Agilent M1165/66/67/75/76/77A Component Monitoring System and Agilent M1205A V24 & V26

User's Reference Manual Volume 2 Parameter Information

Agilent Technologies

Part Number M1046-9001L
Printed 06/2000
First Edition

Notice

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(978) 687-1501

Publication number
M1046-9001L

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The documentation printing date and part number indicate its current edition. The printing date changes when a new edition is printed. (Minor corrections and updates which are incorporated at reprint do not cause the date to change.) The document part number changes when extensive technical changes are incorporated.

First Edition. . . . . June 2000

Important

United States federal law restricts these devices to sale by or on the order of a physician.

The M1165/66/75/76A Systems comply with UL544, CSA 22.2-125, IEC 601-1, EN 60601-1, and EN 60601-1-2 and carries CE 0366 Marking to Council Directive 93/42/EEC, European Medical Device Directive (MDD).

The M1167/77A Systems comply with UL2601-1, CSA 22.2 No. 601.1-M90, IEC 601-1, EN 60601-1, and EN 60601-1-2 and carries CE 0366 Marking to Council Directive 93/42/EEC, European Medical Device Directive (MDD).

The M1205A Systems comply with UL2601, IEC 601-1, CSA C22.2 no. 601-1, EN60601-1, and EN60601-1-2 and carries CE 0123 Marking to Council Directive 93/42/EEC, European Medical Device Directive (MDD).

Electromagnetic Interference

Anomalies due to electromagnetic interference are not unique to the M1165/66/67/75/76/77A or the M1205A but are characteristic of patient monitors in use today. This performance is due to the very sensitive high gain front end amplifiers used to display the physiological signals. Among the many similarly performing monitors already in use by customers, interference from electromagnetic sources is rarely a problem in actual use.

Avoiding Electromagnetic Interference

When electromagnetic interference (EMI) is encountered there are a number of actions that can be taken to mitigate the problem.

- Eliminate the source. Possible sources of EMI can be turned off or moved away to reduce their strength.
- Attenuate the coupling. If the coupling path is through the patient leads, the interference may be reduced by moving and/or rearranging the leads. If the coupling is through the power cord, plugging the monitor into a different circuit may help.
- Reduce the sensitivity of the system. In all of the EMC testing the monitor was adjusted to maximum sensitivity. For the ECG amplifier the gain was four times what is normally required. By reducing the gain of the system receiving the EMI, the interference can often be eliminated.
- Add external attenuators. If EMI becomes an unusually difficult problem external devices such as an isolation transformer or a transient suppressor may be of help. An Agilent Customer Engineer can be of help in determining the need for external devices.

Intended Use

Description

The Agilent M1165/66/67/75/76/77A Component Monitoring System and the Agilent M1205A V24 and V26 Monitors are network connectable bedside patient monitoring devices.

The Agilent M1205A Models V24CT and V26 CT may powered by either AC line power or by battery power.

Purpose

The Agilent M1165/66/67/75/76/77A Component Monitoring System and the Agilent M1205A V24 and V26 monitors measure and display multiple physiological parameters and waves, and generate alarms and recordings. They exchange information with compatible devices. The Agilent M1165/66/67/75/76/77A Component Monitoring System and the Agilent M1205A V24 and V26 monitors are not therapeutic devices.

Patient Population

The Agilent M1165/66/67/75/76/77A Component Monitoring System and the Agilent M1205A V24 and V26 monitors are intended to be used on adult, pediatric, and neonatal patients.

Environment

The Agilent M1165/66/67/75/76/77A Component Monitoring System and the Agilent M1205A V24 and V26 monitors are intended to be used in a clinical environment by trained healthcare professionals. They are not intended for home use.

They communicate with devices such as a central station through network interface ports and a serial I/O port.

The Agilent M1165/66/67/75/76/77A Component Monitoring System and the Agilent M1205A V24 and V26 Monitors are prescription devices and will carry the following label, “United States Federal law restricts this device to sale by or on the order of a physician.”

Indications for Use

Condition

The Agilent M1165/66/67/75/76/77A Component Monitoring System and the Agilent M1205A V24 and V26 Monitors are generally indicated when the clinician decides there is a need to measure and display multiple physiological parameters and waves, to generate alarms and recordings of adult, pediatric, or neonatal patients.

