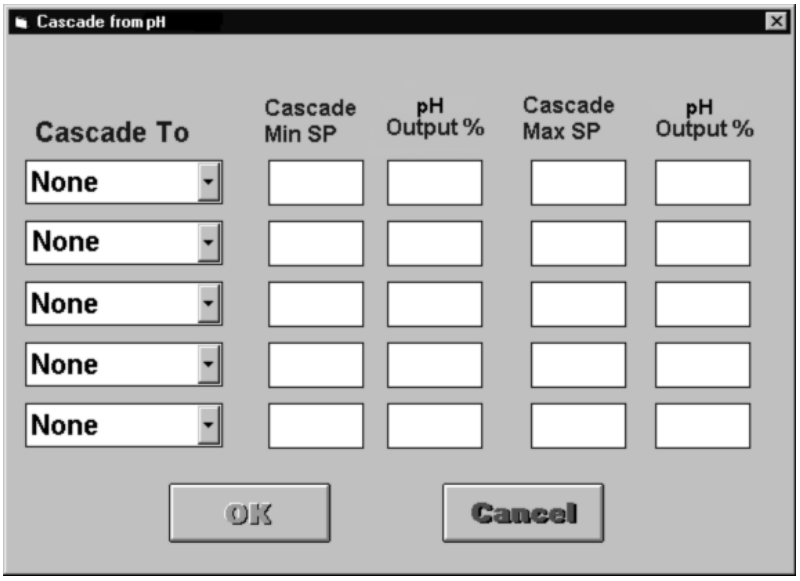
As shipped from the factory:

- **Pump 1 shall be cascaded from the base output of pH**
- **Pump 2 shall not be assigned**
- **Pump 3 shall be cascaded from the antifoam output**
- **The auxiliary output shall not be committed.**

To cascade from the pH control loop to **PUMP 1** and **PUMP 2**:

- At the touchscreen, go to the **GAUGE SCREEN**. Press the **CASC BUTTON**. The **CASCADE CONTROL SCREEN** will appear.

- Select the control loop that you want to cascade from, in this case pH. The **CASCADE SCREEN** will appear.



- The control loop selected, i.e. pH, will appear in the upper left as **CASCADE FROM pH**. The loop name, pH, will also appear above the columns labeled **OUTPUT%**.

- In the column labeled **CASCADE TO**, select **PUMP 1** in the first data box. If **PUMP 1** is not a selection, refer the instructions in this manual for adding a loop.

- In the column labeled **CASCADE MIN. SP**, enter the minimum setpoint for pH. Regardless of output of the cascade-from loop, the setpoint of this cascade to loop will not go below the value you enter here.

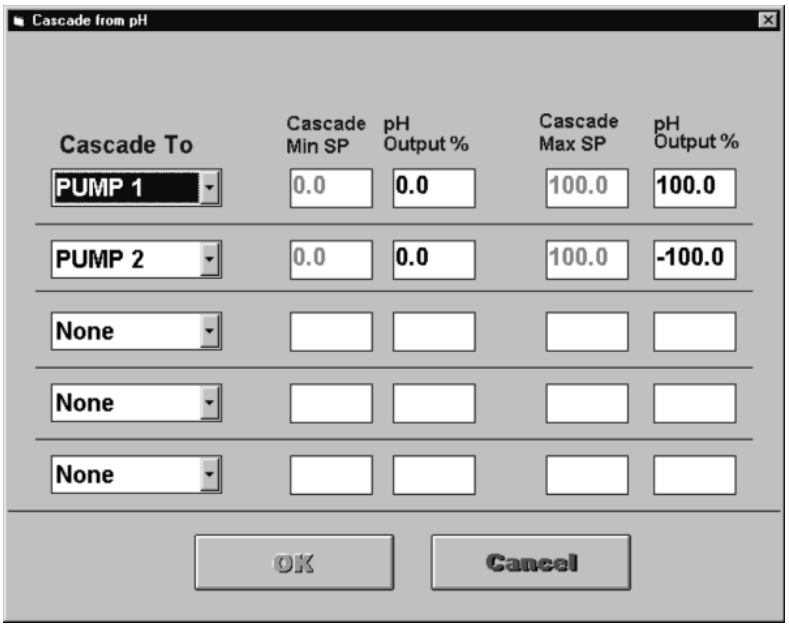
- In the first data entry box of the **OUTPUT%** column (immediately to the right of the **CASCADE MIN. SP** column), enter the minimum *cascade-from* loop output that will produce the minimum setpoint entered in the previous column. Lower outputs will not change the setpoint.

- In the first data entry box of the of the **CASCADE MAX SP** column, enter the maximum setpoint for this loop. Regardless of output of the *cascade-from* loop, the setpoint of this *cascade-to* loop will not go above the value you enter here.

- In the first data entry box of the last **OUTPUT%** column, enter the maximum c*ascade-from* loop output that will produce the maximum setpoint entered in the previous column. Higher outputs will not change the setpoint.

- This completes the setup for **PUMP 1** *cascaded-to* the pH control loop.

- **PUMP 2** is cascaded from pH in the same manner as described above by entering **PUMP 2** in the data box.



- When data entry is complete, press **OK**.

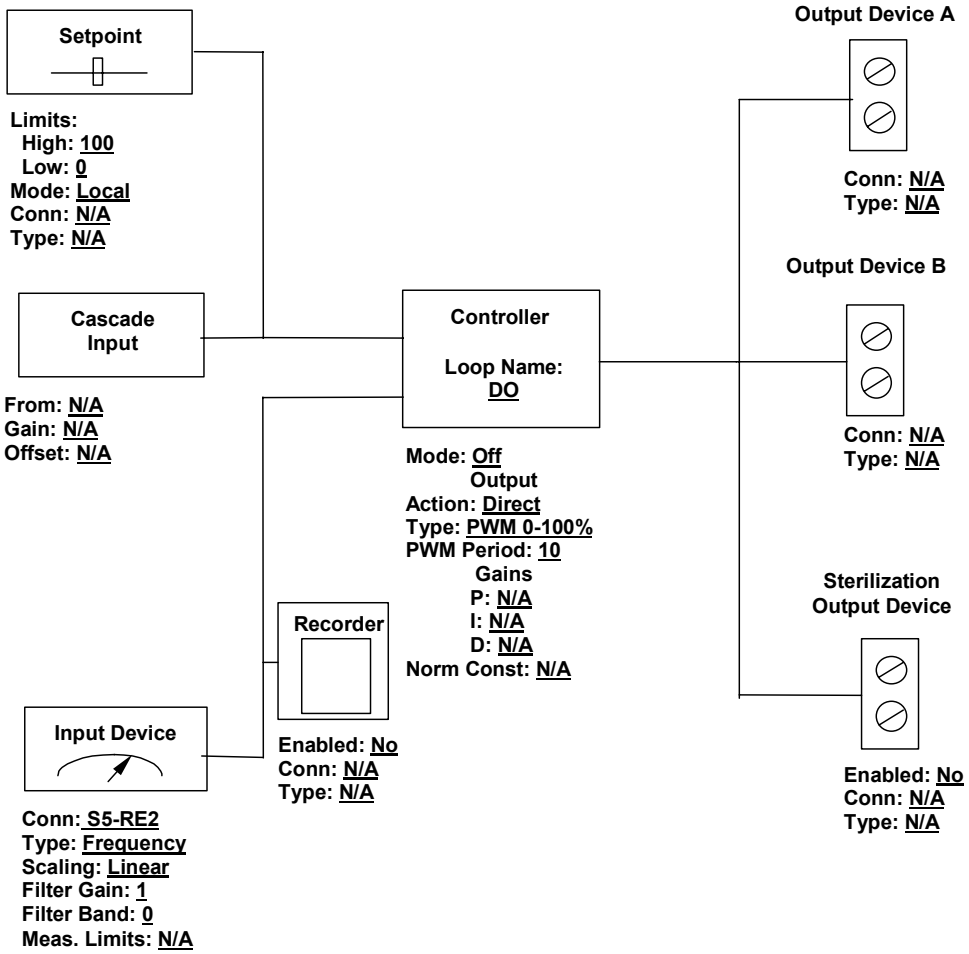
17 ML-6100 DO CONTROL

NOTE:

The following procedures refer *only* to the use of the BioFlo 4500 *equipped with the ML-6100 controller*.

During the growth cycle, control of the dissolved oxygen (DO) level may be required. The BioFlo 4500 may be configured with an optional system to control DO. A typical control scheme for DO is as follows:

Figure 32: DO Control Loop Configuration



A side entering 25 mm polarographic dissolved oxygen electrode with replaceable membrane manufactured by Ingold or Broadley James is provided. The DO probe is inserted into a 25 mm Ingold type sidewall port subsequent to filling the vessel. Alternately, a DO probe that can be inserted through a 19mm headplate port may be used. The electrodes are steam-sterilized in place at the same time that the media and vessel are sterilized.

Once inserted into the vessel, the DO probe is connected via a probe cable to the DO connector located on the front panel of the console.

The DO probe generates an mV signal that is amplified and conditioned near the probe to become the input to the controller that monitors the dissolved oxygen. Dissolved oxygen is read on a scale of 0-l00% that represents the percentage of air saturation at a particular pressure and temperature of the media.

When the dissolved oxygen level deviates from the desired value, the controller changes the agitation rate (the aeration rate or the nutrient flow rate) as set into the factory-set control strategy. (Refer to the agitation control loop configuration scheme.)

Operation, maintenance and troubleshooting of DO probe and controller are described in corresponding manuals which accompany this manual.

17.1 Calibration of DO Probe

Inspect the probe for possible shipping damage. If damage is observed or parts are missing, immediately notify the Service Department of New Brunswick Scientific Co., Inc.

The DO probe provided is an Ingold or Broadley James polarographic probe and should be set up in accordance with its operating manual.

Polarographic probes require a polarization period of at least 6 hours before calibration can be attempted. Polarization is accomplished by connecting the probe to the console and turning power to the fermentor on. The probe is polarizing as long as the power is turned on and the probe is connected. A polarizing device is also available from NBS or the probe manufacturer. This device keeps the probe polarized when it is disconnected from the fermentor. This module may be connected directly to the probe to maintain the probe in a polarized state.

A two-point calibration of the DO probe should be performed after each sterilization. Since the DO reading varies with temperature, calibration should be carried out at the growth temperature where DO control is required.

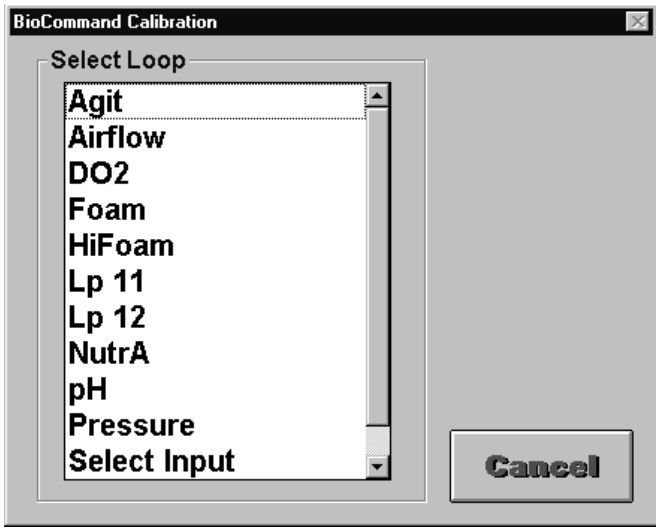
There is a choice of two methods for calibrating DO zero point:

- An electronic method
- Sparging with nitrogen

17.1.1 Electronic Method to Calibrate DO Zero Point

- Polarize the probe for a minimum of six hours.

- At the touchscreen, press the **CAL. BUTTON** in the **GAUGE SCREEN**. The **CALIBRATION SELECTION WINDOW** will appear.



- Select the DO control loop from the list by pressing on it.

- Unplug the DO probe from the console.

NOTE:

Do not leave the DO disconnected from the fermentor for more than one minute. Prolonged disconnection will result in depolarization of the probe.

- With the probe unplugged, set the "zero". Ensure that the **SET ZERO** function is selected, then use the onscreeen keypad to enter the appropriate value into the **ZERO STD** text box. Use the **Clr, +/- BUTTON** to clear any unwanted information from the text box. Once the desired number is entered, press the **SET ZERO** number.

17.1.2 Sparging with Nitrogen to Calibrate DO Zero Point

A more accurate zero setting is obtained by assuring the probe has stabilized at the desired growth temperature and then by setting agitation speed to 500 rpm and sparging nitrogen into the vessel. After the DO reading stabilizes for at least 5 minutes, enter the "zero" on the **PROBE CALIBRATION SCREEN**.

To calibrate the span:

To calibrate the span value, the fermentor should be on and operating at the desired growth temperature. Then proceed as follows:

- Set the agitation speed to 500 rpm and vigorously sparge air into the vessel.
- Carefully monitor the current value reading of DO control loop display gauge. Once the reading has stabilized, press the **CAL BUTTON**. The **CALIBRATION SELECTION WINDOW** will appear.
- Select the DO control loop from the list by pressing on it. The **LOOP CAILBRATION SCREEN** will appear.
- To set the span, ensure that the **SET SPAN FUNCTION** is selected, and enter 100 into the span text box using the onscreen keyboard. Once the number is entered, press the **SET SPAN** button. The value entered will then become the span value.
- Press CLOSE to exit this window.

NOTE:

The probe is calibrated in percentage air saturation at a given temperature, a given pressure (calibration conditions). If pressure is raised, then readings may be obtained which are higher than 100%.

NOTE:

Monitoring DO during calibration can be done by viewing the DO gauge or by setting up a Trend Graph for DO and viewing the graph. *(See section on Creating a Trend Graph)*.

18 ML-6100 LEVEL CONTROL

NOTE:

The following procedures refer *only* to the use of the BioFlo 4500 *equipped with the ML-6100 controller*.

18.1 Sensor

The optional conductivity (or Level) probe is located in the headplate and is adjustable in height.

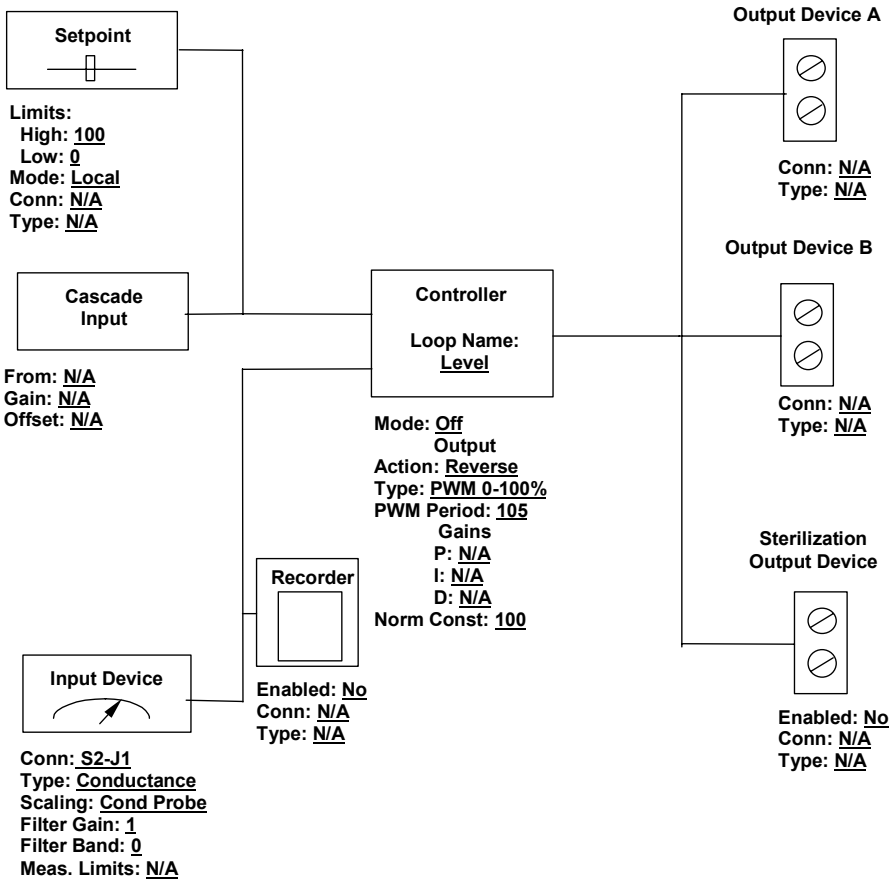
18.2 Control

Level is controlled by providing a signal to an assignable peristaltic pump located on the front panel of the console.

In order for the level probe to function, the **LEVEL PROBE GROUND CABLE** must be connected to the ground connection on the console and its clip must be clipped to the vessel.

Typical settings for the level control loop are shown on the following page.

Figure 33: Level Control Loop Configuration



NOTE:

When positioning the level probe, ensure that the probe does not contact any vessel parts. The probe should be placed as far as possible from any metal surfaces, otherwise false readings can occur.

