AQUA LUNG

Military & Professional

PHODS

Portable Helicopter Oxygen Delivery System

User's Manual

Rev. 02/20

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(PHODS) Portable Helicopter Oxygen Delivery System
User's Manual P/N 102999M2
PHODS P/N 102935M2

You can contact a Technical Advisor via e-mail at:
milprosupport@aqualung.com

NOTICE OF NON-LIABILITY

Before the (PHODS) Portable Helicopter Oxygen Delivery System is put to use, it is the responsibility of any user who will use this device to become familiar with the operation and safety aspects of this device. Using the system improperly could cause a failure and lead to possible damage and/or personal injury.

Aqua Lung assumes no responsibility for damage, accidents, injury or death that may result from the misuse of this device or equipment. This includes any use of this device or equipment outside the scope of common sense, the instruction manual, inserts and other related documentation. *(Portions of this manual are excerpts from the MH OPC-M2 instruction manual, used by permission of Mountain High Equipment & Supply Company®, Redmond, OR.)*

WARNINGS, CAUTIONS AND NOTES

Pay special attention to information provided in warnings, cautions, and notes which are accompanied by these symbols:

A **WARNING** indicates a procedure or situation that may result in serious injury or death to the user.

A **CAUTION** indicates any situation or technique that will result in potential damage to the product.

*A **NOTE** is used to emphasize important points, tips, and reminders.*

CONTENTS

GLOSSARY OF TERMS AND ACRONYM LIST

Pressure Altitude: PA The altitude inferred directly from the local barometric pressure. Under "Standard" conditions, pressure altitude would equate to the actual physical altitude, but otherwise barometric pressure is affected by the local weather conditions and pressure altitude is therefore merely an approximation of the actual altitude. However, for the purposes of oxygen delivery, pressure altitude is actually a much better measure than physical altitude as it directly correlates to the physiological processes that affect oxygen needs.

Threshold Altitude: The pressure altitude reference that controls the operation of the OPC in **ON** mode. At or above the "threshold" altitude, the OPC dispenses oxygen; below the threshold altitude, it does not. The OPC has been configured with a threshold altitude of 8,000 ft PA. When the barometric pressure is low, operation will begin at a slightly lower physical altitude than when the barometric pressure is high. The threshold altitude does not affect the operation of the OPC in either **F20** or **R/M** mode.

Relative Humidity: RH

Non-Condensing: NC (referring to humidity).

Oxygen Pulse Controller: OPC

Mean Sea Level: MSL

GENERAL PRECAUTIONS & WARNINGS

WARNING: Oxygen is a highly oxidizing gas and can vigorously accelerate combustion. It can provide a catalyst for spontaneous combustion resulting in personal injury or death if not used properly and with caution. DO NOT use any type of oil or grease on any of the fittings, valves or cylinders. DO NOT smoke while in use. DO NOT operate near an open flame.

WARNING: This device is classified as, and is only suitable for use as, a supplementary breathing apparatus (SBA) for aviation use up to 18,000 MSL. It is intended to supply the needed amount of oxygen for persons during excursions at flight altitudes where supplemental oxygen is needed. This device is not suitable for any type of medical operations. This device is not suitable for SCBA (Self Contained Breathing Apparatus) or SCUBA (Self Contained Underwater Breathing Apparatus) operations.

WARNING: When operating the PHODS around high power emitters such as friendly or threat systems, PHODS may stop providing oxygen, or may start pumping oxygen when not expected or required. If the unit is not operational, turning the OPC power OFF then ON will be required. An operational check must therefore be performed immediately prior to use at high altitudes.

WARNING: Before using the PHODS, it is important to receive hypoxia awareness and aeromedical training. Use of the PHODS without proper training is dangerous and can result in serious injury, or death.

WARNING: DO NOT apply any type of petroleum-based lubricant or grease to any part of the PHODS. Hydrocarbon contamination, including petroleum-based lubricants, can cause spontaneous combustion when exposed to compressed oxygen.

WARNING: It is important to fill the cylinder only with Oxygen 90% or greater. If filling the PHODS from any other source than a Deployable Oxygen Refill Station (DORS) ensure that the moisture content does not exceed 0.005 milligrams of water vapor per liter of gas at 760 millimeters of mercury (mmHg) at a temperature of 70ºF / 21.1ºC. Excess water vapor in the breathing gas can cause ice to form inside the PHODS and interfere with the operation of the system at colder temperatures.

WARNING: Do not attempt to loosen or remove the regulator CPC fitting or safety burst plug on the regulator under any circumstances. This should only be done by a qualified technician.

WARNING: The oxygen cylinder may burst from impact of small arms fire, resulting in overpressure shock, shrapnel injury and/or flash fire.

WARNING: DO NOT modify or alter the length of any hoses or tubing. This should only be done by a qualified technician, using original manufacturer hose assemblies.

CAUTION: DO NOT apply any type of aerosol spray to the PHODS. Doing so may cause permanent damage to certain plastic components, including the delivery tubing.

CAUTION: PHODS operation has not been verified below -25ºF / -32ºC and performance may be degraded at lower temperatures.

NOTE: *DO NOT store the OPC connected to the cylinder while the inlet is under pressure. If the lines are disconnected the ends must be covered to prevent the entry of debris, dust or dirt into clean hoses.*

NOTE: *Factory prescribed service for the PHODS must be performed every 12 months by a factory trained service technician.*

NOTE*: When instructed to* ***"OPEN"*** *the handwheel, turn the handwheel counter-clockwise.* ***the red indicator ring will not be visible*** *in the handwheel window, this indicates the system is in the* ***"ON"*** *position. When instructed to* ***"CLOSE"*** *the handwheel, turn the handwheel clockwise.* ***the red indicator ring will be visible*** *in the handwheel window, this indicates the system is in the* ***"OFF"*** *position.*

NOTE*: When instructed to disconnect or reconnect the OPC hose to the CPC fitting, use the following method:*

Disconnect: Depress the button on the CPC fitting to remove the OPC hose.

Reconnect: Insert the OPC hose into the CPC fitting, making sure the button "Pops Up". Check that the OPC hose is firmly attached prior to pressurizing the system.

If you have any questions or do not understand the information in these Warnings, Cautions, and Notes, please contact an Aqua Lung Technical Advisor before proceeding.

PRODUCT DESCRIPTION

(PHODS) Portable Helicopter Oxygen Delivery System is an oxygen delivery system that can be attached directly to a crew member's vest and helmet to support missions at high altitudes.

The (PHODS) Portable Helicopter Oxygen Delivery System is made up of the following components:

- Regulator and oxygen cylinder.
- Automatic oxygen pulse controller with inlet and outlet hoses.
- Flexible nasal cannula w/ QD coiled hose assembly.