Part of Body or Type of Tissue with Which the Device Interacts

The Agilent M1165/66/67/75/76/77A Component Monitoring System and the Agilent M1205A V24 and V26 monitors do not contact the body or tissue of the patient. Signals are obtained from accessory electrode, transducer, and sensor devices.

Frequency of Use

The Agilent M1165/66/67/75/76/77A Component Monitoring System and the Agilent M1205A V24 and V26 monitors are indicated for use when prescribed by a clinician.

Physiological Purpose

The Agilent M1165/66/67/75/76/77A Component Monitoring System and the Agilent M1205A V24 and V26 Monitors are indicated when the purpose is to gain information for treatment, to assess adequacy of treatment, or to rule out causes of symptoms. The Agilent M1165/66/67/75/76/77A Component Monitoring System and the Agilent M1205A V24 and V26 monitors are well suited for patient monitoring.

Patient Population

Adult, pediatric, and neonatal non-ambulatory patients.

Prescription Versus Over-the-Counter

The Agilent M1165/66/67/75/76/77A Component Monitoring System and the Agilent M1205A V24 and V26 Monitors are prescription devices.

Warnings, Cautions, and Notes

Warnings, cautions, and notes are used throughout this User's Manual to give you additional information about the Agilent M1165/66/67/75/76/77A Component Monitoring System and the Agilent M1205A V24 and V26 monitors. The warnings and cautions included in this safety section refer to the equipment in general.

Warning

A "warning" calls attention to the user of imminent hazard to people if proper procedures are not followed.

- For continued safe use of this equipment, it is necessary that the listed instructions are followed. Instructions in this manual in no way supersede established medical procedures.
- Explosion Hazard- Do not use this equipment in the presence of flammable anesthetics.
- Alarms - Do not rely exclusively on the audible alarm system for patient monitoring. Adjustment of alarm volume to a low level or off during patient monitoring may result in patient jeopardy. Remember that the most reliable method of patient monitoring combines close personal surveillance with correct operation of monitoring equipment.
- This equipment is only intended for use in healthcare facilities by trained healthcare professionals.
- The product is not intended for outside hospital use such as a helicopters or ambulances.
- This product is not intended for home use.
- To reduce the risk of electrical shock, do **NOT** remove any cover. Refer servicing to qualified personnel.
- This equipment may interfere with ultrasound imaging equipment by causing interference on the ultrasound display. Try to keep the instruments as far apart as possible.

- Exposure of electrical contacts or connections to saline or other liquids and gels is dangerous. Electrical contacts and connections such as cable connectors, power supplies, parameter module plug-in connections and rack connections must be kept clean and dry. Thoroughly dry any electrical connections that become contaminated with liquids. If additional decontamination is required please contact your biomedical department or Agilent Technologies Response Center.
- Although this equipment is shielded against Electromagnetic Interference (EMI), it is recommended to avoid the use of electrically radiating devices in close proximity to this equipment.
- Connecting the Agilent monitoring network (SDN) cable when the product is powered on is not supported. Error codes and Agilent monitoring network (SDN) interface lock-up may occur. Power cycling the product will recover the product. No permanent damage will result. To prevent unintentional disruption in monitoring, be sure the SDN interface cable is properly secured at both ends when connecting to the Agilent monitoring network (SDN).
- Do not connect a second rack by a cable when using a module rack docked to the back of the Agilent V24CT or V26CT. Using a second rack connected by a cable may disrupt module communication.

Caution

A “caution” calls attention to a condition or possible situation that could cause injury to the user.

- Ventilation Requirements - Failure to meet ventilation requirements may cause equipment failure and, in turn, jeopardize the functions of automated monitoring. Do not locate equipment in an enclosed area which could restrict heat dissipation.
- Maintenance - Failure on the part of the responsible individual, hospital, or institution employing the use of this equipment to implement a satisfactory maintenance schedule may cause undue equipment failure and possible health hazards.
- Do not spray cleaning solutions directly onto the monitor. Moisture droplets may enter the internal components and cause equipment malfunction or failure. Cleaning solutions should be applied to a cloth and the cloth used to wipe the monitor clean. The monitor should be turned off during cleaning.