19 ML-6100 NUTRIENT CONTROL

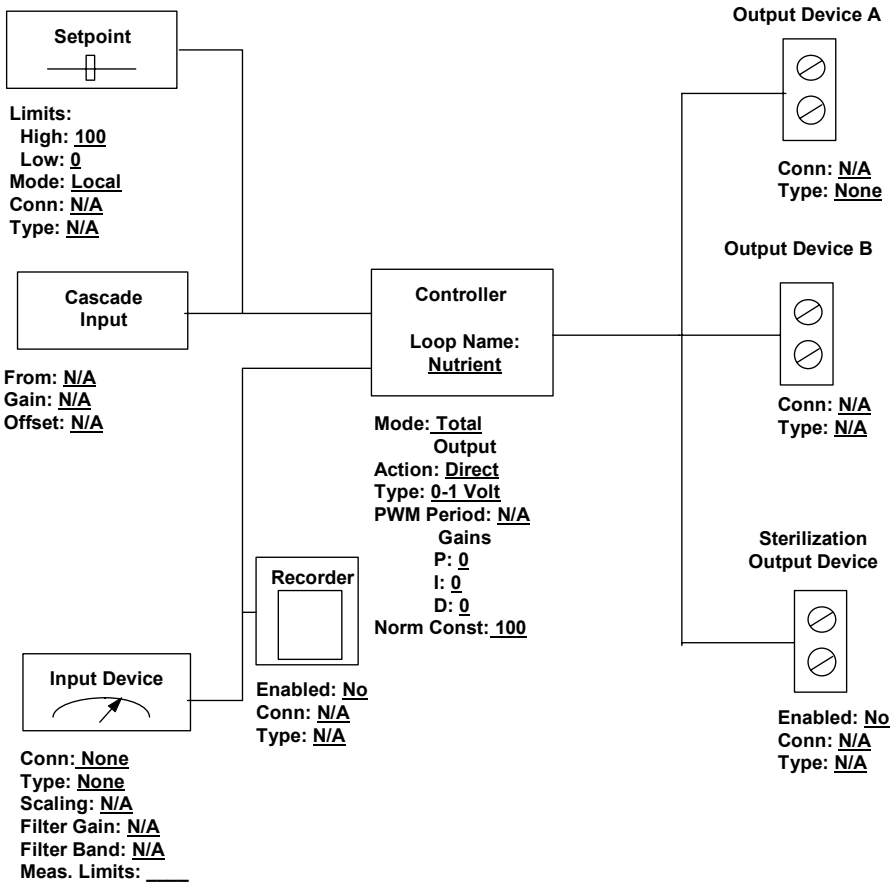
NOTE:

The following procedures refer *only* to the use of the BioFlo 4500 *equipped with the ML-6100 controller*.

The addition of nutrient via an assignable peristaltic pump can be controlled up to 100%, set on a user-defined basis. The 0 to 100% setpoint adjustment will be directly proportional to the duty pump cycle. This optional system can be set such that pump will stop when liquid level reaches the level probe.

Typical settings for a nutrient control loop are as follows:

Figure 34: Nutrient Control Loop Configuration



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20 SAVING THE ML-6100 CONTROLLER CONFIGURATION

NOTE:

The following procedures refer *only* to the use of the BioFlo 4500 *equipped with the ML-6100 controller*.

Once the controller on your BioFlo 4500 has been configured for use with your application, the controller settings (configuration) should be stored to disk for later use. Depending on the options included on your BioFlo 4500, this information can be stored on the resident hard drive of the unit, or on an external computer, or on a diskette.

When a configuration is saved, configuration data such as control loop names, loop calibrations, PID values, and alarm settings are saved. Current values, trend data, and setpoints of the control loops in the process are not saved.

When a configuration is loaded from disk, all current controller configurations will be deleted.

NOTE:

If your BioFlo 4500 is equipped with an internal computer, the factory-set controller configuration is stored as a read-only file in the C:\BCLOCAL directory. If your BioFlo 4500 is equipped with the external computer option, the controller configuration file is stored in the same directory on the external computer.

NOTE:

If your BioFlo 4500 is equipped with an internal computer and you wish to save or load a controller configuration file from a floppy disk, you must remove the right (facing front) side panel to gain access to local floppy drive. Refer to the instructions in this chapter before attempting to save or load a configuration file to or from the floppy drive.

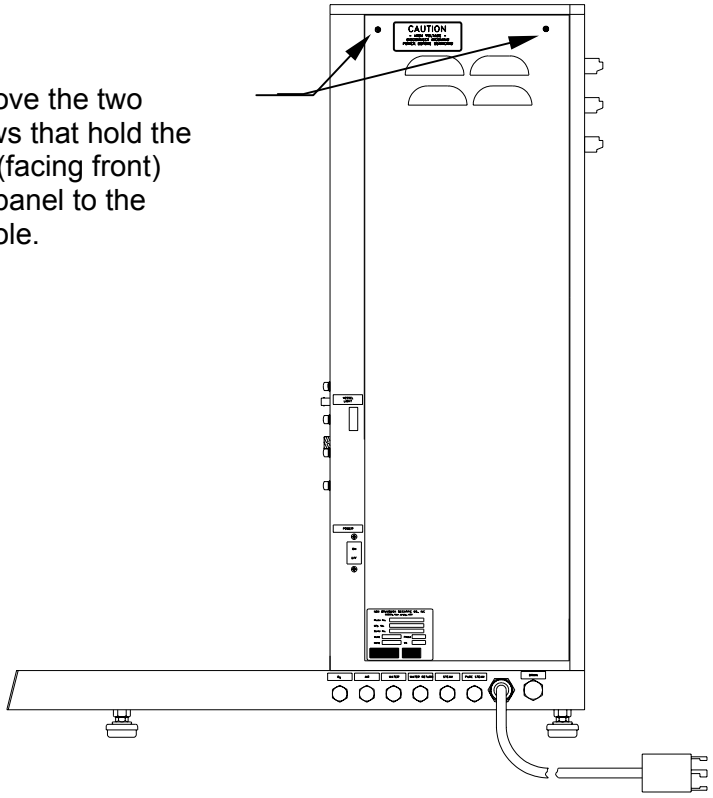
20.1 Internal Floppy Drive

On units equipped with an internal computer, there is a floppy drive mounted inside the console. To gain access to this drive:

1. Turn the unit off by setting the power switch in the Off position.

Figure 35: Side Panel Removal

2. Remove the two screws that hold the right (facing front) side panel to the console.



3. Lift and slide the panel from the console. The floppy drive should be visible. It is mounted so that the face of the drive is facing down.

4. Reconnect the power cord and turn the unit on.

5. Insert a diskette into the drive, and follow the procedures to save or to load a configuration file.

6. Remove the diskette when finished.

7. Replace the panel on the console and secure it in place with the two screws.

20.2 Saving a Configuration

To save a controller configuration:

1. From the **GAUGE SCREEN**, press the **CONFIG BUTTON**. The **MAIN CONFIGURATION SCREEN** will appear.

2. Press the **SAVE BUTTON**. The **SYSTEM CONFIGURATION PASSWORD** prompt will appear.

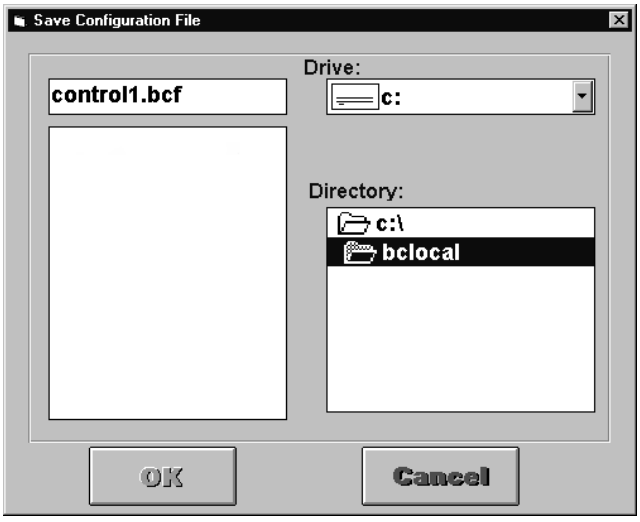
3. Enter the password on the keyboard and press **OK**. If the **SYSTEM CONFIGURATION PASSWORD** is set to blanks, the prompt will not appear. The **SAVE CONFIGURATION WINDOW** will appear.

4. Select the desired **DRIVE** and **DIRECTORY**. Enter the appropriate file name in the text area using the onscreen keyboard.

NOTE:

If your BioFlo 4500 is equipped with an internal computer, the drive designations are as follows:

- **DRIVE C is the resident hard drive of the computer**
- **DRIVE A is the floppy disk drive located inside the console.**



5. Press **OK** to save the file. If the file name is invalid, a prompt will appear. Press **OK** to acknowledge the prompt, and enter a valid file name.

6. To return to the **GAUGE SCREEN**, press **CLOSE** in the **MAIN CONFIGURATION SCREEN**.

20.3 Loading a Controller Configuration

To load a previously saved configuration:

1. From the **GAUGE SCREEN**, press the **CONFIG BUTTON**. The **MAIN CONFIGURATION SCREEN** will appear.

2. Press the **LOAD BUTTON**. The **SYSTEM CONFIGURATION PASSWORD** prompt will appear.

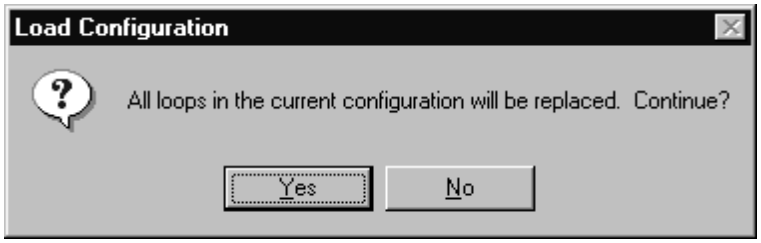
3. Enter the password on the onscreen keyboard and press **OK**. If the **SYSTEM CONFIGURATION PASSWORD** is set to blanks, the prompt will not appear. When a configuration is loaded from disk, it will replace the current displayed configuration.

NOTE:

If your BioFlo 4500 is equipped with an internal computer, the drive designations are as follows:

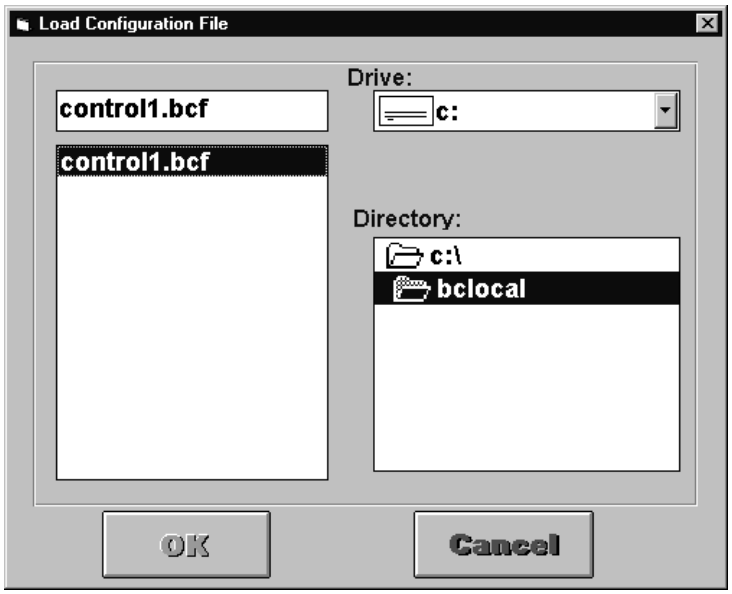
- **DRIVE C is the resident hard drive of the computer**
- **DRIVE A is the floppy disk drive located inside the console.**

4. A loop configuration message will appear after the **SYSTEM CONFIGURATION PASSWORD** is entered. If you wish to proceed with loading a process configuration, press **YES**. If not, press **NO**.



5. If you press **YES**, the **LOAD CONFIGURATION WINDOW** will appear. Select the desired **DRIVE** and **DIRECTORY**.

6. Enter the file name of the configuration you want to load in the text area.



7. Press **OK** to load the file.

8. To return to the **GAUGE SCREEN**, press **CLOSE** in the **MAIN CONFIGURATION SCREEN**.

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21 ML-6100 CASCADE CONTROL

NOTE:

The following procedures refer *only* to the use of the BioFlo 4500 *equipped with the ML-6100 controller*.

A cascade is a control scheme in which the output of one control loop influences the setpoint of one or more other loops. In other words, it uses one parameter to influence others. For example, if the Dissolved Oxygen (DO) control loop is cascaded to Agitation, whenever the DO current value drops below its setpoint causing an increase in DO control loop output, the agitation setpoint will increase. This is effective, because agitation strongly influences DO. With this type of cascade, errors in DO are corrected by changes in agitation RPM.

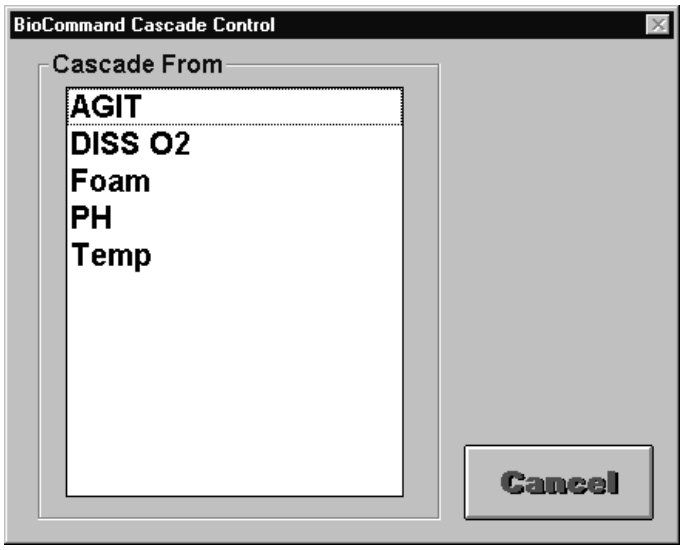
This controller allows cascading from any loop to as many as five other loops. Dissolved oxygen is the most commonly *cascaded-from* loop. Agitation, airflow, and pressure (each complete loops with their own probes and actuators) commonly receive the cascade from DO, altering their respective setpoints to correct errors in DO.

When more than one loop is configured as the recipient of a cascaded output, they may respond simultaneously or in sequence, depending on how the cascade has been set up. Sequential cascades generally give more predictable control responses. Sometimes a small region of overlap, where two loop setpoints vary simultaneously, is used to smooth the transition from one loop to another.

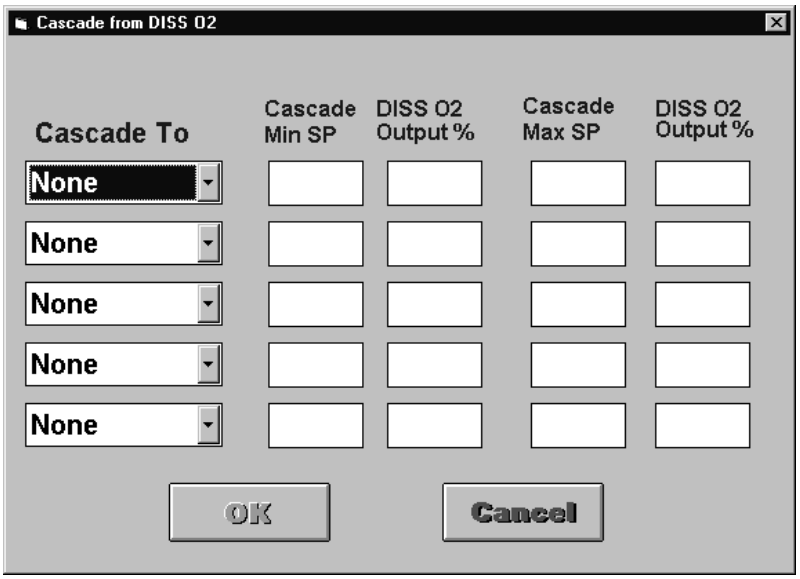
21.1 Creating a Cascade

To create a Cascade:

1. From the **GAUGE SCREEN**, press the **CASC BUTTON**. The **CASCADE CONTROL SCREEN** will appear.



2. Press the control loop that you want to cascade from. The **CASCADE SCREEN** will appear. The control loop that you selected will appear in the title bar. The loop name will also appear above the columns labeled OUTPUT%.



3. In the first data entry box of the **CASCADE** column, select the first control loop that will be cascaded to by pressing on the arrow in the first data entry box. A loop list appears.

4. Press your selection.

5. In the first data entry box in the **CASCADE MIN SP** column, enter the minimum setpoint for this loop. Regardless of output of the *cascade-from* loop, the setpoint of this *cascade-to* loop will not go below the value you enter here.

6. In the first data entry box of the **OUTPUT%** column (immediately to the right of the **CASCADE MIN SP** column), enter the minimum *cascade-from* loop output that will produce the minimum setpoint entered in the previous column. Lower outputs will not change the setpoint.

7. In the first data entry box of the of the **CASCADE MAX SP** column, enter the maximum setpoint for this loop. Regardless of output of the *cascade-from* loop, the setpoint of this *cascade-to* loop will not go above the value you enter here.

8. In the first data entry box of the last **OUTPUT %** column, enter the maximum c*ascade-from* loop output that will produce the maximum setpoint entered in the previous column. Higher outputs will not change the setpoint.

