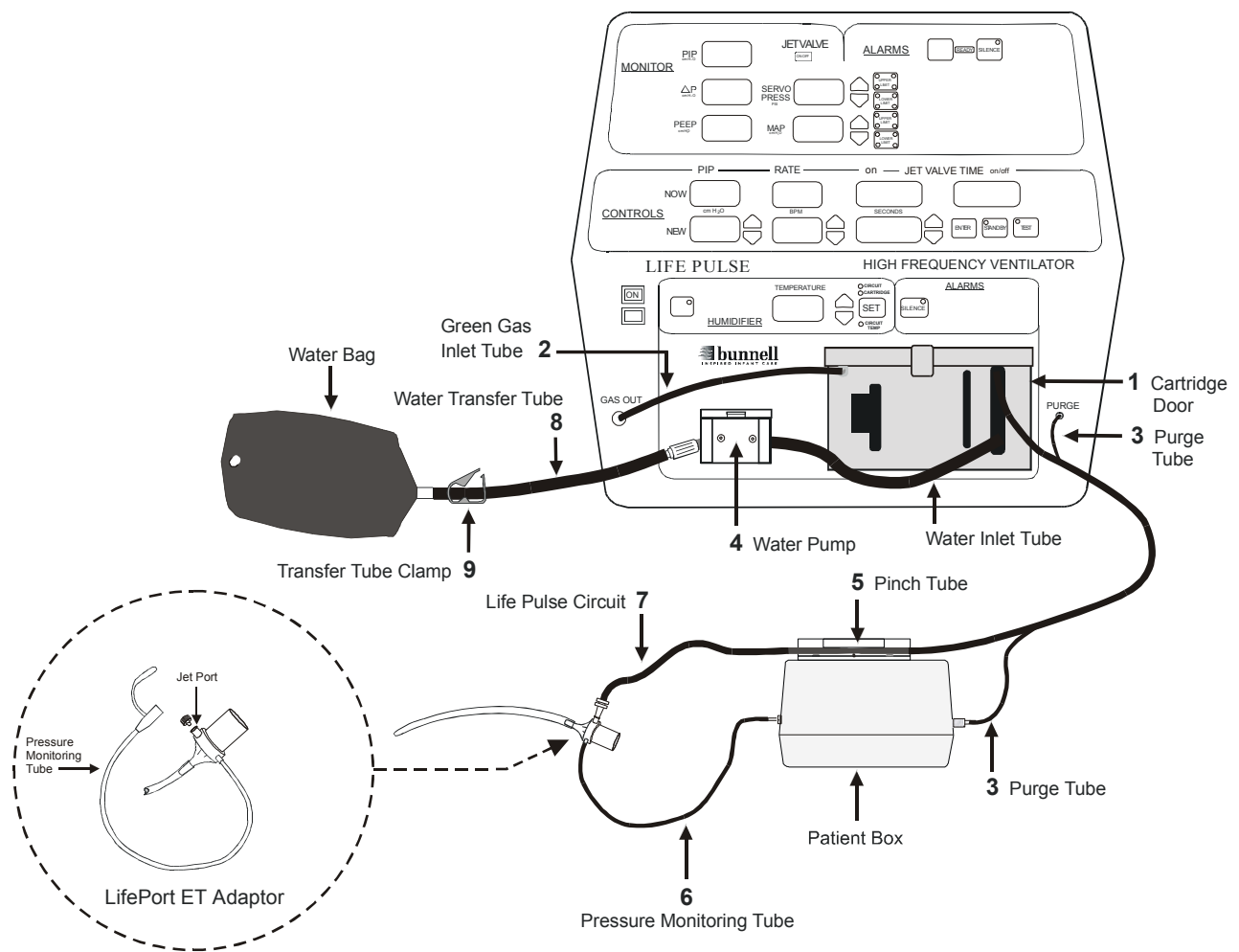


LIFE PULSE™ HIGH-FREQUENCY VENTILATOR

QUICK REFERENCE GUIDE

01388-09.12



(Follow Number Sequence for Correct Circuit Set-Up)