- Replacement Parts - It is highly recommended that only Agilent Technologies recommended parts and accessories be used with this equipment. Failure to do so may result in the degradation of performance. Accessories and parts for individual modules and components are listed at the back of the appropriate section in this manual.

Note—A note gives special instructions to highlight an operating procedure or practice. Notes may precede or follow the applicable text.

At this time, Agilent Technologies will make available on request, and in English only, such circuit diagrams, component part lists, descriptions, calibration instructions, or other information which will assist the user's appropriate qualified technical personnel to repair those parts of the equipment which are classified by Agilent Technologies to be repairable. A list of Agilent Sales and Support Offices is provided at the end of this manual.

Using This Manual

To enable you to find information easily, there is a contents list at the front of the guide and a comprehensive index at the back.

The User's Reference Manual is separated into two parts; the core document and the parameter module guides.

The Core Document

This section of the guide contains all the general information about the system. It is a good place for new users to start because it gives an introduction to the system and the way it works, and shows you how to get started. Here is a list of the major sections:

- Introducing the Agilent M1165/66/67/75/76/77A Component Monitoring System and the Agilent M1205A V24 and V26 monitors
- Getting Started
- Configuring the System
- Other Patients
- Alarm Functions
- Recording Functions
- Trends and Data Management
- Installation and Patient Safety
- Care and Cleaning

Parameter Module Sections

These sections each contain information for one parameter module. This covers setting-up, monitoring, and problem solving if you encounter difficulty. Each section is separated with a white tab which has the title of the section.

Note— The User's Reference Manual contains information for all the parameter modules available for the system. This means, of course, that depending on the model and number of modules you have ordered, the screens will not always apply to your system. However, the information for the parameters and functions is valid for all the systems.

Note—The screenshots displayed in this manual were generated in demo mode and may therefore differ from what actually appears on your screen during patient monitoring.

Notice to the User

Although there may be products in your area that look similar to the Agilent M1165/66/67/75/76/77A Component Monitoring System and the Agilent M1205A V24 and V26 monitors, their functionality may not be the same. This User's Reference Manual is intended to be used with the Agilent M1165/66/67/75/76/77A Component Monitoring System, the M1026A Anesthetic Gas Module and the Agilent M1205A V24 and V26 monitors only.

This Manual is only applicable for Release C.0 versions of the monitors listed above. A Release C.0 monitor can be identified by:

a. the Release C.0 label on the monitor, or

b. the suffix of the EPROMpack part number. To view this number, press **Monitor Setup** → **Monitor Revision** → **Show SW Rev**.
The suffix of the EPROMpack part number on a Release C.0 Agilent CMS is **A**.
The Software Revision of a Release C.0 Agilent V24 or V26 monitor is **L.xx.xx**

Responsibility of the Manufacturer

Agilent Technologies only considers itself responsible for any effects on safety, reliability and performance of the equipment if:

assembly operations, extensions, re-adjustments, modifications or repairs are carried out by persons authorized by Agilent, and

the electrical installation of the relevant room complies with national standards, and

the instrument is used in accordance with the instructions for use.

To ensure optimum usage, we recommend that Agilent parts and accessories are used in conjunction with the Agilent M1165/66/67/75/76/77A Component Monitoring System, the Agilent M1026A Anesthetic Gas Module and the Agilent M1205A V24 and V26 Monitors, wherever available. If non-Agilent parts are used, Agilent Technologies is not liable for any damage that these parts may cause to the Agilent equipment.

Manufacturer´s Address

For South America, North America and Canada:

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Contents

14
ECG and ECG/Respiration Module Section

This chapter describes the ECG module and the ECG/RESP module. You will find information on ECG and respiratory monitoring, troubleshooting, and ST Segment monitoring. It includes the following sections:

Note—**EASI**™ is a trademark of Zymed Inc.

Introduction to ECG Parameter Module

What does it Measure?

Monitoring the ECG produces a continuous waveform of the patient's cardiac electrical activity to enable an accurate assessment of his current physical state.

- The system displays the average Heart Rate (HR), this can be derived from the ECG or a remote arrhythmia computer.
- You can select HR or PULSE (PULSE can only be selected if you are monitoring invasive pressure or pleth) as the alarm parameter - both share the same alarm limits.