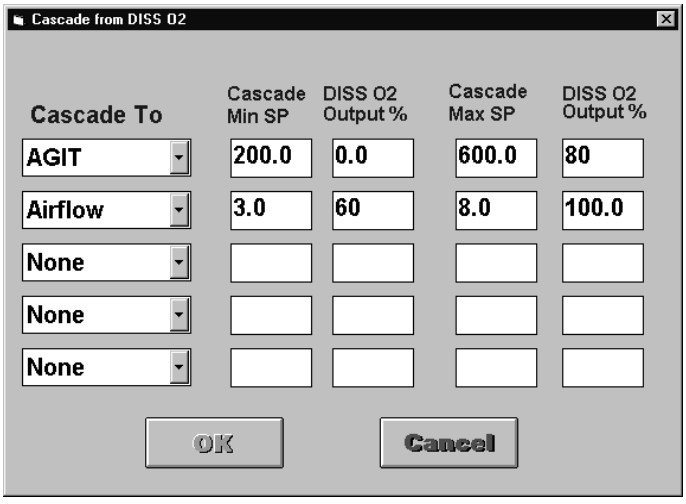
9. This completes the setup for the first *cascaded-to* loop. If up to four additional loops will be cascaded to, repeat steps the previous steps for the second, third, fourth and fifth rows of data entry boxes in the **CASCADE SCREEN**, as needed.

10. Press **OK** when data is correctly entered.

21.2 Controlling Dissolved Oxygen (DO) Using a Cascade

Example: Cascading DO to Agitation and Airflow

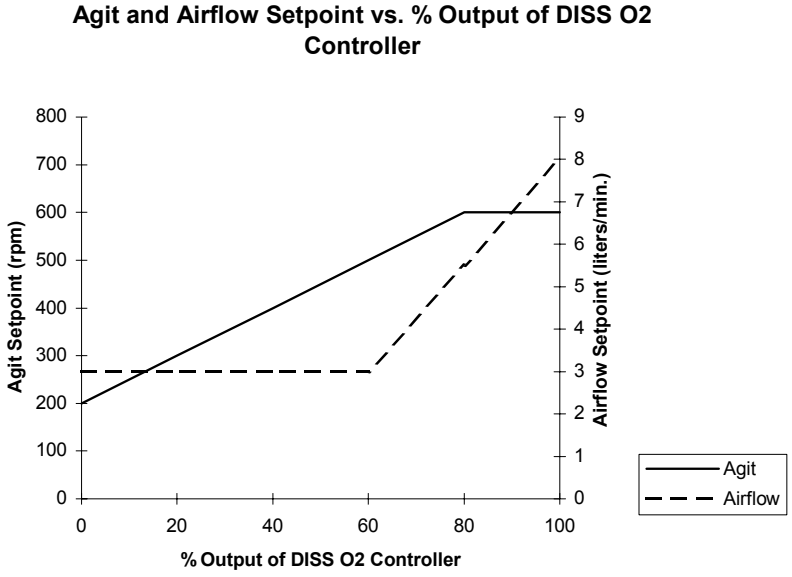
In this example (see sample screen below), dissolved oxygen is cascaded to agitation and airflow. DO will be maintained at its setpoint by automatic adjustments to the setpoints of agitation and airflow. Agitation in this example is limited to between 200 and 600 RPM. Airflow is limited to between 3 and 8 liters per minute.



Assuming that DO output ranges from 0 to 100%, a cascade setup as explained below will cause the agitation and airflow setpoints to vary with DO output as follows:

- At DO output values below 60%, airflow is constant at its minimum setpoint, only agitation varies.
- For DO output values between 60% and 80%, both agitation and airflow vary with DO output. This output range is a region of overlap.
- For DO output values greater than 80%, agitation remains constant at maximum setpoint; only airflow varies with DO output.

The following graph shows the influence of the DO controller output percentage on the agitation and airflow setpoints using the above-mentioned values:



22 ML-6100 TREND BUTTON

NOTE:

The following procedures refer *only* to the use of the BioFlo 4500 *equipped with the ML-6100 controller*.

The **TREND BUTTON** allows you to display a graph of up to four hours of recent data. Up to four plots can be placed on the graph. The graph and data are only available when the fermentor is on. Data cannot be stored (saved).

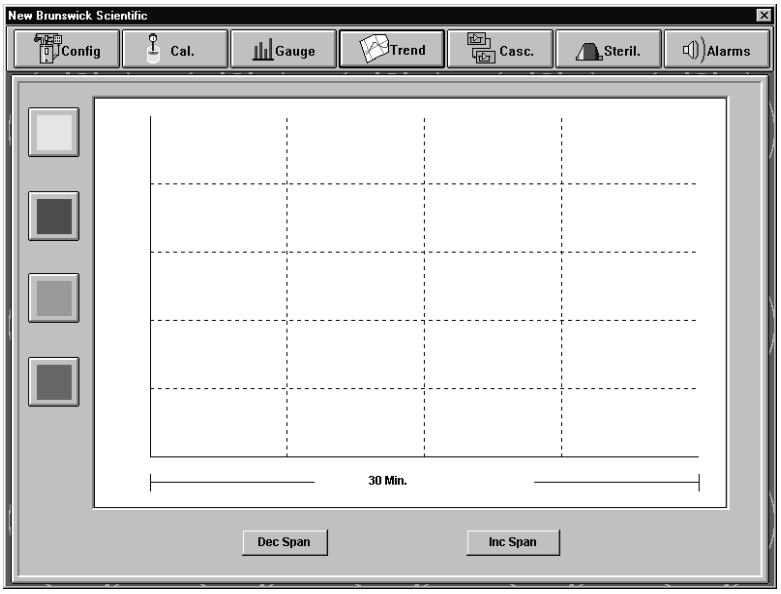
NOTE:

Data archiving can be accomplished through the use of the *BioCommand Supervisory Software* package. Contact your local NBS Sales Office or Representative for more information on the features of *BioCommand Supervisory Software*.

22.1 Creating a Trend Graph

To display a graph of up to four control loops:

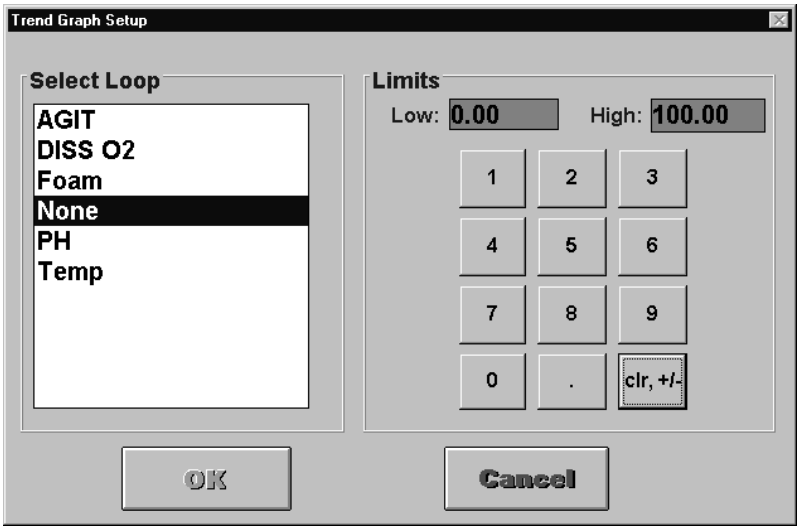
1. From the **GAUGE SCREEN**, press the **TREND BUTTON**. An empty coordinate axis will appear, along with four different colored buttons.



2. To display a control loop, press one of the four colored boxes. The vertical scale axis and plot of that loop will appear in the color of the box selected.

3. The **TREND GRAPH SET-UP WINDOW** will appear. Select the control loop that you want to display on the graph by pressing on it.

4. To set the low and high display limits of the graph, press each text box and enter the values by pressing on the onscreen keypad. The **Clr, +/- BUTTON** can be used to clear the text boxes and to assign positive or negative values to the limits. The default limits are 0.0 for Low and 100.0 for High.



5. After the limits have been set, press **OK** to display the graph or cancel to exit.

6. Press **OK** to continue, and the selected loop will appear on the trend graph.

7. Repeat the previous steps to add more loops or to edit the trend graph.

8. To remove a graph from the coordinate axis, press the color you want to remove and select **NONE** as the control loop in the **TREND GRAPH SET-UP** WINDOW.

9. The time span options for trend graphs are: 10 minutes, 30 minutes, 1 hour, 2 hours and 4 hours. Press the **INC. SPAN BUTTON** to scroll through increasing time spans, and press the **DEC. SPAN BUTTON** to decrease the span. The current time span will be displayed beneath the graph.

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23 ML-6100 GAUGE BUTTON

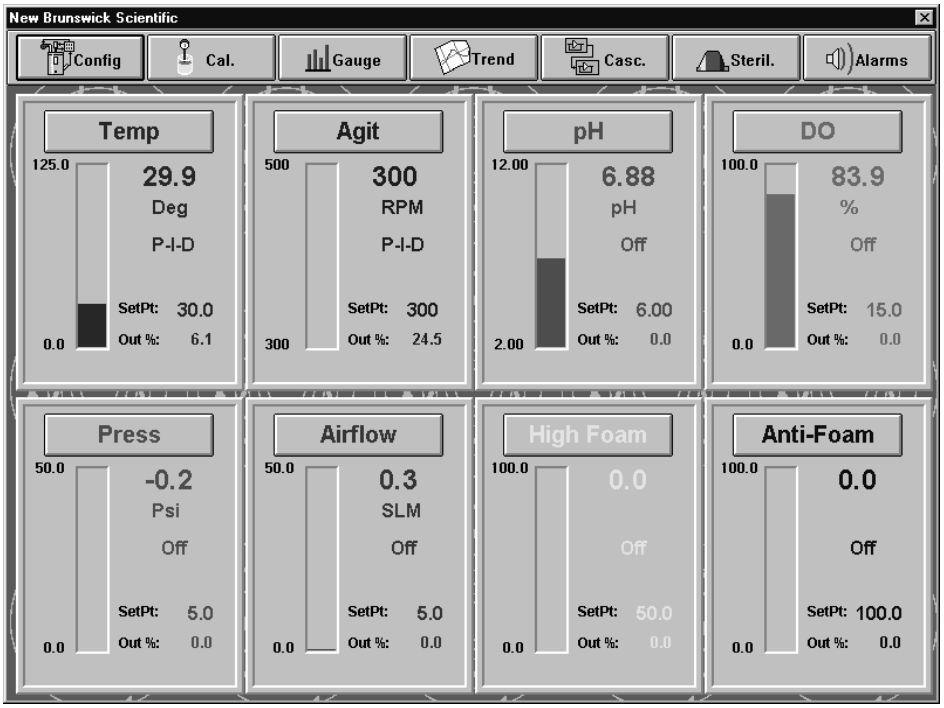
NOTE:

The following procedures refer *only* to the use of the BioFlo 4500 *equipped with the ML-6100 controller.*

The ML-6100 Controller has the capacity to control up to 16 control loops. In the **GAUGE SCREEN**, the operator can only view eight (8) loop **DISPLAY GAUGES** at a given time. After eight (8) loops, the controller software places the remaining **DISPLAY GAUGES** on a second **GAUGE SCREEN**. Pressing on the **GAUGE BUTTON** enables the operator to move between these two screens.

The **GAUGE BUTTON** can also be used to return the operator to the initial **GAUGE SCREEN** (which features **DISPLAY GAUGES** one through eight when a trend plot is displayed).

Figure 36: Gauge Screen



24 ML-6100 ALARMS BUTTON

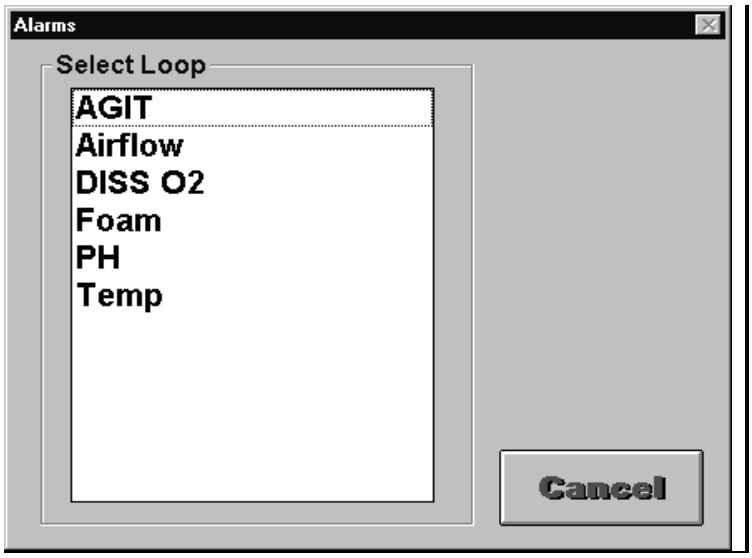
NOTE:

The following procedures refer *only* to the use of the BioFlo 4500 *equipped with the ML-6100 controller*.

24.1 Setting Alarms

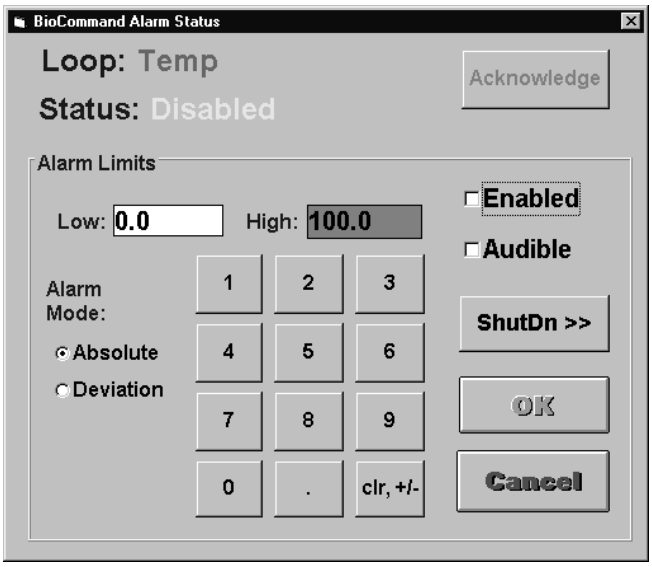
To set alarms:

1. From the **GAUGE SCREEN**, press the **ALARM BUTTON**. The **ALARMS SCREEN** will appear.



2. If you wish to exit this screen press CANCEL. If you want to continue, select a loop from the process loop list by pressing on it.

3. Once a loop is selected, the **ALARM STATUS SCREEN** will appear. The name of the selected loop will appear next to the word **LOOP** and its status will appear next to the word **STATUS**. If the alarm has not yet been activated, the word **DISABLED** will appear next to **STATUS**.



The status of the alarm will change to indicate the current condition of the alarm for the loop. The alarm status will display **DISABLED, NORMAL, HIGH** or **LOW. DISABLED** will appear when the alarm feature is off. **NORMAL** will appear when the loop conditions fall within the loop limits for the alarm. When an alarm condition exists, **HIGH** appears if the condition is *above* the normal limit, and **LOW** appears if the condition is *below* the normal limit.

24.1.1 Alarm Mode

Before setting alarm limits, choose the desired **ALARM MODE**. There are two possible selections:

- **ABSOLUTE** The alarm will trigger when the Current value of the control loop falls below the low alarm limit or rises above the high alarm limit.

- **DEVIATION** This means Setpoint Deviation. If the Current value of the control loop falls below the specified increment from the lower limit setpoint value or rises above the specified increment in the high limit, an alarm will be triggered

The default value of the **ALARM MODE** is **ABSOLUTE**. To change the **ALARM MODE**, press the selection of choice.

24.1.2 Visual & Audible Alarms

There are also two options for alarms that can be used with the control loop:

- **ENABLED** This option allows a visual alarm to flash on screen when an alarm is triggered. The visual alarm is a flashing thick red line around the display gauge of the control loop in an alarm condition.

- **AUDIBLE** This selection triggers an alarm that is both visual and audible. Any alarm will flash on the screen (as described above) *and* make a beeping noise.

NOTE:

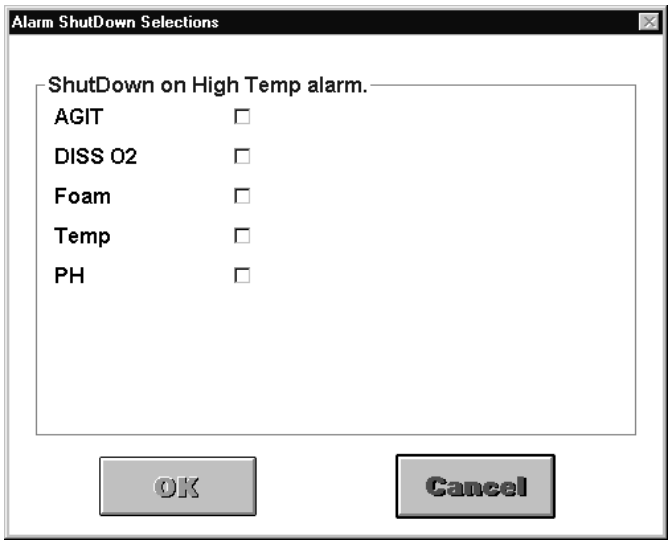
External alarm is not active unless AUDIBLE is active.

