

Pulse oximetry

Instructions for use

HAMILTON-C1/T1

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Software version 2.2.x

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HAMILTON-C1 SN > 6000

HAMILTON-T1 SN > 3000

HAMILTON
MEDICAL

Intelligent Ventilation since 1983

Instructions for use

Pulse oximetry

2019-08-30

624992/01

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About this guide

Selected Hamilton Medical ventilators support input of SpO₂ and related pulse oximetry data, and provide integrated monitoring and data display.

This guide provides information about the use and configuration of SpO₂ sensors and data. It is designed for use together with your ventilator *Operator's Manual*, and refers to information provided therein.

Conventions used in this guide

In this manual:

- Button and tab names are shown in a **bold** font.
- The notation **XX > XX** shows the sequence of buttons/tabs to touch to open the associated window.
For example, the text "Touch **System > Settings**" means touch the **System** button, then touch the **Settings** tab.
- Window names are shown using the sequence of buttons/tabs used to open them.
For example, "Alarms > Limits 1 window" means the window accessed by touching the **Alarms** button, then the **Limits 1** tab.
- The graphics shown in this manual may not exactly match what you see in your environment.
- Not all features are available in all markets.
- Pressure is indicated in cmH₂O, length in cm, and temperature in degrees Celsius (°C). The units of measure for pressure and length are configurable.

- Pulse oximeter technologies offered with this device are provided by Masimo and Nihon Kohden.
- The pulse oximeter is also referred to as a pulse *CO-oximeter/SpO₂ adapter*, and the sensor is also referred to as a *probe*. The terms as used in this manual are synonymous.
- In general, warnings, cautions, and notes related to CO-oximetry are specific to Masimo technology only.
- Phrases referring to an SpO₂ adapter are specific to the enclosure containing the optional oximetry or CO-oximetry solution that allows connection to either standard pulse oximetry sensors (Masimo or Nihon Kohden), or pulse CO-oximetry sensors (Masimo only).
- The Masimo **rainbow SET** option¹ is only available with a Masimo SET^S pulse oximeter.
- The PI and PVI¹ monitored parameters are only available with a Masimo SET pulse oximeter.

Safety messages are displayed as follows:

WARNING

A **WARNING** alerts the user to the possibility of injury, death, or other serious adverse reactions associated with the use or misuse of the device.

CAUTION

A **CAUTION** alerts the user to the possibility of a problem with the device associated with its use or misuse, such as device malfunction, device failure, damage to the device, or damage to other property.

¹ Not available in all markets.

NOTICE

A NOTICE emphasizes information of particular importance.

In tables, safety messages are indicated as follows:

 **WARNING!**

 **CAUTION!**

 **NOTICE!**

Note for HAMILTON-C1 neo ventilator users

This guide provides pulse oximetry information that applies to all patient groups: adult, pediatric, and neonatal. Where there are differences in device function or settings between the patient groups, only the function and settings defined for the **Neonatal** patient group apply for the HAMILTON-C1 neo ventilator.

1

Safety information

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1.1 General safety information

The pulse CO-oximeter is to be operated by, or under the supervision of, qualified personnel only. Review the manual, accessories, directions for use, all precautionary information, and specifications before using the pulse oximetry system.

Safety information is organized by general area of application:

- General safety
- Safety related to pulse oximetry measurements
- Sensor safety
- Maintenance (see Chapter 3)

WARNING

- *Explosion/Fire hazard.* Never use the SpO2 adapter in a hyperbaric oxygen chamber. Failure to comply with this warning can cause explosion or fire.
- *Explosion/Fire hazard.* NEVER use the SpO2 adapter in the presence of any flammable anesthetics or other flammable substance in combination with air, oxygen-enriched environments, or nitrous oxide. Failure to comply with this warning can cause explosion or fire.
- The pulse CO-oximeter is intended only as an adjunct device in patient assessment. It should not be used as the sole basis for diagnosis or therapy decisions. It must be used in conjunction with clinical signs and symptoms.
- DO NOT diagnose patients based solely on the data from the pulse oximeter. Overall judgment must be made by a physician who understands the limitations and characteristics of the pulse oximeter and can read the biomedical signals acquired by other instruments.
- Additional ventilator-independent patient monitoring (bedside vital sign monitoring or arterial blood gas (ABG) measurement) must be used during automatic or guided ventilation. Check PaCO2 against displayed PetCO2 and SaO2 against displayed SpO2.
- Verify the compatibility of the adapter, sensor, and cables before use. Use of incompatible components can result in patient injury.
- DO NOT use the pulse CO-oximeter if it appears, or is suspected to be, damaged.
- DO NOT place the SpO2 adapter or accessories in any position that might cause them to fall on the patient.
- DO NOT start or operate the pulse CO-oximeter unless the setup has been verified to be correct.
- The pulse CO-oximeter is NOT an apnea monitor.
- To ensure safety, avoid stacking multiple devices or placing anything on the instrument during operation.
- Only use the SpO2 adapter and SpO2 sensors that are listed as compatible with Hamilton Medical ventilators. The safety of the attachment section (including the SpO2 adapter and the sensor) depends on the specifications of the connected instrument. If the SpO2 adapter is used with an instrument or SpO2 sensor other than those specified, the patient and operator can get an electrical shock and the SpO2 adapter can become hot.
- SpO2 is empirically calibrated in healthy adult volunteers with normal levels of carboxyhemoglobin (COHb) and methemoglobin (MetHb).

- To ensure patient electrical isolation, connect only to other equipment with electrically isolated circuits.
- DO NOT use the pulse CO-oximeter during magnetic resonance imaging (MRI) scanning or in an MRI environment.
- DO NOT permit the operation of mobile phones, small wireless devices and other devices that produce strong electromagnetic interference around a patient, except for devices allowed by the hospital administrator. Radio waves from devices such as mobile phones or small wireless devices can cause the display of incorrect data.
- The pulse CO-oximeter should NOT be used for arrhythmia analysis.
- Do NOT place the pulse CO-oximeter on electrical equipment that may affect the instrument, preventing it from working properly.
- To minimize radio interference, other electrical equipment that emits radio frequency transmissions should NOT be in close proximity to the pulse CO-oximeter.
- Avoid permanent direct contact of the SpO2 sensor with the body. It can burn the skin as the sensor may reach a temperature of 41°C (105.8°F).
- Do NOT place the CO-oximeter where it can be reached by the patient.

CAUTION

- *If using pulse CO-oximetry during full body irradiation, keep the sensor out of the radiation field. If the sensor is exposed to the radiation, the reading might be inaccurate or the unit might read zero for the duration of the active irradiation period.*
 - *Never disassemble or repair the SpO2 adapter. Disassembly and repair must be performed by qualified service personnel.*
 - *The instrument must be configured to match your local power line frequency to allow for the cancellation of noise introduced by fluorescent lights and other sources.*
 - *When patients are undergoing photodynamic therapy they may be sensitive to light sources. Pulse oximetry may be used only under careful clinical supervision for short time periods to minimize interference with photodynamic therapy.*
- NOTICE**
- (USA only) Federal law restricts this device to sale by or on the order of a physician.
 - Only use components specified by Hamilton Medical.
 - All devices are *not* protected against the effect of the discharge of a cardiac defibrillator.
 - A functional tester *cannot* be used to assess the accuracy of the pulse CO-oximeter.
 - Do *not* shake or swing the SpO2 adapter or sensor while holding the cable. This can break the SpO2 adapter, sensor (probe), or cable.
 - Ensure that the accessories used during transport are adequately protected against water ingress.
 - The Masimo rainbow SET option is only available in the USA.

- The Masimo SET pulse oximetry equipment has been tested and found to comply with the Class B limits for medical devices according to the EN 60601-1-2, Medical Device Directive 93/42/EEC. These limits are designed to provide reasonable protection against harmful interference in a typical medical installation.

1.2 Pulse oximetry measurements safety information

WARNING

- If any measurement seems questionable, first check the patient's vital signs by alternate means and then check the pulse CO-oximeter for proper functioning.
- Inaccurate pulse rate measurements may be caused by:
 - Improper sensor application
 - Low arterial perfusion
 - Motion artifact
 - Low arterial oxygen saturation
 - Excessive ambient or environmental noise
- Inaccurate SpO₂ readings may be caused by:
 - Improper sensor application
 - Elevated levels of carboxyhemoglobin (COHb) or methemoglobin (MetHb). High levels of COHb or MetHb may occur with a seemingly normal SpO₂. When elevated levels are suspected, perform a laboratory analysis of a blood sample.
 - Dye injected into the blood, such as indocyanine green or methylene blue
 - Externally applied coloring and texture, such as nail polish, acrylic nails, glitter, and so on
 - Birthmarks, tattoos, skin discolorations, moisture on skin, deformed or abnormal fingers, and so on
 - Skin color disorders
 - Elevated levels of bilirubin
 - Elevated levels of dyshemoglobin
 - Vasospastic disease, such as Raynaud's, and peripheral vascular disease
 - Hemoglobinopathies and synthesis disorders such as thalassemias, Hb s, Hb c, sickle cell, and so on
- Hypocapnic or hypercapnic conditions:
 - An electrosurgical unit is used
 - During CPR
 - Measuring at a site with a venous pulse
 - Low arterial perfusion
 - Severe anemia
 - The pulse wave is small (the patient has insufficient peripheral circulation)
 - Motion artifact
- Interfering substances: Dyes or any substance containing dyes that change usual blood pigmentation may cause erroneous readings.
- SpO₂ measurement for patients with carbon monoxide poisoning can be incorrect.
- In case of anemia and blood loss, the SpO₂ sensor is unable to detect tissue hypoxia.
- Loss of pulse signal can occur when:
 - The sensor is too tight
 - The patient has hypotension, severe vasoconstriction, severe anemia, or hypothermia

- There is arterial occlusion proximal to the sensor
- The patient is in cardiac arrest or is in shock
- The pulsations from intra-aortic balloon support can be additive to the pulse rate on the oximeter pulse rate display. Verify the patient's pulse rate against the ECG heart rate.
- When not measuring SpO₂, disconnect the Nihon Kohden adapter from the ventilator. Otherwise, noise from the sensor may interfere and incorrect data may be displayed.

CAUTION

- Verify SpO₂ periodically by comparing measured SpO₂ against the patient's SaO₂ with an arterial blood gas (ABG) measurement.
- If SpO₂ values indicate hypoxemia, a laboratory blood sample should be taken to confirm the patient's condition.
- Skin pigmentation can affect the SpO₂ value. Periodically verify the SpO₂ value by checking the plethysmographic waveform and the quality index of the measured SpO₂ value.
- If the Low Perfusion message is frequently displayed, find a better perfused monitoring site. In the interim, assess the patient, and, if indicated, verify oxygenation status through other means.
- To ensure that alarm limits are appropriate for the patient being monitored, check the limits each time the pulse CO-oximeter is used.

NOTICE

- When static electricity affects the measurement, take necessary remedial actions, such as sufficiently discharging static electricity from the patient and operator, and increasing humidity in the room.
- When a parameter shows dashes (---) or no value, it is not used in any calculations.
- When SpO₂ cannot be measured on a patient with insufficient peripheral circulation or IABP, check the SpO₂ Sensitivity mode setting on the ventilator. The configuration of the Sensitivity mode may affect whether SpO₂ can be measured.
- In the following cases, an SpO₂ value may appear on the ventilator display even when the sensor is detached from the patient:
 - The adapter is connected to a ventilator without a defined Sensitivity mode for SpO₂ monitoring.
 - The adapter is connected to a ventilator where the Sensitivity mode is set to its highest setting. For details on the settings, see Chapter 6.