The EASI™ option allows you to derive all 12 standard ECG leads, using a 5-electrode ECG cable and a special electrode placement. This is described on "EASI™ 12-lead ECG Display, Printing and Recording" on page 14-33

How the ECG/RESP Parameter Works

With the ECG or the ECG/RESP modules listed below, you can use a 5- or a 3-electrode ECG cable set to derive up to 8 selectable ECG leads which can be displayed in up to 3 channels.

Note—**EASI™**: With any of the ECG modules listed below and the EASI™ option switched on, you can use a 5-electrode ECG cable set to derive the 12 standard ECG leads of which up to 3 can be displayed on the monitor.

Modules

- M1001A/B ECG Module
- M1002A/B ECG/RESP Module
- **CMS Only:** M1002A Option C01 ECG/RESP Module with Analog Respiration Output

- If you are monitoring with a 3-lead set you can select one lead out of I, II or III to be displayed in 1 channel.
- If you are monitoring with a 5-lead set you can select any two leads from I, II, III, aVR, aVL, aVF, V or MCL_1 to be displayed in

channel 1 and channel 2. Channel 3 (CH3) will only monitor the V lead.

- **EASI™:** With a 5-lead set and EASI™, you can select any lead you want to monitor in all three channels.

Automatic 3-lead versus 5-lead Detection

- If the monitor is turned on with a 3-lead cable connected to the ECG module and your monitor is configured for 2 or 3 ECG channels, a limb lead will automatically be monitored in channel 1, even if you have configured a different lead (for example aVR or aVF). After 1 minute, channels 2 and 3 will be automatically turned off.

- If you unplug the 3-lead cable and plug in the 5-lead cable, the Monitor automatically recovers its configured state, as long as a lead has not been changed, or a channel has not been switched ON or OFF manually in the meantime.

    a. If you are using a 5-lead set (without using EASI™ software and placement) and the RL electrode falls off, then the Monitor automatically switches to a limb lead and monitors a 3-lead set in channel 1. You can recover the Monitor's original 5-lead state as follows:
        1. Reattach the RL electrode within 1 minute.
        2. unplug and plug in the cable again, or unplug and plug in the frontend module again.

    b. If you are using a 5-lead set with EASI™ and the RL (N) or A electrode falls off, the Monitor cannot switch to a limb lead so an INOP will result.

The Patient Cable

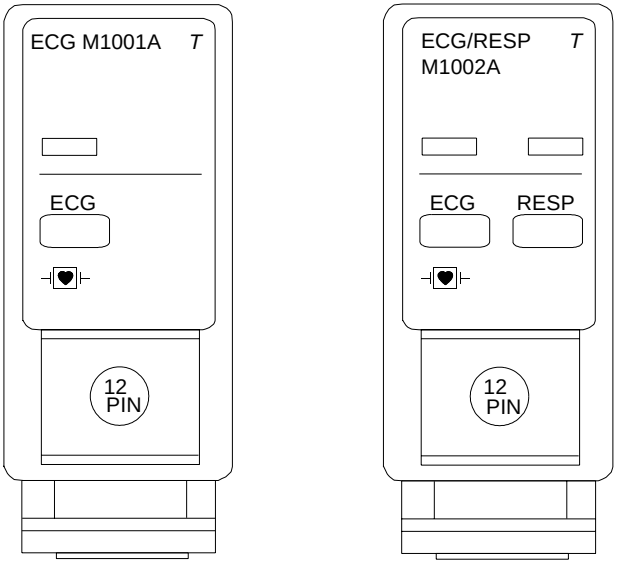
The patient cable is either single-piece or consists of 2 sections:

1. The trunk cable which connects to the monitor.
2. The lead set which connects to the patient.

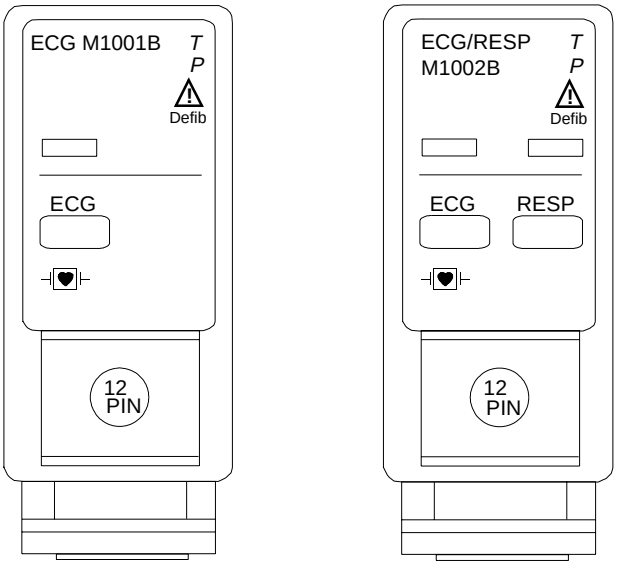
The Module

- The front of the module has the key(s):
    – The ECG key for parameter setup, a light will appear above the key when you are in the setup.

– (M1002A/B only) The RESP key for parameter setup, a light will appear above the key when you are in the setup.



The settings are transferred with ECG and ECG/RESP modules that have a *T* on the front. For more information on Parameter Settings Transfer, refer to “Parameter Settings Transfer” on page 14-46



Note—All ECG and ECG/RESP modules **without** a *P* on the front have a signal delay of <20ms
All ECG and ECG/RESP modules **with** a *P* on the front have a signal delay of <30ms

Warning

⚠ Defib **Your ECG/Defibrillator combination is configured to detect R waves from a high lead ECG signal. According to the specifications defined by AAMI the peak of the synchronized defibrillator discharge should be delivered within *60msec* of the peak of the R wave.**
The Agilent M1001A/B and M1002A/B ECG modules meet the AAMI specifications, however your biomedical engineer should verify that your ECG/Defibrillator combination does not exceed the recommended maximum delay of 60msec.

RESP Parameter

If you want to monitor respiration this can be done from the ECG electrodes. See “Respiratory Monitoring Setup” on page 14-18.

Considerations When Monitoring ECG

Listed below are important considerations to remember when monitoring ECG.

- Interference from a non-grounded instrument near the patient, and ESU interference can cause problems with the waveform. Refer to *Recommended ECG Lead Placement for Surgical Patients* in this section for more details.
- Radiated field strengths above 0.7V/m may cause noise on the ECG and respiration waves at various frequencies, though this noise does not influence the accuracy of the Heart Rate or Respiration Rate. If operating under conditions according to the EMC-standard 60601-1-2 (Radiated Immunity 3 V/m), field strengths above 1 V/m may cause erroneous measurements at various frequencies. Therefore it is recommended to avoid the use of electrically radiating equipment in close proximity to ECG/respiration measurements.
- If an ECG module is inserted into the System and ECG monitoring commenced when the patient is in asystole, the asystole alarm will be generated about 15 seconds later.
- If you get an INOP caused by pacemaker activity, reduce the size of ECG-CH1 until the status message is removed, or select a lead that produces a smaller pace pulse. (This INOP does not occur if you are using the EASI™ option).
- After defibrillation, the screen display will recover within 10 seconds if the correct electrodes are used and applied in accordance with the manufacturers instructions.

Warning

DO NOT TOUCH THE PATIENT, OR TABLE OR INSTRUMENTS DURING DEFIBRILLATION

When connecting electrodes and/or patient cables, ensure that the ECG leads and connectors do not come into contact with other conductive parts or earth.

ECG Monitoring Setup

1. Check that the ECG or ECG/RESP module is inserted in the rack.
2. Plug in the patient cable to the ECG module.
3. Prepare the patient's skin prior to placing the electrodes.

   The skin is a poor conductor of electricity, therefore preparation of the patient's skin is important to facilitate good electrode to skin contact. Recommendations:

   – Shave hair from sites, if necessary.

   – Wash sites thoroughly with soap and water. (Never use ether or pure alcohol, because this increases skin resistance).

   – Dry briskly to increase capillary blood flow in the tissues and remove skin cells and oil.

   – Attach clip or snap to electrode prior to placement.

4. Place the electrodes on the patient. Use electrode gel prior to placement if pre-gelled electrodes are not used.

   Remember to select a site where the signal will not be interfered with by either movement or bones.

5. Attach the electrode leads to the patient cable.
6. Switch on the monitor (if it was not on before) using power ON/OFF switch.

