MH OPC-M2 USER MANUAL

Digital Electronic Pulse-Demand™ Aviation Oxygen Delivery System

Pulse-Demand™ is a patented innovative oxygen control technology that automatically delivers the precise amount of oxygen required at altitude.

READ THIS MANUAL CAREFULLY BEFORE USE.

Aviation Oxygen Systems

MOUNTAIN HIGH Equipment & Supply Company

Proudly Made in the USA

Covered by one or more of the following patents
8,439,034 8,661,910
Other Patents Pending

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5MOPC-0002-00$-0 2019-045 2019-09-24

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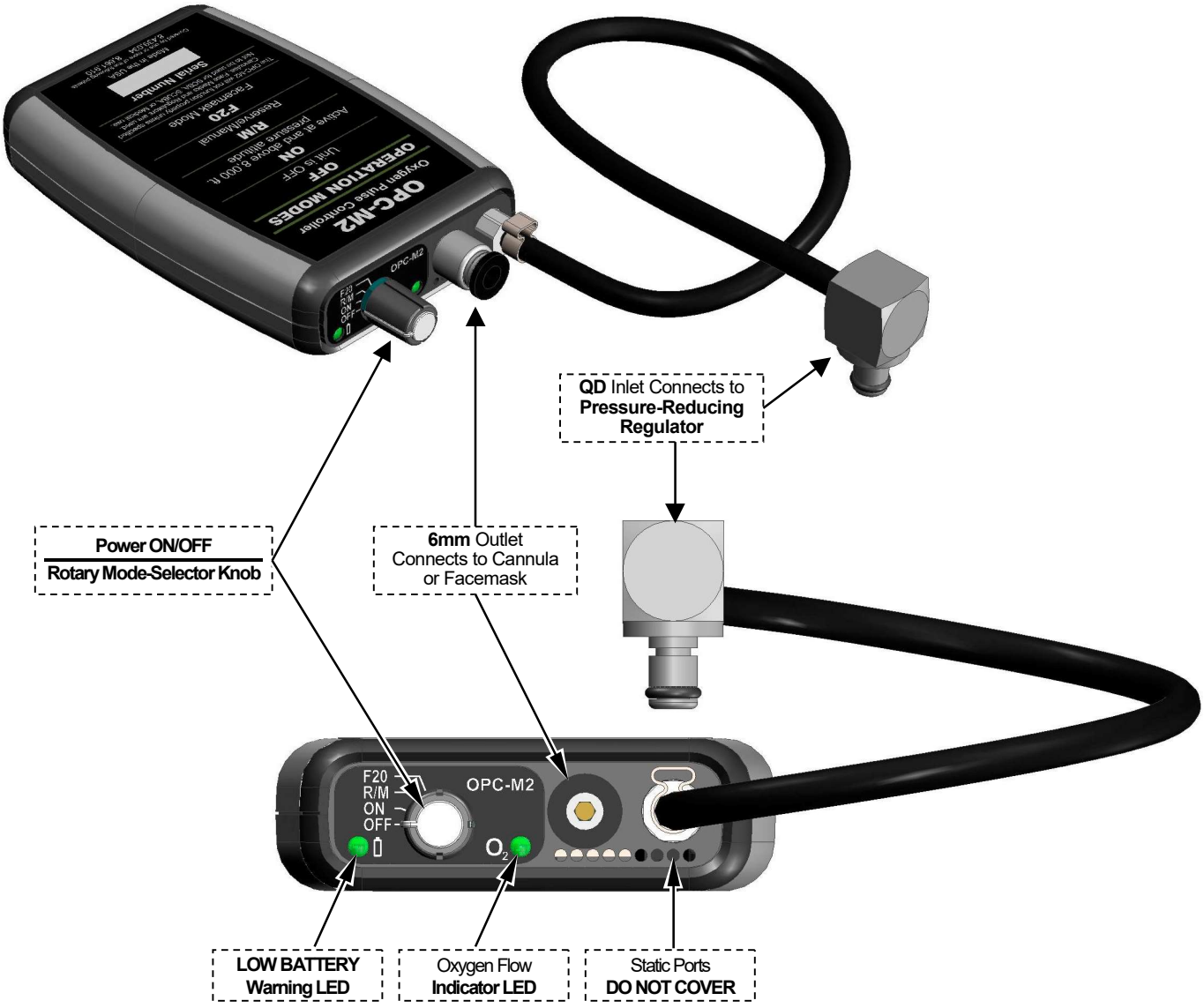
INTRODUCTION