1.3 Sensor safety information

WARNING

- If the SpO2 adapter is used with SpO2 sensors other than those specified, the patient and operator can receive an electric shock and the SpO2 adapter can become hot.
- Avoid permanent contact of the SpO2 sensor and the body.
- If a sensor or cable is damaged in any way, discontinue use immediately. Do *not* use a sensor or patient cable with exposed optical or electrical components.
- Keep the patient away from the cable as much as possible. If the cable coils around the patient by their body movement, the patient can get injured. If this happens, remove the cable promptly.
- As with all medical equipment, carefully route patient cabling to reduce the possibility of patient entanglement or strangulation.
- The sensor cable must face away from the patient. Safely secure the sensor cable out of the way by attaching the sensor cable holding clips to the airway tubing, and connecting the sensor cable to the clips.
- Use disposable sensors only once. They cannot be sterilized and can cause cross contamination.
- To avoid cross contamination, only use single-use sensors on the same patient.
- When using Masimo reusable sensors, the site must be checked at least every four (4) hours to ensure adequate adhesion, circulation, skin integrity, and correct optical alignment. For adhesive sensors, check every eight (8) hours, or more frequently when perfusion is poor. If the circulatory condition or skin integrity has deteriorated, the sensor should be applied to a different site.
- When using Nihon Kohden sensors, change the SpO2 sensor measurement site regularly: every eight (8) hours for disposable and every four (4) hours for reusable sensors. The skin temperature may increase at the attached site by 2°C or 3°C degrees and cause a burn or pressure necrosis.
- Check the circulation condition by observing the skin color peripheral to and at the sensor measurement site and the pulse waveform.
- Do *not* use tape to secure the sensor to the site; this can restrict blood flow and cause inaccurate readings.
- Tissue damage can be caused by incorrect application or use of a sensor, for example, by wrapping the sensor too tightly. Inspect the sensor site as directed in the sensor's *Directions for use* to ensure skin integrity and correct positioning and adhesion of the sensor.
- Venous congestion may cause under-reading of actual arterial oxygen saturation. Therefore, assure proper venous outflow from the monitored site. The sensor should *not* be below heart level (for example, sensor on hand of a patient in bed with arm dangling to the floor).
- Misapplied sensors or sensors that become partially dislodged may cause either over or under reading of actual arterial oxygen saturation.
- Avoid placing the sensor on any extremity with an arterial catheter, blood pressure cuff, or intravascular

line to avoid potential inaccurate measurements or loss of pulse signal.

- Detach the SpO2 sensor before defibrillation.
- To protect from shock, always remove the sensor from the patient and completely disconnect the SpO2 adapter before bathing the patient.

CAUTION

- *Under normal conditions, this probe is almost unaffected by light. However, when measuring under strong light (surgical light, sunlight), cover the probe with an ambient light shield made of opaque material. Otherwise, measurement accuracy is affected.*
- *Do NOT pull, twist, turn, or bend the sensor cable, and do not let caster feet run over the sensor cable. Failure to follow these cautions may cause cable discontinuity, short circuit, skin burn on the patient, and incorrect measurement data, and can permanently damage the sensor. Replace any broken sensor with a new one.*
- *Redness or skin irritation may appear at the attachment site. Take extreme care of patients with weak skin. In case of redness or skin irritation, change the attachment site or stop using the sensor.*
- *Routinely check circulation distal to the sensor site.*
- *If the sensor is wrapped too tightly or supplemental tape is used, venous congestion/pulsations may occur causing erroneous readings and/or pressure injuries.*
- *When using the probe on the following patients, take extreme care and change the measurement site more frequently according to symptoms and degree:*
 - *Patient with a fever*
 - *Patient with insufficient peripheral circulation*
 - *Neonate or low-birth-weight infant with delicate skin*
- *If the probe is attached to the same limb that is used for NIBP measurement or an IABP catheter, the blood circulation at the attachment site is affected and the measurement might not be correct. Attach the probe to a limb where the blood circulation is not affected.*
- *To avoid poor circulation, do not secure the sensor too tightly. Check the blood circulation condition by observing the skin color and congestion at the skin peripheral to the probe attachment site. Even for short-term monitoring, there can be burn or pressure necrosis from poor blood circulation, especially on neonates or low birth weight infants whose skin is delicate. Accurate measurement cannot be performed on a site with poor peripheral circulation.*

NOTICE

- Read all of the safety information before using the sensor.
 - Before use, carefully read the sensor's *Directions for use*.
 - With Masimo SET pulse oximetry, use only Masimo sensors for SpO2 measurements.
 - High-intensity extreme lights (such as pulsating strobe lights) directed on the sensor may not allow the pulse CO-oximeter to obtain vital sign readings.
 - When using the **Maximum Sensitivity** setting, performance of "Sensor Off" detection may be compromised. If the instrument is in this setting and the sensor becomes dislodged from the patient, the potential for false readings may occur due to environmental noise such as light, vibration, and excessive air movement.
 - *HAMILTON-T1 only*. The environmental limitations for the SpO2 sensors are different from those for the ventilator. See the sensor specifications in these *Instructions for use* and the ventilator specifications in your ventilator *Operator's Manual*.
-

This guide includes several descriptions, warnings, and specifications for the pulse oximetry adapter and sensors.

Not all of the information is included here.

- For detailed information about Masimo pulse oximeters, see the Masimo Starter Kit documentation, sensor inserts, and the manufacturer's *Directions for use*. Additional information may also be available at the manufacturers' website: www.masimo.com.

Note that possession or purchase of this device does not convey any express or implied license to use the device with unauthorized sensors or cables which would, alone or in combination with this device, fall within the scope of one or more of the patents relating to this device.

For information on Masimo patents, see www.masimo.com/patents.htm

- For detailed information about Nihon Kohden pulse oximeters, see the manufacturer's *Directions for use*.

Be sure to also read the safety information for the ventilator, provided in the ventilator *Operator's Manual*.

2

SpO2 monitoring

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2.1 Overview

The HAMILTON-C 1/T1 support SpO2 pulse oximeters from two manufacturers: Nihon Kohden and Masimo. The pulse oximeter comprises a sensor, cables, and adapter.

The sensor takes continuous measurements to provide accurate, reliable data for various pulse oximetry parameters, together with a signal quality indicator. Working with the adapter, the sensor sends this information to the ventilator.

These parameters are available:

- In the Monitoring window
- As main monitoring parameters (MMPs)
- In the Dynamic Lung
- As trends

They are subject to applicable alarms, all of which are controlled at the ventilator. You can configure an alarm delay for the SpO2 high/low alarms that specifies a short waiting period after an alarm condition occurs before the system sounds an audible alarm.

Support for pulse oximetry is available with installation and activation of the SpO2 option and related hardware. For ordering details, see the ventilator product catalog.

Table 2-1 describes the options available with each oximeter. Details on each option² are provided in this chapter.

Table 2-1. SpO2 pulse oximeter options

| Options, Measurements | Nihon Kohden ⁵ | Masimo SET ⁵ | Masimo rainbow SET ⁵ |
|--|---------------------------|-------------------------|---------------------------------|
| SpO2 | X | X | X |
| Pulse | X | X | X |
| Plethysmogram | X | X | X |
| Alarm delay | X | X | X |
| Perfusion index (PI) | | X | X |
| Pleth variability index (PVI) ³ | | X | X |
| SpCO (carboxyhemoglobin) | | | X |
| SpMet (methemoglobin) | | | X |
| SpHb (total hemoglobin) | | | X |
| SpOC (oxygen content) | | | X |

² Masimo rainbow SET measurements are purchasable options for the Masimo pulse CO-oximeter. They require the use of the Masimo SpO2 pulse CO-oximeter. For details, see the Masimo rainbow SET *Instructions for Use*. Not available in all markets.

³ The PVI parameter must be enabled on the adapter firmware and in the ventilator software. For details about Masimo rainbow SET parameters, contact your Hamilton Medical technical representative.

2.1.1 About the Nihon Kohden pulse oximeter

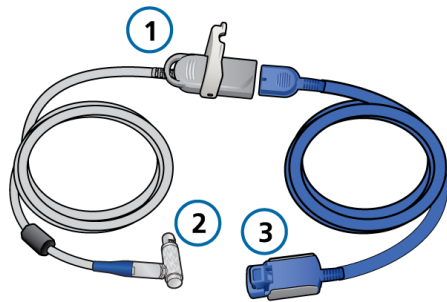
The Nihon Kohden pulse oximeter comprises a sensor and adapter, with integrated cable and locking cover.

The sensor takes continuous measurements to provide accurate, reliable data for SpO2 and pulse, together with a signal quality indicator. Working with the adapter, the sensor sends this information to the ventilator.

Figure 2-1 shows the Nihon Kohden system components⁴.

For connection information, see Section 2.4.1. For configuration details, see Chapter 6.

Figure 2-1. Nihon Kohden pulse oximeter components



- 1 SpO2 adapter main unit with locking cover (part of cable to ventilator)
- 2 Cable to ventilator
- 3 Sensor and cable

2.1.2 About the Masimo SET pulse oximeter

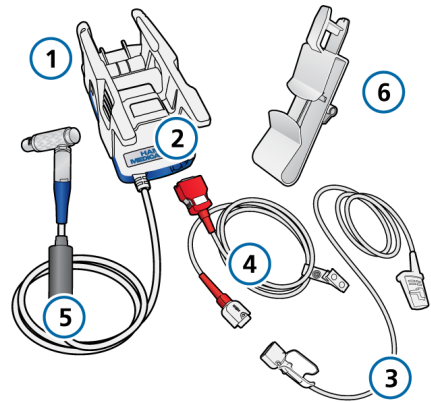
The Masimo SET pulse oximeter comprises a sensor, cables, and adapter.

The sensor takes continuous measurements to provide accurate, reliable data for SpO2, pulse, perfusion index (PI), and pleth variability index (PVI), together with a signal quality indicator. Working with the adapter, the sensor sends this information to the ventilator.

Figure 2-2 shows the Masimo SET system components⁴.

For connection information, see Section 2.4.2. For configuration details, see Chapter 6.

Figure 2-2. Masimo SET components



- 1 Adapter
- 2 Connection ports
- 3 Sensor
- 4 Patient cable
- 5 Adapter cable to ventilator
- 6 Sensor cable holder

⁴ The SpO2 connection on the ventilator is not shown.

2.2 Getting started

Getting up and running involves just a few steps.

Table 2-2. Configuration and set up

| For technical personnel See ... | |
|---|---|
| <i>These one-time initial configuration tasks are completed by technical personnel.</i> | |
| Installing and enabling the communication board | See the board documentation or the ventilator <i>Installation Guide</i> |
| Configuring sensor settings | Chapter 6 |
| For medical caregivers See ... | |
| <i>The following tasks are performed by medical personnel caring for patients.</i> | |
| Enabling SpO2 monitoring in the ventilator System window | Section 2.3 |
| Connecting the components | Section 2.4 |
| Verifying measurements | Section 2.5 |
| Setting alarm limits | Section 2.6.1 |
| Monitoring the patient data | Section 2.7 |
| Cleaning and maintenance | Chapter 3 |

2.3 Enabling SpO2 monitoring

Sensor data is integrated with the ventilator monitoring system.