24-hour HOTLINE: 800-800-4358

www.bunl.com

Setting Up the Life Pulse

Provide Gas Source	Connect ventilator to a low flow blender (0-30 L/min.) or to low flow output (2-100 L/min.) of a standard air/oxygen blender.
Provide Electrical Power	Plug Life Pulse into electrical outlet.
Turn On Life Pulse	Press the ON/OFF switch on front panel. Press SILENCE button to quiet "Power ON" alarm.
Install Cartridge/Circuit	Remove plastic tube from guide pins on back of cartridge. ①Place cartridge into cartridge door and latch securely. ②Attach green gas inlet tube to GAS OUT connector. ③Attach purge tube to PURGE connector on front panel and Patient Box.
Latch Water Inlet Tube Into Pump Housing	④Place water inlet tube into pump housing and latch pump door securely.
Install Pinch Tube in Patient Box	⑤ Press "PUSH TO LOAD" button on top of Patient Box and gently stretch pinch tube into pinch valve.
Attach LifePort Adapter to Circuit and Patient Box	⑥ Connect pressure monitoring tube of LifePort to Patient Box and ⑦ connect Life Pulse circuit to jet port on the LifePort adapter.
Attach Sterile Water & Place At or Below Humidifier Level	⑧ Connect sterile water supply to water inlet tube on humidifier cartridge via water transfer tube, then ⑨ unclamp water transfer tube.
Perform Systems Test	Attach LifePort Adapter and Endotracheal Tube to Test Lung. Press TEST button and verify that Life Pulse runs through test sequence and returns to STANDBY mode with audible alarm sounding. Press SILENCE button to quiet "PASSED TEST" alarm.
Perform Functional Test	Perform a functional test. Press ENTER button to start default settings (PIP 20, Rate 420, On-Time 0.02) while attached to test lung. Verify that READY condition can be met, monitored pressures are stable, and monitored PEEP is 0.0 ± 1 cm H ₂ O when no PEEP is being applied.
Place Life Pulse Into <u>Standby</u>	Place Life Pulse into STANDBY mode after Tests are completed and prior to connecting to the patient. (See Warning)
Before Connecting to Patient, Remove and Save Test Supplies	Remove Test set-up from Life Pulse circuit and Patient Box. Save LifePort, ET tube, and Test Lung for future use.
WARNING: The water inlet tube of the humidifier cartridge/circuit must be latched into the pump housing to prevent cartridge overflow and delivery of water to the patient by gravity feed.	
WARNING: The water supply should be positioned at or below the level of the humidifier cartridge to decrease the potential of overflowing the cartridge by gravity feed.	

Preparing Patient for High-Frequency Ventilation

Establish Proper Airway	Replace standard 15mm endotracheal tube adapter with the Bunnell LifePort adapter.
Continue Conventional Ventilation	The CV provides PEEP, background "sigh" breaths, and fresh gas for patient's spontaneous breathing.
Monitor CV Pressures Using Life Pulse in the STANDBY Mode	<p>The Life Pulse monitors tracheal pressures using pressure transducer located in Patient Box. In the STANDBY mode the operator must:</p> <ol style="list-style-type: none"> 1. Attach green patient end of Life Pulse circuit to the jet port of the LifePort adapter. 2. Attach clear pressure monitoring tube of LifePort adapter to Pressure Monitor Tube connector on Patient Box. 3. Keep Life Pulse in the STANDBY mode. 4. Monitor values for PIP, PEEP and MAP displayed in Life MONITOR section until stable.
Monitor Patient	<p>Monitoring should include:</p> <ol style="list-style-type: none"> 1. Continuous transcutaneous or equivalent monitoring of arterial CO₂ and O₂ concentrations. 2. Periodic monitoring of arterial blood pressure. 3. Recording of Life Pulse Ventilator settings. 4. Recording of monitored pressures on Life Pulse. 5. Periodic arterial blood gases. 6. Periodic chest x-rays. 7. Other monitoring as clinically indicated.
<p>WARNING: All patient connections to the Life Pulse circuit must only be made while the Life Pulse is in the STANDBY mode. Failure to comply may result in a high volume of gas being delivered at pressure to the patient, which may result in severe patient injury.</p>	

Beginning High-Frequency Ventilation

All infants treated with the Life Pulse must be connected to a conventional ventilator and continuous blood gas monitors (transcutaneous and/or pulse oximetry). They must have a Bunnell LifePort adapter on the standard ET tube and be intubated. The following steps may then be taken:

Monitor CV PIP with Life Pulse in the STANDBY Mode	Monitor PIP, PEEP, and MAP delivered by CV or HFV using Life Pulse in STANDBY mode. (Wait at least 90 seconds for averaging of PIP and PEEP samples to equilibrate.)
Record Baseline Blood Gases	Note blood gas monitor values and/or draw an arterial blood gas sample before starting high-frequency ventilation.
Set Life Pulse PIP	Adjust NEW PIP of Life Pulse to be equal to 90-100% of average CV PIP (90% for air leaks; 100% for poor compliance) as displayed in MONITOR section of the Life Pulse.
Set Life Pulse Rate	Adjust NEW RATE of Life Pulse to intermediate frequency (420 b/m is recommended).
Set Life Pulse On-Time	Adjust NEW ON-TIME of Life Pulse to 0.020 seconds.
Begin High-Frequency Ventilation	Press the ENTER button on Life Pulse to convert NEW settings to NOW settings. PIP will quickly rise towards set NOW PIP. Life Pulse may pause every time a breath is delivered by the conventional ventilator.
Eliminate Life Pulse Interruptions	If Life Pulse is pausing, reduce CV PIP until the high-frequency pulses are no longer interrupted (when CV PIP is less than the Life Pulse NOW PIP).
Lower CV Rate	Lower CV rate to between 0 and 10 b/m. (Use 0 to 4 b/m if air leak is patient's primary problem. Use 5 to 10 b/m and/or higher PEEP if poor oxygenation is main problem.)
Assure READY Light is On	Watch for READY light to illuminate, which indicates the pressures are stable and the alarms are active.
Adjust PEEP	Adjust CV gas flow and/or PEEP to obtain the desired PEEP. (Reduce Life Pulse rate if monitored PEEP exceeds CV PEEP.)
Reassess Blood Gases	Note blood gas monitor values and/or draw arterial blood gas samples to determine if ventilator adjustments are necessary.

WARNING: Before leaving the Life Pulse, during initial start-up and following a circuit change, a properly trained person must observe the cartridge fill with sterile water for inhalation, USP, to the second water level sensing pin and the pump stop pumping.

Patient Management During HFV

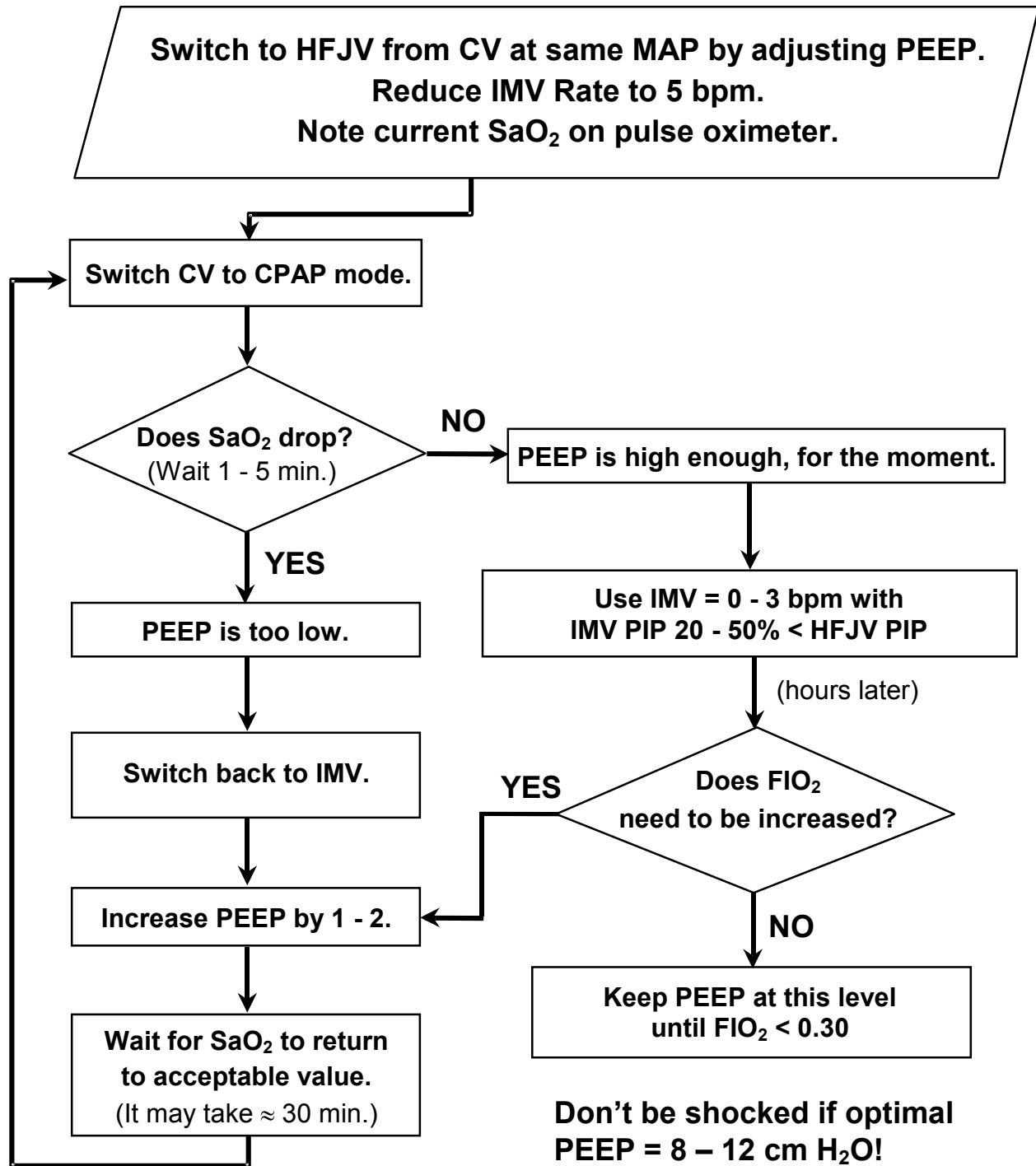
1. HFV ΔP (PIP - PEEP) is the primary determinant of PaCO₂. HFV rate is secondary.
2. Resting lung volume (FRC supported by set PEEP) and mean airway pressure are crucial determinants of PO₂.
3. Avoid hyperventilation and hypoxemia by using optimal PEEP. (See When to Raise PEEP below.)
4. Minimize IMV at all times, using very low rates (typically 0 – 3 bpm), unless IMV is being used to dilate airways or *temporarily* to recruit collapsed alveoli. In general, keep IMV PIP 20 – 50% < HFV PIP.
5. To overcome atelectasis, IMV rates up to 10 bpm can be used for 10 – 30 minutes. Thereafter, IMV rate should be dropped back to 0 – 3 bpm. In general, keep IMV I-time = 0.4 – 0.6 sec.
6. If lowering IMV rate worsens oxygenation, PEEP is probably too low. Higher PEEPs and lower IMV rates reduce the risk of iatrogenic lung injury.
7. Lower FIO₂ before PEEP when weaning until FIO₂ is less than 0.53.