To choose either of these options, press the appropriate checkbox.

24.2 Alarm Shutdown

There is also an alarm shutdown feature. This allows the user to shut down a specified control loop or group of loops when the high alarm is triggered.

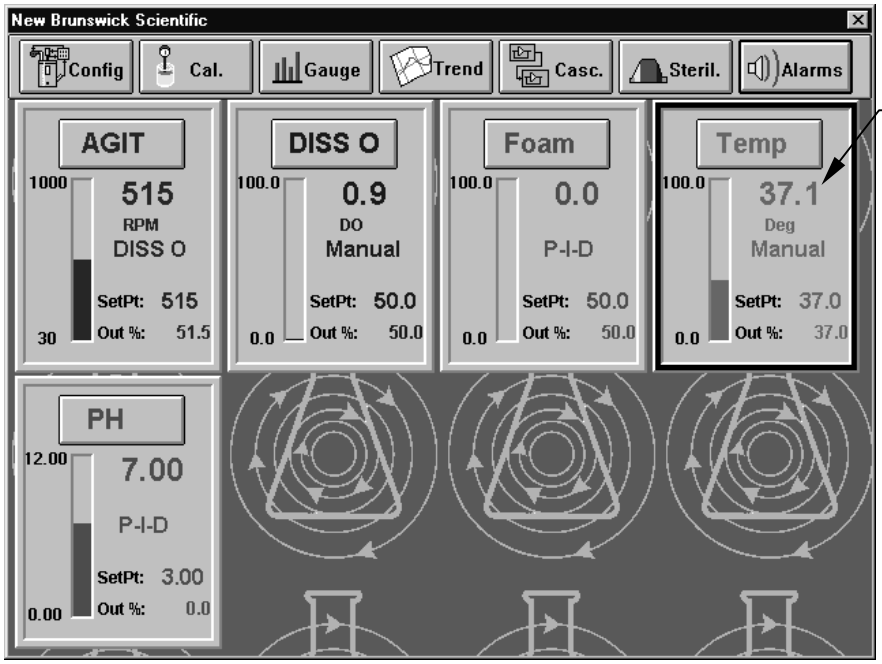
To enable the shutdown feature, press the **SHUTDOWN BUTTON**. The **ALARM SHUTDOWN SELECTIONS SCREEN** will appear (see sample screen below).



Press the loop(s) you wish to shut down. A check will appear in the checkbox for each loop selected. Then press **OK** to accept the selection. The software will return to the **ALARM STATUS SCREEN**.

24.3 Responding to Alarms

When an alarm is triggered, a thick red flashing line appears around the affected **DISPLAY GAUGE** and, if **AUDIBLE** was selected in the alarm set-up, a repeating beep is sounded from the console.



Typical operator responses to the alarm condition are to do the following:

- Acknowledge the alarm. This stops the flashing outline and silences the beep.
- Eliminate the alarm condition by:

    1. Identifying and correcting the cause.
    2. Changing a setpoint.
    3. Changing alarm settings.

24.3.1 Acknowledging the Alarm

To acknowledge an alarm:

1. From the **GAUGE SCREEN**, press the **ALARM BUTTON**. The **ALARMS SCREEN** will appear.

2. Press the loop that is in an alarm condition. The **ALARM STATUS SCREEN** will appear. The alarm type, either **LOW** or **HIGH**, will appear next to the word **STATUS**.

3. Press the **ACKNOWLEDGE** checkbox.

Press **OK** to return to the **GAUGE SCREEN**. The red outline will remain in continuous (non-flashing) mode around the control loop **DISPLAY GAUGE** until the condition that triggered the alarm is resolved.

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25 ML-6100 DEADBAND FEATURE

NOTE:

The following procedures refer *only* to the use of the BioFlo 4500 *equipped with the ML-6100 controller*.

To apply a deadband to a control loop:

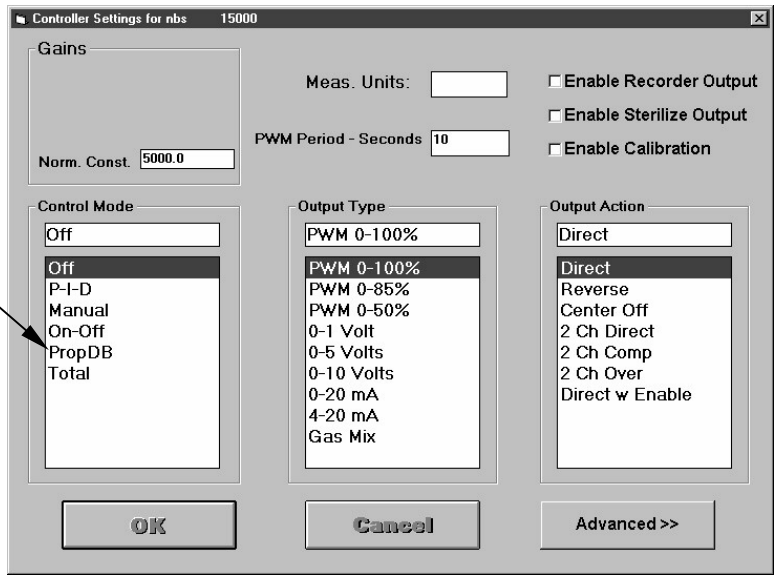
1. Touch the **CONFIG BUTTON** from the **NBS LOCAL CONTROLLER INTERFACE SCREEN**. The *BioCommand* **CONTROL CONFIGURATION SCREEN** will appear.

2. Touch the name of the loop where you wish to set the deadband.

3. Touch **CONFIGURE**. The **LOOP CONFIGURATION SCREEN** will appear.

4. Touch the controller icon. The **CONTROLLER SETTING SCREEN** will appear.

5. In the **CONTROL MODE** pane, touch **PROPDB**



6. In the **DEADBAND** data entry box, enter the range of the desired deadband. **For example**, to extend a pH deadband 0.5 pH units above and 0.5 below the pH setpoint (for a total deadband range of 1.0), enter 1.0.

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26 ML-6100 USE WITH *BIOCOMMAND*

NOTE:

The following procedures refer *only* to the use of the BioFlo 4500 *equipped with the ML-6100 controller*.

BioCommand is New Brunswick Scientific's process control supervisory software system. It enables supervisory control of up to eight controllers from a single computer. It can be used with the BioFlo 4500.

For the controller to work with *BioCommand*, the BioFlo 4500 must:

- Be connected to the *BioCommand Software* via the 25-pin AFS port on the rear panel of the console. Refer to the corresponding *BioCommand Bioprocessing Software User's Guide* for detailed instructions.

- Have a unique Node Number (Multidrop Address or Unit ID) within the range of 0 through 19.

Only the control loop setpoints can be changed through *BioCommand*. The configuration of the BioFlo 4500 cannot be changed or modified.

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27 PREPARING FOR ML-6100-CONTROLLED FERMENTATION

NOTE:

The following procedures refer *only* to the use of the BioFlo 4500 *equipped with the ML-6100 controller*.

After becoming familiar with the components and operation of each of the systems, subsystems, options and ML-6100 controller that are included on your BioFlo 4500, you are ready to set up the fermentor/bioreactor for a run.

NOTE:

When preparing the fermentor/bioreactor for a run, always make sure that all hardware is set up to control the process prior to entering any setpoints or activating the system at the controller.

27.1 Systems Check

Prior to any fermentation or cell culture run, make sure that all standard and optional systems provided with the BioFlo 4500 are operational:

- Exhaust
- Temperature Control
- Aeration Control
- Two-/Three-/Four-Gas Control
- Agitation Control
- Pressure Control
- Nutrient Control
- Foam Control
- High Foam Control
- Level Control
- pH Control
- DO Control
- Pumps
- Addition Valves
- Sample Valves
- Harvest/Drain

Also review the following checklist:

1. Ensure that the fermentor is clean and ready for operation.

2. Confirm that all O-rings, gaskets, seals, filters and septa are in place and in good condition.

3. Check to make sure that the drain valve and any sample and/or addition valves present are closed.

4. Make sure that the **RTD TEMPERATURE PROBE** is securely in place in the vessel.

5. If sensors such as pH, DO, foam, high foam and level probes are to be used, make sure that they have been properly inserted and are secure.

6. Connect the pH and DO probe cables to the probes and connect the connectors to the pH and DO connectors to the console.

7. Connect the foam, high foam and level probe cables to the appropriate probes at the console.

8. Connect the speed sensor cable to the appropriate connection on the console.

9. Ensure that the fermentor/bioreactor is ready to run by confirming that all the services have been properly connected and regulated.

10. At the touchscreen (*ML-6100 Controller only*), make sure the main screen has been configured so all desired process parameters will be monitored and controlled during the run.

11. Enter all setpoints and confirm that you have selected the desired mode of operation for each process loop.

12. The vessel is now ready to operate.

27.2 Adding Media to the Vessel

Media may be added to the vessel in several ways. Usually the headplate is left in place, and media is added through the powder or liquid charging/light port.

WARNING!
During operation, the lamp housing gets hot. Allow it to cool thoroughly before attempting to open the powder or liquid charging (and light) port.

To add media through the powder or liquid charging/light port, remove the light by opening the Tri-clamp connector.

Dry components may be added through this port. Liquid may then be added; the solids dissolve in the vessel (the unit and agitator may be turned on to facilitate dissolution of the solids). Do not add liquid beyond the maximum working volume allowable for the vessel, and remember to allow room for the inoculum which will be added after sterilization.

Liquid media may also be added through the charging/ light port or through any of the other ports normally plugged in the headplate.

Once the media has been added, the port used must be closed.
Also verify that all valves are closed.

NOTE:

Media, liquid and solid, can be also added to the vessel by removing the headplate and adding the required components. If media is added in this manner, make sure that the headplate is reinstalled securely in place prior to turning on the system.

27.3 Sterilization of Vessel Using Heat-Labile Media

Cell culture media is often composed of a variety of heat-labile components. If filter-sterilized media is to be added to the vessel, the vessel may be sterilized empty or with phosphate-buffered saline (PBS) in the vessel. After sterilization the PBS can be aseptically removed and pre-sterilized liquid media (or media components) can be added aseptically though a re-sterilizable addition port.

If the vessel is to be sterilized empty, the instructions for sterilization with liquid in the vessel should be followed **with the exception that the drain valve should be open instead of closed during sterilization and a slight modification of the sterilization valve sequence be performed**. *(Refer to the Section 28, Automatic Sterilization.)*

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28 ML-6100-CONTROLLED AUTOMATIC STERILIZATION

NOTE:

The following procedures refer *only* to the use of the BioFlo 4500 *equipped with the ML-6100 controller*.

Automatic Sterilization is activated at the touchscreen interface. The controller is preconfigured for this feature.

28.1 Sterilization (with Liquid In Vessel)

NOTE:

Recommended sterilization parameters are 30 minutes at 121.5° C.

This procedure utilizes the temperature control elements of the system.

1. Before proceeding, complete the *Water Priming Procedure* (*see Section* 6.2).

2. Insert the calibrated pH probe and the DO, Foam, and Level probes (if used) into the vessel. Connect the probes into the proper jacks on the console.

3. Verify that mineral oil or glycerin has been added to the thermowell and that the RTD Temperature probe is properly inserted and connected.

4. Close the Drain valve, the Sample valve and all lower vessel valves. Check that all lower vessel ports are sealed. Make sure that ring nuts on ports are tight.

5. Open the Powder or Liquid Charging/Light port cap or other suitable port and add water and/or media that is not heat-labile. **Make allowances for inoculum to be added later.** Replace fill port cap and tighten securely.

6. Verify that the fermentor is turned on and that the touchscreen and computer are also on and operational.

7. At the touchscreen, set Temperature control loop for the desired operating temperature after sterilization. Turn the Temperature control loop **ON** by setting the temperature control loop to **PID** control mode.

8. Set the sparge airflow rate and the vessel pressure desired for operation after sterilization. The thermal mass flow controller control loop should be set to the **PID** control mode.

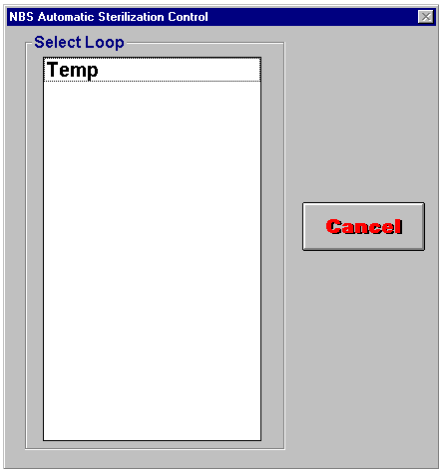
9. Ensure all headplate ports and upper side-entry ports are closed. All ports should either have a piece of equipment inserted or be capped or plugged. All clamps on ports should be secure.

10. Turn on the fermentor and set the agitation rate at the touchscreen. During sterilization, Agitation control loop should be set to a rate of 150 - 200 RPM. Turn on the Agitation control loop by putting the loop in **PID** control.

11. The steam inlet valve to any optional re-sterilizable valve present on the vessel must be open during sterilization to allow for the sterilization of the addition or sample valve. The steam inlet valve must be opened to the valve either (a) when the sterilization cycle is begun, or (b) at the same time the temperature reaches the user-defined sterilization temperature for the vessel.

12. Go to the touchscreen. From the **GAUGE SCREEN**, press the **STERIL. BUTTON**. The **NBS AUTOMATIC STERILIZATION CONTROL DIALOG** will appear.

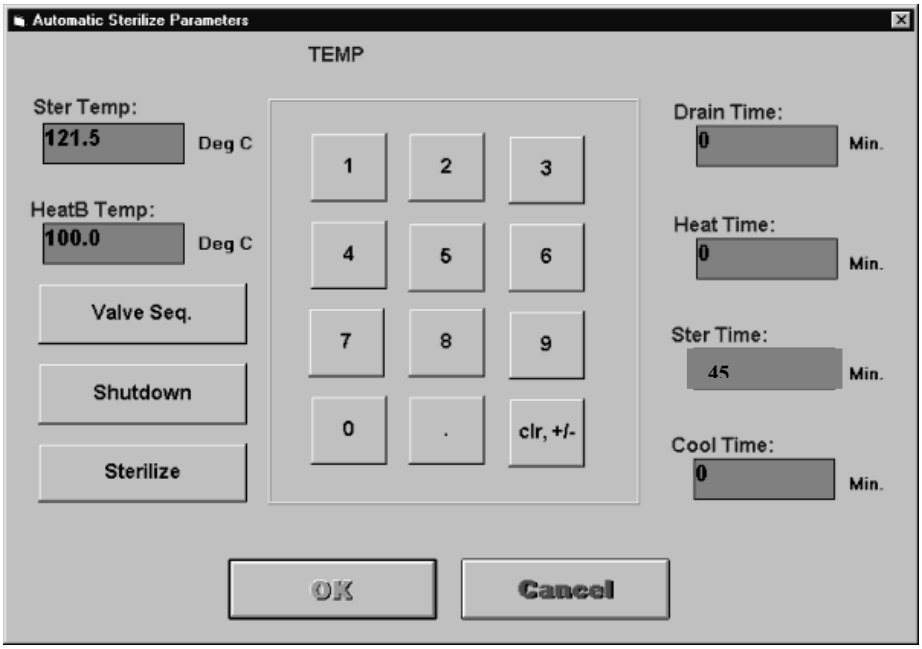
13. Select the Temperature control loop by pressing on its name. The **AUTOMATIC STERILIZE PARAMETERS WINDOW** will appear. The selected control loop name will appear at the top of the window.



NOTE:

The sterilization parameters have been preconfigured at the factory. The operator may make changes to the sterilization parameters by following the instructions below.

The factory set sterilization parameters are the shown below:



28.1.1 Resetting Sterilization Parameters

Enter the parameters by pressing on any of the text boxes and entering the values on the keyboard. Press **OK** to accept the parameters. The parameters are as follows:

- **STER TEMP** Sterilization Temperature, range: 0°C - 130°C.
- **HEAT B TEMP** Temperature at which steam is allowed to directly enter the vessel, in °C. The valve must be less than or equal to (≤) the **STER TEMP**.
- **DRAIN TIME** Drain Time, range: 0-500 minutes. At the factory it is set to 0.

- **HEAT TIME** — Heat Time, range: 0-500 minutes. For the fastest heat time possible, set to 0. At the factory it is set to 0.
- **STER TIME** — Sterilization Time, 0-500 minutes. At the factory it is set to 45.
- **COOL TIME** — Cool Time, 0-500 minutes. For the fastest cool time possible, set to 0. At the factory it is set to 0.

