



Life Pulse™ High Frequency Ventilator

Alarms and Advanced Troubleshooting Guide

02684-01.1

Bunnell Incorporated
Salt Lake City, Utah 84115

Phone: 801-467-0800
Hotline: **800-800-4358**

Fax: 801-467-0867
Website: ***www.bunl.com***

CONTENTS

Servo Pressure Alarms	1
MAP Alarms	2
Jet Valve Fault Alarm	3
Ventilator Fault Alarms	4
Low Gas Pressure Alarm	5
Cannot Meet PIP Alarm	6
Loss of PIP Alarm	7
High PIP Alarm	8
Humidifier Temperature Alarms	9
Humidifier Water Level Alarms	10
Circuit Fault Alarms	11
Appendix	12

Introduction:

Successful troubleshooting combines a thorough knowledge of the ventilator with a systematic approach to problem solving.

In general, troubleshooting should start with the patient and work back to the ventilator.

Is the patient's interaction with the vent or the patient's condition causing the alarm?

Is the ET tube in good position and clear of secretions?

Is there moisture (excess-humidity) interfering with the pressure signal?

Is the LifePort adapter properly connected and is the pressure monitoring tube up between 10 to 2 o'clock?

Did changing the LifePort adapter correct the problem?

Is the circuit installed properly? Are there any kinks or poor connections?

Is the Patient Box running properly? Has the sound or rhythm changed?

Is the ventilator running or has it been affected by electrical fluctuations? Is it plugged into a UPS?

Is the humidifier running? Are the contact pins o.k.? Are the temperature controls set properly? Is there water available for the humidifier?

To be effective at troubleshooting you have to understand how the Life Pulse works, what the alarms are telling you and what can be done to correct the situation.

As always, if you can't resolve the alarm **quickly**, call the **Hotline, 800.800.4358**, and have one of our clinical specialists help you.

If the alarm persists, call the **Bunnell Hotline @ 800.800.4358 (HFJV)**

Upper and Lower Servo Pressure Alarms

Definition: The Servo Press alarm alerts the user to changes in the internal driving pressure or flow rate required to deliver breaths at the Now PIP, rate, and jet valve on-time.

<u>Servo Pressure</u>	<u>Alarm Window</u>	<u>Approx. Patient Size</u>
< 1 psi	± 0.2 psi	< 700 gm
1- 5 psi	± 20% (0.2-1.0 psi)	701 – 4000 gm
> 5 psi	± 1.0 psi	> 4001 gm

Checks:

1. High Servo Press alarms

- a. Examine the patient for spontaneous breathing, crying, coughing, hiccups, seizures, bronchospasm, or the need for suctioning. Calm, medicate, sedate, or suction the patient.
- b. Inspect LifePort adapter and connections for any leaks or cracks. If the adapter integrity is in question, replace the LifePort adapter with a new one.
- c. Inspect the breathing circuit for leaks, poor connections, or occlusions. Correct these conditions if present.
- d. Inspect the Life Pulse circuit between the humidifier and patient box for signs of over-humidification (droplets of water). Adjust the circuit and cartridge temperature setting to minimize rainout (see Appendix A).

Note: Keep circuit temperature at 40 degrees C.

- e. Evaluate the “WhisperJet” patient box for abnormal function (odd sounds or visible problem with pinch valve operation). Change the patient box if necessary.
- f. Examine the patient for re-expansion of the lung due to evacuation of an air leak, such as pneumothorax, bronchopleural fistula, or for improved lung volume following recruitment.

2. Low Servo Press alarms

- a. Inspect the tracheal tube for improper position, plugging, or occlusion. Correct these conditions if present.
- b. Examine the patient for signs of airway obstruction.
- c. Inspect the exhalation limb of the conventional breathing circuit for kinks.
- d. Examine the patient for a tension pneumothorax or atelectasis.
- e. Evaluate conditions a. - e. listed under High Servo Press alarm.

If the alarm persists, call the **Bunnell Hotline @ 800.800.4358 (HFJV)**

Upper & Lower MAP Alarms

Definition: The MAP alarm alerts the user to changes in the mean airway pressure, as monitored by the Life Pulse.