The patented MH Pulse-Demand™ Electronic Delivery System (**EDS**) is designed to deliver oxygen in the most efficient and convenient manner possible. With its user-selectable settings and small size, the MH EDS is the most flexible portable digital electronic oxygen delivery system in the world.
The MH Oxygen Pulse Controller (**OPC**) is a specialized member of the MH EDS family with features that are specifically tailored for military applications. The MH **OPC-M2** is an improved version of the original MH OPC-M1. The OPC unit is a compact, lightweight, self-contained oxygen-delivery device that is well-suited to either aviation or ground operations. The OPC operates solely on battery power without the need for external power support or connectors and is thus inherently mobile. Two (2) readily-available AA alkaline batteries provide more than enough power for all but the most extreme missions (mission duration is far more limited by oxygen supply than by battery capacity).
All that is needed to create a mobile, autonomous oxygen system is an oxygen supply (cylinder), a pressure-reducing regulator with a compatible output pressure, an OPC-M2 unit, and a cannula or facemask to deliver oxygen to the user.

The patented EDS delivery technology supplies the oxygen needed to remain alert and functioning at full capacity when operating at altitude. It ensures that the proper amount of oxygen is delivered by automatically adjusting flow according to pressure altitude and breathing rate. The efficiency of this method dramatically increases cylinder duration, which provides the option of either saving weight and space with a smaller cylinder, or extending mission length potential.

- Compact, light-weight, easy-to-use.
- Battery powered, autonomous operation.
- Automatically adjusts oxygen flow for pressure altitude.
- Reduced oxygen consumption through more efficient oxygen delivery compared to constant-flow systems.
- Rugged MIL-spec control switch for improved reliability. Positive position-detents provide excellent tactile feedback and resistance to inadvertent changes.
- Large easy-to-grip indicator knob for ease of use and good visibility.
- Rotary mode-switch selects the OPC operating mode:
  ON (normal operation), **R/M** (Reserve/Manual) or high-flow **F20** Facemask setting.
- Night Vision Goggle (NGV) compatible Green LEDs indicate oxygen flow status and alarm conditions.
- **FLOW-FAULT ALARM** informs user of kinked, pinched or disconnected oxygen lines

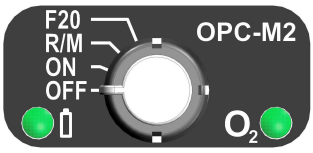


MODES OF OPERATION

The Rotary Mode-Selector knob controls operation of the OPC.

The OPC provides three modes of operation:

ON:	**Standard Flow**	**Commences above 8000 ft Pressure Altitude**
R/M:	**Extreme Flow**	**All Altitudes**
F20:	**Enriched Flow**	**All Altitudes** (Facemask mode)



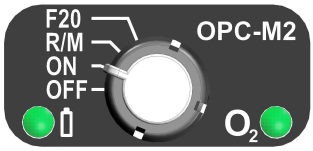
Mode Selector Knob
in "OFF" position

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** (page 5) 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

ON mode is the "normal" operational setting. Oxygen flow commences when a pressure altitude threshold of 8000 ft is reached, and ceases when the pressure altitude drops below 8000 ft.



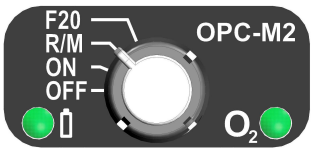
Flow amount:	Standard	**Altitude Compensating:**	Yes
Flow start:	8,000 ft.	**Use with:**	Cannula

Notes:

- Below 8000 ft pressure altitude (see Glossary, page 15), 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 most efficient delivery setting and will provide the greatest oxygen duration.

R/M: "Reserve/Manual"

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.



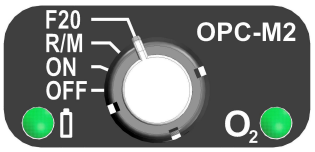
Flow amount:	Extreme	**Altitude Compensating:**	Yes **(1)**
Flow start:	All altitudes	**Use with:**	Facemask or Cannula

Notes:

- **(1)** An extremely enriched but fixed amount of oxygen is delivered at all altitudes up to ~ 32000 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,** page 5.
- 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 otherwise mitigate the effects of sudden hypoxia.

F20: "Facemask" Mode

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.