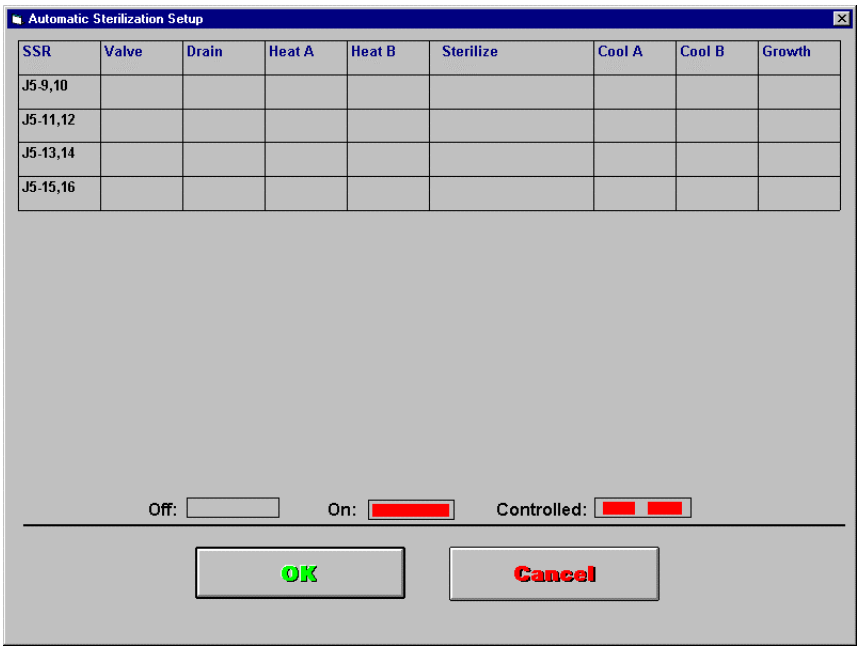
Press OK to accept the parameters. The **SYSTEM CONFIGURATION PASSWORD PROMPT** will appear if the controller configuration is passworded. Enter the **SYSTEM CONFIGURATION PASSWORD** to accept the changes to the **AUTOMATIC STERILIZE PARAMETERS WINDOW**.

28.2 Valve Sequencing

The controller has been preconfigured to sequence a set of valves on the BioFlo 4500 during the automatic sterilization cycle. The operator may make changes to the valve sequencing by following these instructions.

To sequence a set of valves for automatic sterilization, press the **VALVE SEQ. BUTTON** in the **AUTOMATIC STERILIZE PARAMETERS WINDOW** to access the **AUTOMATIC STERILIZATION SETUP WINDOW**. Valve sequencing is done by labeling each valve with its appropriate connection and placing the specified operation of the valve in each column or step in the sterilization process. This is accomplished by touching the screen at the appropriate valve box. The screen will change to indicate whether the value is off or controlled.

After the valve operation data has been entered, press **OK**. The **SYSTEM CONFIGURATION PASSWORD** prompt will appear. Enter the password on the keyboard and press **OK**. If the **SYSTEM CONFIGURATION PASSWORD** is set to blanks, the prompt will not appear. The software will then return to the **AUTOMATIC STERILIZE PARAMETERS WINDOW**.



The column headings or operations for valve sequencing are as follows:

- **VALVE** Valve name or ID.
- **DRAIN** Jacket drain operation.
- **HEAT A** Heating at temperatures below the **HEAT B** temperature setting in the **AUTOMATIC STERILIZE PARAMETERS WINDOW,** at which steam does not directly enter the vessel.
- **HEAT B** Heating at temperatures above the **HEAT B** temperature setting in the **AUTOMATIC STERILIZE PARAMETERS WINDOW,** at which steam directly enters the vessel.
- **STER** Heating operation at sterilization temperature
- **COOL A** Cooling with temperature more 10°C above normal operation temperature setpoint.
- **COOL B** Cooling with temperature within 10°C above normal operation temperature setpoint.
- **GROWTH** Cooling with temperature within than 1°C above normal operation temperature setpoint.

The factory settings for the sterilization valve sequence **with media in the vessel** are the following:

	SLOT 5	VALVE		DESCRIPTION	STERILIZATION			COOLING		GROWTH
					HEAT A	HEAT B	STERILIZATION	COOL A	COOL B	
	J3-1,2	TCV-5N	NO	EXHAUST (W/O INCINERATOR)	■	■	■	■	■	
			NO	EXHAUST (W/ INCINERATOR)	■			■	■	
*	J3-3,4	TCV-5M	NC	EXHAUST FILTER CONDENSATE						
		TCV-5S	NC	INLET FILTER CONDENSATE	■	■	■			
	J3-5,6	TCV-6G	NC	JACKET STEAM CONDENSATE & DRAIN	■	■	■			
	J3-7,8	TCV-5E	NC	INLET FILTER STEAM		■	■■■			
	J3-9,10	TCV-6D	NC	JACKET STEAM	■	■	■■■			
	J3-11,12	TCV-5C	NC	RAPID COOLING				■	■	
*	J3-13,14	TCV-6BB	NC	EXHAUST CONDENSER & SEAL STEAM WATER						
		FCV-2C	NC	AIR INLET				■	■	■
	J3-15,16	TCV-5F	NO	JACKET OVERFLOW	■	■	■			

NOT SHOWN ON SCREEN

-----	-----	--	ELECTRICAL HEATING						■■■
J5-3,4	TCV-6C	NC	COOLING						■■■

The factory settings for the sterilization valve sequence **with the vessel empty** are the following:

	SLOT 5	VALVE		DESCRIPTION	STERILIZATION			COOLING		GROWTH
					HEAT A	HEAT B	STERILIZATION	COOL A	COOL B	
	J3-1,2	TCV-5N	NO	EXHAUST (W/O INCINERATOR)	■	■	■	■	■	
			NO	EXHAUST (W/ INCINERATOR)	■			■	■	
*	J3-3,4	TCV-5M	NC	EXHAUST FILTER CONDENSATE						
		TCV-5S	NC	INLET FILTER CONDENSATE	■	■	■			
	J3-5,6	TCV-6G	NC	JACKET STEAM CONDENSATE & DRAIN	■	■	■			
	J3-7,8	TCV-5E	NC	INLET FILTER STEAM	■	■	■■■			
	J3-9,10	TCV-6D	NC	JACKET STEAM	■	■	■■■			
	J3-11,12	TCV-5C	NC	RAPID COOLING				■	■	
*	J3-13,14	TCV-6BB	NC	EXHAUST CONDENSER & SEAL STEAM WATER						
		FCV-2C	NC	AIR INLET				■	■	■
	J3-15,16	TCV-5F	NO	JACKET OVERFLOW	■	■	■			

NOT SHOWN ON SCREEN

-----	-----	--	ELECTRICAL HEATING						■■■
J5-3,4	TCV-6C	NC	COOLING						■■■

OFF ON CONTROL

NOTE:

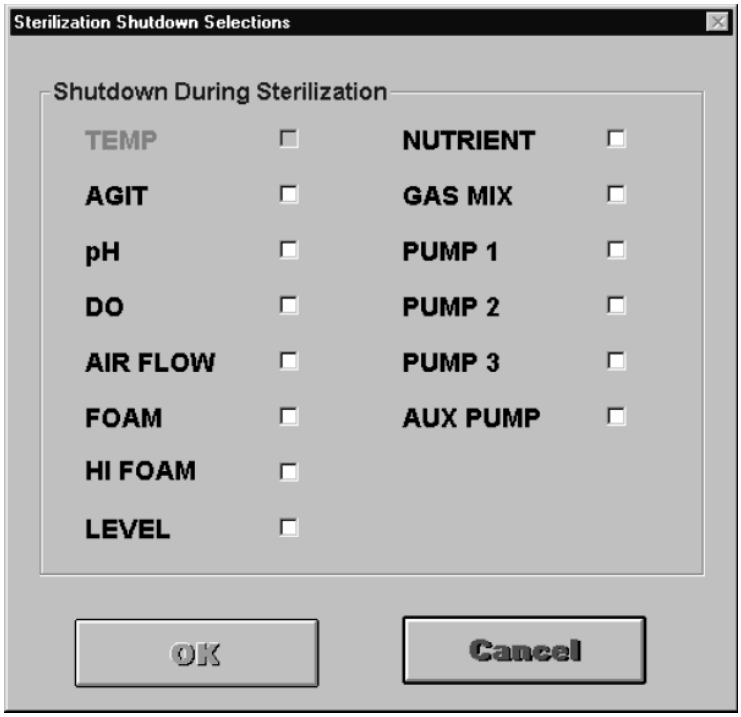
*** only first valve shown on screen**

28.3 Shutdown During Sterilization

The **AUTOMATIC STERILIZATION PARAMETERS WINDOW** also includes a shutdown feature. This allows the user to shut down or disable specific loops during the sterilization process. Once the sterilization process is enabled, selected loops are inoperative until the sterilization process is completed and the sterilization control loop has returned to its normal operating temperature setpoint.

To shut down or disable loops during sterilization:

1. Press the **SHUTDOWN BUTTON**. The **STERILIZATION SHUTDOWN SELECTIONS WINDOW** will appear:



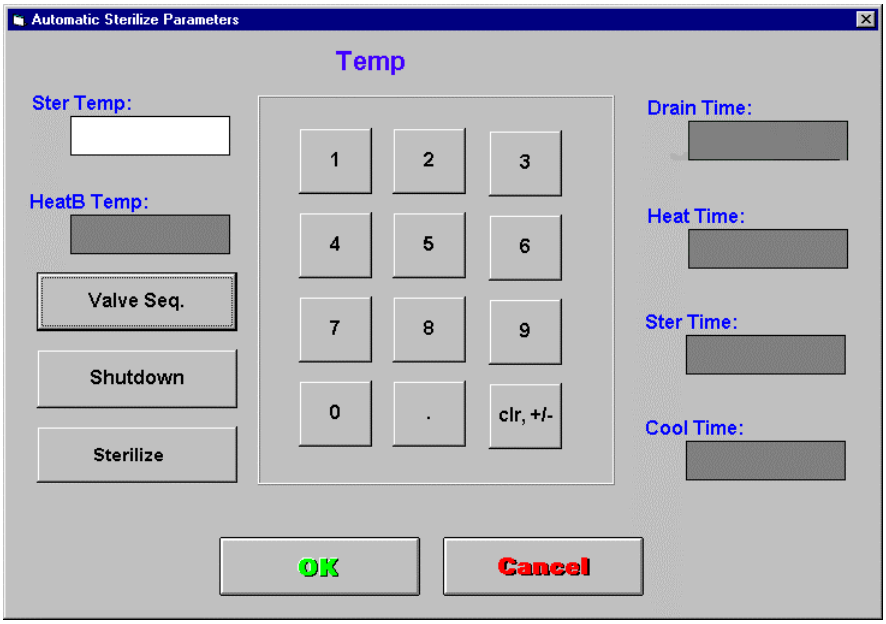
2. Select the loops you wish to disable by pressing on the check box next to each loop. The temperature loop will be grayed out in the loop list to prevent it from being selected.

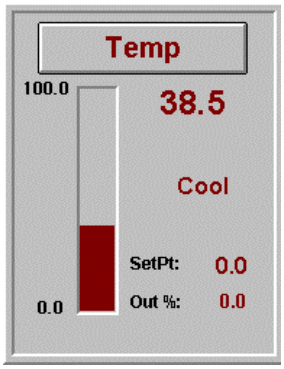
3. After making your choices, press **OK** to accept the selections.

Shutdown of control loops is optional, depending on whether or not they are connected to the vessel. **If liquid is in the vessel, the agitation loop should not be shut down.**

28.4 Enabling Sterilization

To start the sterilization process, press the **STERILIZE BUTTON**. The software will then return to the **GAUGE SCREEN**. Each phase of the sterilization process will be displayed in the control mode of the selected control loop's display gauge.

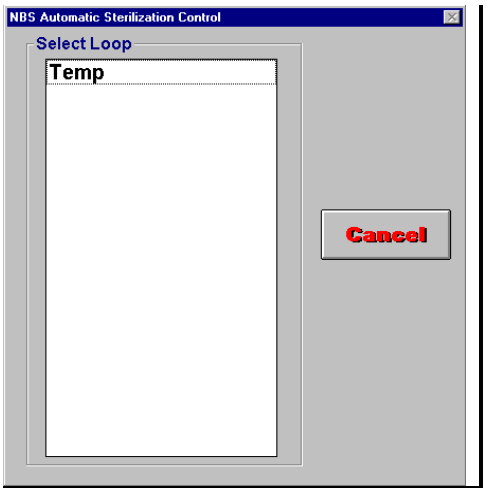




28.5 Aborting Sterilization

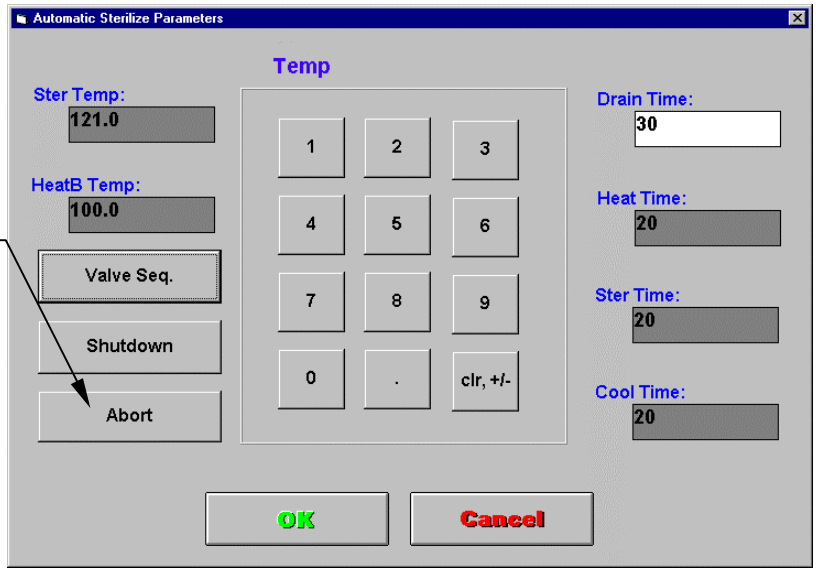
The sterilization process may be stopped or aborted at any time after the process has been started. To abort the sterilization process:

1. From the **GAUGE SCREEN**, press the **STERIL. BUTTON**. The **NBS AUTOMATIC STERILIZATION CONTROL DIALOG** will appear:



2. Select the control loop by pressing on the loop name. The **AUTOMATIC STERILIZE PARAMETERS WINDOW** will appear, but will be slightly modified. Because the sterilization process has been enabled, the STERILIZE **BUTTON** has been replaced by the **ABORT BUTTON**.

3. To cease sterilization, press the **ABORT BUTTON**. The software will return to the **GAUGE SCREEN**.



4. The word **COOL** will be displayed in the control mode of the control loop display gauge until the current temperature of the loop is within its setpoint limits.

28.6 Sterilization (Vessel Empty)

If the vessel is to be sterilized empty, the instructions for sterilization with liquid in the vessel should be followed *with the exception* that the drain valve should be open instead of closed during sterilization.

The sterilization valve sequence must be changed to reflect the valve sequence diagram with the vessel empty.

29 INOCULATION & ADDITION VALVE (OPTIONAL)

19 mm re-sterilizable inoculation and addition valves with quick-connect fittings are optional. The two-position poppet addition valve is designed to attach to the vessel via a retaining ring that holds the valve onto a welded fitting. A steam inlet line delivers pressurized steam to the interior and exterior of the valve before and after each use. Liquid is transferred via a quick-connect fitting. A stainless steel steam port cap maintains the sterility of the fitting. Outlet steam is fed to a condensate trap. The valve is designed to eliminate blind pockets and crevices. The two-position valve is spring-loaded so that the entrance port opens a steam path though a hollow tube. When the valve is in the forward position, the tube is extended into the vessel to allow sterile liquid to be introduced into the vessel.

The prerequisites for sterile inoculum and addition transfer are:

- Sterile culture media in the culture vessel has cooled down to the operating temperature.
- Adjustment of suitable airflow rate and set-up of sterile inlet and exhaust conditions.
- Adjusted agitation speed.
- Adjusted pH of the culture media.
- Suitable seed culture conditions.

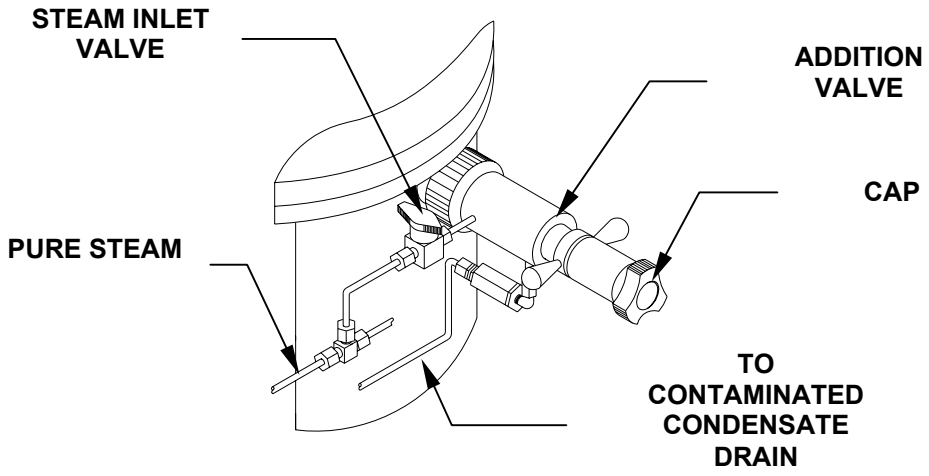
29.1 Sterilization

To make an addition aseptically, the valve must be sterilized prior to use. It is a good habit to re-sterilize the valve immediately after each use so that it is ready for any subsequent addition.