To enable SpO2 monitoring

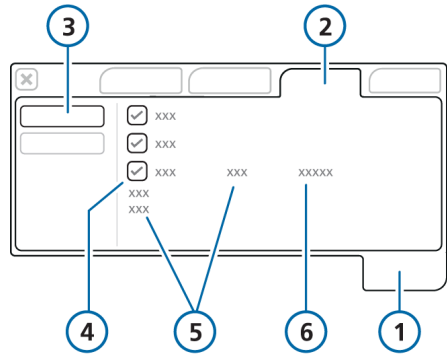
1. Touch **System > Sensors**.
2. Touch the **On/Off** button on the left, if not already selected.
3. Touch the SpO2 sensor checkbox.

The status text **active** appears next to the checkbox as long as the adapter is connected to the ventilator.

If the status area is empty, the adapter is not connected.

You can also specify sensor acquisition settings, if needed. See Sections 6.5 and 6.4.

Figure 2-3. Enabling SpO2 monitoring



- | | |
|-----------|--|
| 1 System | 4 Sensor options (O2, CO2, SpO2) |
| 2 Sensors | 5 Sensor and cable status (<i>Masimo only</i>) |
| 3 On/Off | 6 Sensor type (Nihon Kohden or Masimo) |

2.4 Connecting the components

Before connecting the patient, carefully read the warnings and cautions at the beginning of this guide.

For additional details about setting up the sensor cable holder, see the *SpO2 Sensor cable holder user guide*.

See the following sections depending on your pulse oximeter:

- For Nihon Kohden, see Section 2.4.1.
- For Masimo, see Section 2.4.2.

2.4.1 Connecting the Nihon Kohden pulse oximeter

Connecting the components comprises the following steps:

1. Connect the cables to the sensor and to the ventilator.
2. Attach the sensor to the patient.

Once connected, verify the sensor measurements on the ventilator display. See Section 2.5.

Figure 2-4. Connecting the Nihon Kohden adapter cable to ventilator

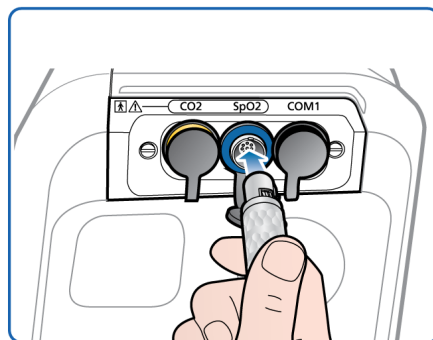
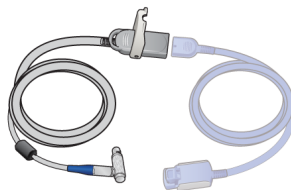
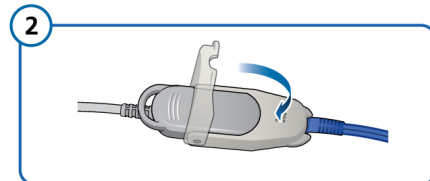
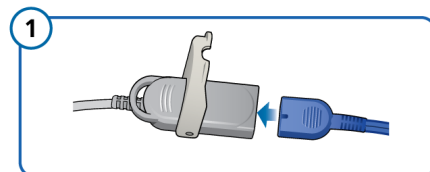
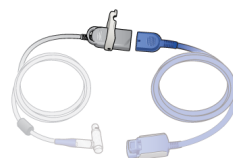


Figure 2-5. Connecting the sensor cable to Nihon Kohden adapter

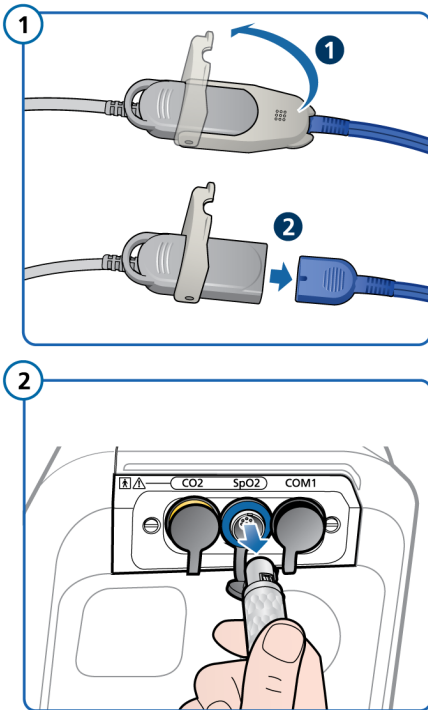


2.4.1.1 Disconnecting Nihon Kohden components

To disconnect the components

1. Remove the sensor from the patient.
2. Open the adapter cover and disconnect the sensor cable.
3. Disconnect the adapter cable from the communication board on the ventilator by gently pulling back the connector and pulling it out from the connection port.
4. Cover the port with the attached rubber cover.

Figure 2-6. Disconnecting the Nihon Kohden pulse oximeter components



2.4.2 Connecting the Masimo pulse oximeter

Refer to the sensor *Directions for use* for connection and disconnection details.

Connecting the components comprises the following steps:

1. Attach the adapter where desired, ensuring the adapter handle clicks into place and is securely attached. For detailed instructions, see the *Sensor Cable Holder User Guide* (PN 627167).
2. Connect the cables.
3. Attach the sensor to the patient.

If you are transporting the patient, see Section 2.4.2.1 for setup details.

Figure 2-7. Connecting the components

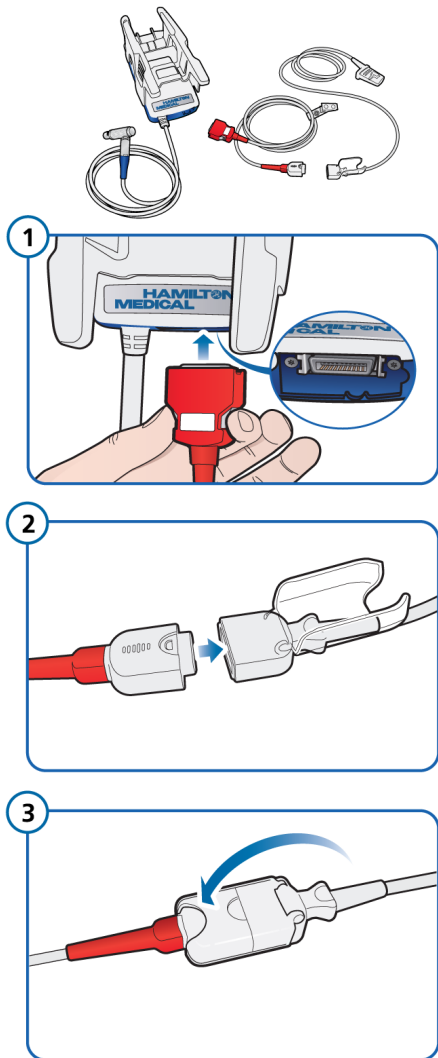
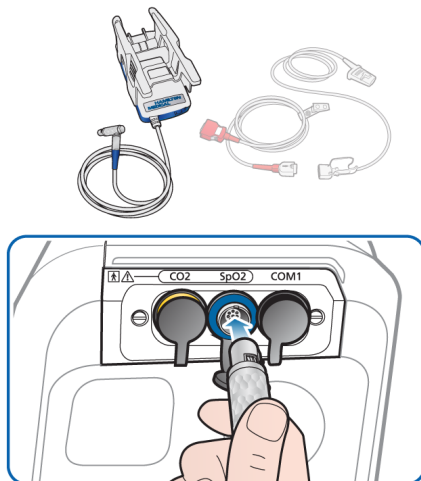


Figure 2-8. Connecting Masimo adapter to ventilator



Once connected, attach the sensor to the patient, and verify the sensor measurements on the ventilator display. See Section 2.5.

2.4.2.1 Connecting the Masimo adapter for transport

This information applies for use with ventilators approved for inter-hospital transport using a Masimo pulse oximeter.

A transport case is available. The case completely encloses and protects the adapter, while leaving the bottom free for the cables. See the product catalog for ordering details. Use the case if you are not using a trolley for the ventilator.

To connect the adapter for transport using the HAMILTON-C1/T1 trolley

1. Attach the SpO2 adapter to the trolley rail.
2. Connect the patient cable to the bottom of the adapter.
3. Connect the ventilator cable to the SpO2 connection port on the communication board.
4. Attach the patient cable to the SpO2 sensor.

To connect the adapter for transport using the transport case and the HAMILTON-T1

For illustrated instructions, see the SpO2 transport case *Instructions for use*.

1. Remove the SpO2 adapter from its current position. Detach the adapter rail-mount handle top piece from the base by squeezing the sides together and pulling out and up, then unhooking it from the base.
2. Place the SpO2 adapter into the transport case and fasten the straps tightly. The case fits snugly around the adapter.

3. Secure the thin VELCRO strap on the back of the transport case to the front of the handle on the HAMILTON-T1. Tighten the strap and ensure the adapter is securely attached.
4. Connect the patient cable to the bottom of the adapter.
5. Connect the ventilator cable to the SpO2 connection port on the communication board.
6. Attach the patient cable to the SpO2 sensor.

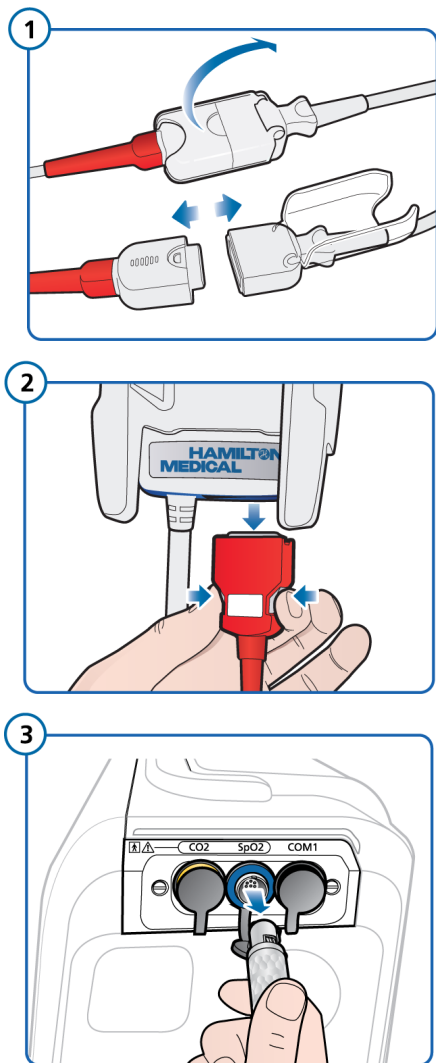
2.4.2.2 Disconnecting the Masimo components

Refer to the sensor *Directions for use* for connection and disconnection details.