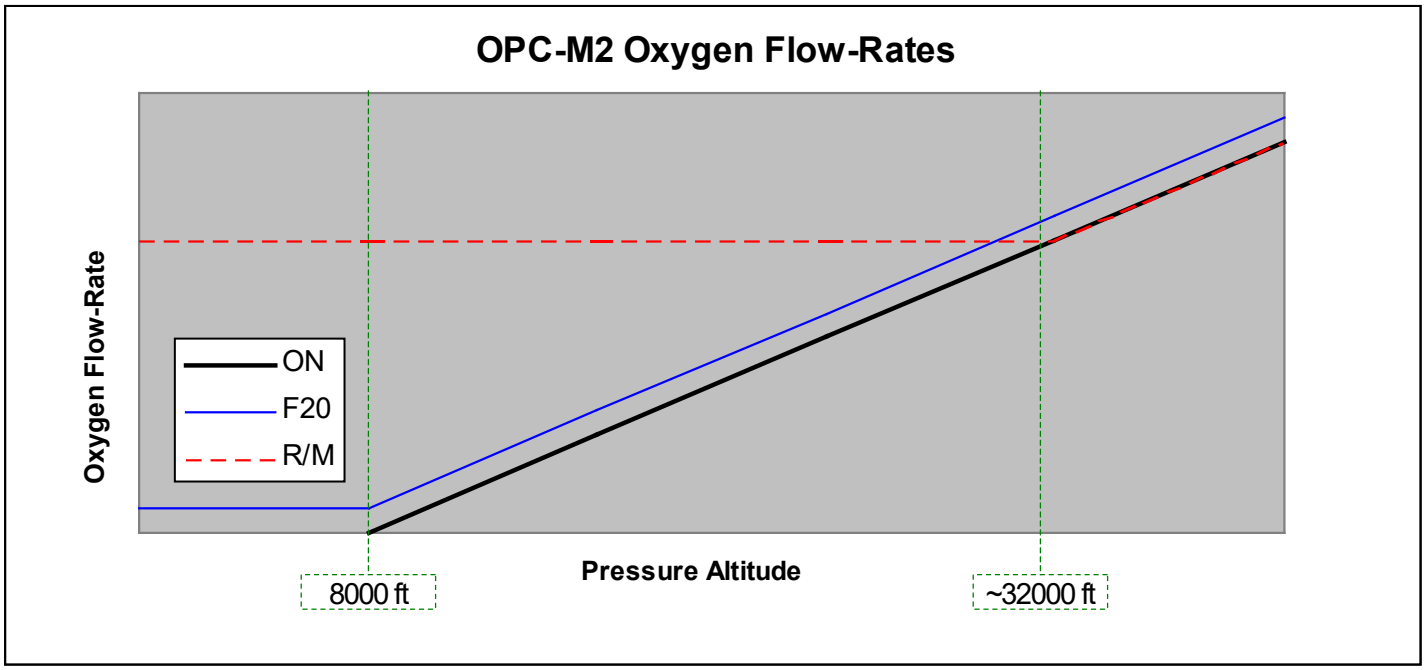


Flow amount:	Enriched	**Altitude Compensating:**	Yes
Flow start:	All altitudes	**Use with:**	Facemask or Cannula

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,** page 5.
- Pilots making night approaches and landings may use the **R/M** or **F20** modes to provide additional oxygen in order to enhance night vision.

The following graph illustrates the relative rates of oxygen delivery for the various OPC operating modes.



ON Mode

- Oxygen is only delivered above the 8000 ft pressure altitude (PA) threshold (see Glossary, page 15).
- Oxygen delivery is suspended when the altitude drops below 8000 ft PA.
- Above 8000 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 8000 ft PA.
- Above 8000 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 **ON** mode (enriched flow).

R/M Mode

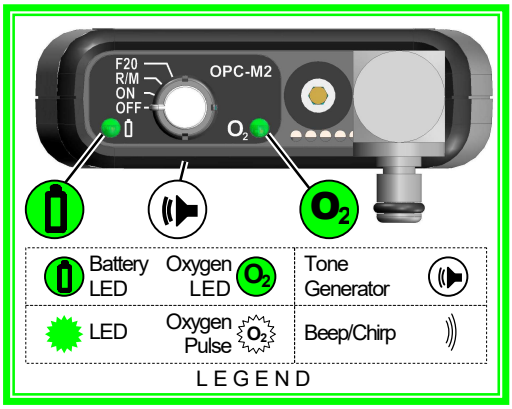
- Oxygen is delivered at all altitudes.
- A fixed amount of oxygen is delivered at all altitudes up to ~ 32000 ft PA.
- The fixed amount of oxygen delivered in the lower altitude range is significantly greater than what would otherwise be provided in either **ON** or **F20** mode (extremely enriched flow).
- The amount of oxygen delivered above ~32000 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 32000 ft PA, although at such high altitudes physiological factors begin to compromise the effectiveness of an SBA (Supplemental Breathing Apparatus) system such as the MH OPC-M2.

ALARMS & ALERTS

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.