PHODS Component Identification *(Fig. 1)*

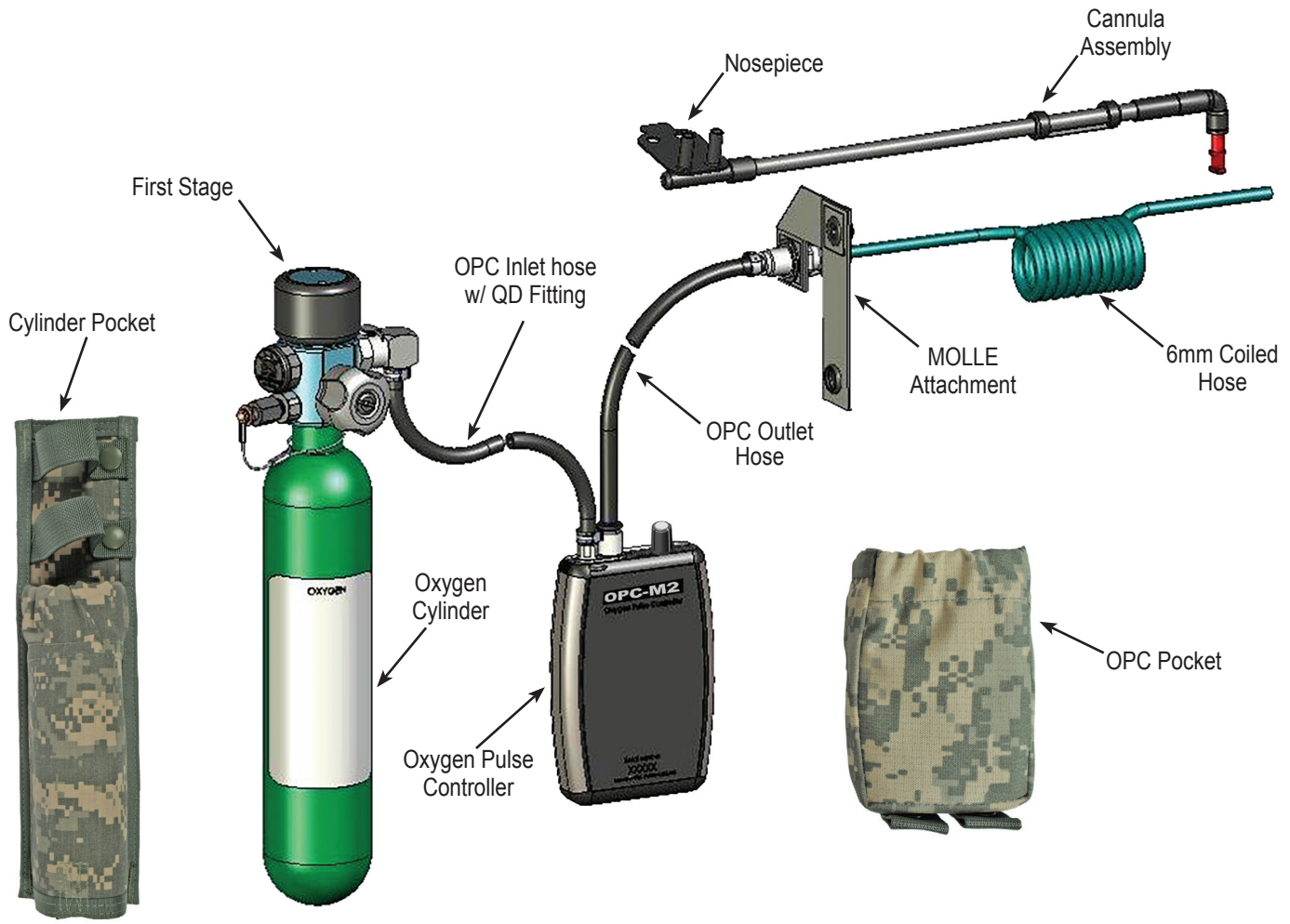


Figure 1

PREPARATION AND SET-UP

1. Slowly open the handwheel to pressurize the system. Verify there is no red showing in the valve handwheel window ***(Figs. 2 & 3)***.

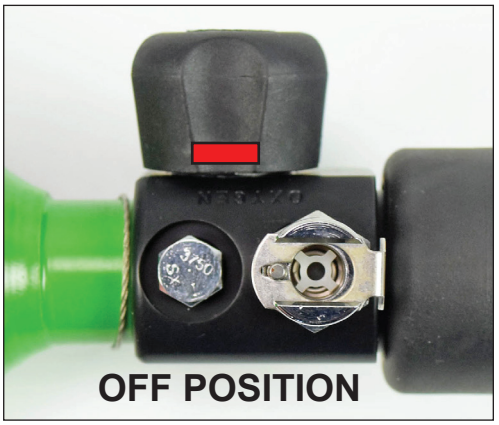


Figure 2

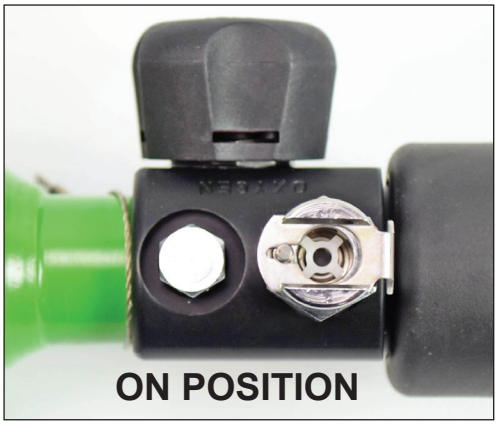


Figure 3

2. Verify the cylinder is fully charged and the dial indicator is reading in the "GREEN" ***(Fig. 4)***.

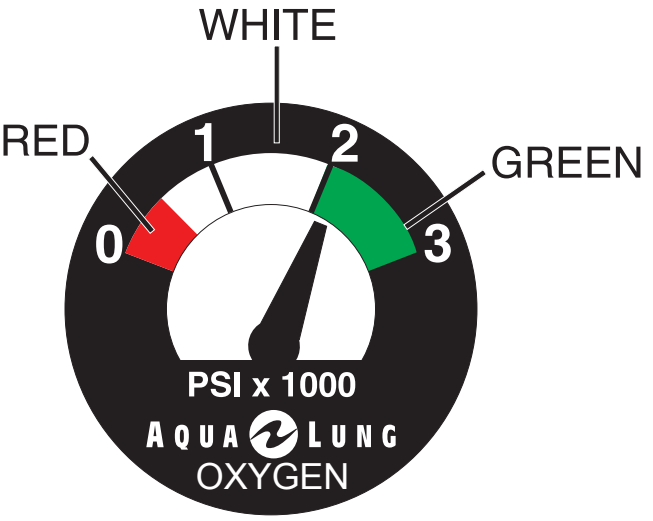


Figure 4

> ***NOTE:*** *Due to the small size of the dial indicator and the working pressure of 2100 psi (145 BAR), it is possible that the needle will only go just to the green or next to it. This is acceptable provided the unit is charged on a calibrated filling system.*

> ***NOTE:*** *While the dial indicator indicates a full cylinder on the ground, the colder temperatures at higher altitudes will reduce the pressure in the cylinder. This is a normal occurrence. At higher altitudes, aircrew members must check the cylinder pressure in the user worn cylinders more often.*

3. Ensure the cylinder pocket is installed correctly on the vest using the MOLLE system straps. Install the cylinder into the pocket on the vest ***(Fig. 5)***.

Figure 5

4. Ensure the OPC pocket is installed correctly on the vest using the MOLLE system straps. Install the OPC into the pocket. Insert the 90° QD fitting into the CPC connector on the regulator until it "clicks" into place ***(Figs. 6 & 7)***.

Figure 6

Figure 7

5. Connect outlet tube into OPC. **To Insert Tubing:** Push the tubing into the connector until resistance is felt, then push a little further, about 1/8 inch / 3mm ***(Fig. 8)***. Gently tug on the tubing to make sure it is captured. **To Remove Tubing:** Push the tubing in slightly, then push in the connector collar while pulling gently on the tubing.

Figure 8

CAUTION: DO NOT pinch the outlet hose when inserting it into the "out" connector.

CAUTION: When removing the tubing, DO NOT pull without first pushing in on the collar, as this will likely damage the connector.

6. Attach the opposite end of the outlet tube to the MOLLE strap on the vest using the MOLLE attachment. Attach the OPC inlet hose to the hook and loop fastener ***(Fig. 9).***

Figure 9

7. After donning the helmet, insert the coiled hose QD fitting into the CPC connector on the outlet hose ***(Fig. 10)***.

Figure 10

NASAL CANNULA MOUNTING TO HELMET

> ***NOTE:*** *If the nasal cannula mount is not installed in the helmet, it must be installed prior to the use of PHODS.*

> ***NOTE:*** *The nasal cannula must be removed to use the facemask.*

Internal Mount

1. Shown is the internal nasal cannula mounting clip installed on the inside right dome of the helmet via two bolts ***(Fig. 11).***

Figure 11

2. To mount the nasal cannula, align the interface of the nasal cannula and the clip with the nose piece to the front, and press tightly until it snaps into place ***(Fig. 12)***.

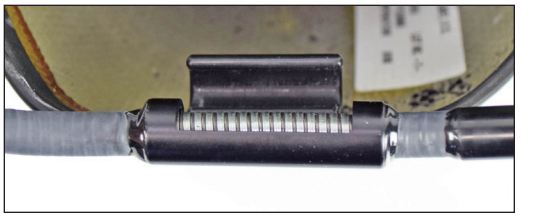


Figure 12

3. After mounting the nasal cannula, ensure the 90° fitting is pointing down and out of the rear of the helmet ***(Fig. 13)***.

4. To remove the nasal cannula, grasp the nasal cannula firmly on one side of the clip and pull down firmly.

Figure 13

5. Prior to donning the helmet, insert the open end of the coiled hose into the 90° fitting on the nasal cannula. Push the hose into the 90° fitting until it stops ***(Fig. 14)***.