To disconnect the components

1. Remove the sensor from the patient.
2. Open the adapter cover and disconnect the sensor cable.
3. Disconnect the patient cable from the adapter.
4. Disconnect the adapter cable from the communication board on the ventilator by gently pulling back the connector and pulling it out from the connection port.
5. Cover the port with the attached rubber cover.
6. Remove the adapter from the rail, if needed.

Figure 2-9. Disconnecting Masimo components



2.5 Verifying sensor measurements on the ventilator

When SpO2 monitoring is enabled on the ventilator and the sensor is connected to the ventilator and to the patient, measurements recorded by the pulse oximeter are displayed in the **Monitoring > SpO2** window.

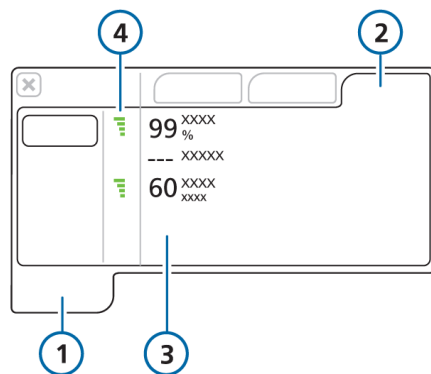
The values may take up to 30 seconds to be displayed. When SpO2 is not monitored for 30 seconds, the SpO2 adapter judges that no pulse is detected, generating a patient disconnection alarm.

To verify that measurements are being recorded

1. Start ventilating the patient.
2. On the ventilator, touch **Monitoring > SpO2** (Figure 2-10).

The SpO2 value is displayed approximately 10 seconds after placing the sensor.

Figure 2-10. Pulse oximetry data, Monitoring window



- | | |
|--------------|------------------------------|
| 1 Monitoring | 3 Monitored parameter values |
| 2 SpO2 | 4 Quality index |

During active ventilation, if the device does not detect a pulse for 30 seconds, the ventilator generates a patient disconnection alarm.

If you do not see any oximeter-related measurements, ensure that the SpO2 sensor is enabled in the **System > Sensors > On/Off** window. See Section 2.3.

You can configure sensor acquisition settings as appropriate for the patient during ventilation. See Sections 6.4 and 6.5.

2.5.1 Reviewing the Masimo sensor and cable status

Masimo sensors and cables incorporate a specified lifetime. When this lifetime expires, the affected sensor or cable no longer functions and must be replaced.

Use the **System > Sensors** window to monitor the sensor and cable lifetime and operation status.

Hamilton Medical recommends that you check the sensor and cable status before each patient use.

To review Masimo sensor and cable status

- ▶ Touch **System > Sensors > On/Off** (Figure 2-3).

The sensor and cable status are listed below the SpO2 checkbox.

Table 2-3. Masimo sensor and cable operation status

| Status message | Description |
|-----------------|---|
| Ok | The device is operational. |
| Near expiration | The device is approaching its intended maximum usage. Be sure to change the affected component before the next patient use. |
| Expired | The device is expired and no longer operational. An SpO2 sensor error message is generated. Replace the device. |

2.6 Working with alarms

You can specify alarm limits for several pulse oximetry parameters. In addition, default ranges can be defined in **Configuration**. For the list of alarms, see Section 2.6.3.

See the ventilator *Operator's Manual* for details about reviewing and working with alarms.

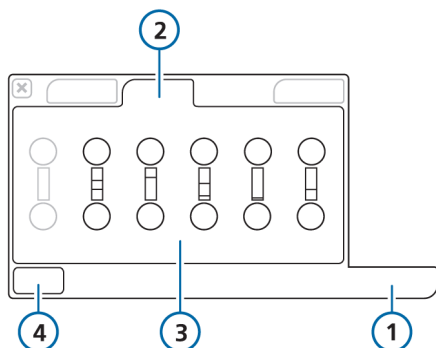
2.6.1 Setting alarm limits

NOTICE

The ventilator **Auto** alarm function does not apply to pulse-oximetry alarms.

Pulse-oximetry-related alarms are displayed in the **Alarms > Limits 2** window⁵.

Figure 2-11. Pulse oximetry alarms



- | | |
|----------------------------|------------|
| 1 Alarms | 2 Limits 2 |
| 3 Pulse oximetry alarms | 4 Auto |

The PI and PVI alarm limits are available only with Masimo sensors, and when enabled.

The high and low SpO₂ alarm limits are a special case: you can set a short alarm delay as described in Section 2.6.2.

2.6.2 SpO₂ alarm delay

Oxygen saturation levels can be relatively variable but the changes are transient, and as such, do not generally require clinical intervention.

To reduce the number of alarms that are not actionable (that is, nuisance alarms), a short delay of up to 15 seconds can be configured after an SpO₂ low or SpO₂ high alarm condition occurs *before* the system displays the message and sounds the alarm.

The alarm delay is set in the **System > Sensors** window. See the appropriate section for Nihon Kohden or Masimo in Chapter 6.

⁵ Additional ventilator alarm settings are available in the **Alarms > Limits 1** window. When the Masimo rainbow SET option is enabled, related alarm settings are available in the **Alarms > Limits 3** window.

2.6.3 Pulse-oximetry-related alarms

The following table lists the pulse-oximetry-related alarms.

Table 2-4. SpO2 alarms, priority, and corrective actions

| Alarm/Priority | Definition/Corrective action |
|--|--|
| SpO2: Adapter missing <i>Medium priority.</i> | SpO2 adapter is disconnected from ventilator. To resolve <ul style="list-style-type: none"> • Connect an adapter. • Replace adapter. |
| SpO2: Light interference <i>Medium priority.</i> | Light interference with the sensor. To resolve <ul style="list-style-type: none"> • Check sensor for visible contamination, clean sensor windows. • Cover sensor or change attachment site. • Verify line frequency setting (Configuration). • Replace sensor. |
| SpO2: Low perfusion index <i>Medium priority.</i> | <i>Masimo only.</i> Perfusion index was too low for at least 30 seconds. To resolve Move sensor to a better perfused site. |
| SpO2: Poor signal <i>Medium priority.</i> | <i>Nihon Kohden only.</i> Pulse from SpO2 sensor was not found. Sensor may be detached from patient or secured too tightly, preventing circulation. To resolve <ul style="list-style-type: none"> • Check patient condition. • Change attachment site. • Reattach sensor less tightly. |
| SpO2: Probe missing <i>Medium priority.</i> | Sensor disconnected from adapter or cable is defective. To resolve <ul style="list-style-type: none"> • Connect sensor to adapter. • Replace adapter, patient cable, and/or sensor. |

| Alarm/Priority | Definition/Corrective action |
|--|--|
| SpO ₂ : Patient disconnected <i>Medium priority.</i> | Sensor is disconnected from patient or not properly attached to patient, or sensor is faulty. To resolve <ul style="list-style-type: none"> • Check sensor attachment to patient. • Replace sensor. |
| SpO ₂ : Sensor error <i>Medium priority.</i> | Any of the following: <ul style="list-style-type: none"> • Hardware problem with sensor or connected sensor is incompatible. • Sensor/cable has expired (Masimo only). To resolve Replace adapter, patient cable, and/or sensor. |
| High PI <i>Medium priority.</i> | <i>Masimo only.</i> Peripheral perfusion exceeds the set limit. To resolve <ul style="list-style-type: none"> • Check patient condition. • Check settings, including alarms. |
| Low PI <i>Medium priority.</i> | <i>Masimo only.</i> Peripheral perfusion is below the set limit. To resolve <ul style="list-style-type: none"> • Check patient condition. • Move sensor to a better perfused site. |
| High PVI <i>Medium priority.</i> | <i>Masimo only.</i> Pleth perfusion variability exceeds the set limit. To resolve <ul style="list-style-type: none"> • Check patient condition. • Check settings, including alarms. |
| Low PVI <i>Medium priority.</i> | <i>Masimo only.</i> Pleth perfusion variability is below the set limit. To resolve <ul style="list-style-type: none"> • Check patient condition. • Move sensor to better perfused site. |

| Alarm/Priority | Definition/Corrective action |
|--|---|
| <p>High pulse <i>Medium priority.</i></p> | <p>Pulse rate exceeds the set limit.</p> <p>To resolve</p> <ul style="list-style-type: none"> • Check patient condition. • Check settings, including alarms. |
| <p>Low pulse <i>Medium priority.</i></p> | <p>Pulse rate is below the set limit.</p> <p>To resolve</p> <ul style="list-style-type: none"> • Check patient condition. • Check settings, including alarms. |
| <p>High SpO2 <i>Low priority.</i></p> | <p>SpO2 exceeds the set limit.</p> <p>To resolve</p> <ul style="list-style-type: none"> • Check patient condition. • Check settings, including alarms. |
| <p>Low SpO2 <i>High priority or medium priority.</i></p> | <p>The low SpO2 alarm has two levels of priority, depending on how much below the limit the measured value is.</p> <p><i>Medium priority.</i></p> <p>SpO2 meets all of the following conditions:</p> <ul style="list-style-type: none"> • Below the set limit. • Above 85%. • Above (<i>limit - 2% of set limit</i>). <p><i>High priority.</i></p> <p>SpO2 is either of the following:</p> <ul style="list-style-type: none"> • Lower than (<i>limit - 2% of set limit</i>) even if above 85%. • Below 85%. <p>To resolve</p> <ul style="list-style-type: none"> • Check patient condition. • Check settings, including alarms. |

2.7 Viewing pulse oximetry data

Sensor data is updated every second.

Pulse oximeter data is readily available as follows:

| View SpO2-related data ... | See ... |
|----------------------------|---------------|
| In the Monitoring window | Section 2.7.2 |
| On the main display | Section 2.7.3 |
| In the Dynamic Lung panel | Section 2.7.4 |
| In a plethysmogram | Section 2.7.5 |
| As a trend graph | Section 2.7.6 |

Basic sensor information is displayed in the **System > Sensors** window. Additional sensor data is available in **Configuration** (Chapter 6).

2.7.1 Monitored parameters

The following tables provide an alphabetical list of the pulse-oximetry-related monitored parameters.

This data is displayed in the **Monitoring > SpO2** window. The measured SpO2 value is also displayed under the MMP list at the bottom left of the display.

- Section 2.7.1.1 describes parameters supported with Nihon Kohden.
- Section 2.7.1.2 describes parameters supported with Masimo.

2.7.1.1 Parameters supported with Nihon Kohden

For parameter ranges and accuracy information, see Chapter 4.

Table 2-5. Nihon Kohden SpO2 parameters

| Setting | Description |
|---|---|
| Pulse rate (bpm) <i>(displayed on device as 1/min)</i> | Pulse |
| SpO2 (%) | Arterial oxygen saturation in blood |
| SpO2/FiO2 (%) | Calculated approximation of PaO2/FiO2 when SpO2 is 94% or lower ⁶ . Calculated as: <i>100*SpO2 / Oxygen</i> For details, see Section 2.9. |

⁶ When SpO2 exceeds 94%, the SpO2/FiO2 ratio is not calculated; the display shows dashes (---).

2.7.1.2 Parameters supported with Masimo SET

For parameter ranges and accuracy information, see Chapter 5.