Note—In both auto and manual modes, if the lead of the first channel is in INOP for at least 10 seconds, the leads in channel one and two are automatically exchanged. This means that the lead of channel two is displayed in channel one so that the heart rate counter can continue to count. If the situation which caused the INOP is rectified, and the user selected lead is out of INOP for at least 10 seconds, the leads will be swapped back again.
The automatic swapping of the leads can be configured on or off during

the installation of the monitor. If automatic swapping is set to off, the lead in channel one is only displayed when a signal is available.

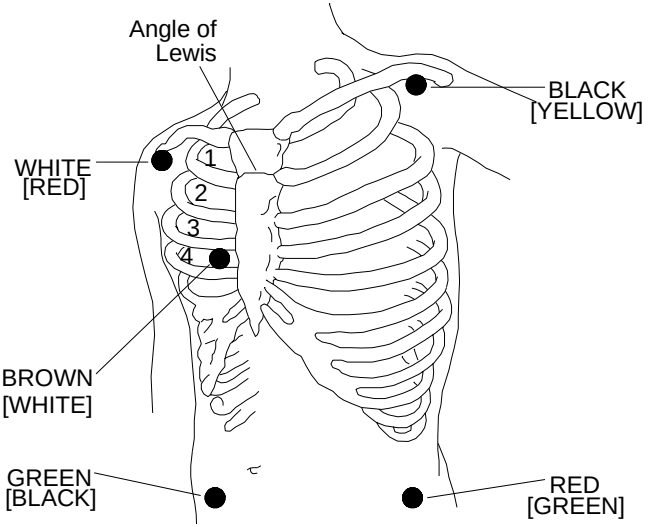
Note—**EASI™:** If the E, S or I electrodes fall off, the monitor shows a non-standard lead (that is, one of the 3 EASI™ vectors) labelled "ECG" until the electrode is reattached.
There is no automatic lead swapping for EASI™.

Placing the Electrodes for ECG Monitoring

Note—When EASI™ lead placement has been configured, “EASI” is shown beside the 1mV calibration bar on the ECG wave in channel 1. For EASI™ lead placement, see “Electrode Placement with a 5-Lead Set for EASI™ 12-lead.” on page 14-33.
You can switch from EASI to standard lead placement in the Change Lead Task Window of each channel. See “Switching between EASI and Standard leads” on page 14-22 for details.

Note—Electrode labels and colors are given for U.S. norm and in square brackets [-] for European norm.

Standard Electrode Placement with a 5-Lead Set.

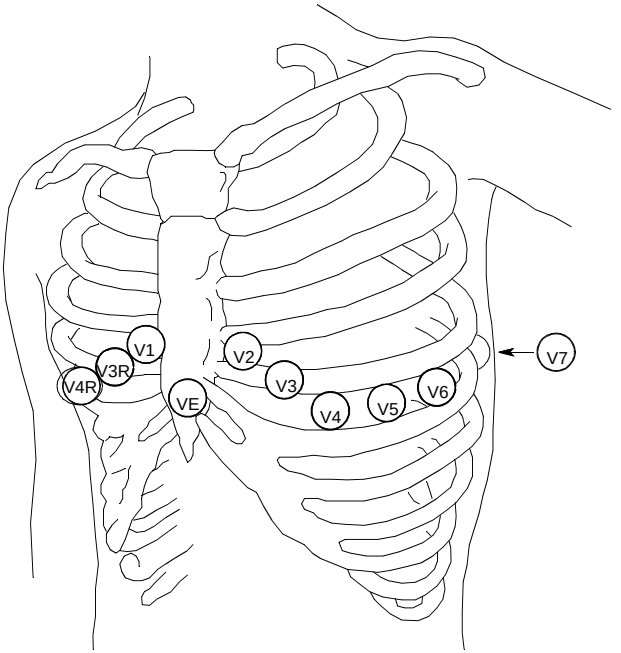


COLOR CODING

Label	AAMI Color Coding	IEC Color Coding	
RA	WHITE	(RED)	place directly below the clavicle and near the right shoulder.
LA	BLACK	(YELLOW)	place directly below the clavicle and near the left shoulder.
C	BROWN	(WHITE)	place on the chest as illustrated on following page.
RL	GREEN	(BLACK)	place in right lower abdomen.
LL	RED	(GREEN)	place in left lower abdomen.

Note—To ensure patient safety, all leads must be attached to the patient.