To sterilize the valve (with reference to Figure 37 on the following page):

1. Ensure that the stainless steel cap is in place.
2. Open the **STEAM INLET VALVE** on the 19 mm port.
3. Allow steam to pass through the valve for about 15 minutes.
4. Close the **STEAM INLET VALVE**.
5. Allow the valve to cool thoroughly before use.

Figure 37: Addition Valve Detail



29.2 Addition & Inoculation

29.2.1 Method A

1. Prepare a pre-sterilized additive in an appropriate addition vessel fitted with tubing and a fitting that allows easy attachment to the quick-connect.

2. Reduce the vessel pressure to 0 PSIG, manually or at the touchscreen.

3. Assuming a previously sterilized port, carefully remove the inoculation port steam cap and aseptically attach an inoculation container using silicone or Tygon type tubing.

4. To open the inoculation valve, press the black polymer handles in (toward the vessel) and turn clockwise. This brings the valve's entrance port forward into the vessel.

5. Add the liquid inoculum by gravity feed or via a peristaltic pump.

6. After inoculation, close the inoculation valve: press the black polymer handles in and turn counterclockwise, then release.

7. Break the addition vessel connection by removing the connecting tubing from the quick-connect fitting.

8. Replace the stainless steel cap.

9. Re-sterilize the port.

Follow this procedure for any other additives.

29.2.2 Method B

1. Prepare a presterilized additive in an appropriate addition vessel fitted with tubing and a resterilizable quick-connect.

NOTE:

Refer to your local NBS parts distributor or sales office for quick-connect options. (Prior to use with the valve, the quick-connect has to be autoclaved in the closed position and aseptically connected to the addition valve.) Quick-connect fittings are available for 19 mm and 25 mm Ingold type ports.

2. Remove steam port cap from inoculation/addition valve and attach the quick-connect to the port.

3. Ensure that the stainless steel cap is in place.

4. Open the **STEAM INLET VALVE** on the 19 mm port.

5. Allow steam to pass through the valve for about 15 minutes.

6. Close the **STEAM INLET VALVE**.

7. Allow the valve to cool thoroughly before using.

8. Reduce the vessel pressure to 0 PSIG, manually or at the touchscreen.

9. Open the valve on the sterile quick-connect by pressing the black polymer handles in (toward the vessel) and turning clockwise. This brings the valve's entrance port forward into the vessel.

10. Add the liquid inoculum by gravity feed or by a peristaltic pump.

11. After inoculation, close the inoculation valve: press the handles in and turn counterclockwise, then release.

12. Close the valve on the quick-connect.

13. Detach the sterile quick-connect from the inoculation/addition valve.

14. Replace the stainless steel cap.

15. Re-sterilize the port.

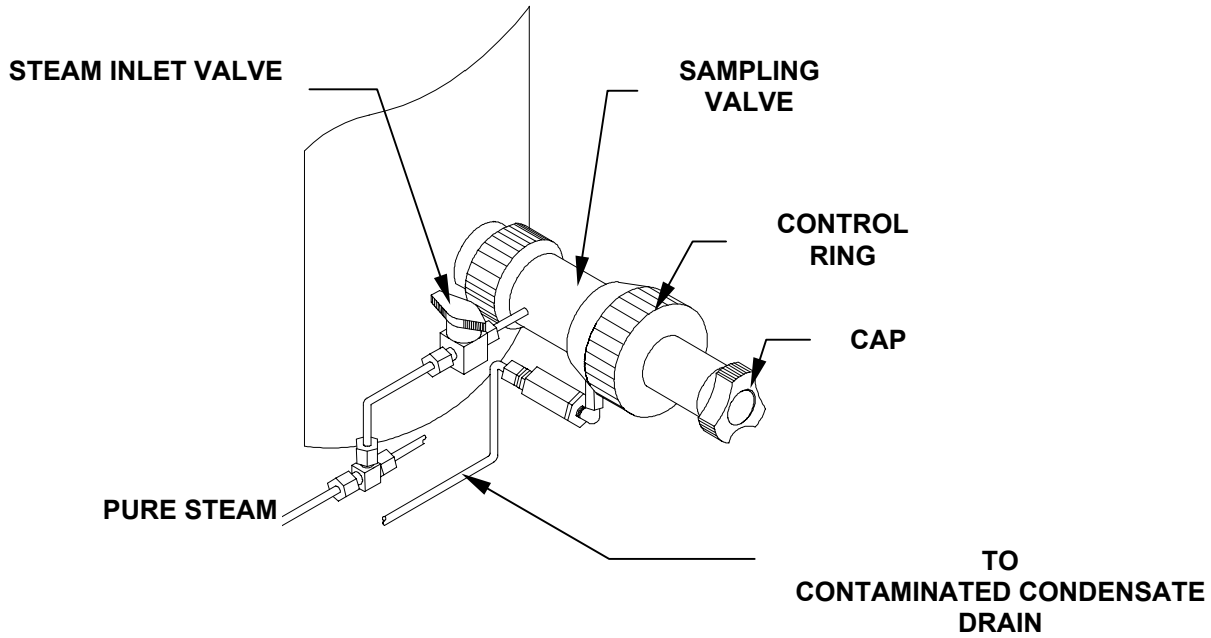
30 SAMPLING VALVES (OPTIONAL)

A 19 mm resterilizable sample valve with quick-connect fitting is optional. The variable flow sample valve is designed to attach to the vessel with a retaining ring that holds the valve onto a welded fitting. A steam inlet line delivers pressurized steam to the interior and exterior of the valve before and after each use. Liquid is transferred via a quick-connect fitting. A stainless steel steam port cap maintains sterility of the fitting. Outlet steam is fed to a condensate trap. The valve is designed to eliminate blind pockets and crevices. When the control ring is turned clockwise, the tube is extended into the vessel so that sterile liquid may be extracted.

To take a sample aseptically, the valve must be sterilized prior to use. It is a good habit to re-sterilize the valve immediately after each use so that is sterile and cooled for any future sampling.

In situations where aerosol containment is necessary, an aerosol containment system is available for the 19 mm sampling ports. Refer to the *Replacement Parts and Accessory Information* section of this manual or contact your local NBS sales representative or parts distributor for details.

Figure 38: Sampling Valve Detail



30.1 Sterilization

1. Make sure that the stainless steel cap is in place.
2. Open the STEAM INLET VALVE.
3. Allow steam to pass through the valve for about 15 minutes.
4. Close the STEAM INLET VALVE.
5. Allow the valve to cool thoroughly before using.

30.2 Sampling

30.2.1 Method A

1. Prepare an appropriate sample vessel ready to receive the sample (or vessel fitted with tubing and a fitting that allows easy connection to the quick-connect).

2. Remove the protective stainless steel cap.

3. Position the sample vial, tube, etc. (sampling of liquid is usually accomplished by gravity), and aseptically connect the sample line onto the quick-connect fitting.

4. To open the channel into the vessel, turn the clear polymer **CONTROL RING** clockwise. This brings the valve's entrance port forward into the vessel. The adjustment is variable so the flow can be controlled. In this way, a sample of a few milliliters can be taken, or the flow can be increased to take a larger sample.

5. To close the valve, turn the **CONTROL RING** counterclockwise.

6. Remove the sampler vessel connecting tubing from the quick-connect fitting.

7. Replace the stainless steel cap, and sterilize the valve.

30.2.2 Method B

1. Prepare an appropriate presterilized sample vessel fitted with tubing and a quick-connect.

NOTE:

Refer to your local NBS parts distributor or sales office for quick-connect fittings.

2. Remove steam port cap from sampling valve and connect the quick-connect on the port.

3. Make sure that the stainless steel cap is in place.

4. Position the sample vial, tube, etc. (sampling of liquid is usually accomplished by gravity), and aseptically connect the sample line onto the quick-connect fitting.

5. Open the valve on the sterile quick-connect.

6. To open the channel into the vessel, turn the clear polymer **CONTROL RING** clockwise. This brings the valve's entrance port forward into the vessel. The adjustment is variable so the flow can be controlled. In this way, a sample of a few milliliters can be taken, or the flow can be increased to take a larger sample.

7. To close the valve, turn the CONTROL RING counterclockwise, close the valve on the quick-connect, and detach the quick-connect from the sampling valve.

8. Replace the stainless steel cap, and sterilize the valve.

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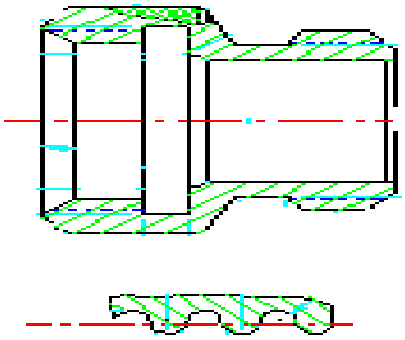
31 SEPTUM PORTS (OPTIONAL)

31.1 Headplate Septum Port Kit

Figure 39: Septum & Septum Cover (NBS PN M1214-9941)



Septum port kits allow for sterile access to the vessel. This septum port kit can be installed into any 19 mm headplate port. The septum membranes are self-sealing and can be punctured several times. However, a new septum membrane should be used for each new process.

To assemble the septum port kit:

1. Place the **SEPTUM MEMBRANE** into the headplate port.

2. Check all O-rings of the **SEPTUM COVER** and **PLUG**; clean and replace if necessary.

3. Place the **SEPTUM COVER** into the port and tighten it until the **SEPTUM MEMBRANE** stops it.

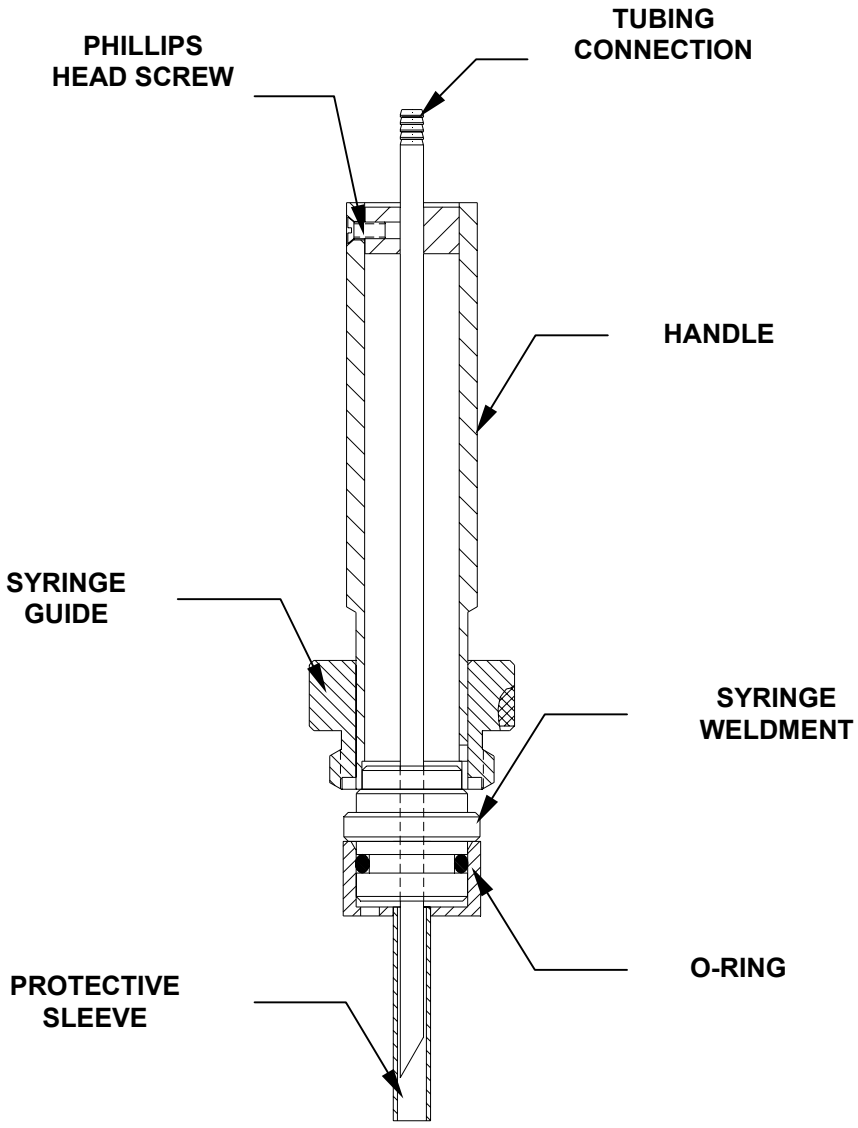
4. Place the **PLUG** into the **SEPTUM COVER** and tighten. This will keep the membrane clean until you connect the inoculation kit or wish to inoculate the vessel.

NOTE:

Several other types of Septum Ports are available for use on the BioFlo 4500. Contact your local NBS representative for the information on these options.

31.2 Syringe Port Assembly

Figure 40: Syringe Port Assembly



The syringe port assembly kit allows sterile access to the culture vessel. This kit requires a 19 mm headplate port equipped with a septum port kit. The syringe port assembly is available with 3 mm bore (PN M1214-5011) or 6 mm bore syringe (PN M1214-5013)

To assemble the syringe port kit:

1. Loosen Phillips head screw at the **HANDLE**.

2. Attach the **SYRINGE WELDMENT** to the **HANDLE** and **SYRINGE GUIDE**. Tighten down the screw to secure the **SYRINGE WELDMENT** to the **HANDLE**.

3. Attach a desired length of silicone or Tygon tubing for medium transfer to the tubing connection. Connect the other end of the tubing to an addition bottle that will transfer the media to the vessel after sterilization.

4. Place the protective sleeve over the end of the syringe that will puncture the septum.

5. Prepare the addition bottle or container. Place both the bottle and the syringe assembly in an autoclave and sterilize.

31.2.1 Luer Lok Syringe Adapter

A Luer Lok Adapter is available from NBS. This device has a hose barb fitting on one end and a standard Luer Lok connection on the other. This is used to allow for easy connection of flexible tube (as from an additional vessel) to a Luer Lok needle.

Figure 41: Luer Lock Syringe Adapter

For use of the septum without the syringe portion, see Section 31.1 above.

After sterilization:

1. Remove the **PLUG** from the **SEPTUM COVER** on the headplate port.

2. Remove the **PROTECTIVE SLEEVE** from the syringe assembly.

3. Place the syringe assembly into the port and puncture the septum membrane.

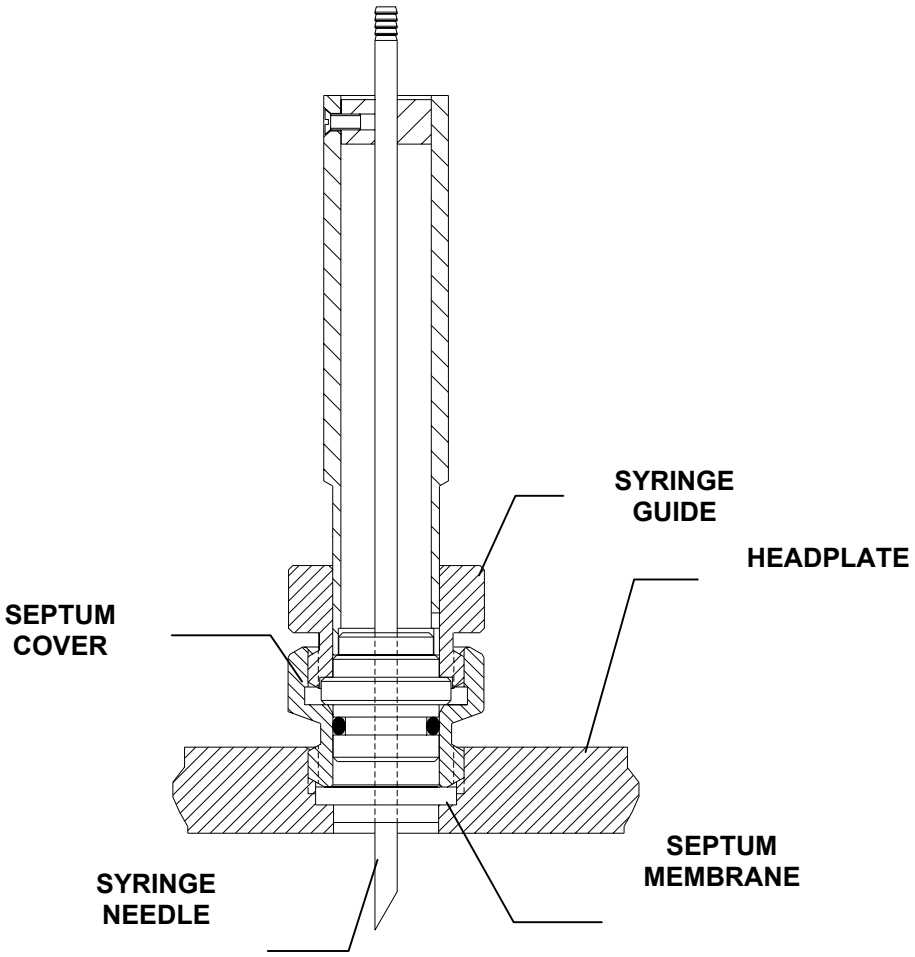
4. Tighten down the syringe assembly by screwing the **SYRINGE GUIDE** into the **SEPTUM COVER**.