High Limit = MAP value at the time the Ready light comes on + 1.5 cm H₂O

Low Limit = MAP value at the time the Ready light comes on -1.5 cm H₂O

Checks:

1. High MAP alarms

- a. Inspect the exhalation limb of the conventional breathing circuit and get rid of any kinks or water.
- b. Inspect the conventional ventilator for changes in setting or performance.
- c. Inspect the pressure monitoring tube of the LifePort adapter for excess condensation or plugging. If necessary, reduce the humidifier cartridge temperature to reduce water condensation (see Appendix A).

Note: Keep circuit temperature at 40 degrees C.

- d. Inspect the tracheal tube or airway for obstruction.
- e. Inspect the “WhisperJet” patient box pinch valve for complete closure.

2. Low MAP alarms

- a. Inspect the conventional ventilator for changes in settings or performance.
- b. Inspect the pressure monitoring tube of the adapter for excess condensation or plugging. If necessary, reduce the cartridge temperatures to reduce condensation (see Appendix A).

Note: Keep circuit temperature at 40 degrees C.

- c. Inspect the tracheal tube for positioning.
- d. Inspect the breathing circuit and humidifier cartridge for leaks, poor connections or kinks.

If the alarm persists, call the **Bunnell Hotline @ 800.800.4358 (HFJV)**

Jet Valve Fault

Definition: The Jet Valve Fault alarm indicates that the pinch valve timing is out of synchrony with the Life Pulse's drive signal.

Checks:

1. Replace the patient box to determine if it is the cause of the alarm.
2. If the alarm continues after changing the patient box, change out the Life Pulse ventilator.

If the alarm persists, call the **Bunnell Hotline @ 800.800.4358 (HFJV)**

Ventilator Fault Alarm

Definition: The Ventilator Fault alarm indicates a possible problem with the Life Pulse electronics or valves.

Checks:

1. Inspect the purge tubing for disconnections or kinks at the front panel and patient box purge connectors.
2. Inspect the LifePort pressure monitoring tube for disconnections or kinks at the patient box pressure monitoring tube connector.
3. Replace the patient box to determine if the purge valve or some other component in the patient box is the cause of the alarm.

Ventilator Fault Codes:

- 01 – A/D converter failure
- 02 - Test of purge valve/airway transducer
- 03 – Test of PWM valve/servo transducer
- 04 – Test of watchdog
- 05 – RAM failure
- 06 – ROM check sum error
- 07 – NMI failure to execute
- 08 – IRQ failure to execute
- 09 – Both IRQ and NMI failure to execute
- 10 – Significant and rapid rise in servo pressure

During Self-Test: Code #s 02-04

The **02 code** is related to the purge system. It can be caused by a lack of purge gas supply from the Life Pulse, a failure of the purge valve in the patient box or the pressure transducer in the patient box. The 02 code will appear if a test lung is not attached to the Life Pulse circuit or if the pressure monitoring line is not attached to the patient box.

The **03 code** is related to the servo control valves or the servo pressure transducer. The 03 code will appear if any of the valves do not open during the test, or if the servo transducer does not recognize (respond to) the opening of the servo control valve. Sometimes running the Life Pulse on a test lung for 5 minutes will correct this alarm condition.

If the alarm persists, call the **Bunnell Hotline @ 800.800.4358 (HFJV)**

The **04 code** is related to the electronic watchdog circuit that monitors certain electronic functions in the Life Pulse. If this code is activated during the test and stops the test from proceeding, it is likely due to an electronic failure in the Life Pulse.

If any of these codes appear during the self test, call the Bunnell Hotline. Turn the main power button off and back on to clear the failed test, so you can retry the self test when troubleshooting with the Bunnell clinical specialist.

During Run: Code #s 01 & 05-10

If the Vent Fault alarm does not force the Life Pulse into Standby, there will be no code # displayed, and the problem is likely due to a faulty purge valve or purge tube connections. If purge tubing is connected at both the Purge fitting on the Life Pulse front panel and the From Purge fitting on the patient box, the patient box will likely need to be replaced.

The 01 & 05-09 are all related to microprocessor or electronic problems.

These codes place the Life Pulse in Standby mode, where you have to ***turn off the power to reset the microprocessor***. Run the operational test on a test lung before restarting on a patient.

Ventilator Fault alarms are frequently caused by electrical fluctuations at hospital electrical outlets, including those labeled as protected by emergency backup generators. Plugging the Life Pulse into a high quality Uninterruptible Power Supply will prevent such problems.