SETTING	USUAL	WHEN TO RAISE	WHEN TO LOWER
HFV PIP	whatever produces desired PCO ₂	To lower PCO ₂ .	To raise PCO ₂ . (Raise PEEP simultaneously to keep MAP and PO ₂ constant.)
HFV Rate	420 bpm (neonates) 300 bpm (peds)	To decrease PCO ₂ in <u>smaller</u> patients; <u>or</u> To increase MAP and PO ₂ .	To eliminate inadvertent PEEP by lengthening exhalation time <u>or</u> To increase PCO ₂ when weaning.
HFV I-Time	0.02 sec	To enable Jet to reach PIP at low HFJV rates in <u>larger</u> patients (> 15 kg).	Keep at the minimum of 0.02in almost all cases.
IMV Rate	0 – 3 bpm	To reverse atelectasis or dilate restricted airways (5-10 bpm)	To minimize volutrauma, especially when air leaks are present, <u>or</u> To decrease hemodynamic compromise.
IMV PIP	PIP necessary to get adequate chest rise	To reverse atelectasis or dilate airways; PIP may be > or < HFJV PIP.	To minimize volutrauma, especially when air leaks are present, <u>or</u> To decrease hemodynamic compromise.
IMV I-Time	0.4 sec	To reverse atelectasis or dilate airways.	To minimize volutrauma, especially when air leaks are present, <u>or</u> To decrease hemodynamic compromise.
PEEP	7 – 12 cm H ₂ O (Neonates) 10 – 15 cm H ₂ O (Peds)	To improve oxygenation <u>and</u> decrease hyperventilation. <u>To find optimal PEEP:</u> Raise PEEP until SaO ₂ stays constant when switching from IMV to CPAP.	<u>Lower PEEP only:</u> • when it appears that cardiac output is being compromised; <u>or</u> • when oxygenation is adequate <u>and</u> • when lowering PEEP doesn't decrease PaO ₂ .
FIO₂	< 0.60	Raise as needed <u>after</u> optimizing PEEP.	Lower FIO ₂ in preference to PEEP when weaning until FIO ₂ < 0.3.