Table 2-6. Masimo SET SpO2 parameters

| Settings | Description |
|--|--|
| Perfusion index (PI) (%) | Pulse strength. |
| Pleth variability index (PVI) (%) | Measure of peripheral perfusion changes. For details, see Section 2.7.1.3. |
| Pulse rate (bpm) <i>(displayed as 1/min)</i> | Pulse. |
| SpO2 (%) | Arterial oxygen saturation in blood. |
| SpO2/FiO2 (%) | Calculated approximation of PaO2/FiO2 when SpO2 is 94% or lower ⁷ . Calculated as: $100 * SpO2 / Oxygen$ For details, see Section 2.9. |

2.7.1.3 About the Pleth Variability Index (PVI)

PVI⁸ is only supported with use of a Masimo SET pulse oximeter. This parameter must be enabled on the adapter firmware.

PVI is a measure of the dynamic changes in the perfusion index (PI) that occur during the respiratory cycle. It can be closely related to intrathoracic pressure changes.

This index can be used as an early indicator by the clinician to help determine whether to administer fluids to the patient.

PVI is displayed in the Monitoring window, as well as in the Dynamic Lung panel.

You can set high and low alarm limits.

You can check whether the option is available in the **Configuration > Sensors > Upgrade** window. For details, contact your Hamilton Medical technical representative.

For additional information about the PVI parameter, see the following:

- Chapter 5 of this guide
- Masimo SET product documentation

⁷ When SpO2 exceeds 94%, the SpO2/FiO2 ratio is not calculated; the display shows dashes (---).






⁸ The PVI parameter must be enabled on the adapter firmware and in the ventilator software. For details about Masimo rainbow SET parameters, contact your Hamilton Medical technical representative.

2.7.2 Viewing data in the Monitoring window

The **Monitoring > SpO2** window provides access to the pulse oximetry data. See Section 2.5.

The quality index shows the sensor's evaluation of the signal quality. A low quality index indicates a poor signal due to interference from excessive motion or other cause.

Table 2-7. Quality index display

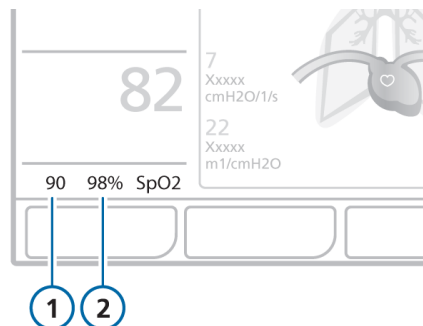
| Quality indicator | Confidence value |
|--|--|
| 4 gray (or blue) bars, no data  | OFF (no information). |
| 1 red bar, poor quality  | The data from the sensor is not usable or the parameter measurement is still initializing. |
| 2 orange bars, medium quality  | The data from the sensor is acceptable for most uses. An alarm may be active that could affect how accurately this parameter is currently measured. |
| 3 green bars, good quality  | The data from the sensor is reliable. |
| 4 green bars, best quality  | The data from the sensor is highly stable and reliable. |

2.7.3 Viewing data on the main display

As with other parameters, any of the monitored pulse oximetry parameters can be configured as a main monitoring parameter (MMP). For configuration details, see your ventilator *Operator's Manual*.

When SpO2 monitoring is enabled, the **low SpO2 alarm limit** and measured SpO2 value are always displayed under the MMP list, as shown in Figure 2-12.

Figure 2-12. SpO2 data in main display



- | | |
|------------------------|-----------------------|
| 1 Low SpO2 alarm limit | 2 Measured SpO2 value |
|------------------------|-----------------------|

2.7.4 Viewing data in the Dynamic Lung panel

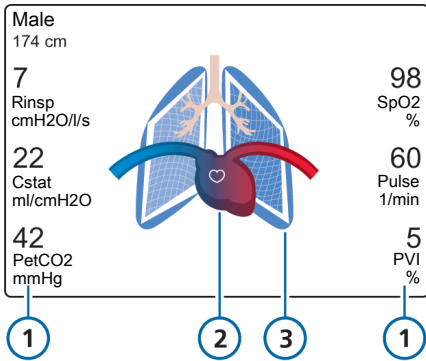
NOTICE

If the large heart is not displayed, the SpO2 option is disabled or not installed.

When the SpO2 option is enabled, the Dynamic Lung panel is expanded to show the circulation of blood through the heart, superimposed on the breathing of the lungs. See your ventilator *Operator's Manual* for details.

The Dynamic Lung panel displays the following data: Rinsp, Cstat, PetCO2, SpO2, Pulse, PVI (*Masimo only*)



Figure 2-13. Dynamic Heart/Lung panel



- 1 Parameter values⁹
- 2 Dynamic heart and pulse display
- 3 Dynamic Lung display

The heart and pulse display varies as described next.

Table 2-8. Heart and pulse display

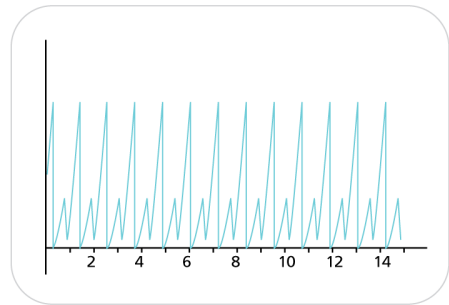
| | |
|---|---|
|  | The data from the SpO2 sensor is not usable or the parameter measurement is still initializing. |
|  | The small white heart pulsates in time with the patient's pulse. SpO2 is being measured. |

For additional details about the Dynamic Lung panel, including how to display it, see your ventilator *Operator's Manual*.

2.7.5 Reviewing the plethysmogram

A **plethysmogram** is a waveform that represents the pulsating blood volume; it is generated by the pulse oximeter.

Figure 2-14. Plethysmogram waveform (adult)



The time scale displayed is the same as for other waveforms. For details, see your ventilator *Operator's Manual*.

With Masimo sensors, the graph also shows the currently selected sensor sensitivity setting when set to **Maximum** or **APOD** (see Section 6.5.2). No text is displayed when the setting is **Normal**.

⁹ The PVI parameter is displayed only with Masimo sensors.

To display the plethysmogram

1. Touch the area of the display where you wish to show the plethysmogram as described in your ventilator *Operator's Manual*.

The graphics selection window appears.

2. Touch the **Waveforms** tab, and then the **Plethysmogram** button.

The plethysmogram is displayed.

2.7.6 Viewing data as trends

You can view trend data for the following pulse oximetry-related parameters: SpO₂, Pulse, SpO₂/FiO₂, PI (*Masimo only*), PVI (*Masimo only*), and QI-SpO₂

For details, see your ventilator *Operator's Manual*.

2.8 Troubleshooting

Table 2-9 describes how to address some potential pulse oximeter issues. Be sure to also check the information provided in Section 2.6.3.

Note that one of the most common reasons for a poor or absent signal is having one or more bent pin(s) in the connector head.

Table 2-9. Troubleshooting issues

| Message/Issue | Details | Actions |
|--|---|--|
| No SpO2 tab or disabled SpO2 tab in Monitoring window | SpO2 monitoring is not enabled. | When no SpO2 tab is visible, the SpO2 hardware is not enabled. Check Configuration . Ensure the SpO2 checkbox is selected in the System > Sensors > On/Off window. |
| No pulse oximetry data is displayed in the Monitoring > SpO2 window | <ul style="list-style-type: none"> • A component is damaged: for example, pins may be bent in the connector head. • An unsupported sensor is connected. | Replace adapter, patient cable, or sensor, as appropriate. |
| The Monitoring > SpO2 window shows values as dashes | <ul style="list-style-type: none"> • A component is disconnected or damaged. • A sensor/adapter- or disconnection-related alarm is generated. | <ul style="list-style-type: none"> • Check the connection from the adapter to the ventilator. • Check the patient cable connection to the adapter. • Check the connection between the sensor and the patient cable. |
| No pulse oximetry data in Configuration > Sensors > Upgrade window | The communication board is not installed. | Have the communication board installed. |
| No reading for a patient with an intra-aortic balloon pump (IABP) or insufficient peripheral circulation | Sufficient blood perfusion is required to generate a valid SpO2 signal. | Check the SpO2 real-time waveform and the quality indicator. If the quality is poor, do the following: <ul style="list-style-type: none"> • Reattach the probe to a different site. • Reconnect the pulse oximeter components. • Replace the probe. |

| Message/Issue | Details | Actions |
|---|---|--|
| An SpO ₂ value is displayed on the ventilator when the sensor is detached from, or not attached to, the patient. | The system may also display no signal, poor signal, no sensor, or patient disconnected message. | <p>Check the SpO₂ real-time waveform and the quality indicator. If the quality is poor, do the following:</p> <ul style="list-style-type: none"> • Reattach the probe to a different site. • Reconnect the pulse oximeter components. • Replace the probe. |

2.9 About the SpO₂/FiO₂ ratio

For the diagnosis of acute respiratory distress syndrome (ARDS) and acute lung injury (ALI), the PaO₂/FiO₂ ratio index is used. PaO₂ is the partial pressure of oxygen in the arterial blood measured by an arterial blood gas test, and FiO₂ is the fraction of inspired oxygen (Oxygen control) set on the ventilator. PaO₂/FiO₂ is used as a measure of blood hypoxia.

The SpO₂/FiO₂ ratio (%) is an approximation of the PaO₂/FiO₂ ratio, which, in contrast to PaO₂/FiO₂, can be calculated noninvasively and continuously.

The SpO₂/FiO₂ ratio is a useful monitoring value for bedside assessment of a patient's oxygenation status. It can also be helpful for ALI and ARDS diagnoses and patient follow up.

The ventilator calculates and displays the SpO₂/FiO₂ ratio when the measured SpO₂ is 94% or lower.

When SpO₂ exceeds 94%, the SpO₂/FiO₂ ratio is not calculated; the display shows dashes (---). At these higher oxygen saturation levels, the correlation between SpO₂ and PaO₂ is poor (the oxygen-hemoglobin curve flattens out), so SpO₂/FiO₂ is no longer a good approximation of PaO₂/FiO₂.

3

Maintenance

| | | |
|-----|--|----|
| 3.1 | Safety information | 40 |
| 3.2 | Cleaning the adapter and sensor..... | 41 |
| 3.3 | Replacing the adapter, cables, or sensor..... | 41 |
| 3.4 | Disposing of the adapter, cables, and sensor | 41 |

3.1 Safety information

Maintenance safety information

WARNING

- **Electric shock hazard.** Only a qualified operator may perform maintenance procedures specifically described in this manual.
- To protect against injury, follow the directions below:
 - Avoid placing the device on surfaces with visible liquid spills.
 - Do *not* soak or immerse the device in liquids.
 - Do *not* attempt to sterilize the device.
 - Use cleaning solutions only as instructed in these *Instructions for use*.
 - Do *not* attempt to clean the device while monitoring the patient.
- Do *not* adjust, repair, open, disassemble, or modify the pulse CO-oximeter or accessories. Injury to personnel or equipment damage could occur. Return the pulse CO-oximeter for servicing if necessary.