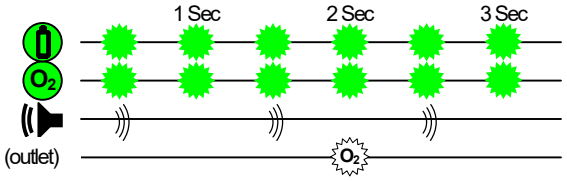
The Oxygen Flow Indicator LED (**O_2**) displays conditions related to oxygen flow, while the Battery Warning LED displays battery-related conditions. An initial oxygen pulse {**O_2**} is delivered as part of the Power-Up Test sequence. Oxygen pulses are subsequently delivered with each inhalation during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

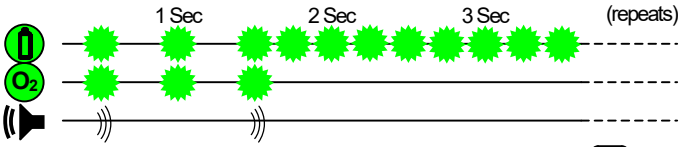
The **POWER-UP TEST** checks the battery voltage and verifies valve operation and oxygen supply continuity as well as exercising the LEDs. A successful POWER-UP TEST is indicated by the OPC emitting 3 short beeps, flashing both LEDs 6 times, and delivering an oxygen pulse (~ ½ second) to the OPC outlet.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



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 **OXYGEN SYSTEM PRE-MISSION**, page 8.

POWER-UP TEST: FAIL (BAD BATTERY ALARM)

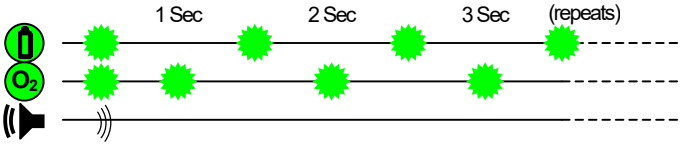
If the battery test fails during the **POWER-UP TEST,** the OPC generates a **BAD BATTERY ALARM**. After the first 2 short beeps, the Battery Warning LED begins flashing continuously. The batteries are too low to operate the OPC unit and it will not dispense oxygen.



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**.

POWER-UP TEST: FAIL (INTERNAL ERROR ALARM)

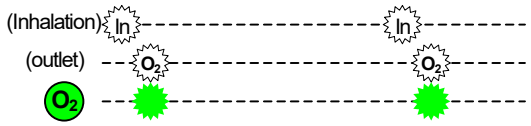
The OPC **POWER-UP TEST** also verifies the integrity of internal sensors and components and generates an **INTERNAL ERROR ALARM** if any of these checks fail. Immediately following the first beep, the Battery Warning and Oxygen Flow (**O_2**) LEDs begin flashing alternately in "Rail-Road" mode.



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

INHALATION EVENT & OXYGEN DELIVERY NOTIFICATION

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.

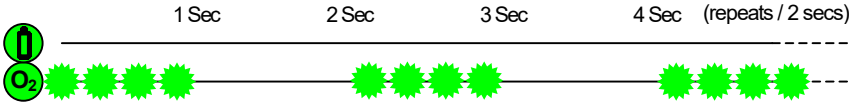


Exceptions:

- In **ON** mode but below 8000 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

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



An **APNEA ALARM** is generated if the time since the last inhalation event exceeds an interval that is dependant 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 (see page 14). The **APNEA ALARM** does not respond below 8000 ft pressure altitude when operating in **ON** mode (see page 4).

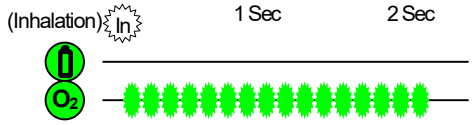
An **APNEA ALARM** typically occurs for one of the following reasons:

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

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.***



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

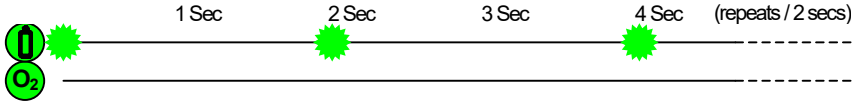
1. The oxygen cylinder valve is not open.
2. The oxygen supply line is pinched or disconnected.
3. The valve in the OPC unit has failed to operate.

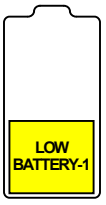
A **FLOW FAULT ALARM** is not necessarily a low oxygen pressure warning.

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)

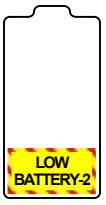
Battery Warning LED displays continuous *single* flashes. From the time a **LOW BATTERY-1 ALERT** is first issued, the OPC should continue to operate properly for about another eight (8) hours (@ 77°F/25°C, and depending on battery quality).





LOW BATTERY-2 ALARM (Second Warning)

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.



- **REPLACE THE BATTERIES IMMEDIATELY** if either of the **LOW BATTERY** Warnings are received during the **OXYGEN SYSTEM PRE-MISSION** check (page 8).
- If operation continues *beyond* the Second Warning, the batteries will ultimately deplete to the point where the valve ceases firing. At this point, the OPC will no longer be dispensing oxygen (see **BATTERY LIFE AND DEPLETION**, page 9).