If power fluctuations are internal, the Life Pulse will have to be switched out to remedy the problem.

Code 10 indicates a significant and rapid rise in Servo Pressure, which can be caused by a dramatic change in ventilator settings such as changing Rate from 480 to 240 bpm. If this alarm arose shortly after making such a dramatic setting change, you should check for mechanical problems such as tubing disconnects, then press the Enter button to restart the Life Pulse. If no such ventilator setting changes were made just prior to this alarm, support the patient with the conventional ventilator while you disconnect the Life Pulse from the patient, connect it to a test lung, and press TEST. If the Life Pulse passes the TEST successfully, verify its operation by running it on the test lung for a few minutes, then reconnect the Life Pulse to the patient and resume operation from the Standby mode.

If the alarm persists, call the **Bunnell Hotline @ 800.800.4358 (HFJV)**

Low Gas Pressure Alarm

Definition: The Low Gas Pressure alarm indicates that the pressure of the gas supply to the Life Pulse is below 30 psi.

Checks:

1. See if a gas supply is connected.
2. Is the gas supply pressure less than 30 psi? Check high pressure supply hoses for leaks. Change the gas source, blender or high pressure hoses as needed.
3. If the alarm persists, there may be a problem with the pressure switch in the LifePulse, in which case you will have to switch to another Life Pulse ventilator.

If the alarm persists, call the **Bunnell Hotline @ 800.800.4358 (HFJV)**

Cannot Meet PIP

Definition: The Cannot Meet PIP alarm indicates that the monitored PIP has not been stable within +2.0 and – 1.5 cm H₂O of the Now PIP setting while the servo pressure has risen to its maximum output of 20 psi, or

The monitored PIP has not stabilized within +2.0 and -1.5 cm H₂O of the Now PIP for 20 seconds within three minutes of pressing the Enter or Reset buttons.

Checks:

1. Examine the patient for spontaneous breathing, crying, coughing, hiccups, seizures, bronchospasm, or the need for suctioning. Calm, medicate, sedate, or suction the patient.
2. Has the servo pressure reached the maximum output of 20 psi before reaching the Now PIP? The patient is too large to be ventilated by the Life Pulse at the current settings?
3. Over-humidification of Life Pulse circuit is causing water droplets to interfere with pressure monitoring. Check the LifePort adapter orientation to make sure the pressure monitoring tube is pointed up. Adjust humidifier temperature settings to minimize rainout (see Appendix A).

Note: Keep circuit temperature at 40 degrees C.

4. Inspect the breathing circuit and humidifier cartridge for leaks or poor connections.
5. Check the pinch valve for possible malfunction resulting in fluctuating pressures. Replace the patient box while the Life Pulse is in the Standby mode.

If the alarm persists, call the **Bunnell Hotline @ 800.800.4358 (HFJV)**

Loss of PIP

Definition: The Loss of PIP alarm is activated by one or more of the following conditions:

The monitored PIP has dropped below 25% of the Now PIP, or

The monitored PIP is less than 3 cm H₂O, or

Monitored value for delta P is ≤ 2 cm H₂O.

Checks:

Warning: If pinch valve is not cycling during Loss of PIP alarm, put the Life Pulse in Standby mode before troubleshooting.

1. Examine the patient for spontaneous breathing, crying, coughing, hiccups, seizures, bronchospasm, or the need for suctioning. Calm, medicate, sedate, or suction the patient.
2. Over-humidification of the Life Pulse circuit may be causing water droplets to interfere with pressure monitoring. Check LifePort adapter orientation to make sure the pressure monitoring tube is pointed up. Adjust the humidifier temperature settings (i.e, lower the Cartridge Temperature in 1-degree increments) to minimize rainout (see Appendix A).

Note: Keep circuit temperature at 40 degrees C.

3. Inspect the breathing circuit and humidifier cartridge for leaks or poor connections.
4. Inspect the pinch valve for possible malfunctions resulting in low PIP. Replace the patient box while the Life Pulse is in the Standby mode.

Note: If a Loss of PIP occurs in the **Non-Ready** condition, the servo control valves are turned off and the dump valve will open to decrease servo pressure and protect the patient. The alarm is activated if the PIP is ≤ 3 cm H₂O, or a delta P is ≤ 2 cm H₂O 12 seconds after the Enter button is pressed. No other alarms are active in the Non-Ready condition. Pressing the Enter button will clear the alarm and allow the Life Pulse another attempt to reach the Now settings.