Use only the cannula supplied with PHODS as other cannula's may not work properly with the OPC.

Figure 14

External Mount

1. To install the external nasal cannula mounting clip, loosen the microphone knurled knob on the helmet. Slip the clip over the post behind the knob. Retighten knob and adjust the clip as needed ***(Fig. 15)***.

Figure 15

2. To mount the nasal cannula, align the interface of the nasal cannula and the clip with the nose piece to the front, and press tightly until it snaps into place ***(Fig. 16)***.

Figure 16

3. After mounting the nasal cannula, ensure the 90° fitting is pointing down and out of the rear of the helmet ***(Fig. 17)***.

4. To remove the nasal cannula, grasp the nasal cannula firmly on one side of the clip and pull it outwards, away from the helmet.

Figure 17

5. Prior to donning the helmet, insert the open end of the coiled hose into the 90° fitting on the nasal cannula. Push the hose into the 90° fitting until it stops ***(Fig. 18)***.

Use only the cannula supplied with PHODS as other cannula's may not work properly with the OPC.

Figure 18

OPC MODES OF OPERATION

The Rotary Mode-Selector knob controls operation of the OPC ***(Fig. 19)***.

The OPC provides three modes of operation:

- **ON: Standard Flow Commences above 8,000 ft Pressure Altitude**
- **R/M: Extreme Flow All Altitudes**
- **F20: Enriched Flow All Altitudes** (Facemask mode)

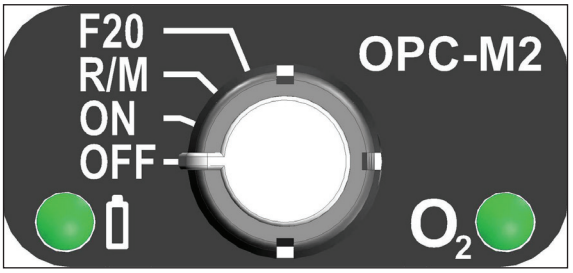


Figure 19

Notes:

- The OPC oxygen delivery schedule is calibrated to provide the oxygen normally required by a healthy average-size person using a cannula at a given altitude. Individual needs may be different.
- In all modes, the OPC delivers more oxygen as altitude increases (altitude compensating).
- See ***OXYGEN FLOW RATES (Fig. 23)*** for a comparison of oxygen flow rates for the different OPC modes.
- Mode setting changes are indicated by a brief flash of the Battery LED.

ON: "Normal" Operation Mode *(Fig. 20)*

ON mode is the "normal" operational setting. Oxygen flow commences when a pressure altitude threshold of 8,000 ft is reached, and ceases when the pressure altitude drops below 8,000 ft.

Flow amount:	Standard
Altitude Compensating:	Yes
Flow Start:	8,000 ft.
Use with:	Cannula

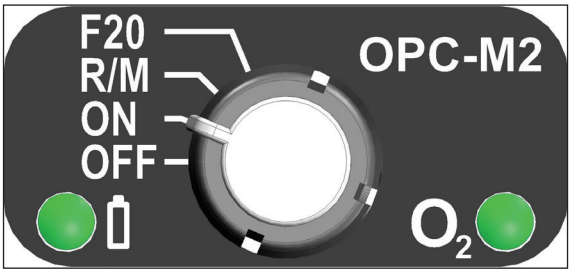


Figure 20

Notes:

- Below 8,000 ft pressure altitude, no oxygen is dispensed, but the OPC continuously monitors breathing.
- When the barometric pressure is low, operation will begin at a slightly lower altitude than when the barometric pressure is high.
- **ON** mode is the <u>most</u> efficient delivery setting and will provide the greatest oxygen duration.

R/M: "Reserve / Manual" Mode *(Fig. 21)*

The **R/M** ("Reserve/Manual") setting causes the OPC to immediately begin providing an extremely enriched oxygen flow. Operation commences (and continues) regardless of pressure altitude.

Flow amount: Extreme ([1])
Altitude Compensating: Yes
Flow Start: All altitudes
Use with: Facemask or Cannula

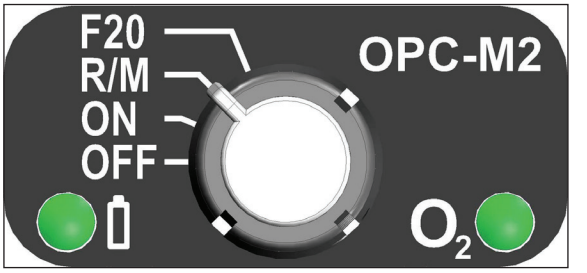


Figure 21

Notes:

- ([1]) An extremely enriched but fixed amount of oxygen is delivered at all altitudes up to ~ 32,000 ft PA. Above that, the amount of oxygen delivered increases with additional altitude (altitude compensating) and is actually the same amount that would otherwise be delivered in **ON** mode in that altitude range. See ***OXYGEN FLOW RATES (Fig. 23)***.
- At lower altitudes, much more oxygen will be used than with **ON** mode, and oxygen duration will be significantly decreased. **R/M** is by far the least efficient delivery setting in the lower altitude range.
- **R/M** may also be considered **"Recovery/Medical"** mode as the flow provided is more on the order of an emergency ventilation protocol. **R/M** may be used with discretion to "recover" from exertion or to otherwise mitigate the effects of sudden hypoxia.

F20: "Facemask" Mode *(Fig. 22)*

The **F20** setting is provided for use with a Facemask, but may also be used with a cannula if more oxygen is required than is otherwise provided by the **ON** mode Operation commences (and continues) regardless of pressure altitude.

Flow amount: Enriched
Altitude Compensating: Yes
Flow Start: All altitudes
Use with: Facemask or Cannula

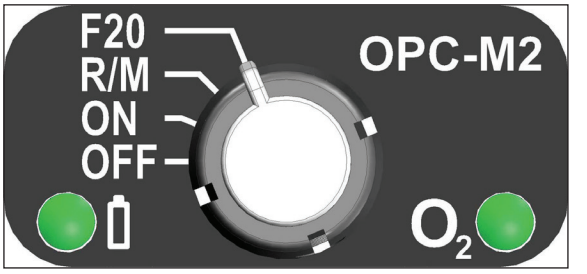


Figure 22

Notes:

- **F20** setting augments the amount of oxygen otherwise provided at a given pressure altitude in order to compensate for the additional plenum volume associated with a facemask.
- More oxygen will be used than with **ON** mode, and oxygen duration will be decreased. See ***OXYGEN FLOW RATES (Fig. 23).***
- Pilots making night approaches and landings may use the **R/M** or **F20** modes to provide additional oxygen in order to enhance night vision.

Oxygen Flow Rates

The following graph illustrates the relative rates of oxygen delivery for the various OPC operating modes. ***(Fig. 23)***.