Fresh batteries should be installed prior to each mission.

OXYGEN SYSTEM PRE-MISSION

The following procedures should be performed prior to every mission.

1. CHECK OXYGEN SUPPLY

- Prior to each mission, check the pressure gauge on the oxygen supply cylinder(s). Refill or replace as needed.
- As required, verify that additional oxygen cylinders are readily available for "change-out" during extended missions.
- Take into account that *more* oxygen may be needed than "normal". Be conservative in any estimates to allow for delays or other contingencies.
- Cylinder pressures below 300 psi will compromise the operation of the pressure-reducing regulator and affect the amount of oxygen delivered. Below 300 psi, less oxygen may be received than otherwise prescribed, but with no indication of a problem.

2. CONNECT OXYGEN SYSTEM

Secure/stow the oxygen cylinder as required. Connect the oxygen supply line from the OPC to the pressure regulator and the cannula/facemask outlet line to the OPC. Verify all connections.

3. OPEN OXYGEN CYLINDER VALVE

The oxygen cylinder valve should always be closed when not in use. Open the valve ***SLOWLY***.

4. OPC POWER-UP AND BATTERY TEST

Turn the Mode-Selector knob to the **ON** position to **POWER-UP** the OPC (see **POWER-UP TEST**, page 6). The Battery Monitoring function will require several seconds to properly assess the condition of the batteries. Continue to observe the unit after **POWER-UP** to watch for indication of a **LOW BATTERY** or **BAD BATTERY** condition (may take 10-15 seconds). If you receive any of these **LOW BATTERY** Alerts, **REPLACE THE BATTERIES IMMEDIATELY** *prior* to the mission (page 9).

***Fresh batteries** should be installed **prior** to each mission, and a spare set of batteries kept readily available.*

5. OPC FUNCTIONAL TEST

Turn the Mode-Selector knob to either the **F20** or **R/M** position (this test may not work otherwise if the pressure altitude is less than the 8000 ft threshold). Don the cannula/facemask and make sure that the outlet tubing is properly connected to the OPC and not kinked or pinched. Take a breath (inhale) and verify that oxygen is being delivered. The Oxygen Flow LED (**O_2**) on the OPC will flash Green and a puff of oxygen should be felt in the nostrils (the opening of the valve may also be heard inside the OPC unit itself). The entire oxygen system has now been verified to be functioning properly.

6. CHECK SPARES

- Spare set of fresh, quality AA alkaline batteries. ***A spare set of fresh batteries should always be available.***
- Additional back-up oxygen cylinders for "change-out" during extended missions.

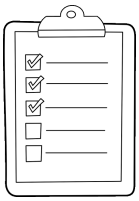
It is recommended that the cannula be worn for the entire mission if a need for supplemental oxygen is anticipated. At the point when the onset of hypoxia is a possibility, it is better to not have to deal with the otherwise unnecessary task of donning the cannula. Facemask users may also want to consider this. If the cannula/facemask is removed at any point, it should be stowed in such a manner that the outlet tubing will not become kinked or pinched when re-donning it.

Even if an immediate need for oxygen is not anticipated, it is recommended that the OPC be set to the **ON** mode as a default. This way, oxygen will automatically begin dispensing when 8000 ft pressure altitude is reached. The OPC may be switched to **R/M** or **F20** mode at any time to begin receiving more oxygen. If using the **ON** Mode (page 4), it is recommended that the cannula or facemask be donned before reaching the 8000 ft threshold altitude, rather than using the **APNEA Alarm** (page 7) as a "put-on-your-cannula/facemask" reminder.

OXYGEN SYSTEM POST-MISSION

1. **Turn off the OPC unit.**
2. **Close the oxygen cylinder valve.** Leaving the pressure-reducing regulator pressurized when not in use can shorten its service life.
3. Disconnect the OPC oxygen supply line.
4. Bleed the pressure-reducing regulator in order to relieve *internal* pressure inside the regulator. Leaving the regulator pressurized when not in use can shorten its service life. Refer to the documentation provided with the regulator for information on how to do this.
5. **Stow cannulas/facemasks/tubing** to prevent contamination (see **STORING THE OPC**, page 10)
6. **Remove the batteries and store the OPC (see INSTALLING & REPLACING BATTERIES, STORING THE OPC, page** 10).