Special Air Leak Considerations

1. Minimize IMV by using HFV + adequate CPAP.
2. If oxygenation is compromised, raise PEEP, *even if the lungs are overexpanded on xray.*
(Rationale: you are going to have to raise something, and PEEP is less hazardous than IMV breaths. It may also help interstitial gas find its way out of the lungs via more patent airways.)

Finding Optimal PEEP during HFJV *



* when switching from CV to HFJV.

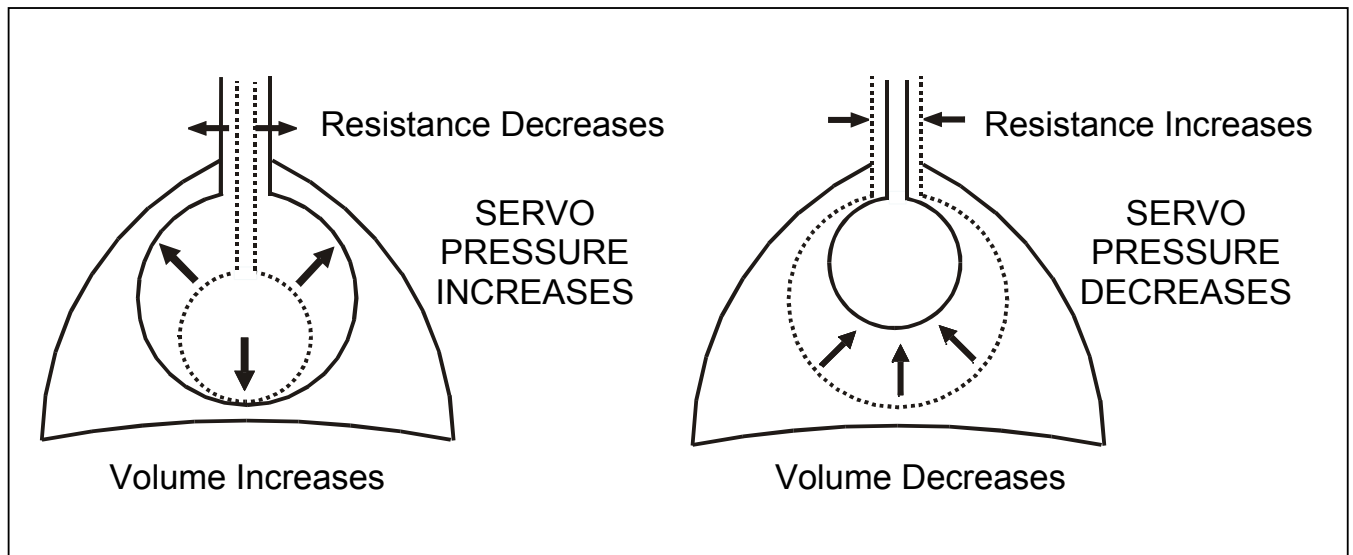
Warnings: Lowering PEEP may improve SaO₂ in some cases.

Optimal PEEP may be lower in patients with active air leaks or hemodynamic problems.

Using IMV with high PEEP is hazardous. Do not assume high PEEP causes over-expansion.

THE IMPORTANCE OF SERVO PRESSURE

- Servo Pressure = driving pressure that automatically regulates flow.
- Servo Pressure changes as lung volume or mechanics change.



Servo Pressure changes: early warning of changes in patient condition.

SERVO PRESSURE INCREASES WITH:

- Improving compliance or resistance
- Leak around ETT
- Tubing leak

SERVO PRESSURE DECREASES WITH:

- Worsening compliance or resistance
- Obstructed ETT
- Tension Pneumothorax
- Right mainstem intubation
- Patient needs suctioning

Charting Servo Pressure simplifies patient management decisions.