CAUTION

- **Electrical shock hazard.** Carry out periodic tests to verify that leakage currents of patient-applied circuits and the system are within acceptable limits as specified by the applicable safety standards. The summation of leakage currents must be checked and in compliance with IEC 60601-1 and UL60601-1. The system leakage current must be checked when connecting external equipment to the system. When an event such as a component drop of approximately 1 meter or greater, or a spillage of blood or other liquids occurs, retest before further use. Injury to personnel could occur.
- Do **NOT** submerge the pulse CO-oximeter in any cleaning solution or attempt to sterilize by autoclave, irradiation, steam, gas, ethylene oxide, or any other method. This will seriously damage the pulse CO-oximeter.
- Do **NOT** immerse the SpO2 adapter in any chemical solution or water. Do **NOT** use a wet SpO2 adapter; correct measurement may not be possible. If the adapter is immersed, wipe off liquid with a dry cloth and thoroughly dry the adapter.
- Before maintenance or cleaning, disconnect the SpO2 adapter from the ventilator. Failure to do so may result in electrical shock and SpO2 adapter error.
- Do **NOT** modify, alter, or repair the sensor and/or adapter in any way. Alterations or modification may affect performance and/or accuracy, as well as the manufacturer's warranty.
- After cleaning and before use, wipe liquid off with a dry cloth and thoroughly dry the adapter.

- *If there is a possibility that the SpO2 adapter may come into contact with a chemical solution, use the SpO2 adapter with the sensor connector in a vertical and downward position.*
- *If fluid is spilled into the SpO2 adapter, stop using it and contact the manufacturer.*
- *Do NOT disinfect and sterilize the SpO2 adapter. Doing so will damage the adapter.*
- *Disposal of product: Comply with local laws in the disposal of the instrument and/or its accessories.*

3.2 Cleaning the adapter and sensor

To clean the adapter

1. Periodically clean the SpO2 adapter by wiping it with a soft cloth moistened with ethanol (15°C (59°F), 76.9% to 81.4% by volume).
2. Dry the adapter completely after cleaning.

To clean a reusable sensor

1. Remove the sensor from the patient.
2. Disconnect the sensor and the patient cable from the adapter.
3. *Nihon Kohden:* Wipe the components with a soft cloth moistened with a 2.0% glutaraldehyde solution or 0.5% alkylidiaminoethylglycine hydrochloride.
Masimo: Wipe the components with a soft cloth moistened with a 70% isopropyl solution.
4. Allow to air dry before reuse.

3.3 Replacing the adapter, cables, or sensor

When an SpO2 adapter, cable, or sensor is broken, cracked, or visibly damaged, immediately stop using it and replace it with a new one.

3.4 Disposing of the adapter, cables, and sensor

Follow your local laws for environmental protection when disposing of an SpO2 adapter, cables, and/or sensors. For detailed information, contact your Hamilton Medical technical representative.

4

Specifications: Nihon Kohden

| | | |
|-----|--------------------------------|----|
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4.1 Parameter specifications

Table 4-1. Pulse oximetry parameters, ranges, and resolution

| Parameter (units) | Range | Resolution |
|--|----------|------------|
| Pulse (bpm) <i>(displayed as 1/min)</i> | 0 to 240 | 1 |
| SpO2 (%) | 0 to 100 | 1 |
| SpO2/FiO2 ¹⁰ (%) | 0 to 500 | 1 |

4.1.1 Accuracy of measurements

Table 4-2. Nihon Kohden SpO2 parameters, accuracy

| Parameter | Accuracy |
|--|----------------------------------|
| <i>SpO2 accuracy guaranteed at temperatures between 18°C and 40°C (64.4°F and 104°F)</i> | |
| SpO2 | 70% to 100% ±3% ¹¹ |
| Pulse rate (bpm) | ±3%, ±1 bpm |

Table 4-3. Nihon Kohden SpO2 sensor accuracy: Sensor SpO2 values compared to functional SaO2 measured by a CO-oximeter (see Notes below)

| SpO2 sensor | TL-271T, TL-272T, TL-273T, TL-274T, TL271T3, TL-272T3, TL-273T3, TL-274T3 | TL-051S, TL-052S, TL-061S, TL-062S | TL-201T | TL-631T1, TL-631T3, TL-220T |
|--------------|---|---|---------|-----------------------------------|
| 70% to 79.9% | 2.03% | 1.93% | 1.62% | 2.79% |
| 80% to 89.9% | 1.57% | 1.84% | 1.16% | 1.87% |
| 90% to 100% | 1.23% | 1.30% | 1.01% | 1.07% |

¹⁰ When SpO2 exceeds 94%, the SpO2/FiO2 ratio is not calculated; the display shows dashes (---).

¹¹ For SpO2 measurements from 80% to 100% the accuracy is ±2%.

Neonatal use

Clinical functionality has been demonstrated on a population of hospitalized neonate patients. The observed SpO₂ accuracy measured by the sensor was within 2.6% of the measured SaO₂ value by a CO-oximeter in a study of 55 patients weighing between 447 and 2,458 grams. 368 observations were made spanning a range of 70% to 100% SaO₂.

Notes

The following information relates to accuracy of Nihon Kohden pulse oximetry measurements.

- The SpO₂ accuracy was tested using the TL-201T, TL-260T, TL-271T, TL-631T, TL-051S, and TL-535U SpO₂ probes. The testing was performed during induced hypoxia on healthy volunteers (Ethnicity: 10 Caucasians, 2 Africans, 4 Asians, 1 Haitian, 3 Hispanics, 2 Hispanics/Caucasians, 6 Indians; Skin: 7 Light, 4 Light/Medium, 10 Medium, 1 Med/Dark, 6 Dark; Age: 21 to 30; Gender: 17 men and 11 women) under the condition of no motion. Arterial blood was sampled and measured by a CO-oximeter. The difference between SpO₂ measured by the SpO₂ probe and functional SaO₂ measured by a CO-oximeter was calculated using the root-mean-square (rms) according to ISO 80601-2-61:2011. This measurement accuracy figure represents two-thirds of all test measurements.
- A pulse oximeter tester that generates simulated signals can be used to check the difference from the design specification, but it cannot be used as a replacement for human signals for testing accuracy.

- In the first two graphs that follow, response time is selectable. Options are **Slow**, **Normal**, **Fast**, and **Extra Fast**.

Figure 4-1. Response time, SpO₂ changes 0.6%/s, 70 bpm

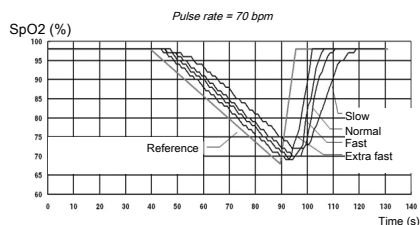


Figure 4-2. Response time, SpO₂ changes 0.6%/s, 140 bpm

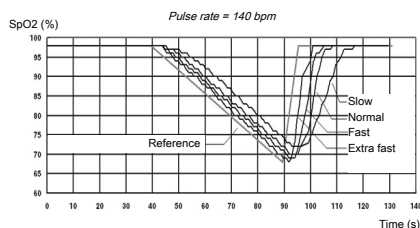
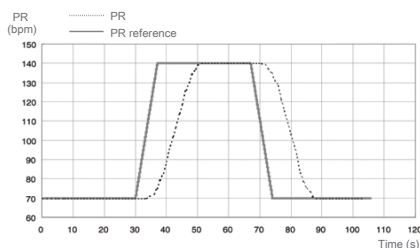


Figure 4-3. Response time, pulse rate changes 10 bpm/s

*In the following graph, only the Normal range is available.
SpO₂ = 97*



4.2 Alarm specifications

Table 4-4. Adjustable alarm ranges, default settings, and resolution

| Alarm (units) | Range: Adult/ped/neo | Default: Adult/ped | Default: Neo | Resolution |
|--|-------------------------|-----------------------|-----------------|------------|
| <i>Beats per minute (bpm) are displayed as 1/min.</i> | | | | |
| Pulse low (bpm) | 30 to 230 | 50 | 100 | 5 |
| Pulse high (bpm) | 35 to 235 | 140 | 180 | 5 |
| SpO2 low (%) | 70 to 99 | 90 | 90 | 1 |
| When SpO2 monitoring is enabled, the low SpO2 alarm limit and measured SpO2 value are always displayed below the MMP list. | | | | |
| SpO2 high (%) | 71 to 100/OFF | OFF | 95 | 1 |

4.3 Technical specifications

For sensor and other additional specifications, refer to the ventilator *Operator's Manual* and the Nihon Kohden product documentation.

Table 4-5. Nihon Kohden adapter specifications

| Feature | Specifications |
|---|---|
| Dimensions (mm) | 34 W x 18 H x 117 D |
| Cable length | 2.5 m |
| Weight | 95 g \pm 10% (including cable and connector) |
| Degree of protection (solid particle and liquid ingress) | IPX1 <i>when the sensor connector is in a vertical and downward position</i> |
| Mode of operation | Continuous |
| Applied part classification (per IEC 60601-1) | Type BF |
| Operating requirements | |
| Operating temperature | 10°C to 40°C (50°F to 104°F) |
| Operating humidity | 30% to 85% relative humidity, noncondensing |
| Operating pressure | 700 to 1060 hPa |
| Storage requirements | |
| Storage temperature | -20°C to 65°C (-4°F to 149°F) |
| Storage humidity | 10% to 95% relative humidity, noncondensing |
| Storage pressure | 700 to 1060 hPa |
| Configuration settings | |
| SpO2 alarm delay (s) | 0, 5 (default), 10, 15 |
| SpO2 response | Slow, Normal (default), Fast, Extra Fast |
| Pulse detection sensitivity | Low, Normal (default), High |
| Sensitivity mode | Maximum, Normal (default) |

| Feature | Specifications |
|---|---|
| Alarms | |
| Out of limit alarms: SpO ₂ , Pulse rate | High/low alarms |
| Sensor condition alarm | No Sensor, Sensor Off, Sensor defect, Sensor error |

5

Specifications: Masimo SET

| | | |
|-----|--------------------------------|----|
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5.1 Parameter specifications

Table 5-1. Pulse oximetry parameters, range, and resolution

| Parameter (units) | Display range | Resolution |
|-------------------------------------|---------------|---------------------------------------|
| Perfusion index (PI) (%) | 0 to 20 | 0.01 if value < 1 0.1 if value ≥ 1 |
| Pleth variability index (PVI) (%) | 0 to 100 | 1 |
| Pulse (bpm) (displayed as 1/min) | 0 to 240 | 1 |
| SpO2 (%) | 0 to 100 | 1 |
| SpO2/FiO2 ¹² (%) | 0 to 500 | 1 |

5.1.1 Accuracy of measurements

Table 5-2. Masimo SET SpO2 parameters, accuracy

| Parameter | Accuracy |
|---|---|
| <i>See the notes after the table for additional details about the accuracy testing. For more information, see the Masimo SET product documentation.</i> | |
| SpO2, no motion, 60% to 80% | ±3% adults/pediatrics/infants |
| SpO2, no motion, 70% to 100% | ±2% adults/pediatrics/infants; ±3% neonates |
| SpO2, motion, 70% to 100% | ±3%, adults/pediatrics/infants/neonates |
| SpO2, low perfusion, 70% to 100% | ±2%, adults/pediatrics/infants/neonates |
| Pulse rate, no motion, 25 to 240 bpm | ±3 bpm, adults/pediatrics/infants/neonates |
| Pulse rate, motion, 25 to 240 bpm | ±5 bpm, adults/pediatrics/infants/neonates |
| Pulse rate, low perfusion, 25 to 240 bpm | ±5 bpm, adults/pediatrics/infants/neonates |

¹² When SpO2 exceeds 94%, the SpO2/FiO2 ratio is not calculated; the display shows dashes (---).