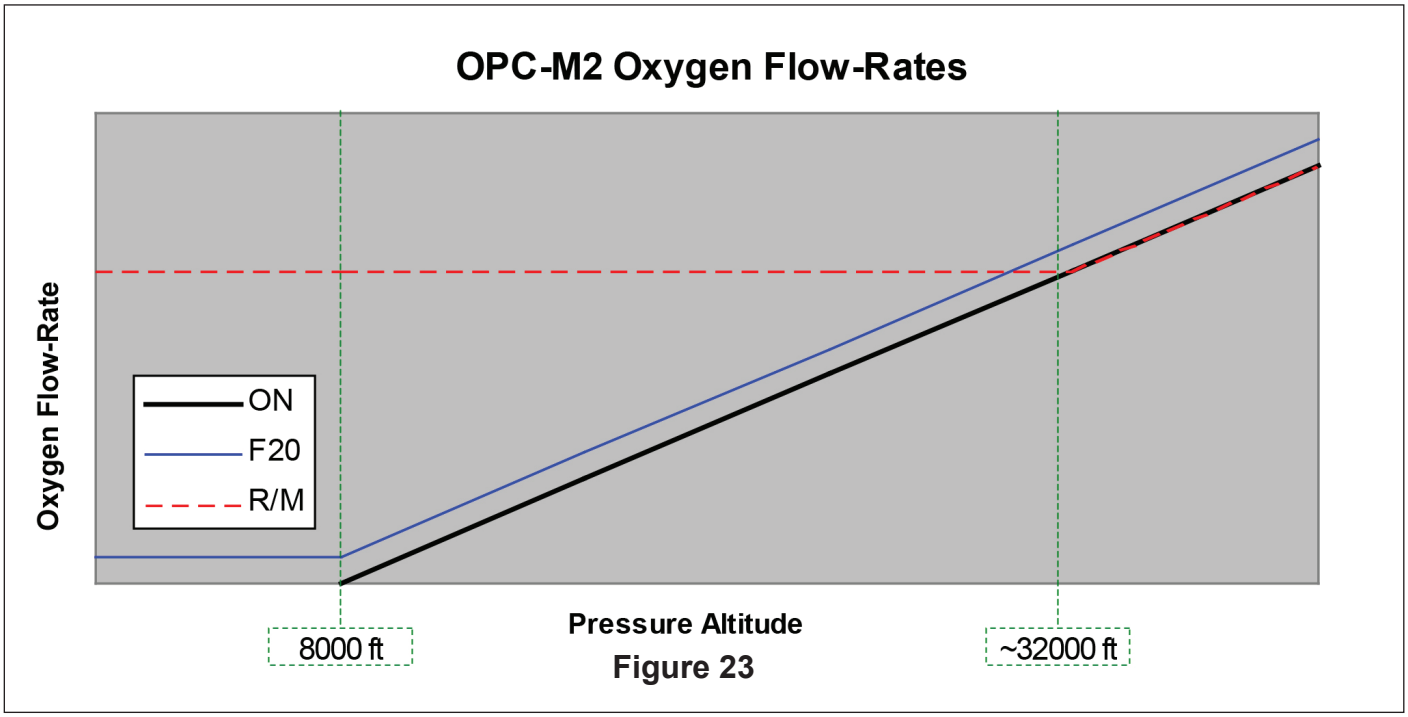


Figure 23

ON Mode

- Oxygen is only delivered above the 8,000 ft pressure altitude (PA) threshold.
- Oxygen delivery is suspended when the altitude drops below 8,000 ft PA.
- Above 8,000 ft PA, more oxygen is delivered as altitude increases (altitude compensating).

F20 Mode

- Oxygen is delivered at all altitudes.
- A fixed amount of oxygen is delivered at all altitudes below 8,000 ft PA.
- Above 8,000 ft PA, more oxygen is delivered as altitude increases (altitude compensating).
- The amount of oxygen delivered at any altitude is greater than what would otherwise be provided in the **ON** mode (enriched flow).

R/M Mode

- Oxygen is delivered at all altitudes.
- A fixed amount of oxygen is delivered at all altitudes up to ~ 32,000 ft PA.
- The fixed amount of oxygen delivered in the lower altitude range is significantly greater than what would otherwise be provided in either **ON** or **F20** mode (extremely enriched flow).
- The amount of oxygen delivered above ~32,000 ft PA is the same as provided in **ON** mode, and likewise, more oxygen is delivered as altitude increases (altitude compensating).

Notes:

- At any altitude, **ON** mode will always provide the best efficiency and greatest oxygen duration.
- **F20** mode will always provide more oxygen than **ON** mode.
- At lower altitudes, **R/M** mode will provide the most oxygen (by far).
- The OPC will continue to operate above 32,000 ft PA, although at such high altitudes physiological factors begin to compromise the effectiveness of an SBA (Supplemental Breathing Apparatus) system such as the OPC.

OPC ALARMS AND ALERTS

The following section will cover the OPC Alarm and Alert modes. This information can also be found on the backside of the unit ***(Fig. 24)***.

Figure 24

The OPC continuously displays its operational STATUS, and also generates various ALARMS and ALERTS to indicate critical warnings or error conditions. System STATUS, ALARM and ALERT conditions are conveyed by front-panel LEDs. The pattern of flashing LEDs associated with each condition is intended to be suggestive of the severity of the condition indicated and otherwise as obvious as possible. A user should nevertheless become familiar with the various ALARMS and ALERTS before using the OPC for the first time, and review periodically. ***(See Legend Fig. 25)***

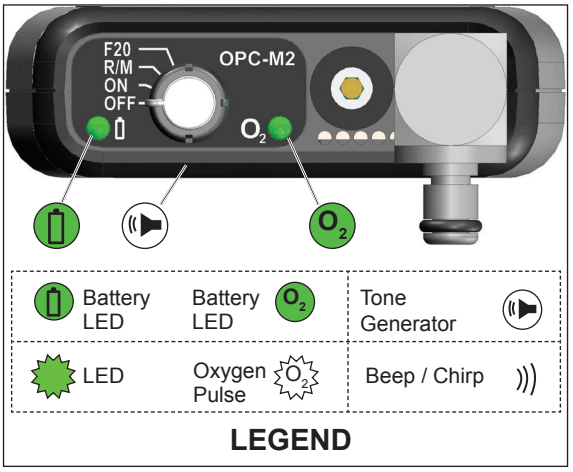


Figure 25

The Oxygen Flow Indicator LED (O_2) displays conditions related to oxygen flow, while the Battery Warning LED displays battery-related conditions. An initial oxygen pulse is delivered as part of the Power-Up Test sequence. Oxygen pulses are subsequently delivered with each inhalation during normal operation.

Notes:

- Status LEDs flash green for Night Vision Goggle (NVG) compatibility, and are therefore difficult to see through the NVG. LEDs should be viewed directly (not through the NVG) and the OPC should be located in such a manner as to make this convenient.
- OPC status should be checked periodically to verify proper operation.

Power-Up Test *(Fig. 26)*

The **POWER-UP TEST** checks the battery voltage and verifies valve operation and oxygen supply continuity as well as exercising the LEDs. A successful **POWER-UP TEST** is indicated by the OPC emitting 3 short beeps, flashing both LEDs 6 times, and delivering an oxygen pulse (~ ½ second) to the OPC outlet. Otherwise, one of the following **POWER-UP TEST** failure modes (see below) will be generated.

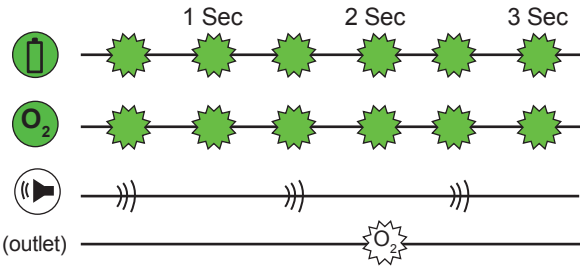
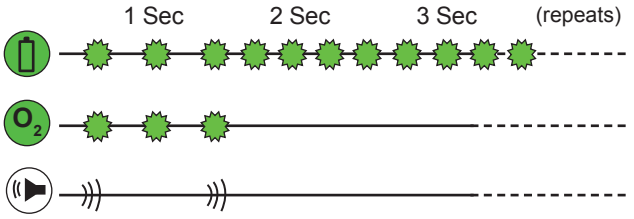


Figure 26

The oxygen pulse will be evident from the sound of the valve opening, or can be felt in the nostrils if the cannula has been donned. See **PHODS PRE-FLIGHT CHECKLIST**.

Power-Up Test: Fail (Bad Battery Alarm) *(Fig. 27)*

If the battery test fails during the **POWER-UP TEST**, the OPC generates a **BAD BATTERY ALARM**. After the first 2 short beeps, the Battery Warning LED begins flashing continuously. The batteries are too low to operate the OPC unit and it will not dispense oxygen.



The battery test is performed at **POWER-UP** only. The OPC may or may not complete the full POWER-UP TEST sequence (initial oxygen pulses, etc.) before generating a **BAD BATTERY ALARM**. If a **BAD BATTERY ALARM** is generated, the OPC will enter "lock-out" mode and will not function other than to display the **BAD BATTERY ALARM**.

Figure 27

Power-Up Test: Fail (Internal Error Alarm) *(Fig. 28)*

The **OPC POWER-UP TEST** also verifies the integrity of internal sensors and components and generates an **INTERNAL ERROR ALARM** if any of these checks fail. Immediately following the first beep, the Battery Warning and Oxygen (O_2) LEDs begin flashing alternately in "Rail-Road" mode.