5. Transfer the media into the vessel. The syringe assembly may be left on the vessel by clamping the tubing from the addition bottle or container.

6. To remove the assembly, unscrew the **SYRINGE GUIDE** from the **SEPTUM COVER** and remove.

7. Replace the **PLUG** on the **SEPTUM COVER**.

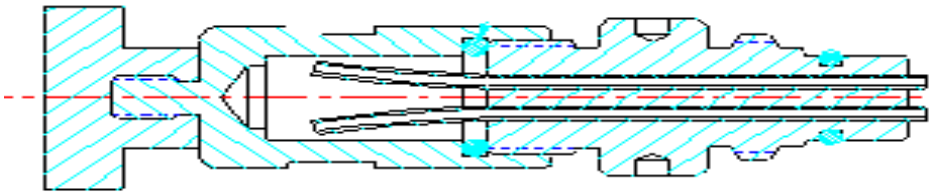
Figure 42: Syringe Assembly Connection



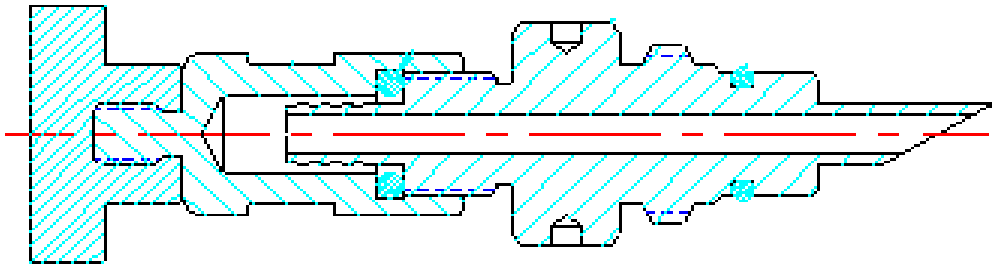
31.3 Optional Hose Barb Ports

There are a variety of hose barb port options that can be used on the BioFlo 4500 headplate. Single, double, and triple ports are available. These ports are steam-sterilized with the vessel and are not re-sterilizable.

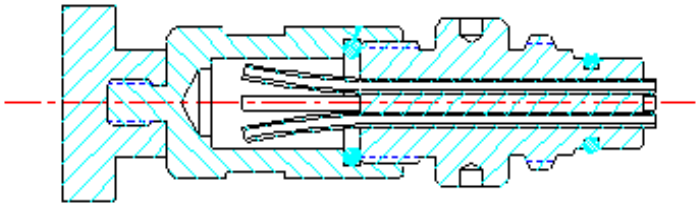
Figure 43: Hose Barb Ports



Part Number M1154-5044
Double Port Assembly (1/16)



Part Number M1154-5043
Addition Port Assembly (1/4)



Triple Port

31.3.1 Hose Barb Addition Port Options

Hose barb port options are summarized in the following table:

NBS Part Number	*Hose Barb Port Assembly*
M1254-5041	Addition Port Assembly, 1/16" (1.5mm)
M1254-5042	Addition Port Assembly, 1/8" (3.17mm)
M1254-5043	Addition Port Assembly, 1/4" (6.35mm)
M1254-5044	Double Port Assembly, 1/16" (1.5mm)
M1254-5045	Double Port Assembly, 1/8" (3.17mm)
M1254-5046	Triple Port Assembly, 1/16" (6.35mm)

32 SHUTDOWN PROCEDURE

After the fermentation or cell culture run, instrument operation and services must be terminated.

We recommend that you follow this procedure:

1. Set the pH control loop to **OFF**.
2. Set the DO control loop to **OFF**.
3. Set the Foam control loop to **OFF**.
4. Set the Pressure control loop to **OFF**.
5. Set the Airflow control loop to **OFF**.
6. Stop Agitation.
7. Stop steam supply to vessel.
8. Drain the contents of the vessel:
    - Remove the vessel drain port cap.
    - Connect an appropriate hose to the quick-connect fitting on the port, to transfer vessel contents.
9. If the fermentor is to remain off for an extensive period of time, close all service supply valves.

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33 POST-RUN VESSEL CLEANING PROCEDURE

After every fermentation or cell culture run, we strongly recommend that you clean the vessel according to the following procedure:

1. Rinse the vessel with tap water as soon as the run is completed, then drain it.

NOTE:

If applicable, be sure to follow the bio-safety regulations regarding the release of cultured microorganisms into the environment.

2. Fill the vessel with tap water again, up to or near the surface of the headplate.

3. Keep Agitation at 200-300 rpm without aeration for about one hour at a temperature setpoint of 30 – 35^0 C.

4. Flush all Sampling, Addition and Harvest Ports with steam.

5. Drain the water while the Air Inlet valve is open; set Airflow rate at 5-10 L/min, then close it.

6. While the Harvest/Drain Valve is open, use NBS Cleaning Tube Assembly (PN M1254-5059) connected to the tap water line to clean any biomass that may remain on the headplate's interior surface or in any other spots. The Cleaning Tube Assembly will be protected with silicone tubing in order to avoid scratching the vessel's interior surfaces.

7. Fill the vessel with tap water again, up to or near the headplate, and leave the Agitation on at 200 rpm for an hour or overnight.

8. Drain the water before the next run.

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34 PREVENTIVE MAINTENANCE

Preventive maintenance is performed to keep equipment in proper working order. When periodically performed, preventive maintenance will result in longer life for the equipment and will reduce time lost due to equipment failure.

34.1 Cleaning

After each fermentation or cell culture run, remove any dirt from the fermentor console, wiring cables and connectors.

Use a clean, dry, lint-free cloth or a dry brush to clean the outside of the fermentor. If necessary, wipe any headplate parts with a clean cloth saturated with water. The vessel may be scoured and flushed clean, **but do not use steel wool** to clean the vessel.

To maintain better life from O-rings and gaskets, be sure all surfaces are clean and that gaskets and O-rings are wiped clean before reassembling filter covers, fermentor tops, vessel and all gasket openings. A **light** coat of silicone grease should be applied to all O-rings before reassembling.

34.2 Vessel Removal

CAUTION!
Always disconnect power to the fermentor and ensure that the port steam valve is closed *before* attempting to remove the vessel from the console.

The procedure to remove the vessel mirrors the installation procedure—in reverse order, with these very important exceptions: disconnect power to the fermentor and close the port steam valve located on the side panel before you do anything else toward disconnecting the vessel from the console.

34.3 Three-Month Intervals

Perform the following checks and inspections every three months:

1. Turn off all power to the fermentor and close all service supply valves.

2. Inspect O-rings on the headplate and their mating surfaces for lack of resilience, tears, cuts or other conditions that may interfere with sealing.

3. Check all fuses on the equipment to make sure the fuses and holders have not corroded, and that the fuses are still good.

4. Check all controls and accessible items (switches, knobs, connections, pilot lights and fuse holders) to make sure that they are properly tightened. Tighten any component that is loose.

5. With steam **OFF**, open and examine steam traps. In order to clean them, unscrew the top. Examine the interior. Remove any foreign matter from the trap.

6. Open and clean all inline check valves that may see media from the vessel. If your media is high in solids content, the inlet air check valve may need to be cleaned more frequently.

7. Check all hand valves, on both the vessel and the piping skid, for tightness of the valve packing (just beneath the handle), which should be tightened to produce a slight drag on the valve handle when operated.

8. Open and inspect, clean or replace all pre-filters on services (i.e., steam, water and air).

9. Remove vessel bottom harvest drain valve and inspect the gaskets and packing for excessive wear.

10. Replace all O-rings on the **INOCULATION**, **ADDITION**, **HARVEST/DRAIN** and **SAMPLING PORTS**. Coat O-rings with **light** film of silicone grease.

11. Check airflow for any variation from the maximum, with vessel empty **and** with water in vessel.

12. Set back pressure regulator or pressure control loop for 20 PSIG (1.3 bar) vessel pressure, then turn off the entire unit once this pressure is reached. Note any vessel pressure decrease. If there is more than a 2 PSI (0.13 bar) drop within one hour, check for leakage.

34.4 One-Year Intervals

Once every year, perform all the three-month checks and inspections plus the following:

1. Inspect and clean all check valves.

2. Install repair kits in air-operated valves.

3. Check all O-rings used in vessel penetrations.

34.5 Air Filter, Inlet & Exhaust

The sterile inlet air and exhaust filters are located in the two-filter housing's tri-clamp fitting on the top of the fermentor console. To replace an element, detach the filter housing and remove the housing from the filter base.

When replacing an element, be careful not to damage filter element or the O-ring at the base of the element.

Remove the cartridges from the sterile air inlet and exhaust filters, and check them for damage or signs of blockage. Also check the O-ring on the cartridge for tears, resilience and other conditions that may interfere with sealing. Apply a small amount of silicone grease to this O-ring before reassembling. Should this O-ring be damaged, verify that its replacement is made of Ethylene Propylene.

These cartridges have a maximum use of 20 sterilizations and it is difficult to tell their condition from visual inspection; bubble point, DOP testing or other tests of this type are the only way to guarantee integrity.

One should also check the color of these cartridges. The exhaust cartridge will normally show signs of media color, but if the inlet cartridge or inner filter body show signs of media penetration, the check valve in the air line should be cleaned or replaced.

CAUTION!
Ensure that the Controller configuration is saved to disk before attempting to replace the batteries inside the Controller.

34.6 Battery Replacement

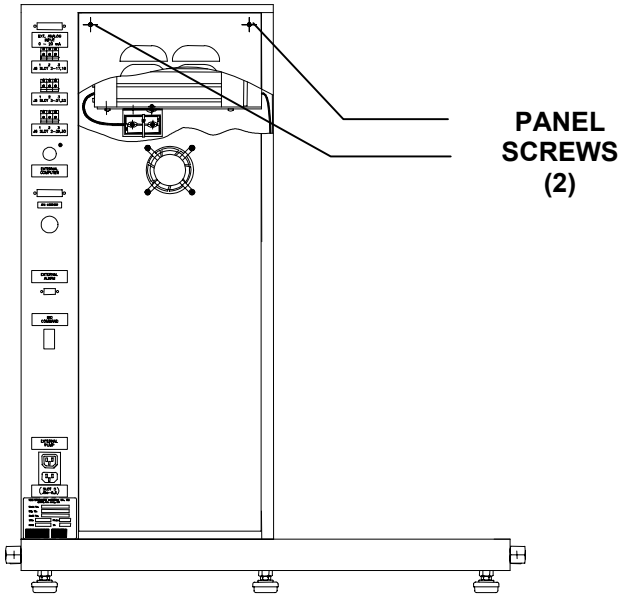
To replace the batteries inside the fermentor:

1. **BEFORE ANYTHING ELSE:** Follow the procedures for **SAVING A PROCESS CONFIGURATION** to disk. If power is cut off to the **CONTROLLER** without the batteries installed, the configuration will be erased.

2. Remove the two Phillips head panel screws on the back panel, setting them aside for reuse.

3. Unplug the exhaust fan, and carefully set the panel down.

Figure 44: Back Panel Removal



4. Locate the **BATTERY HOLDER** and remove the old batteries.

5. Observing the polarity markings on the **BATTERY HOLDER**, replace the old batteries with size AA 1.5V alkaline batteries.

6. Reattach the fan harness.

7. Reinstall the back panel with the panel screws and secure.

NOTE:

If the CONTROLLER configuration was erased during this procedure, whether due to error or failure to take precautions, follow the instructions for LOADING A PROCESS CONFIGURATION.

34.7 Motor Removal

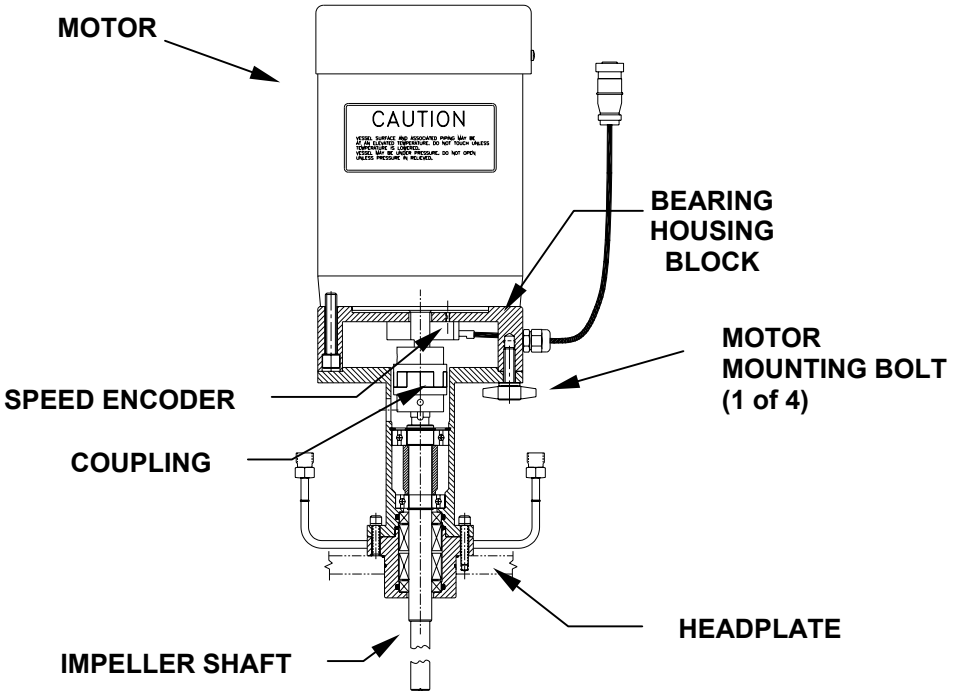
To replace the motor (referring to Figure 45):

1. Unplug the motor cable and the speed sensor cable.

2. Unscrew the four black T-handled bolts that secure the motor. Remove them and set them aside for reuse.

3. Lift the motor directly upward.

Figure 45: Motor Removal



34.8 Motor Installation

1. Align the coupling on the driveshaft with the coupling on the motor, and ease the motor into place.

2. Reinsert and screw in the four black T-handled bolts to secure the motor in place.

3. Plug in the speed sensor cable and the motor cable.

35 TROUBLESHOOTING

If any problems occur with your BioFlo 4500, do not attempt to perform any service on the equipment. Unauthorized servicing may void the warranty. Please contact your local NBS Representative. In any correspondence with NBS, please refer to the Model Number and Serial Number of your BioFlo 4500. This information can be found on the **ELECTRICAL SPECIFICATION PLATE**, located on the right side panel of the console.

35.1 Troubleshooting Guide

Symptom	*Possible Cause*	*Solution*
Message that Local Controller is not responding.	No power to fermentor console. External Computer Cable not connected properly. Internal controller error.	Verify power cord connections. Verify power switch operation. Check that cable is connected and secured to proper ports on both the computer and fermentor. Contact local NBS Service Dept.
Touchscreen monitor blank.	No power to monitor. No power to computer.	Verify power cord connections to both the monitor and console. Verify that LED POWER INDICATOR on monitor is illuminated. Verify that LED POWER INDICATOR is illuminated on computer
Overflow error message in display	Internal controller error	Press OK to acknowledge message. Press the START BUTTON, and select SHUTDOWN. In the SHUTDOWN WINDOWS DIALOG, select “Restart the Computer?” and press YES.

Symptom	*Possible Cause*	*Solution*
No power indicator on fermentor console	No power to fermentor console.	Verify power cord connections. Verify power switch operation. Contact local NBS Service Dept.
Unit fails to communicate with *BioCommand*.	Incorrect Multidrop (Unit ID) Address assigned to Controller in *BioCommand*. Conflicting Multidrop (Unit ID) Address with other equipment in *BioCommand*. Controller software configuration deleted due to battery backup and power failure.	Verify that a single Node Number (Unit ID or Multidrop Address) value of 0 through 19 has been assigned to the Controller. Assign a new Unit ID to equipment and verify that a single Node Number (Unit ID or Multidrop Address) value of 0 through 19 has been assigned to the Controller. Verify that the Controller configuration has been saved and reload the configuration into the software.
Poor loop control	Incorrect loop configuration. Sensors and probes miscalibrated. Agitation loop	Confirm proper configuration settings and connections. Recalibrate probes and sensors. See Below
Inaccurate agitation loop readings	Cable connections may be loose.	Check cable connections. If all connections are firmly seated, replace speed sensor.

36 REPLACEMENT PARTS & ACCESSORY INFORMATION

When ordering replacement or accessory parts, or requesting service information, please provide the Model Number, and Serial Number of your BioFlo 4500**.** This information is on the **ELECTRICAL SPECIFICATION PLATE** on the side panel of the console.