Notes

The following information relates to accuracy of Masimo SET pulse oximetry measurements.

- SpO2 accuracy was determined by testing on healthy adult volunteers in the range of 60% to 100% SpO2 against a laboratory CO-oximeter. SpO2 accuracy was determined on 16 neonatal NICU patients ranging in age from 7 to 135 days old and weighing between 0.5 and 4.25 kg. Seventy-nine (79) data samples were collected over a range of 70% to 100% SaO2 with a resultant accuracy of 2.9% SpO2.
- The Masimo sensors have been validated for no-motion accuracy in human blood studies on healthy adult male and female volunteers with light to dark skin pigmentation in induced hypoxia studies in the range of 70% to 100% SpO2 against a laboratory CO-oximeter and ECG monitor. This variation equals plus or minus one standard deviation, which encompasses 68% of the population.
- The Masimo sensors have been validated for motion accuracy in human blood studies on healthy adult male and female volunteers with light to dark skin pigmentation in induced hypoxia studies in the range of 70% to 100% SpO2 against a laboratory CO-oximeter and ECG monitor. This variation equals plus or minus one standard deviation, which encompasses 68% of the population.
- The Masimo SET technology has been validated for low-perfusion accuracy in bench-top testing against a Biotek Index 2 simulator and Masimo's simulator with signal strengths of greater than 0.02% and transmission of greater than 5% for saturations ranging from 70% to 100%. This variation equals plus or minus one standard deviation, which encompasses 68% of the population.
- The Masimo sensors have been validated for pulse-rate accuracy for the range of 25 to 240 bpm in bench-top testing against a Biotek Index 2 simulator. This variation equals plus or minus one standard deviation, which encompasses 68% of the population.
- The following substances may interfere with pulse CO-oximetry measurements:
 - Elevated levels of methemoglobin (MetHb) may lead to inaccurate SpO2 measurements.
 - Elevated levels of carboxyhemoglobin (COHb) may lead to inaccurate SpO2 measurements.
 - Severe anaemia may cause erroneous SpO2 measurements.
 - Dyes or any substance containing dyes that change usual blood pigmentation may cause erroneous readings.
 - Elevated levels of total bilirubin may lead to inaccurate SpO2 measurements.

A_{RMS} values measured with Masimo SET sensors

The following tables and graphs show A_{RMS} values measured with Masimo SET sensors in a clinical study.

Figure 5-1. A_{RMS} values, A_{dtx}/P_{dtx}

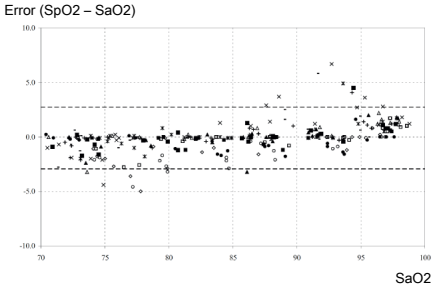


Table 5-3. A_{RMS} values, A_{dtx}/P_{dtx}

| Range | Measured A _{RMS} |
|---------------------------------------|---------------------------|
| 90% to 100% | 1.64% |
| 80% to 89.9% | 1.07% |
| 70% to 79.9% | 1.55% |
| Overall claimed accuracy value | |
| 70% to 100% | 2% |

Figure 5-2. A_{RMS} values, Inf/Neo/NeoPt

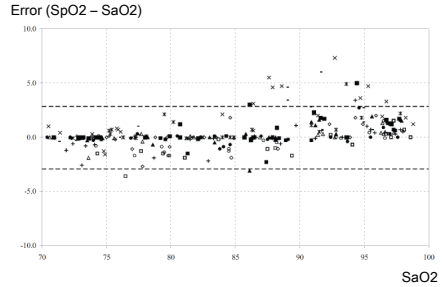
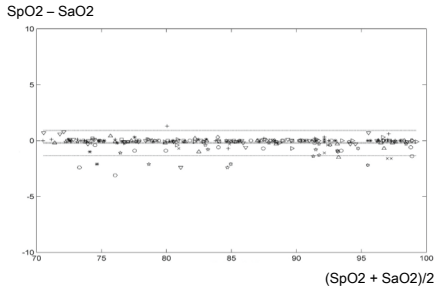


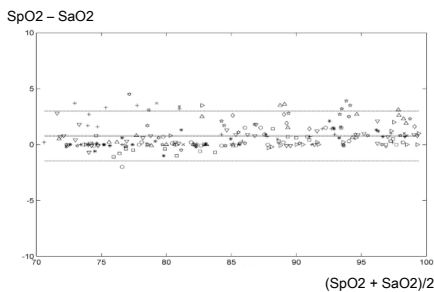
Table 5-4. A_{RMS} values, Inf/Neo/NeoPt

| Range | Measured A _{RMS} |
|---------------------------------------|---|
| 90% to 100% | 1.85% |
| 80% to 89.9% | 1.44% |
| 70% to 79.9% | 0.89% |
| Overall claimed accuracy value | |
| 70% to 100% | Inf: ±2% Neo*: ±2% adults, ±3% neonates Neo Pt*: ±3% |

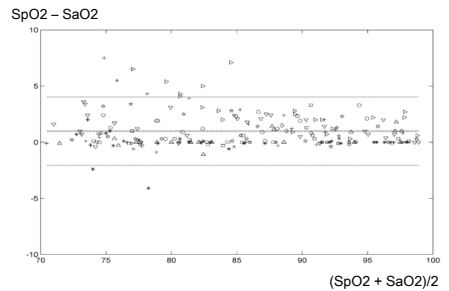
* The saturation accuracy of the neonate and preterm sensors were validated on adult volunteers; 1% was added to account for the properties of fetal hemoglobin.

Figure 5-3. A_{RMS} values, DCI/DCIPTable 5-5. A_{RMS} values, DCI/DCIP

| Range | Measured A_{RMS} |
|---------------------------------------|--------------------|
| 90% to 100% | 0.60% |
| 80% to 89.9% | 0.54% |
| 70% to 79.9% | 0.67% |
| Overall claimed accuracy value | |
| 70% to 100% | 2% |

Figure 5-4. A_{RMS} values, TFITable 5-6. A_{RMS} values, TFI

| Range | Measured A_{RMS} |
|---------------------------------------|--------------------|
| 90% to 100% | 1.45% |
| 80% to 89.9% | 1.22% |
| 70% to 79.9% | 1.41% |
| Overall claimed accuracy value | |
| 70% to 100% | 2% |

Figure 5-5. A_{RMS} values, TCITable 5-7. A_{RMS} values, TCI

| Range | Measured A_{RMS} |
|---------------------------------------|--------------------|
| 90% to 100% | 1.05% |
| 80% to 89.9% | 1.67% |
| 70% to 79.9% | 2.43% |
| Overall claimed accuracy value | |
| 70% to 100% | 3.5% |

5.2 Alarm specifications

The following table provides details for adjustable alarms.

Table 5-8. Adjustable alarms

| Alarm (units) | Range: Adult/ped/neo | Default: Adult/ped | Default: Neo | Resolution |
|--|-------------------------|-----------------------|-----------------|----------------------|
| <i>Beats per minute (bpm) are displayed on the device as 1/min.</i> | | | | |
| PI low (%) | OFF / 0.03 to 18.00 | OFF | OFF | 0.01 < 1 0.10 ≥ 1 |
| PI high (%) | 0.04 to 19.00 / OFF | OFF | OFF | 0.01 < 1 0.10 ≥ 1 |
| PVI low (%) | OFF / 1 to 99 | OFF | OFF | 1 |
| PVI high (%) | 2 to 100 / OFF | OFF | OFF | 1 |
| Pulse low (bpm) | 30 to 230 | 50 | 100 | 5 |
| Pulse high (bpm) | 35 to 235 | 140 | 180 | 5 |
| SpO2 low (%) | 70 to 99 | 90 | 90 | 1 |
| When SpO2 monitoring is enabled, the low SpO2 alarm limit and measured SpO2 value are always displayed below the MMP list. | | | | |
| SpO2 high (%) | 71 to 100/OFF | OFF | 95 | 1 |

5.3 Technical specifications

For additional specifications, refer to the ventilator *Operator's Manual* and the Masimo SET product documentation.

Table 5-9. Masimo SET pulse oximeter specifications

| Feature | Specification |
|---|--|
| Mechanical | |
| Material | Polycarbonate/ABS blend |
| Circuitry | Microprocessor controlled Automatic self-test when powered on Automatic setting of default parameters Automatic alarm messages Trend data output |
| Firmware | MX board/circuitry |
| Environmental | |
| Operating temperature | 0 to 50°C (32°F to 122°F) |
| Storage temperature | -40°C to 70°C (-40°F to 158°F) |
| Relative storage humidity | 10% to 95%, noncondensing |
| Operating altitude | <i>Pressure:</i> 500 to 1060 hPa <i>Altitude:</i> -304.5 to 5486 m (-1000 to 18,000 ft) |
| Configuration settings | |
| SpO2 alarm delay (s) | 0, 5 (default), 10, 15 |
| SpO2 averaging time (s) | 2, 4, 8 (default), 10, 12, 14, 16 |
| SpO2 sensitivity mode | Maximum, Normal (default), APOD |
| PVI averaging mode | Normal (default), Fast |
| FastSat | On, off (default) |
| Line frequency (Hz) | 50 (default), 60 |
| Alarms | |
| Out of limit alarms: SpO2, Pulse rate, PI , PVI | High/low alarms |
| Sensor condition alarm | No Sensor, Sensor Off, Sensor defect, Sensor error |

| Feature | Specification |
|---|--|
| Compliance | |
| EMC compliance | EN 60601-1-2:2007/AC:2010 |
| Electrical safety | IEC 60601-1:2006/A1:2012 ANSI/AAMI ES60601-1:2005/(R)2012 |
| Applied part classification (per IEC 60601-1) (patient cable) | Type BF |
| Degree of protection (solid particle and liquid ingress) | IP21 |
| Mode of operation | Continuous |

Table 5-10. Radiant power specifications for Masimo SpO2 sensors

| Radiant power of light, LNOP, LNCS/M-LNCS sensors, at 50 mA, pulsed |
|---|
| ≤ 15 mW |

Table 5-11. Nominal wavelength specifications for SpO2 sensors

| Sensor | LED | Wavelength |
|---|----------|------------|
| LNOP, LNCS sensors | Red | 660 nm |
| | Infrared | 905 nm |
| LNOP tip clip (LNOP TC-1), LNCS/M-LNCS tip clip (LNCS/M-LNCS TC-1) | Red | 653 nm |
| | Infrared | 880 nm |
| LNOP transreflectance (LNOP ZF-1) forehead, LNCS/M-LNCS transreflectance (LNCS/ LNCS TF-1) | Red | 660 nm |
| | Infrared | 880 nm |

6

Configuration

| | | |
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6.1 Overview

You can access **Configuration** mode settings when the ventilator is in **Standby**. Access requires a configuration code; contact your administrator.