If the alarm persists, call the **Bunnell Hotline @ 800.800.4358 (HFJV)**

High PIP

Definition: The High PIP alarm indicates that the monitored airway pressure has exceeded the Now PIP setting by 5 cm H₂O continuously for 1 second, or

The monitored PIP for all breaths delivered in the last 30 seconds have exceeded the Now PIP by 10 cm H₂O, or

The monitored PIP is 30 cm H₂O above the Now PIP during any 0.75 sec. period, or

The monitored PIP is > 65 cm H₂O at any time.

Checks:

1. Excessive pressure is being delivered by the conventional ventilator due to failure or an occluded exhalation limb of conventional ventilator circuit.
2. Inspect the tracheal tube for improper position, kinking, or occlusion.
3. Inspect the pressure monitoring tube of LifePort for excess condensation or kinking. Check the LifePort adapter orientation to make sure the pressure monitoring tube is pointed up. The LifePort adapter may need to be replaced to correct the situation.
4. Inspect the pinch valve for possible malfunction resulting in high PIP. Replace the patient box while the Life Pulse is in the Standby mode.
5. If the alarm persists, it could be a stuck servo pressure valve. Change out the Life Pulse ventilator.
6. Never connect the Life Pulse to the patient's LifePort adapter while it is running, the servo pressure may be higher than what is needed to achieve the set PIP for the patient; **a high PIP and large tidal volumes may be delivered.**

Warning: Connections to patient's LifePort should only be made while the Life Pulse is in Standby mode.

If the alarm persists, call the **Bunnell Hotline @ 800.800.4358 (HFJV)**

Cartridge Temp High

Definition: The Circuit Temp High alarm indicates that the temperature measured in the humidifier cartridge of the breathing circuit has exceeded the cartridge temperature setting by more than 3 degrees C and has remained high for 10 minutes, or

The measured temp is 44 degrees C, which is the upper allowable limit.

Checks:

1. Place the humidifier in Wait mode. Open the cartridge door and check the spring loaded contact pins to make sure they spring in and out and that all the pins are at about the same level. If any pins look stuck or damaged, try pulling them back out to the level of the other pins. Close the cartridge door, press the Wait button, and see if the alarm has cleared.
2. If the alarm persists, press the Standby button and replace the humidifier cartridge/circuit. Press the Enter button to resume normal operation. If the alarm does not go away, it is likely that the humidifier module has failed internally and the Life Pulse will need to be changed out.

Note: If the circuit has been in use for less than seven days, call Bunnell for a Return Authorization number and return the circuit for a credit.

If the alarm persists, call the **Bunnell Hotline @ 800.800.4358 (HFJV)**

Cartridge Temp Low

Definition: The Cartridge Temp Low alarm indicates that the temperature measured in the humidifier cartridge of the breathing circuit has dropped below the cartridge temperature setting by 3 degrees C and remained there more than 30 minutes.

Checks:

1. Place the humidifier in Wait mode. Open the cartridge door and check the spring loaded contact pins to make sure they spring in and out and that all the pins are at about the same level. If any pins look stuck or damaged, try pulling them back out to the level of the other pins. Close the cartridge door, press the Wait button, and see if the alarm has cleared.
2. If the alarm persists, press the Standby button and replace the humidifier cartridge/circuit. Press the Enter button to resume normal operation. If the alarm does not go away, it is likely that the humidifier module has failed internally and the Life Pulse will need to be changed out.

Note: If the circuit has been in use for less than seven days, call Bunnell for a Return Authorization number and return the circuit for a credit.

If the alarm persists, call the **Bunnell Hotline @ 800.800.4358 (HFJV)**

Circuit Temp High:

Definition: The Circuit Temp High alarm indicates the temperature in the patient breathing circuit, as measured proximal to the patient box, has exceeded the circuit temperature setting by more than 3 degrees C and remained there for more than 1 minutes, or

The measured temp is 44 degrees C, which is the upper allowable limit.