36.1 Descriptions & Part Numbers

Part Description	*NBS Part Number*
O-Ring Kit (includes Headplate O-Ring)	M1254-9904
O-Ring for Headplate (20L)	P0280-8702
O-Ring for Headplate (30L)	P0280-8722
Rupture Disc	P0280-0990C
Rubber Diaphragm for Side Septum Addition Port	P0280-1991
Heater Repair Kit, 20 L	M1254-9905
Heater Repair Kit, 30L	M1254-9906
Bearing Housing Assembly (20 L, Single Seal)	M1254-3015
Bearing Housing Assembly (20 L, Double Seal)	M1254-2240
Bearing Housing Assembly (30 L, Single Seal)	M1254-3017
Bearing Housing Assembly (30 L, Double Seal)	M1254-2241
Shaft (20 L, Single Seal)	M1254-9194
Shaft (20 L, Double Seal)	M1254-9195
Shaft (30 L, Single Seal)	M1254-9196
Shaft (30 L, Double Seal)	M1254-9197
Retaining Ring, Bearing Housing	P0101-0345
Retaining Ring, Bearing Housing	P0101-1765
Retaining Ring	P0101-2505 + P0101-1125
Bearing	P0180-0440
Bearing, Bearing Housing	P0180-0330
Shaft Seal, Bearing Housing	P0280-0120
Filter Cartridge - Inlet/Outlet 0.2µ	P0200-0750
Filter Cartridge - Exhaust Depth	P0200-0752
Steam Trap Kit	P0220-4139
Gasket, Sight Glass 20 and 30L	M1117-1220
Ferrule, Front, Teflon	H-1259
Ferrule, Back, Teflon	H-1260
Check Valve	H-1069
Check Valve	H-1070
Solid State Relay, 45A	P0400-3151
Ingold Polarographic DO Probe	P0720-6270
Ingold pH liquid probe	P0720-5305

Part Description (continued)	*NBS Part Number*
Ingold pH gel probe	P0720-5581
Ingold pH Cable	P0720-2095
Ingold DO Cable	P0720-2331
Ingold Service Kit for DO Probe	P0720-6268
Broadley James pH probe	P0720-5730
Broadley James Polarographic DO probe	P0720-5293
Broadley James pH cable	P0720-2270
Broadley James DO cable	P0720-2330
Broadley James Service Kit for DO probe	P0720-5837
RTD Assembly	M1181-8001
Foam Probe, Level	F5-137
Foam Probe, High Foam	M1254-5029
Lead, Level & Foam Probe	M1153-8025
Digital I/O Module	M1254-5018
General Purpose I/O Module	M1218-7004
Temp/Agit I/O Module	M1218-7003
Septum for top addition port	P0280-2630
Septum cover for top addition port	M1214-9441
Syringe/septum assembly for 19 mm top port (includes 3 mm bore syringe)	M1214-5011
Syringe/septum assembly for 19 mm top port (includes 6.5 mm bore syringe)	M1214-5014
Auxiliary pump Watson Maslow 505, 120 V	P0620-0920
Auxiliary pump Watson Maslow 505, 230 V	P0620-0921
Auxiliary pump Masterflex Early Load II, 115 V	P0620-2410A
Auxiliary pump Masterflex Early Load III, 230 V	P0620-2411A
External cables for pump control via BioFlo4500, 120 V	P0720-2053 + M1273-8015
External cables for pump control via BioFlo4500, 230 V	P0720-2021 + M1273-8022
Aerosol containment system (spares)	M1154-3015
Aerosol containment system	M1154-3016
Sterile quick-connect, 19 mm	M1153-9633
Sterile quick-connect, 25 mm	M1153-9639
Air Prefilter and Regulator	M1117-2030
Water Prefilter and Regulator	M1117-2040
Steam Prefilter and Regulator	M1117-2020
Marine Blade Impeller, left handed, 20 L	P0200-2437
Marine Blade Impeller, right handed, 20 L	P0200-2227
Marine Blade Impeller, left handed, 30 L	P0200-2437
Marine Blade Impeller, right handed,30 L	P0200-2237
Pitched Blade Impeller, 20 L	M1214-5002
Pitched Blade Impeller,30 L	M1254-5034
Replacement Parts, 20 L - Customer	M1254-6010
Replacement Parts, 20 L Double Seal- Customer	M1254-6012
Replacement Parts, 30 L Double Seal- Customer	M1254-6014
Replacement Parts, 30 L - Customer	M1254-6016
Top Port Syringe Assembly - 3 mm bore syringe	M1214-5012

Part Description (continued)	*NBS Part Number*
Top Port Syringe Assembly - 6.5 mm bore syringe	M1214-5013
Battery Holder Assembly	M1254–5023
1.5V Battery	P0480–9030
External Computer Cable (20 ft.)	M1218-8039
Replacement Vessel Lamp Bulb with pushbutton	P0300-0209
Vessel Light with pushbutton	P0300-0201
Metaclamp 2” Tri-Clamp	P0300-0207
Flow Controller	P0460-7040
Solid State Relay Board	M1218-7008
Motor Coupling Insert	P0160-7270

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37 GLOSSARY

2 CH DIRECT	2-Channel Direct output action
2 CH COMP	2-Channel Complementary output action
2 CH OVER	2-Channel Overlap output action
D	Diameter
DO	Dissolved Oxygen
FNPT	Female National Pipe Thread
FS	Full-Scale
HP	Horsepower
ID	Inner Diameter
MAWP	Maximum Allowable Working Pressure
NPT	National Pipe Thread
OTR	Oxygen Transfer Rate
PID	Proportional/Integral/Derivative
PSI	Pounds per Square Inch
PSIG	Pounds per Square Inch, Gauge
PWM	Pulse Width Modulation
RPM	Revolutions Per Minute
RTD	Resistance Temperature Device
SCADA	Supervisory Control And Data Acquisition
SLPM	Standard Liters Per Minute

SSR	Solid State Relay
UPS	Uninterruptible Power Source
VCO	Vacuum Connector O-ring
VVM	Vessel Volume per Minute
W x D x H	Width x Depth x Height

38 DRAWINGS

38.1 Control Schematics

Figure 46: Basic Control Schematics—Detail A

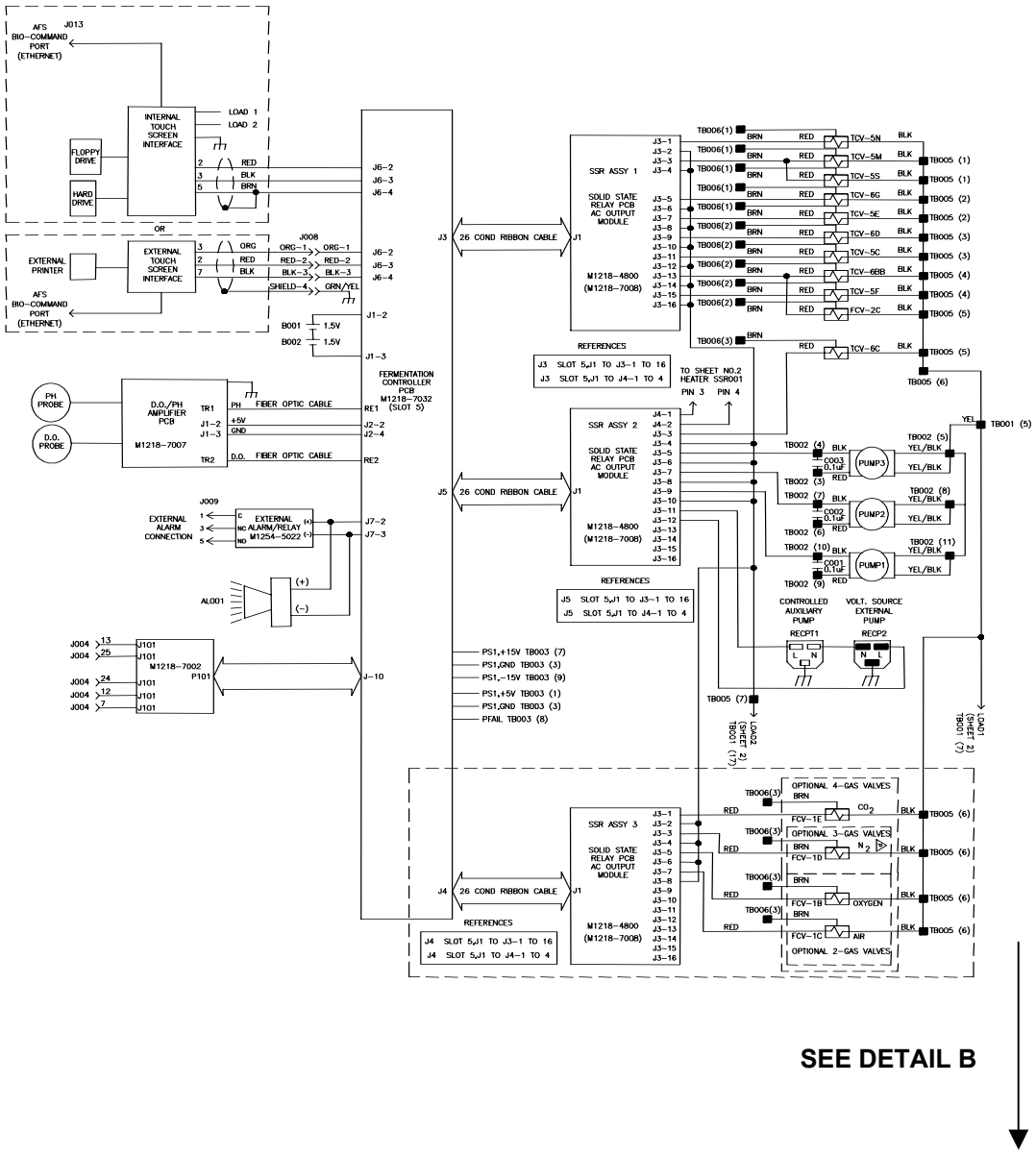

Figure 47: Basic Control Schematics—Detail B

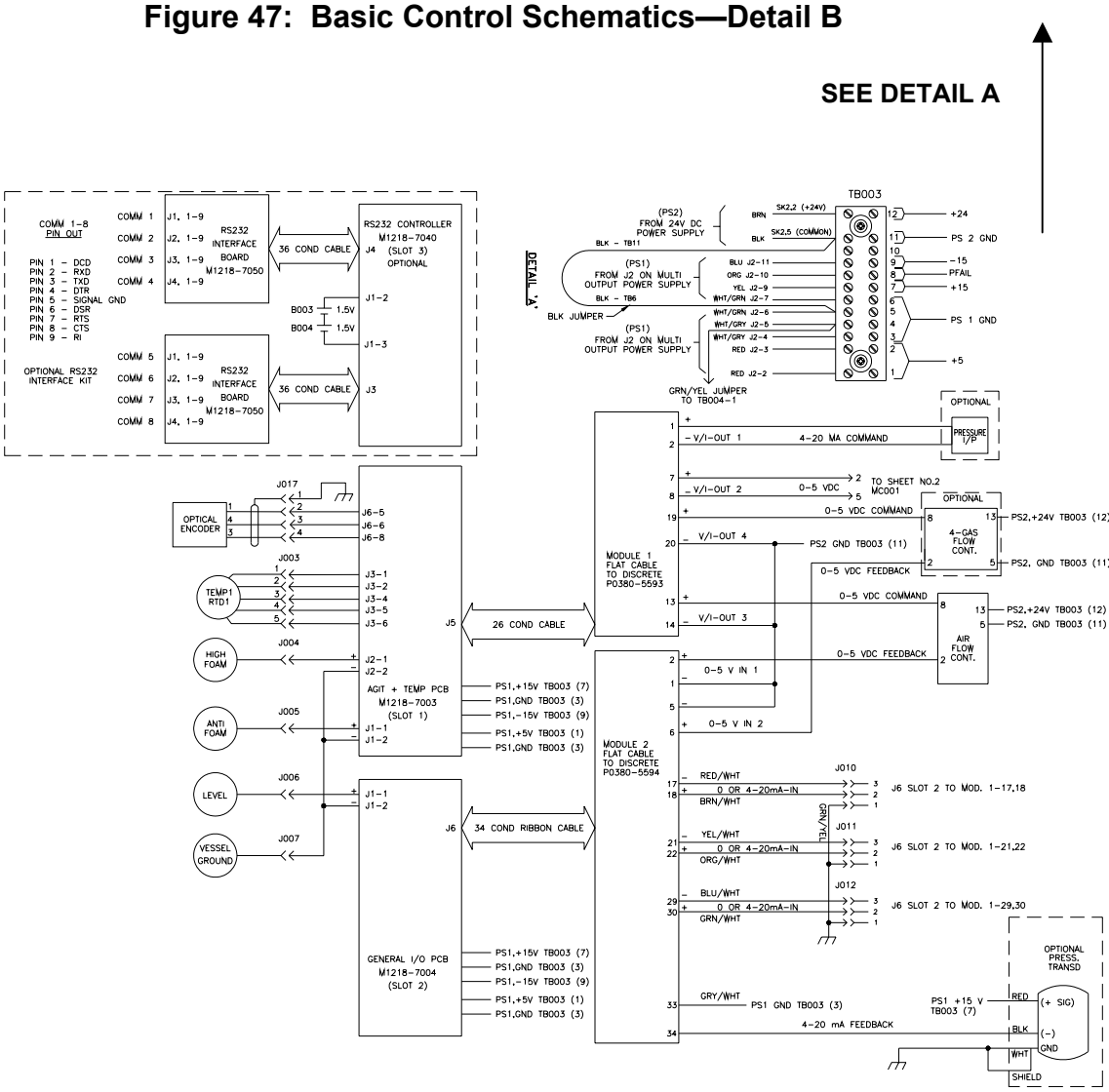

Figure 48: Power Schematics

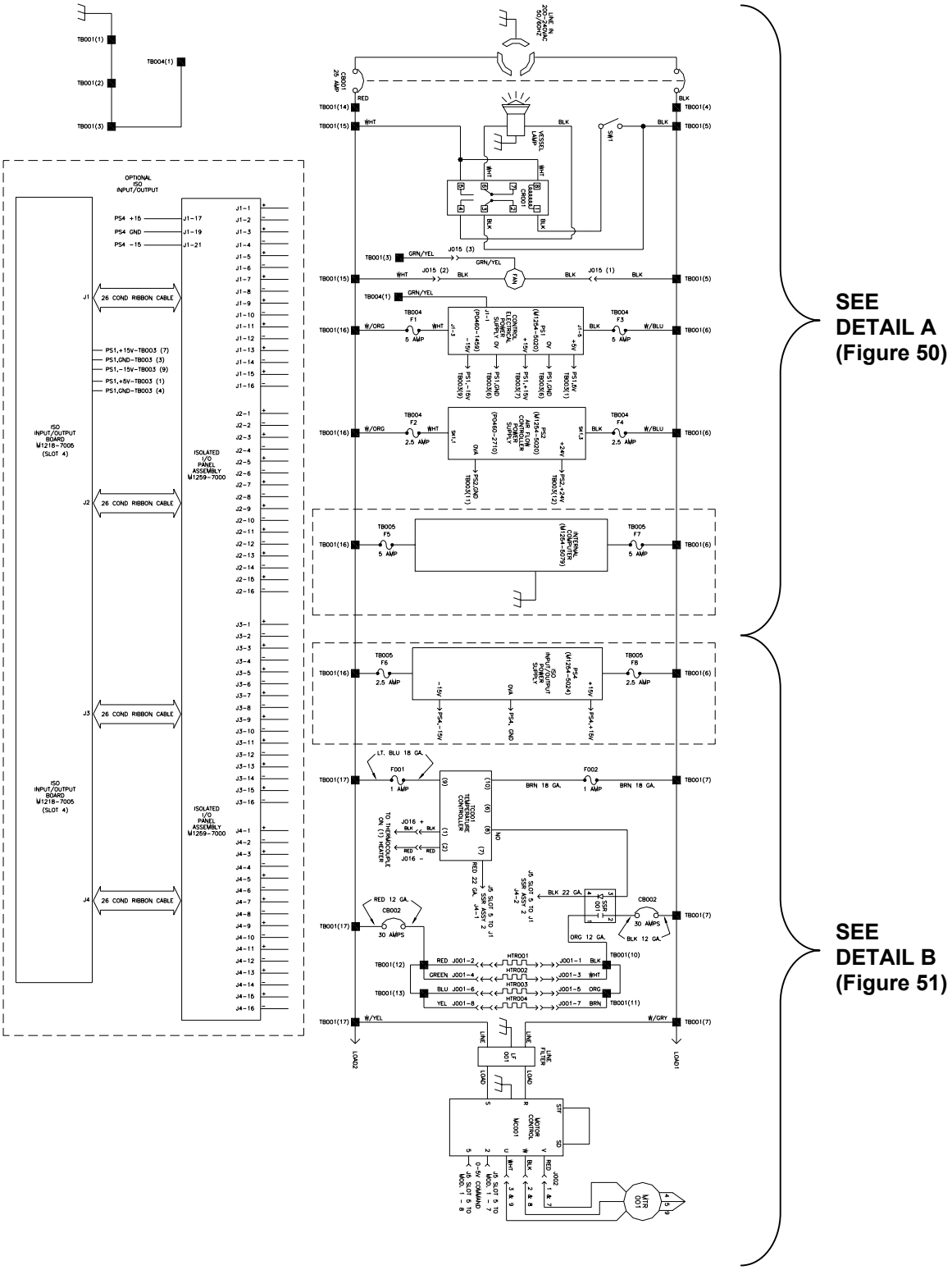

Figure 49: Power Schematics, Detail A