Configuration tasks for setting up a pulse oximeter with your ventilator fall into two categories:

- One-time settings that are specified in **Configuration** mode (Table 6-1)
- Sensor acquisition settings that can be specified during ventilation (Table 6-2)

Table 6-1. Configuring the ventilator for pulse oximetry, Configuration mode

| To ... | See ... |
|-----------------------------------|--|
| Install the communication board | Documentation provided with the communication board or your ventilator <i>Operator's Manual</i> |
| Activate the SpO2 hardware option | Section 6.2 |
| Select the sensor type | Section 6.3 |

Table 6-2. Configuring sensor acquisition settings during ventilation

| To ... | See ... |
|---------------------------------|-------------|
| Select SpO2 sensor data options | |
| Nihon Kohden | Section 6.4 |
| Masimo SET | Section 6.5 |

6.2 Activating the SpO2 hardware option

Before you begin, ensure the SpO2 communication board is installed.

To enable the board

1. In the **Configuration** window, touch the **Options** button on the left.
2. Touch the **HW options** tab.
3. Select the SpO2 checkbox.

The **Sensors** button appears on the left side of the main **Configuration** window.

You can now select your sensor type.

6.3 Selecting the sensor type

The SpO2 communication board must be enabled for the **Sensors** button to be available (Section 6.2).

To select the sensor type

1. In the **Configuration** window, touch **Sensors**.
2. Touch the **Sensor type** tab, if not already selected.
3. Touch the appropriate button for your pulse oximeter: **Nihon Kohden** or **Masimo**.

You can now set the sensor acquisition settings appropriate for your device.

6.4 Configuring Nihon Kohden sensor settings

Before proceeding, ensure that:

- The SpO2 hardware option is activated and the sensor type is selected in Configuration.
- SpO2 monitoring is enabled (Section 2.3).

Sensor settings are persistent. Once you change a setting, the selection remains in force until manually changed.

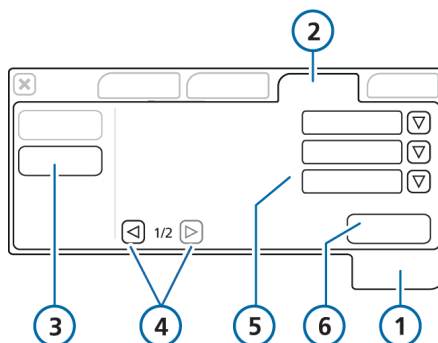
You specify sensor settings in the **System > Sensors > SpO2** window.

To specify sensor data acquisition options

1. Touch **System > Sensors** (Figure 6-1).
2. Touch **SpO2**.
3. Specify the desired settings, as appropriate (Table 6-3).
4. To access the **Sensitivity mode** option, touch the right arrow (4) to display view 2.
5. To reset any of these options to the factory settings, touch **Defaults** (available only in **Standby**).

Configuration is now complete.

Figure 6-1. Sensor data acquisition settings



- | | |
|-----------------------------|---|
| 1 System | 2 Sensors |
| 3 SpO2 | 4 View navigation buttons (view 1 is displayed) |
| 5 Data acquisition settings | 6 Defaults |

Table 6-3. SpO2 sensor data settings for Nihon Kohden

| Parameter | Description |
|--------------------------------|--|
| SpO2 alarm delay (s) | <p>Set in the System > Sensors > SpO2 window.</p> <p>Specifies the length of time, in seconds, that the measured SpO2 value must be outside the set alarm limits before the system generates the alarm. For details, see Section 2.6.2.</p> <p>Options are: 0, 5 (default), 10, 15</p> |
| SpO2 response | <p>Set in the System > Sensors > SpO2 window.</p> <p>Specifies the speed at which the sensor sends data to the system.</p> <p>Choose options as follows, if other than Normal (the default):</p> <ul style="list-style-type: none"> • Normal (default) • Slow: Increase response time to prevent frequent alarms • Fast: Decrease response time to be alerted to alarm conditions quickly • Extra fast: Minimize the response time (this option most closely tracks the reference oxygen saturation) |
| Pulse detection sensitivity | <p>Set in the System > Sensors > SpO2 window.</p> <p>Specifies the sensitivity level of the sensor to detect the pulse.</p> <p>Options are:</p> <ul style="list-style-type: none"> • Normal (default) • Low: Used to lower sensitivity when the pulse oximeter double counts the pulse wave • High: Used to increase sensitivity when the pulse wave amplitude is unstable, for example, due to arrhythmia |
| Sensitivity mode ¹³ | <p>Set in the System > Sensors > SpO2 window.</p> <p>Specifies the sensor sensitivity, which can be tailored to different patient conditions.</p> <p>Options are:</p> <ul style="list-style-type: none"> • Normal (default) • Maximum: Used when it is difficult to detect a pulse, for example, with patients with insufficient peripheral circulation or when an intra-aortic balloon pump is used. |

¹³ If your Nihon Kohden sensor was manufactured prior to 2011, the **Sensitivity mode** setting may not be displayed.

6.5 Configuring Masimo SET sensor settings

Before proceeding, ensure that:

- The SpO2 hardware option is activated and the sensor type is selected in Configuration.
- SpO2 monitoring is enabled (Section 2.3).
- For upgrade information, contact your Hamilton Medical technical representative.

The power line frequency (50 or 60 Hz) for the sensor is specified during device configuration. Additional acquisition settings, such as alarm delay and sensitivity mode, can be changed during ventilation.

Sensor settings are persistent, with one exception: **Maximum Sensitivity** mode. For details, see Section 6.5.3. Once you change a setting, the new selection is in force until manually changed.

Sensor settings are configured in two places: **Configuration** mode and in the **System > Sensors** window.

6.5.1 Specifying sensor settings in Configuration mode

To specify line frequency in Configuration

1. In the **Configuration > Sensors > SpO2** window, touch the **Settings** tab.
2. Set the desired power line frequency: 50 or 60 Hz.
The rest of the sensor settings are specified outside of **Configuration**, in the **System > Sensors** window.
3. Touch **Back** to return to the main **Configuration** window.

6.5.2 Specifying sensor settings during ventilation

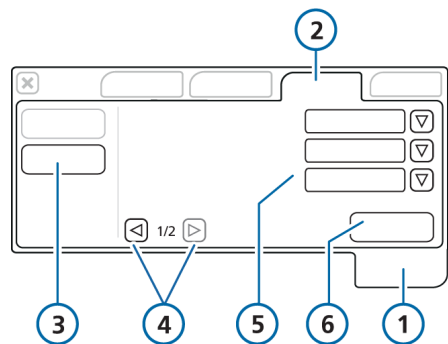
You specify sensor settings in the **System > Sensors > SpO2** window.

To configure sensor data acquisition settings

1. Touch **System > Sensors**.
2. Touch **SpO2**.
3. Specify the desired settings, as appropriate. See Table 6-4.
4. To access the **PVI averaging mode** and **FastSat** options, touch the right arrow (4) to display view 2.
5. To reset any of these options to the factory settings, touch **Defaults** (available only in **Standby**).

Configuration is complete and the system is ready for use.

Figure 6-2. Sensor data acquisition settings



- | | |
|-----------------------------|---|
| 1 System | 2 Sensors |
| 3 SpO2 | 4 View navigation buttons (view 1 is displayed) |
| 5 Data acquisition settings | 6 Defaults |

Table 6-4. SpO2 sensor data settings for Masimo

| Parameter | Description |
|-------------------------|--|
| SpO2 alarm delay (s) | <p>Set in the System > Sensors > SpO2 window.</p> <p>Specifies the length of time, in seconds, that the measured SpO2 value must be outside the set alarm limits before the system generates the alarm. For details, see Section 2.6.2.</p> <p>Options are: 0, 5 (default), 10, 15</p> |
| SpO2 averaging time (s) | <p>Set in the System > Sensors > SpO2 window.</p> <p>Defines how many SpO2 readings will be used to calculate the final value to display. A higher averaging time provides a more accurate value, but takes longer.</p> <p>Options are: 2, 4, 8 (default), 10, 12, 14, 16</p> |
| Sensitivity mode | <p>Set in the System > Sensors > SpO2 window.</p> <p>Specifies the sensor sensitivity, which can be tailored to different patient conditions.</p> <p>Options are:</p> <ul style="list-style-type: none"> • Maximum. Recommended for patients with low perfusion for use during procedures, or in high acuity settings where there is frequent clinician/patient contact. Unlike other settings, this option is not persistent. For details, see Section 6.5.3. • Normal (default). Appropriate for most patients, provides an optimal combination of measurement sensitivity and responsiveness to a detached sensor. • APOD (adaptive probe off detection). Protects against incorrect pulse rate and SpO2 readings due to a detached sensor. Not appropriate for patients with low perfusion. |
| PVI averaging mode | <p>Set in the System > Sensors > SpO2 window¹⁴.</p> <p>Specifies the time period over which the PVI measurement is averaged.</p> <p>Options are:</p> <ul style="list-style-type: none"> • Normal (default). A longer period provides more stable readings over time. • Fast. A shorter period reduces the response time of the device, with higher variability in the measurements. |

¹⁴ The **PVI averaging mode** setting is only displayed if the PVI parameter is enabled in the SpO2 adapter. Contact your Hamilton Medical technical representative for details.

| Parameter | Description |
|---------------------|---|
| FastSat | Set in the System > Sensors > SpO2 window. Provides quicker SpO2 sampling and display. May show more changes in rate, as it is not an averaged value. Options are: On, Off (default) |
| Line frequency (Hz) | Set in the Configuration > Sensors > SpO2 > Settings window. Power line frequency. Options are: 50 (default), 60 Hz |

6.5.3 About the Maximum Sensitivity mode setting

Unlike other sensor data settings, the **Maximum Sensitivity** mode setting is not persistent, and may change depending on how the ventilator is set up for a new patient.

When **Maximum** is already selected, and you start a new patient session:

- If you choose the **Last patient** option in the **Standby** window, the **Sensitivity** mode setting stays at **Maximum**.
- If you choose a new patient option (**Adult/Ped**, **Neonatal**), depending on ventilator model and options, the **Sensitivity** mode setting changes to the default, **Normal**, after ventilation is started.

6.5.4 Reviewing configured options

Once enabled, Masimo SET pulse oximeter configuration data is displayed in the **Configuration > Sensors > Sensor type and Upgrade** windows.¹⁵

The **Sensor type** window shows version number and sensor codes. Note the following:

- If the window shows only dashes (---) for all of the data, an adapter is not connected.
- If a parameter is listed as **OFF**, it is not enabled on the adapter.

¹⁵ The PVI parameter status is displayed in the Upgrade window, as well as Masimo rainbow SET parameters, if enabled.

bpm

Beats per minute; also shown as 1/min

CO

Carbon monoxide

CPR

Cardiopulmonary resuscitation

Dynamic Lung

Intelligent panel that graphically represents tidal volume, lung compliance, patient triggering, and resistance in real time

ECG

Electrocardiogram

IABP

Intra-aortic balloon pump

NIBP

Noninvasive blood pressure amplifier

PaCO₂

Partial pressure of carbon dioxide in arterial blood

PetCO₂

Measured end-tidal CO₂ partial pressure

Plethysmogram

The waveform that visualizes the pulsating blood volume; it is delivered by the pulse oximeter

SaO₂

Saturation level (%) of oxygen in hemoglobin

SpO₂

Oxygen saturation

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