PRE-MISSION

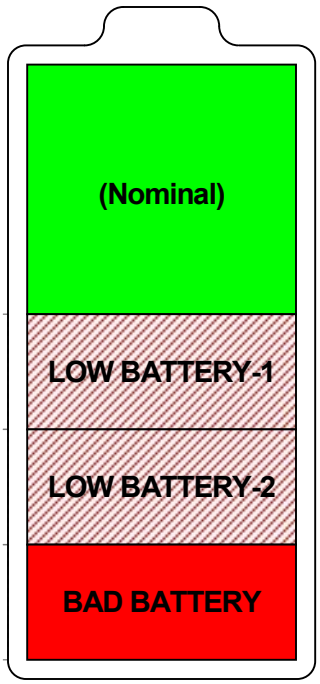


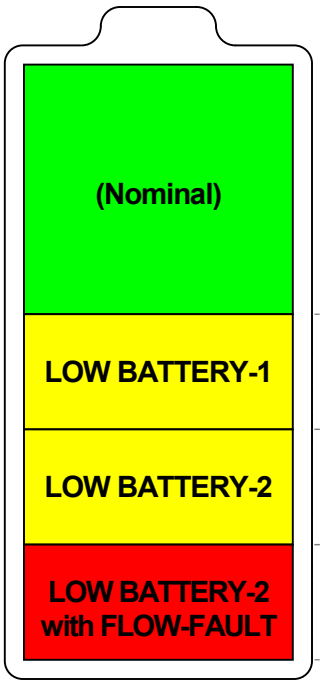
OPC POWER-UP TEST

REPLACE BATTERIES IMMEDIATELY (prior to mission)

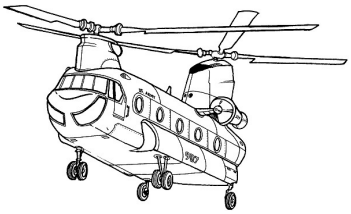
REPLACE BATTERIES IMMEDIATELY (prior to mission)

REPLACE BATTERIES IMMEDIATELY (Inoperable "Lock-Out" Mode)





IN-MISSION



less than 8 hrs remaining
REPLACE BATTERIES AT FIRST OPPORTUNITY

less than 2 hrs remaining
REPLACE BATTERIES AT FIRST OPPORTUNITY

No Longer Dispensing Oxygen
OXYGEN SYSTEM SHUTDOWN

Notes:

- **Replace the batteries *immediately*** if any of the **LOW BATTERY** Alerts are indicated during the **OXYGEN SYSTEM PRE-MISSION** check (page 8). 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 (page 7), the OPC unit may have no more than 2 hours of operation remaining.
- If a mission is begun with a **LOW BATTERY-2** Alarm (page 7), 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** discussion below).
- 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 below).

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 (page 7) 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 that 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 & REPLACING BATTERIES

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.

NOTES:

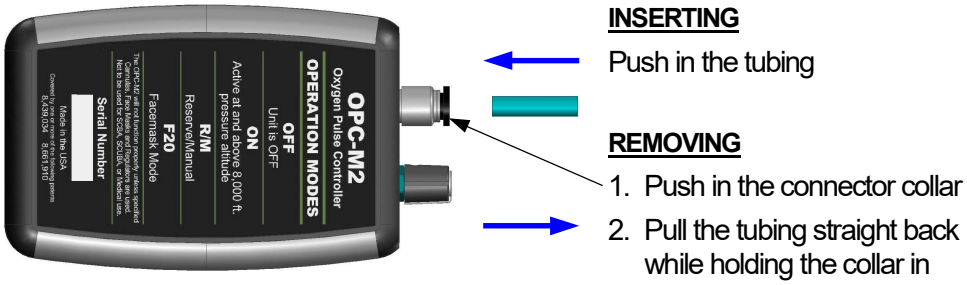
- Batteries will be a tight fit. Take care not to damage the batteries and/or connectors when inserting or removing the batteries. Do not short the battery terminals.
- Install the batteries with the proper polarity as shown.
- ***Use good quality <u>alkaline</u> batteries <u>only</u>*** (DURACELL ULTRA, ENERGIZER MAX or equivalent).
- ***<u>DO NOT</u> USE LITHIUM BATTERIES!*** No damage will result, but the **LOW BATTERY** Alerts <u>WILL NOT</u> function correctly as they are calibrated for alkaline batteries.
- ***<u>DO NOT</u> mix old and new batteries!*** Replace all batteries at the same time.
- ***Remove the batteries during long periods of non-use*** (see **STORING THE OPC**, page 10). 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 **MH OPC-M2 SPECIFICATIONS** on page 14 for battery-life information.

OUTLET TUBING CONNECTOR

To INSERT TUBING: push the tubing into the connector until resistance is felt, then push a little further, about 1/8 inch. 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.

(QD Inlet hose not shown for clarity)



When removing tubing, ***<u>DO NOT</u> pull on the tubing without pushing in the collar,*** as this will likely damage the connector.