Checks:

1. Place the humidifier in Wait mode. Open the cartridge door and check the spring loaded contact pins to make sure they spring in and out and that all the pins are at about the same level. If any pins look stuck or damaged, try pulling them back out to the level of the other pins. Close the cartridge door, press the Wait button, and see if the alarm has cleared.
2. If the alarm persists, press the Standby button and replace the humidifier cartridge/circuit. Press the Enter button to resume normal operation. If alarm does not go away, it is likely that the humidifier module has failed internally and the Life Pulse will need to be changed out.

Note: If the circuit has been in use for less than seven days, call Bunnell for a Return Authorization number and return the circuit for a credit.

If the alarm persists, call the **Bunnell Hotline @ 800.800.4358 (HFJV)**

Circuit Temp Low:

Definition: The Circuit Temp Low alarm indicates the temperature in the patient breathing circuit, as measured proximal to the patient box, has dropped below the circuit temperature setting by more than 3 degrees C and remained there for more than 3 minutes.

Checks:

1. Place the humidifier in Wait mode. Open the cartridge door and check the spring loaded contact pins to make sure they spring in and out and that all the pins are at about the same level. If any pins look stuck, try pulling them back out to the level of the other pins. Close the cartridge door, press the Wait button, and see if the alarm has cleared.
2. If the alarm persists, press the Standby button and replace the humidifier cartridge/circuit. Press the Enter button to resume normal operation. If the alarm does not go away, it is likely that the humidifier module has failed internally and the Life Pulse will need to be changed out.

Note: If the circuit has been in use for less than seven days, call Bunnell for a Return Authorization number and return the circuit for a credit.

If the alarm persists, call the **Bunnell Hotline @ 800.800.4358 (HFJV)**

High and Low Water Level Alarms

Definition: The Level High alarm indicates that the water in the humidifier cartridge has reached the highest water level sensor.

The Level Low alarm indicates the water in the humidifier cartridge has not reached the lowest water level sensor.

Checks:

1. High Water Level Alarms

- a. Make sure sterile H₂O was used to fill the humidifier cartridge.
- b. Make sure the water inlet tube is installed properly in the water pump housing.
- c. Was the humidifier manually filled to the high level sensor?
- d. Was the water supply clamp opened prior to closing the water inlet tube in the water pump housing, so that the humidifier cartridge over-filled by gravity?
- e. Place the humidifier in Wait mode. Open the cartridge door and check the spring loaded contact pins to make sure they spring in and out and that all the pins are at about the same level. If any pins look stuck or damaged, try pulling them back out to the level of the other pins. Close the cartridge door, press the Wait button, and see if the alarm has cleared.
- f. If the alarm persists, press the Standby button and replace the humidifier cartridge/circuit. Press the Enter button to resume normal operation. If the alarm does not go away, it is likely that the humidifier module has failed internally and the Life Pulse will need to be changed out.

2. Low Water Level Alarms

- a. Inspect the water supply tubing from the water reservoir to see if it is clamped off or disconnected. Unclamp or reconnect the supply tubing.
- b. Inspect the water reservoir to see if it is empty. Replace the reservoir if necessary.
- c. Make sure that sterile H₂O was used to fill the humidifier cartridge.
- d. Place the humidifier in Wait mode. Open the cartridge door and check the spring-loaded contact pins to make sure they spring in and out and all at about the same distance out. If any pins look stuck or damaged, try pulling them back out to the level of the other pins. Close the cartridge door, press the Wait button, and see if the alarm has cleared.
- e. If the alarm persists, replace the humidifier cartridge/circuit as described above.

If the alarm persists, call the **Bunnell Hotline @ 800.800.4358 (HFJV)**

Circuit Fault Alarm (Temp or Level)

Definition: The Circuit Fault alarm (Temp) indicates an electrical fault is present in either the humidifier cartridge or patient breathing circuit, or

Circuit Fault alarm (Level) indicates that the humidifier cartridge did not fill to the normal operating level in 86 seconds.

Checks:

1. If the alarm occurs within the first 2 minutes after the Enter button was pushed, check the water reservoir to see if it is empty or disconnected. Also, inspect the water supply tubing coming from the water reservoir to see if it is clamped off or disconnected.
2. Inspect the cartridge housing door to make sure it is closed properly.
3. Place the humidifier in Wait mode. Open the cartridge door and check the spring-loaded contact pins to make sure they spring in and out and that all the pins are at about the same level. If any pins look stuck or damaged, try pulling them back out to the level of the other pins. Close the cartridge door, press the Wait button, and see if the alarm has cleared.
4. Press the Standby button and replace the humidifier cartridge circuit. Press the Enter button to resume normal operation. If the alarm does not go away, it is likely that the humidifier module has failed internally and the Life Pulse will need to be changed out.