Weaning Patient from Life Pulse

Lower Life Pulse PIP Slowly	<ol style="list-style-type: none"> 1. Avoid lowering MAP until FiO_2 is < 0.3. 2. Keep the RATE on the Life Pulse steady. 3. Begin to reduce the Life Pulse PIP. Weaning the Life Pulse PIP should be done slowly (1 to 2 cm H_2O at a time).
Lower Life Pulse and CV PIP to Teens	<ol style="list-style-type: none"> 1. Continue to reduce the PIP on Life Pulse, keeping the RATE on the Life Pulse steady. 2. Reduce the PIP on the Conventional Ventilator (CV) to avoid interruption of the Jet pulses. 3. In most cases, when PIP is < 15 cm H_2O, begin to slowly increase the CV rate while continuing to decrease Life Pulse support. Interrupting the Jet pulses with CV breaths is now okay.
Consider CV Trial	<ol style="list-style-type: none"> 1. Consider a trial of CV alone only when all air leaks are resolved (for 24 hours) and the Life Pulse PIP is ≤ 15 cm H_2O and FiO_2 is < 0.3. 2. Place the Life Pulse into STANDBY mode for a CV trial.
Evaluate Patient During CV Trial	<ol style="list-style-type: none"> 1. Observe the patient to ensure positive a response to the CV trial. 2. Increase the CV rate, if necessary, after the Life Pulse is in STANDBY. If CV PIP has to be increased to ≥ 20 cm H_2O, return to HFV.
Return to HFV if Necessary	<ol style="list-style-type: none"> 1. If the patient responds poorly to the trial, re-ENTER Life Pulse support at the same or higher settings and repeat the steps described above.
Wean From CV if Possible	<ol style="list-style-type: none"> 1. Begin weaning the patient from CV if he responds positively (weaning to CPAP is desirable).

ALARMS: Life Pulse STOPS Running

ALARM	POSSIBLE CAUSES	SUGGESTION
JET VALVE FAULT	Internal electronic or pinch valve solenoid problem.	Support patient with CV. Check Patient Box connections. Reattach Patient Box connector to rear of Life Pulse and conduct TEST on test lung. If TEST is passed, resume ventilation.
	If alarm persists . . .	Call Bunnell Hotline: ☎ 800-800-4358.

VENTILATOR FAULT with code 01 OR 05 - 09 displayed in ON/OFF window	Electronic circuitry or internal power supply problem.	Support patient with CV. Turn off power to Life Pulse to reset it. Turn power on and conduct TEST on test lung. If TEST is passed, resume ventilation.
	If alarm persists	Call Bunnell Hotline: ☎ 800-800-4358.




VENTILATOR FAULT with code 10 displayed in ON/OFF window	Radical change in operating parameters	Evaluate patient and check ventilators. To resume ventilation press ENTER button
	Leak in humidifier cartridge/circuit.	Examine humidifier cartridge/circuit for leaks. Replace circuit if necessary.
	If alarm persists . . .	Call Bunnell Hotline: ☎ 800-800-4358.

ALARMS: During TEST Procedure

ALARM	POSSIBLE PROBLEM	SUGGESTION
VENTILATOR FAULT with code 02, 03, or 04 displayed in ON/OFF window	02: Purge tube is kinked or disconnected at front panel of Life Pulse or at Patient Box	Unkink or connect purge tube and repeat TEST procedure.
	If alarm persists	Replace Patient Box and repeat TEST procedure.
	03 or 04 ventilator fault alarm.	Call Bunnell Hotline: ☎ 800-800-4358.

ALARMS: Life Pulse CONTINUES Running

ALARM	POSSIBLE CAUSES	SUGGESTION
HIGH PIP	ET tube improperly positioned, kinked, or obstructed.	Reposition, unkink, or suction ET tube (may require reintubation).
	Pressure monitoring tube kinked or obstructed.	Unkink pressure monitoring tube or flush pressure monitoring tube with 2-3 cc air.
	Expiratory limb of conventional ventilator circuit kinked or obstructed.	Unkink expiratory limb of circuit and/or clear obstruction (e.g., excess water).
	If alarm persists . . .	Call Bunnell Hotline: ☎ 800-800-4358.
LOSS OF PIP	Pressure monitoring tube obstructed, kinked or disconnected.	Unkink or reconnect pressure monitoring tube, or flush with 2-3 cc air while Life Pulse is running and in READY mode. May need to press ENTER to resume ventilation if READY light is off. Re-evaluate cartridge temp setting (e.g., lower cartridge temp 1-2° C; repeat if necessary. WARNING: do not under-humidify.) Suction patient if necessary.
	Life Pulse circuit is kinked or disconnected.	Unkink or reconnect Life Pulse circuit to Life Port adapter.
	Humidifier cartridge/circuit leaking, kinked, or improperly installed.	Inspect humidifier cartridge/circuit for leaks, kinks, or poor connections; correct condition (e.g., replace circuit).
	Pinch Valve stopped cycling	Place Life Pulse in STANDBY mode, increase CV support, and call Bunnell Hotline.
If alarm persists . . .	Call Bunnell Hotline: ☎ 800-800-4358.	
UNSTABLE PIP	Water or secretions in or around tip of pressure monitoring tube.	Flush pressure monitoring tube with 2-3 cc air while Life Pulse is running and in READY mode. Re-evaluate cartridge temp setting (e.g., lower cartridge temp 1-2° C and repeat if necessary. WARNING: do not under-humidify.) Suction patient if necessary.
	Conventional ventilator breaths or patient's active spontaneous breathing affecting pressure monitoring.	Reduce CV rate (0-5 b/m for airleaks; 5-10 b/m for poor compliance). Consider sedation.
	If problem persists . . .	Call Bunnell Hotline: ☎ 800-800-4358.