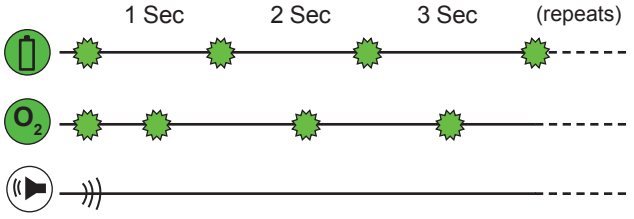


Figure 28

An **INTERNAL ERROR ALARM** indicates that the ***OPC unit will not function properly and must be serviced.***

Inhalation Event & Oxygen Delivery Notification *(Fig. 29)*

Oxygen LED (O_2) flashes (~¼ sec minimum) in conjunction with the delivery of an oxygen pulse to the OPC outlet for each valid inhalation event detected.

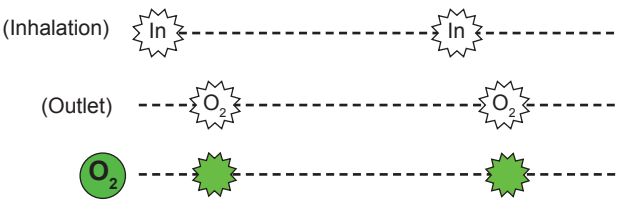


Figure 29

Exceptions:

- In **ON** mode but below 8,000 ft pressure altitude, an oxygen pulse will not be delivered and the Oxygen LED will not flash.
- If the detected breathing rate exceeds 30 bpm (breaths-per-minute), the OPC delivers oxygen only on every other breath.

Apnea Alarm / Abandoned Alert *(Fig. 30)*

Oxygen Flow (O_2) LED emits 4 short flashes when **no** valid inhalation event has been recently detected.

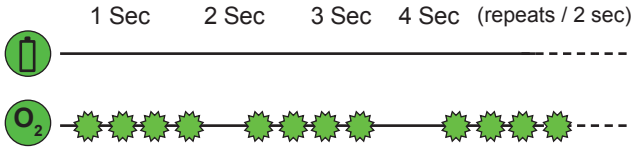


Figure 30

An **APNEA ALARM** is generated if the time since the last inhalation event exceeds an interval that is dependent on the pressure altitude. This interval is ~30 seconds at lower altitudes, but much less at higher altitudes where the onset of hypoxia is more rapid and its effects are more pronounced. The **APNEA ALARM** does not respond below 8,000 ft pressure altitude when operating in **ON** mode.

An **APNEA ALARM** typically occurs for one of the following reasons:

1. The cannula or facemask has been removed or is not being worn properly.
2. The outlet tubing from the OPC unit to the cannula or facemask has become pinched or disconnected.
3. The user is breathing primarily through their mouth while using a cannula or otherwise too softly for inhalation to be detected.

An **ABANDONED ALERT** (displaying the same **APNEA ALARM** sequence) is initiated if no inhalation events are detected for ~ 16 minutes presuming that the OPC unit has been left **ON** inadvertently (abandoned).

Flow-Fault Alarm *(Fig. 31)*

Oxygen Flow LED (O_2) flashes rapidly for 2 seconds in conjunction with an inhalation event. A **FLOW-FAULT ALARM** indicates that an inhalation has been detected, but that an adequate amount of oxygen ***has not been delivered.***

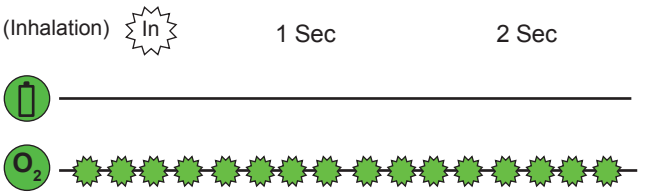


Figure 31

A **FLOW FAULT ALARM** typically means that either:

1. The oxygen cylinder valve is not open.

2. The oxygen supply line is pinched or disconnected.

3. The valve in the OPC unit has failed to operate.

A **FLOW FAULT ALARM** is not necessarily a low oxygen pressure warning.

FLOW FAULT ALARM	APNEA ALARM
coincides with inhalation	independent of inhalation
occurs only at inhalation	repeats until inhalation detected
indicates a problem with oxygen supply (valve, supply tubing, etc.)	indicates a problem with oxygen delivery (outlet tubing, cannula, etc.).

Low Battery-1 Alert (First Warning) *(Fig. 32)*

Battery Warning LED displays continuous *single* flashes. From the time a **LOW BATTERY-1 ALERT** is first issued, the OPC should continue to operate properly for about another eight (8) hours (@ 77°F/25°C, and depending on battery quality).

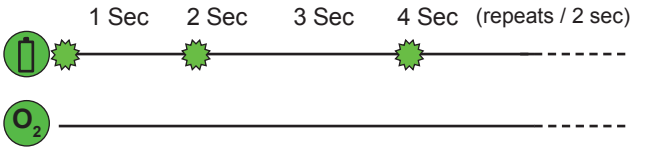
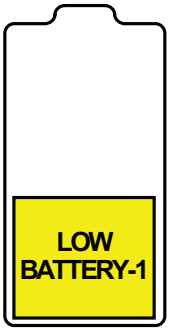


Figure 32



Low Battery-2 Alarm (Second Warning) *(Fig. 33)*

Battery Warning LED displays continuous *double* flashes. From the time a **LOW BATTERY-2 ALARM** is first issued, the OPC may continue to operate for about another two (2) hours.

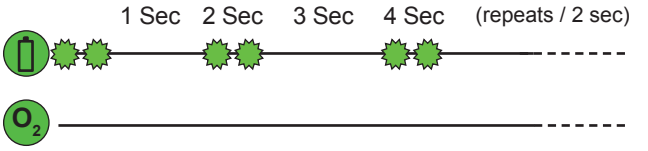
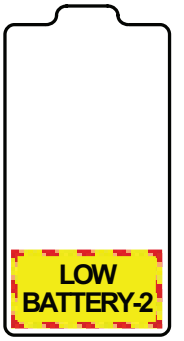


Figure 33

- **<u>REPLACE THE BATTERIES IMMEDIATELY</u>** if either of the **LOW BATTERY** Warnings are received during the **PHODS PRE-FLIGHT CHECKLIST**.
- If operation continues beyond the <u>Second Warning</u>, the batteries will ultimately deplete to the point where the valve ceases firing. At this point, the OPC will <u>no longer be dispensing oxygen</u> (see **BATTERY LIFE AND DEPLETION**).

Fresh batteries should be installed prior to each mission.



OPC BATTERY

Alerts *(Fig. 34)*

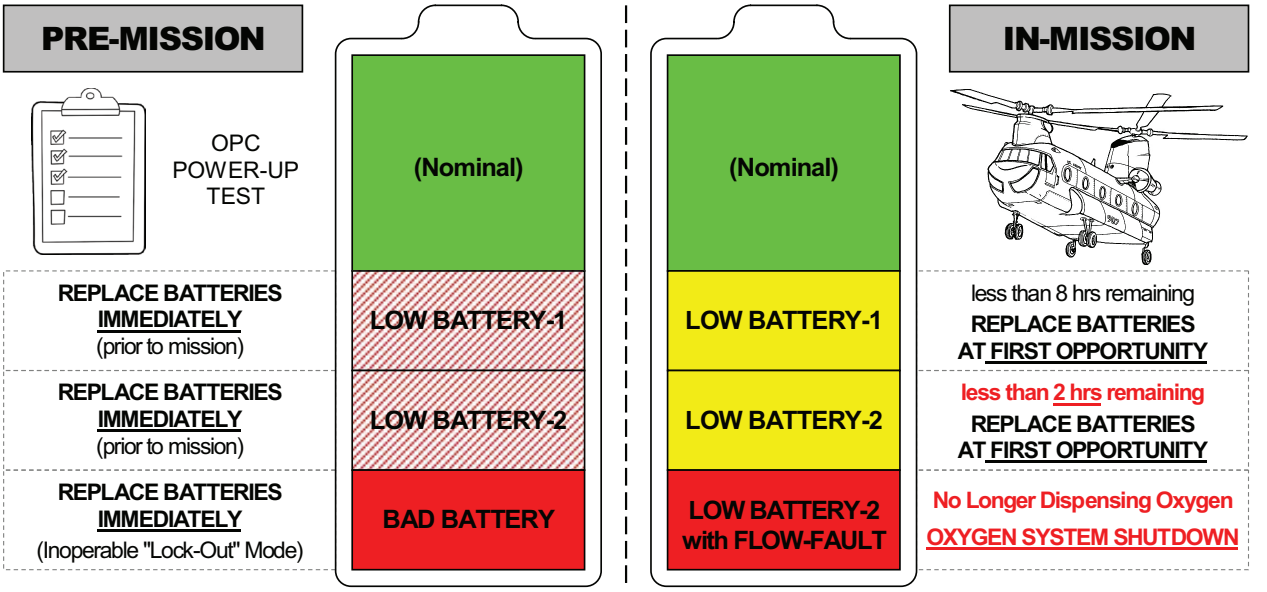


Figure 34

Notes:

- **Replace the batteries *immediately*** if any of the **LOW BATTERY** Alerts are indicated during the **PHODS PRE-FLIGHT CHECKLIST**. DO NOT embark on a mission with weak batteries. A set of fresh AA alkaline batteries should always be included as part of a "spares" kit.
- If a mission is begun with a **LOW BATTERY-1** Alert, the OPC unit may have no more than 2 hours of operation remaining.
- If a mission is begun with a **LOW BATTERY-2** Alarm, the OPC unit may be on the verge of imminent shut down.
- If a **LOW BATTERY-2** Alarm is received during a mission, ***the batteries should be replaced at the first opportunity.***
- If operation is continued with a **LOW BATTERY-2** Alarm and subsequent **FLOW-FAULT** Alarms are received, this likely indicates that the oxygen-dispensing valve has ceased operating, and the OPC unit is no longer dispensing oxygen (see **BATTERY LIFE AND DEPLETION**).
- It is particularly important to heed **BATTERY ALERTS** in the course of missions conducted at higher altitudes.
- The times for remaining operation ("Time-to-Failure") are approximations only, based on nominal conditions (see **BATTERY LIFE AND DEPLETION**).

Battery Life and Depletion

Battery life depends on many variables. First of all, not all batteries are created equal, so use “good quality” (Name- Brand) alkaline batteries. Batteries (even if unused) have a limited shelf life, so make sure batteries are “fresh”. Even so, “brand new” batteries may be faulty or partially depleted.

In addition, the rate at which batteries are depleted is influenced by several factors. The power consumed by the valve varies individually. Altitude and respiration rate (as well as temperature, humidity, etc.) also affects the rate of battery depletion.

Once the OPC has successfully powered-up (without issuing a **BAD BATTERY** Alarm), it will continue to operate as long as possible until the batteries are completely exhausted. As the batteries deplete, the OPC will first issue a **LOW BATTERY-1** Alert indicating that no more than 8 hours of operation remain. With further depletion, the OPC will issue a **LOW BATTERY-2** Alarm indicating that, at best, about 2 hours of operation remain.

Ultimately, the batteries will deplete to the point where the OPC will no longer be able to operate the oxygen-dispensing valve. When the valve ceases operating, the OPC unit will no longer be dispensing oxygen! This is typically heralded by the onset of **FLOW-FAULT** alarms for each breath.

Note: Alkaline batteries will sometimes “rejuvenate” if allowed to “rest”. So although a **LOW BATTERY** Alert may have been received at the end of a previous mission, no warning may be given when powering-up the OPC the next day. This is misleading, and should not be a rationale for postponing battery replacement. Once a **LOW BATTERY** Alert has been issued, the batteries are unreliable and should be ***replaced immediately.***

Installing and Replacing Batteries *(Fig. 35)*

The OPC uses two (2) AA alkaline batteries. Remove the battery door by gently pressing down on the battery cover tab, then slide the door out and away from the unit. Insert the batteries with proper polarity as shown on the label inside the battery compartment. Replace the door by sliding it back in until it snaps into place.

Figure 35

Notes:

- Batteries will be a tight fit. Take care not to damage the batteries and/or connectors when inserting or removing the batteries. Do not short the battery terminals.
- Install the batteries with the proper polarity as shown.
- ***Use good quality alkaline batteries only*** (DURACELL ULTRA, ENERGIZER MAX or equivalent).
- ***DO NOT USE LITHIUM BATTERIES!*** No damage will result, but the **LOW BATTERY** Alerts WILL NOT function correctly as they are calibrated for alkaline batteries.
- ***DO NOT*** mix old and new batteries! Replace all batteries at the same time.
- ***Remove the batteries during long periods of non-use***. Battery leakage and corrosion can damage the OPC.
- ***Fresh batteries should be installed prior to each mission, and removed at the completion of each mission.***
- ***Dispose of batteries properly.*** Do not burn. Use collection points when available.
- See **OPC-M2 SPECIFICATIONS** for battery-life information.

STORING PHODS

PHODS can be stored under a fairly wide temperature range 185°F (+85°C) to -79.6°F (-62°C). To protect the system from excessive humidity/rain, etc. store the unit in the supplied case.

In practical use the following precautions should be observed:

1. The OPC unit, oxygen hoses, nasal cannula's, etc., should be disconnected from the oxygen supply and stored in a secure manner to ensure that dirt and debris do not enter the inlet and outlet tubes. The supplied protective case is recommended.

2. ***Remove the batteries*** from the OPC unit when it is not in use.

3. Always store the cylinder with the handwheel in the closed position *(red indicator ring visible)*. The unit should not be stored with oxygen in the cylinder.

4. PHODS must be tested before use in accordance with the **PHODS PRE-FLIGHT CHECKLIST.**

CARE & MAINTENANCE

PHODS should be returned to its protective case when not in use.

It is important to provide the proper preventative maintenance in order to ensure the best possible performance and reliability of the PHODS.

OBTAIN FACTORY PRESCRIBED SERVICE FOR PHODS EVERY 12 MONTHS BY A FACTORY TRAINED SERVICE TECHNICIAN. YOUR PERSONAL SAFETY AND THE MECHANICAL INTEGRITY OF YOUR PHODS DEPENDS ON IT.

PHODS PRE-FLIGHT CHECKLIST

Check - Oxygen Cylinder / OPC

1. Verify all PHODS components are present.

2. Install two new alkaline AA batteries in the OPC. Ensure the battery compartment door is secure.

3. ***Slowly*** open the cylinder valve and check that the dial indicator reads in the green.

4. Turn the OPC mode-selector knob to the **ON** position. The OPC green O_2 LEDs will produce a series of flashes and the audible alarm will sound. If the LEDs continue to flash rapidly and / or the audible alarm continues after the initial series, refer to the ***Troubleshooting Guide*** section of this manual to determine its possible cause.

5. Verify the cylinder pocket is secured to the vest properly.

6. Verify the OPC pocket is secured to the vest properly.

7. Install the cylinder and regulator into the cylinder pocket and secure with the fasteners.

8. Install the OPC into the OPC pocket.

9. Route the 30” OPC inlet hose through MOLLE straps, over the shoulder and connect the 90° QD fitting into the CPC connector on the regulator. Ensure the QD fitting “clicks” into place.

10. Route the OPC outlet hose through the MOLLE straps from the upper chest to the OPC pocket. Ensure the blue tip of the outlet hose has sufficient length to be pushed into the OPC.

11. Verify the MOLLE attachment on the OPC outlet hose is attached to the vest and the OPC inlet hose is secured in the hook and loop fastener.

12. Push the OPC outlet hose into the 6mm connector on the OPC.

13. Select helmet mounted delivery method.

Check - Helmet / Nasal Cannula

1. Ensure the nasal cannula is mounted to the helmet securely and the 90° connector is pointing down and out the rear of the helmet.

2. Verify the nasal cannula has a removable nose piece installed.

3. Push the open end of the coiled hose into the 90° connector on the index tube until it stops.

4. Don the helmet and push the QD fitting on the coiled hose into the CPC connector on the outlet hose that is attached to the vest.

5. Position the nasal cannula into the nose and inhale while observing the OPC in either the **F20** or **R/M** position. The green O_2 LED should flash once indicating a properly functioning unit.

6. To simulate the flow-fault alarm, disconnect the 90° QD fitting from the CPC connector on the regulator and inhale. The green O_2 LED should produce a constant flashing for 2 seconds. This indicates a flow-fault. Reconnect 90° QD fitting.