STORING THE OPC

Close the cylinder valve, disconnect all tubing (oxygen supply and cannula/facemask), bleed the pressure-reducing regulator (refer to regulator documentation) and ***remove the batteries*** from the OPC unit when it is not being used. <u>Do not</u> store the OPC unit with the inlet under pressure.

Stow oxygen tubing and cannulas/masks in a manner that ensures that they will not be contaminated with dirt or debris. <u>Anytime</u> oxygen lines are disconnected, they must be protected to prevent contamination. Improperly stowed oxygen lines can lead to the following problems:

- Moisture can enter the system. When it evaporates it can then leave a precipitate (scum) on the breathing sensor or valve seat which can compromise the operation of the OPC.
- Foreign Objects or Debris (FOD) can enter the system (including insects). When the OPC is reconnected and gas applied, the debris is pushed into the unit and comes to rest at a constriction. This will most often trigger a **FLOW FAULT**, but partial obstructions can sufficiently reduce the flow enough to affect the amount of oxygen delivered at higher altitudes and create a ***risk of hypoxia***.

Remove the batteries to prevent leakage and corrosion. Before using the unit for the first time after storage, install fresh batteries and verify battery function via the usual **POWER-UP** procedure.

Fresh batteries should be installed prior to each mission.

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 (page 10).
3. Check for corrosion. Clean contacts or replace batteries as required.

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

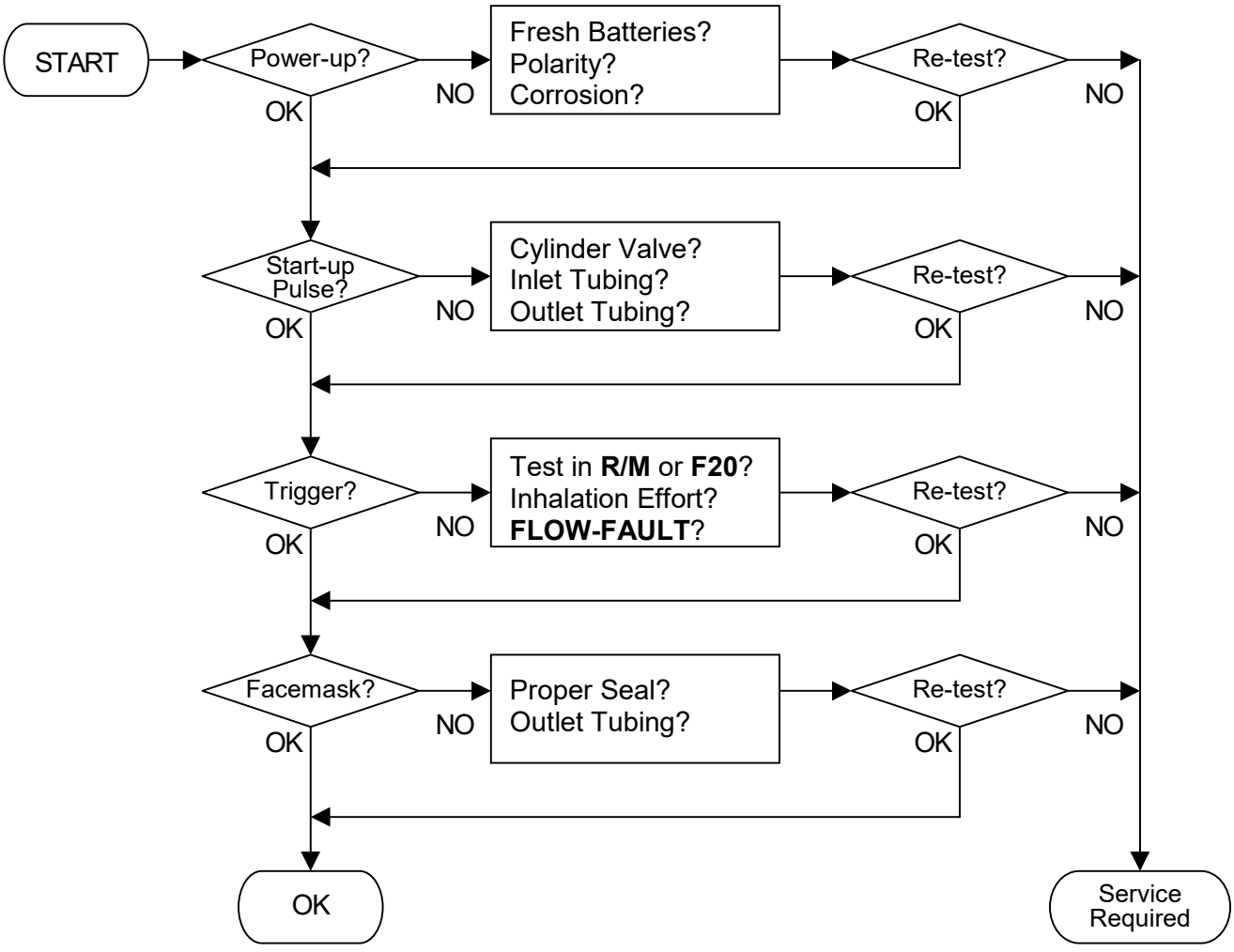
1. Make sure the oxygen cylinder valve is open.
2. Check that oxygen *inlet* tube is properly connected and not kinked, pinched, or otherwise obstructed.
3. Check that oxygen *outlet* tube is properly connected and not kinked, pinched, or otherwise obstructed.