ALARM	POSSIBLE CAUSES	SUGGESTION
CANNOT MEET PIP	Patient "fighting" the Life Pulse.	Patient may need comforting or sedation.
	Patient too large for Life Pulse settings.	Check Servo Pressure. If ≥ 19 psi, patient may be too large for Life Pulse settings. Decrease HFV rate, PIP, and/or increase CV support.
	Humidifier cartridge/circuit leaking, kinked, or improperly installed.	Inspect humidifier cartridge/circuit for leaks, kinks, or poor connections; correct condition (e.g., replace circuit).
	If alarm persists . . .	Call Bunnell Hotline:  800-800-4358.
MEAN AIRWAY PRESSURE: UPPER LIMIT (High MAP)	Conventional ventilator support has been increased.	Press RESET button on front panel.
	Change in patient's condition.	Evaluate patient and manage appropriately.
	Pressure monitor tube kinked, or obstructed.	Unkink pressure monitoring tube or flush with 2-3 cc air while Life Pulse is running and in READY mode. Re-evaluate cartridge temp setting (e.g., lower cartridge temp 1-2° C; repeat if necessary. (NOTE: do not under-humidify.) Suction patient if necessary. Evaluate patient and manage appropriately.
	Expiratory limb of conventional ventilator circuit kinked or obstructed.	Unkink expiratory limb of circuit and/or clear obstruction (e.g., excess water).
	ET tube improperly positioned, kinked, or obstructed.	Reposition, unkink, or suction ET tube (may require reintubation).
If alarm persists . . .	Call Bunnell Hotline:  800-800-4358.	
MEAN AIRWAY PRESSURE: LOWER LIMIT (Low MAP)	Conventional ventilator support has been decreased.	Press RESET button on front panel.
	Change in patient's condition.	Evaluate patient and manage appropriately.
	Humidifier cartridge/circuit leaking, kinked, or improperly installed.	Inspect humidifier cartridge/circuit for leaks, kinks, or poor connections; correct condition (e.g., replace circuit).
	Leak around, or improperly positioned, ET tube.	Examine ET tube for improper positioning or air leak. ET tube may need repositioning or patient may require reintubation with larger ET tube.
If alarm persists . . .	Call Bunnell Hotline:  800-800-4358.	

ALARM	POSSIBLE CAUSES	SUGGESTION
SERVO PRESSURE: UPPER LIMIT (High Servo Pressure)	Patient's compliance has improved.	Examine patient for atelectasis resolution and manage appropriately. Press RESET if satisfied with new Servo Pressure.
	Patient developing an air leak.	Examine patient for new or recurring air leak (e.g., pneumothorax, pneumomediastinum, etc.) and manage appropriately.
	Pressure monitoring tube kinked, disconnected or obstructed.	Unkink, reconnect or clear pressure monitoring tube. Press RESET button.
	Humidifier cartridge/circuit leaking, kinked, or improperly installed.	Inspect humidifier cartridge/circuit for leaks, kinks, or poor connections; correct condition (e.g., replace circuit).
	If alarm persists . . .	Call Bunnell Hotline: ☎ 800-800-4358.

SERVO PRESSURE: LOWER LIMIT (Low Servo Pressure)	Patient's compliance has worsened or tension developing from air leak.	Examine patient for worsening atelectasis or tension pneumothorax and manage appropriately.
	ET tube obstructed or improperly positioned.	Examine ET tube for obstruction or improper positioning. Correct condition.
	Expiratory limb of conventional ventilator circuit kinked or obstructed.	Unkink expiratory limb of circuit and/or clear obstruction (e.g., excess water).
	If alarm persists . . .	Call Bunnell Hotline: ☎ 800-800-4358.