7. The system is verified functional.

8. Remove the nasal cannula from the nose, disconnect the coiled hose from the outlet hose CPC connector on the vest and remove the helmet. Change the mode on the OPC by turning the mode-selector knob to the **ON** position; the unit is ready for use. When not breathing on the device the green O_2 LED with will flash 4 times indicating no breaths have been taken in 30 seconds.

Check - Helmet / Facemask

1. Ensure the nasal cannula is removed from the helmet.

2. Ensure there is a red plug in the other unused 90° fitting on the exhalation side of the mask.

3. Push the open end of the coiled hose into the 90° fitting on the inhalation side of the mask until it stops.

4. Push the QD fitting on the coiled hose into the CPC connector on the outlet hose that is attached to the vest.

5. Don the helmet and attach the facemask. Ensure it is fitted correctly.

6. Inhale while observing the OPC in the **F20** position. The green LED should flash once indicating a properly functioning unit.

7. The system is verified functional.

8. Remove the mask from one side of the helmet, disconnect the coiled hose from the outlet hose CPC connector attached to the vest and remove the helmet; the unit is ready for use. When not breathing on the device the green O_2 LED will flash 4 times indicating no breaths have been taken in 30 seconds.

PHODS POST-FLIGHT CHECKLIST

1. Turn the handwheel on the regulator to the **CLOSED** position

2. Turn the Mode-Selector knob on the OPC to the **OFF** position.

3. Push the button on the outlet hose CPC connector attached to the vest and disconnect the coiled hose.

4. Remove the coiled hose from the facemask or nasal cannula by pushing the black ring on the fitting and pulling the hose out.

5. Remove the outlet hose from the OPC by pushing the black ring on the fitting and pulling the hose out.

6. Release the inlet hose from the hook and loop fastener on the MOLLE attachment. Disconnect the MOLLE attachment from the vest and remove the OPC outlet hose.

7. Disconnect the 90° QD fitting from the regulator by pushing the button on the CPC connector to release.

8. Remove the OPC from the pocket after unthreading the inlet hose from the vest.

9. Unsnap the retaining straps and remove the regulator / cylinder from the pocket.

10. Disinfect the mask or nasal cannula & nose piece with isopropyl alcohol wipe. Let air dry.

11. Remove batteries from OPC and return all components to the proper position in the protective case.

12. Report any discrepancies to the qualified technician upon return.

PHODS CHECKLIST INSERT *(Fig. 36)*

PHODS Checklist Insert

DISPLAY AND ALARM INFORMATION
Normal Operation
- Green O_2 LED single flash per breath during inhalation
- When you set the unit to **ON** mode...you must wear your cannula or facemask. Even though you are below the 8,000 feet threshold, the Apnea alarm is "**ON" and will detect that no one is breathing, causing the alarm to activate with the flashing green O_2 LED. The unit is calibrated for up to 45 BPM (Breaths per Minute) in all active positions.**

FLOW-FAULT ALARM
Coinciding with your inhalation, the OPC will produce a two second flashing green O_2 LED to indicate that the oxygen flow from the regulator has stopped.

APNEA ALARM
Green O_2 LED (4 flashes) every two seconds to indicate that breathing has not been detected within the past 30 seconds and will continue to flash until breathing is resumed.

LOW BATTERY
The OPC provides 3 levels of low battery warning:
(1) Low Battery - 1 green LED will single flash every 2 seconds.
(2) Low Battery - 2 green LED will double flash every 2 seconds.
(3) Bad Battery ~ green LED will flash continuously. The OPC will go into "lock-out" mode and no longer dispense oxygen.

BATTERY CHECK
When OPC is turned **ON** - green O_2 LEDs will flash rapidly and an audible alarm will sound - verifies the batteries and circuits are working. If the batteries are low; green LED will continue to flash & solenoid valve will continue to cycle - replace batteries. Severely depleted batteries will only flash the green LED.

Figure 36 Check List

REGULATOR AND CYLINDER CHANGE OUT

1. To change out an empty or non-operational regulator and cylinder.

2. Close the handwheel on the cylinder in use.

3. Press the button on the CPC connector to disconnect the 90° QD fitting from the regulator.

4. Unsnap the cylinder retaining straps and remove the regulator and cylinder from the pocket.

5. Obtain a full cylinder from the qualified technician or from the mission kit while in flight.

6. Open the handwheel on the new cylinder and verify that it is full with the dial indicator reading in the green. Turn off the cylinder valve.

7. Install the new cylinder in the pocket and attach the straps.

8. Push the 90° QD fitting into the CPC connector on the regulator.

9. Open the handwheel to pressurize the cylinder.

10. Check the OPC for flow and proper operation.

TROUBLESHOOTING GUIDE

General Checks

WARNING - If after consulting the troubleshooting guide section of this manual the situation is not resolved, immediately return the PHODS system to a qualified technician for inspection or contact an Aqua Lung Technical Advisor.

1. Verify sufficient oxygen is in the cylinder.

2. Confirm audible alarm, green O_2 LEDs flashing & pulsing solenoid valve are functioning properly on initial OPC start-up:

- Replace batteries immediately if the OPC is not functioning properly. Severely depleted batteries will only flash the green LED.

3. If any of the following conditions exist, descend to safer altitude as soon as possible.

OPC unit emits no sound or start-up oxygen pulse when turned on:

1. Check batteries. Install fresh, quality **alkaline** batteries as required.

2. Make sure the batteries are installed with the correct polarity.

3. Check for corrosion. Clean contacts or replace batteries as required.

4. Check oxygen cylinder valve is in the **ON** position.

5. Check oxygen inlet / outlet tube for proper connection / obstructions.

Start-up sound is heard, but no start-up oxygen pulse delivered:

1. Make sure the oxygen cylinder valve is in the **ON** position.

2. Check that the oxygen inlet / outlet tube is properly connected and not kinked, pinched, or otherwise obstructed.

OPC does not trigger on inhalation:

1. Use **R/M** or **F20** modes for test (OPC may not respond in **ON** mode if below 8,000 ft threshold altitude).

2. Some inhalation effort is required. Avoid breathing through your mouth. Shallow breathing may not trigger the OPC.

3. If a **FLOW-FAULT** alert is received, re-check the oxygen cylinder and inlet / outlet tubing as above.

When using the facemask, no oxygen pulse on inhalation:

1. Make sure the facemask seals properly against the skin.

2. If a **FLOW-FAULT** alert is received, re-check the oxygen cylinder and inlet / outlet tubing as above.

3. At altitude to allow breathing, make certain you are in **F20** mode.

Oxygen pulses are delivered, but the green O_2 LED indicates no flow condition:

1. Check the batteries to make certain they are fresh.

2. Check for obstructions in the nasal cannula / facemask and tubing.

The OPC does not trigger at higher altitudes:

1. Turn the OPC to the **OFF** Mode, then return to the previous mode.

2. Try a different mode.

3. Descend to a lower, safer altitude.

OPC AUTO-COMPENSATE

Breathing Sensor and Altitude Compensation

As absolute atmospheric pressure decreases with altitude, breathing efforts consequently assert less pressure on breathing sensors to the point where inhalation may not be properly detected at higher altitudes. Additionally, breathing *effort* tends to diminish as the partial pressure of CO_2 also decreases with altitude. The OPC must compensate for these physical and physiological effects when ascending to higher altitudes.

The OPC employs an active algorithm that constantly and automatically adjusts the sensitivity of the breathing sensors based on pressure altitude and detected breathing effort. It also filters out false-triggers due to pneumatic artifacts. This helps ensure that all breaths are correctly detected so that the OPC can respond reliably and deliver the proper amount of oxygen. This function is entirely automatic and involves no user settings.

Automatic Respire-Metric Compensation

An average size adult, with no compromising pulmonary conditions or illnesses, will have an average respiration rate of 12 to 18 breaths per minute. The respiration effort at rest generally becomes less as the rate increases. Shallow breathing with an elevated respiration rate is typical with exposure to altitude and/or anxiety.

Respiration is primarily controlled by chemoreceptors that detect dissolved CO_2 in the blood. Higher CO_2 levels (e.g., from physical work) trigger higher respiration until CO_2 is re-normalized. Higher respiration consequently increases oxygen levels. As the amount of dissolved CO_2 in the blood decreases, so does the urge to respirate. Therefore, as the partial pressure of CO_2 drops during excursions to higher altitudes, breathing effort will generally decrease, as the body is not compelled to respirate to expel any more CO_2. Unfortunately, this exacerbates hypoxia as less oxygen is inhaled and admitted into the blood.