OPC does not trigger on inhalation:

1. Use **R/M** or **F20** modes for test (OPC may not respond in **ON** mode if below 8000 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. Check oxygen outlet tubing for proper connection, no obstructions.



EDS AUTO-COMPENSATION

BREATHING SENSOR 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 EDS must compensate for these physical and physiological effects when ascending to higher altitudes.

The EDS 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 EDS 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 EDS 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 EDS 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 EDS 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 re-breathe 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.

NOTICE OF NON-LIABILITY

This device is classified as a **Supplemental Breathing Apparatus (SBA)**, and is *only* suitable for use as such. It is intended to help supply the amount of oxygen needed when operating at altitudes where supplemental oxygen is needed. This device is not suitable for SCBA (Self Contained Breathing Apparatus), SCUBA (Self Contained Underwater Breathing Apparatus), medical use, or any other types of life support applications.

Warning: It is the responsibility of the user to become familiar with the operational and safety aspects of this device before using it. Improper use of the system could cause failure and lead to possible ***property damage, personal injury or death!***

OXYGEN SYSTEM BACKUP

For pilots who consistently fly above 18,000 feet, the oxygen system should have a supplementary gauge that is visible by the pilot during flight in order to monitor the oxygen cylinder pressure. An **Emergency Oxygen System (EOS)** should also be carried as a back-up safety feature in case the primary oxygen system stops working (the **MH Co-Pilot** is one example of a portable EOS).

It is the absolute responsibility of the pilot to determine that there is adequate pressure in the oxygen cylinder prior to flight, as well as assuring that an adequate emergency back-up is in place in the event of a system failure.

A back-up EOS should also be considered for ground operations conducted at high altitude.

BASIC OXYGEN SAFETY

Observe all cautions and use proper procedures when handling oxygen. Pure oxygen vigorously accelerates combustion. Some materials such as oil will burn in oxygen with explosive violence, which could result in ***severe damage, personal injury or death***.

- ***Relieve pressure in the Pressure-reducing regulator before removing it from the Cylinder.***
- **DO NOT** use any type of oil or grease on any oxygen fittings or components.
- **DO NOT** operate near an open flame.
- **DO NOT** smoke while in use.

MH OPC-M2 SPECIFICATIONS

Specifications are subject to change without notice.
Altitude references infer *pressure altitude* (see Glossary, page 15).

Physical Characteristics

Width	(widest point)	3.1”	[79 mm]
Height	(with connectors)	5.23”	[130 mm]
Depth	(front to rear)	0.95”	[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 (~500 ms max)	**~100 ma**	
Battery Life		***(fresh batteries should be installed prior to each mission)***
NOM	**(up to) 100 Hrs**	(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 32000 ft, ~100% RH NC, -40° to +60°C
Vibration:	5 to 500 Hz random, 2.5 g RMS Sin wave, 15 minutes per axis

EDS Auto-Compensation

Respiration rate 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**, page 7).

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

EDS 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 8000 ft pressure altitude.

- 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 (page 10).
- ***DO NOT mix old and new batteries!*** Replace all batteries at the same time. (page 10).
- Remove batteries during long-term storage to prevent battery leakage and corrosion (page 10).
- 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** then. 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**, page 9).
- The OPC **POWER-UP TEST** also verifies the integrity of internal components and sensors and generates an **INTERNAL ERROR ALARM** (see **POWER-UP TEST**, page 6) if any of these checks fail. An **INTERNAL ERROR ALARM** indicates that the OPC unit will not function properly and must be serviced.

Glossary

Pressure Altitude (abbr **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 need.

Threshold Altitude: The *pressure altitude* reference that controls the operation of the OPC-M2 in **ON** mode. At or above the "threshold" altitude, the OPC-M2 dispenses oxygen; below the threshold altitude, it does not. The OPC-M2 has been configured with a threshold altitude of 8000 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-M2 in either **F20** or **R/M** mode.

PA: Abbreviation for "Pressure Altitude".

RH: Abbreviation for "Relative Humidity".

NC: Abbreviation for "Non-Condensing" (referring to humidity).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