0.0 SERVO PRESSURE	Servo pressure transducer has failed.	Call Bunnell Hotline: ☎ 800-800-4358.
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LOW GAS PRESSURE	Faulty O ₂ blender or high pressure hose.	Replace blender or high-pressure hose.
	Faulty hospital gas supply.	Manually ventilate patient until gas supply returns. Re-start Life Pulse.
	If alarm persists . . .	Call Bunnell Hotline: ☎ 800-800-4358.

VENTILATOR FAULT	Purge tube kinked or disconnected at front panel or Patient Box.	Unkink or reconnect purge tube. Call Bunnell Hotline if alarm persists.
	Pressure monitoring tube disconnected.	Reconnect pressure monitoring tube.
	If alarm persists . . .	Call Bunnell Hotline: ☎ 800-800-4358.

HUMIDIFIER ALARMS

ALARM	POSSIBLE CAUSES	SUGGESTION
<p>HIGH LEVEL</p> <p>(Water level too high)</p>	Water inlet tube not secured in water pump housing.	Place water inlet tube in pump housing and latch door securely (see cover illustration).
	Poor electrical connections between cartridge and humidifier.	Check cartridge door and latch to assure they are secure. Re-install cartridge.
	Broken electrical tracing on back of cartridge.	Check cartridge for scratches across electrical tracings. Replace circuit if necessary.
	Problem with water level sensing pins.	Make sure sterile water, not normal saline, is being used. Replace circuit if necessary.
	If alarm persists after circuit change . . .	Call Bunnell Hotline: ☎ 800-800-4358.
<p>LOW LEVEL</p> <p>(water level too low)</p>	Water supply empty or water transfer tube kinked or clamped.	Replace water supply if empty. Unkink or unclamp water transfer tube.
	Maximum fill time exceeded.	If water level is below middle level sensing pin, press WAIT button twice to reset fill time and resume filling.
	Problem with water level sensing pins.	Make sure sterile water, not normal saline, is being used. Replace circuit if necessary.
	Poor electrical connections between cartridge and humidifier.	Check cartridge door and latch to assure they are secure. Re-install cartridge.
	Water pump stuck.	Press WAIT button, clamp water transfer tube, open pump door, press WAIT button again. Pump should activate. Re-install water inlet tube and latch pump door. Unclamp water transfer tube.
If alarm persists after circuit change . . .	Call Bunnell Hotline: ☎ 800-800-4358.	
<p>CIRCUIT FAULT</p>	Water supply empty or water transfer tube kinked or clamped ("LEVEL" also displayed).	Replace water supply if empty. Unkink or unclamp water transfer tube.
	Cartridge not secure in cartridge door.	Make sure plastic tube has been removed from back of cartridge. Re-install cartridge and latch door securely.
	Poor electrical connections between cartridge and humidifier.	Check cartridge door and latch to assure they are secure. Re-install cartridge.
	Humidifier cartridge/circuit problem ("TEMP" may also be displayed).	Replace humidifier cartridge/circuit.
	If alarm persists after circuit change . . .	Call Bunnell Hotline: ☎ 800-800-4358.

ALARM	POSSIBLE CAUSES	SUGGESTION
CIRCUIT TEMP HIGH (Temperature in Circuit may be too high)	Poor electrical connections between cartridge and humidifier.	Check cartridge door and latch to assure they are secure. Re-install cartridge.
	Faulty Circuit temperature sensor.	Replace humidifier cartridge/circuit.
	If alarm persists . . .	Call Bunnell Hotline: ☎ 800-800-4358.

CIRCUIT TEMP LOW (Temperature in Circuit may be too low)	Poor electrical connections between cartridge and humidifier.	Check cartridge door and latch to assure they are secure. Re-install cartridge.
	Faulty Circuit temperature sensor.	Replace humidifier cartridge/circuit.
	If alarm persists . . .	Call Bunnell Hotline: ☎ 800-800-4358.

CARTRIDGE TEMP HIGH (Temperature in Cartridge may be too high)	Poor electrical connections between cartridge and humidifier.	Check cartridge door and latch to assure they are secure. Re-install cartridge.
	Faulty Cartridge temperature sensor.	Replace humidifier cartridge/circuit.
	If alarm persists . . .	Call Bunnell Hotline: ☎ 800-800-4358.

CARTRIDGE TEMP LOW (Temperature in Cartridge may be too low)	Poor electrical connections between cartridge and humidifier	Check cartridge door and latch to assure they are secure. Re-install cartridge.
	Faulty Cartridge temperature sensor.	Replace humidifier cartridge/circuit.
	If alarm persists . . .	Call Bunnell Hotline: ☎ 800-800-4358.