One way to encourage respiration at higher altitudes would be to actually deliver a small amount of CO_2 with each inhalation. The OPC instead augments the amount of oxygen delivered to help ensure that each individual receives the full amount of oxygen that they require in spite of reduced respiration. The OPC uses a poly-metric method of dynamically adjusting the amount of oxygen delivered on a breath-by-breath basis as a function of pressure altitude, respiration rate and (in some cases) breathing effort. If the OPC is unable to establish meaningful respire-metrics for the current user (due to pneumatic artifacts or an improperly worn cannula or facemask), it will revert to default parameters to cover a known mean pulmonary profile.

Facemask Plenum Volume Compensation

A facemask, unavoidably, has a volume of space (plenum) that does not directly contribute to the admission of oxygen. This plenum volume can compromise the initial admission of oxygen by allowing the user to rebreathe CO_2 at the most important point of the inhalation phase and consequently displace a portion of the delivered pulse of oxygen. While a small amount of re-inhaled CO_2 can actually be beneficial at higher altitudes as it encourages respiration, missing the full complement of the prescribed amount of oxygen is not.

The **F20** Mode setting of the OPC helps mitigate this effect by providing an additional bolus of oxygen with each breath to compensate for the plenum volume associated with the facemask. The **F20** Mode setting can also be used if the user determines that they may need more oxygen than is automatically prescribed.

OPTIONAL FACEMASK

The oxygen mask design includes the mounting brackets necessary to connect the mask to the HGU-56/P helmet, with or without the maxillofacial shield installed. It may be used with the optional snap adapters to connect the mask to the HGU-84/P helmet without the maxillofacial shield installed. This provides versatility to air crew members allowing them to customize the system according to mission demands. The system remains stable throughout the flight performance envelope of helicopters, is easy to don, and has quick disconnect features. The mask assembly's quick release snaps and adjustable fasteners allow three unique configurations wherein the maxillofacial shield and oxygen mask can be used independently or together for maximum protection.

The mask includes an integrated M-169A/AIC dynamic 5-ohm microphone to aid communications.

Use of a mask will supply an adequate oxygen mixture to users who are under mental or physical stress and who, as a result, will breathe through their mouths instead of their noses. Oxygen enters from the OPC regulator hose and travels through 90° oxygen inlet port of the mask to allow the oxygen to enter the mask cavity. Exhaled gases exit the mask through the exhalation valve ***(Fig. 37)***. Ensure the GMM Plug is inserted into the 90° elbow on the opposite side of the mask ***(Fig. 38)***.

WARNING - The GMM plug must be inserted into the 90° inlet port on the opposite side of the mask in order to function properly.

WARNING - Oxygen should be delivered to the inlet port on the inhalation valve side of the mask to ensure the proper dilution of oxygen with the ambient air in the mask cavity.

WARNING - Disinfect the facemask or nasal cannula & nose piece after each use to avoid bacteriological contamination and for cleanliness. Cleaning can be accomplished with isopropyl alcohol.

Figure 37

Figure 38

PHODS TECHNICAL SPECIFICATIONS

OPC-M2 UNIT

Physical Characteristics

Width: 3.1 in (79 mm)
Height: 5.23 in (130 mm)
Depth: 0.95 in (24 mm)
Weight (with batteries)**:** 9.3 oz (264 g)

Battery Operation

Battery Type	1.5 Volt AA Alkaline (2 ea.)	
Battery Voltage		
NOM	~ 2.875 VDC	
Low Battery-1 Level	~ 2.40 VDC ± 0.04 VDC	
Low Battery-2 Level	~ 2.25 VDC ± 0.04 VDC	
MIN Start-Up Voltage	~ 2.00 VDC ± 0.04 VDC	
Battery Current		
Average	~ 3.25 ma	
Peak	~ 100 ma	
Battery Life		***(fresh batteries should be installed prior to mission)***
NOM	(up to) 100 Hours	*(fresh batteries, normal operating conditions)*
Low Battery-1 Alert	~ 8 Hours	*(time remaining at onset)*
Low Battery-2 Alarm	~ 2 Hours	*(time remaining at onset)*
Test Conditions	25° C, ~ 25% RH	

Operating Ranges

Inlet Pressure, MIN	15 psig [1 bar] **Dynamic** (cannula w/ 1.5m [5ft] of 4 mm inlet tubing)
Inlet Pressure, MAX	25 psig [1.72 bar] **Static**
Temp Range (Storage)	-40° to +60°C, ~ 10% RH (complete unit less batteries)
Temp Range (Operating)	-40° to +60°C, ~ 100% RH NC
Altitude Range	-100 to 32,000 ft, ~100% RH NC, -40° to +60°C
Vibration	5 to 500 Hz random, 2.5 g RMS Sin wave, 15 minutes per axis

OPC Auto-Compensation

Respiration Limits Adaptive: ~ 5 - 30 bpm. For respiration rates over 30 bpm, the OPC unit delivers oxygen only on every other breath, which provides a behavior more to the expectations of the user *(See **Inhalation Event & Oxygen Delivery Notification**)*.

Apnea Time-to-Alert Adaptive (continuous as function of pressure altitude):

Altitude	Time-to-Alert
(any)	32 sec (MAX)
~10 K ft	~25 sec
~15 K ft	~22 sec
~26 K ft	~16 sec

OPC units will initiate an **ABANDONED ALERT** (conveyed by displaying the APNEA ALERT sequence) if no breathing is detected for ~16 minutes in any setting to inform the user that the unit has been left on.

*Note: In **ON** mode, the **APNEA ALARM** does not respond below 8,000 ft pressure altitude.*

PHODS TECHNICAL SPECIFICATIONS (continued)

Regulator and Cylinder

Pressure Rating: 2100 psi (145 BAR)

Capacity:1.7 ft^3 (48.36 L)

Floodable Volume: 20.4 in^3 (.334 L)

Height: 12.00 in (30.48 cm) Cylinder - 9.25 in (23.5 cm) & Regulator - 2.75 in (6.99 cm)

Diameter: 2.00 in (5.08 cm)

Weight: Empty 2.47 lb (1.12 kg.) Full approx. 2.5 lb (1.13 kg)

Testing and characterization was done under normal operating conditions i.e. 77ºF / 25ºC and responding to a respiration rate of about 15 breaths per minute. Specifications are subject to change without notice.

Notes:

- Specifications and limits are characterized from test results, or derived from underlying specifications.
- Unit is not water-proof! Keep away from rain and spray.
- Nominal Battery Voltage/Current values measured in **ON** mode setting @ 15 bpm typical.
- Battery-life values assume fresh alkaline batteries and normal operating conditions.
- Fresh batteries should be installed prior to each mission, and removed at the completion of each mission.
- Use good quality alkaline batteries only. DO NOT use Lithium batteries.
- DO NOT mix old and new batteries! Replace all batteries at the same time..
- Remove batteries during long-term storage to prevent battery leakage and corrosion.
- The Battery Minimum 'Start-Up' voltage is the level at which the OPC unit will initiate the POWER-UP TEST. If the battery level is too low, the OPC will immediately generate a BAD BATTERY ALARM. Otherwise the OPC will proceed to issue the initial oxygen pulse. This not only exercises the valve and verifies the integrity of the entire oxygen system, but also serves as a stress-test for the batteries. If the battery level is too low following the initial pulse, the OPC will generate a BAD BATTERY ALARM. Only when the OPC successfully passes all of these tests will it then commence operating (with or without a LOW BATTERY Warning). This behavior should help the operator in determining if the OPC unit is bad or if the batteries are just too low.
- If a BAD BATTERY ALARM is generated, the OPC unit will enter "lock-out" mode and will not function other than to display the BAD BATTERY ALARM. Batteries must be replaced at this point for the OPC unit to resume proper functioning. However, once the OPC is running, it will continue to operate as long as possible until the batteries are completely exhausted (see ***BATTERY LIFE AND DEPLETION***).
- The OPC POWER-UP TEST also verifies the integrity of internal components and sensors and generates an INTERNAL ERROR ALARM (see ***POWER-UP TEST***) if any of these checks fail. An INTERNAL ERROR ALARM indicates that the OPC unit will not function properly and must be serviced.

MAINTENANCE NOTES

PHODS

Portable Helicopter Oxygen Delivery System

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