If the alarm persists, call the **Bunnell Hotline @ 800.800.4358 (HFJV)**

Appendix A

Proper Control of Humidification For Bunnell Life Pulse HFV

Humidification on the Life Pulse may need to be adjusted for different environmental conditions. Where is the patient's bed relative to air conditioning or heating vents, doorways, traffic patterns? Is the patient in an open intensive care bed or a closed bed? The humidifier is programmed so that the *circuit* (air) temperature is set at 40 degrees C and the *cartridge* (water) temperature is set at 38 degrees C. In many situations these settings work fine, but that doesn't mean they are always appropriate.

The circuit temperature should always remain at 40 degrees because the gas temperature cools as it accelerates through the patient box and the LifePort adapter. We know from our testing that the delivered temperature at the ET tube is 37 degree C or less. To control humidity (minimize rain-out) you have to adjust the cartridge temperature. The first step is to lower the temperature one degree, clear the excess water from the Life Pulse circuit and wait 20-30 minutes to see if the situation improves. If it does not, drop the cartridge temperature 0.5 degrees and repeat the process. Your goal is to have the clear portion of the circuit between the humidifier and the patient box dry (small packs of mist or fog are ok but no droplets) and the green portion between the patient box and the patient covered in mist, so that if you tapped the circuit, droplets would immediately form. Again, we can help you with this process over the hotline, 800.800.4358.

Water droplets that get pushed through the LifePort adapter from the circuit or secretions that come up and out of the patient from the ET tube cause the same symptoms with respect to pressure monitoring. They cause the PIP to drop and the PEEP to rise, simultaneously. Once the moisture moves through the LifePort, the pressures move back, the PIP rises and the PEEP drops. This is always characteristic of moisture interference. If the patient is causing the pressure to fluctuate it is usually isolated to the PIP dropping with the PEEP staying relatively constant in comparison.

Additional information on humidification control can be referenced on the Bunnell website www.bunl.com under the Clinical menu, Clinical Directory, Support Materials, In-service Manual, Chapter 5, page 25, Identifying Proper Humidification.

If the patient on the Life Pulse is in one of the new closed-style ICU beds (e.g., **Giraffe™**), the easiest way to control over-humidification is to put as much of the Life Pulse circuit inside the closed hood as possible. The shorter the circuit is outside the bed the less rainout will occur.

If the alarm persists, call the **Bunnell Hotline @ 800.800.4358 (HFJV)**

Appendix B

Test Procedure for Bunnell HFJV

The fastest way to determine if the Life Pulse is functioning properly is to run it on a test lung.

The test lung should consist of a 2.5 or 3.5 mm LifePort adapter connected to a 2.5 - 3.5 mm standard ET tube with a model lung on the patient end (a finger from a surgical glove or a finger cot taped in place work fine). If you have a test lung that incorporates a Hi-Lo Jet ET (triple lumen Jet) tube, discard the Hi-Lo Jet tube and replace it with a standard tube and LifePort adapter. The pressure monitoring tube of an old Hi-Lo ET tube can become compressed over time and result in erroneous pressure information.

Note: The conventional ventilator is not needed for testing the Life Pulse. The 15-mm connection of the LifePort adapter is left open to the room during both test procedures.

The first procedure is to run an internal test by pressing the Test button. This test checks all of the primary functions of the Life Pulse. If a problem is detected the test sequence will stop and a code will be displayed in the ON/OFF ratio display in the Control section.

If this internal test is passed, run an operational test by pressing the Enter button. If the set PIP is reached, the Ready light is activated (indicating the alarms have been activated) and the PEEP is zero $(0) \pm 1$ cm H₂O, the operational test has been passed. If both tests are passed, the Life Pulse is functioning normally and can be placed into service. This test sequence should only take 5 minutes to perform

If either the internal test or the operational tests fail, call the Bunnell Hotline at 800.800.4358 for technical assistance.

If the alarm persists, call the **Bunnell Hotline @ 800.800.4358 (HFJV)**