For 5-Lead configuration. Place the V electrode at one of the locations shown below, so as to get the best quality signal:



Note—For accurate V lead placement and monitoring it is important to locate the 4th intercostal space. The 4th intercostal space is determined by first locating the first intercostal space. Because patients vary with respect to body shape, it is difficult to palpate the 1st intercostal space with accuracy. Thus, locate the 2nd intercostal space by first palpating the little bony prominence, called the **Angle of Lewis**, where the body of the sternum joins the manubrium. This rise in the sternum identifies where the second rib is attached, and the space just below it is the second intercostal space. Palpate and count down the chest until you locate the 4th intercostal space.

- V1 on the 4th intercostal space at the right sternal border.
- V2 on the 4th intercostal space at the left sternal border.
- V3 midway between V2 and V4 electrodes.

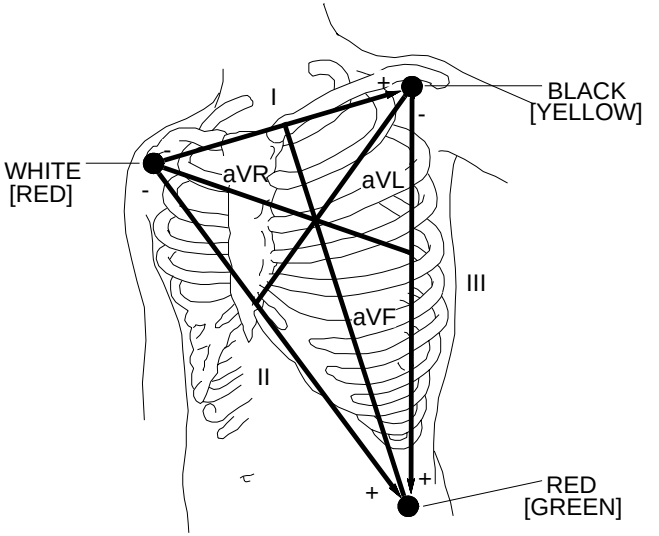
- V4 on the 5th intercostal space at the left midclavicular line.
- V5 on the left anterior axillary line, horizontal with V4 electrode.
- V6 on the left midaxillary line, horizontal with V4 electrode.
- V3R-V6R on the right side of the chest in positions corresponding to those on the left.
- VE over the xiphoid process.

For posterior V lead placement, place the V electrode at one of the following locations.

- V7 on posterior chest at the left posterior axillary line in the 5th intercostal space.
- V7R on posterior chest at the right posterior axillary line in the 5th intercostal space.

Electrode Placement with 3-Lead Sets (Standard Configuration)

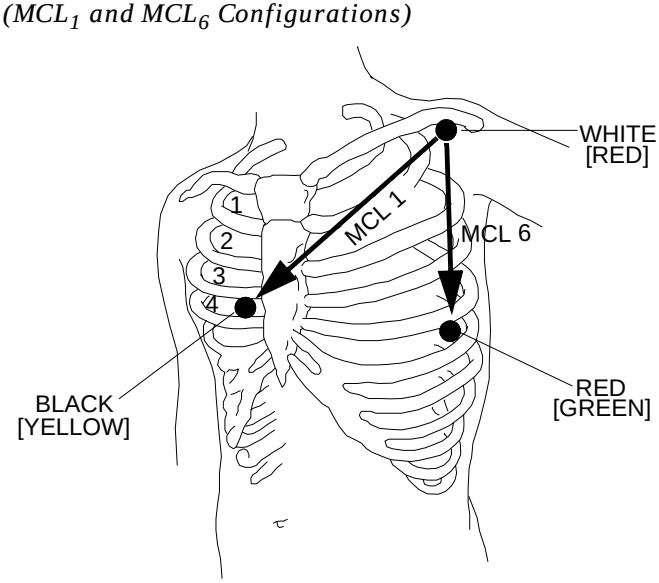
Note— Not for simultaneous monitoring of more than one ECG lead. For more than one simultaneous channel of ECG, use 5-lead electrode set.



- White(RA) electrode - place directly below the clavicle and near the right shoulder.
- Black(LA) electrode - place directly below the clavicle and near the left shoulder.
- RED(LL) electrode - place in left lower abdomen.

Lead Position	(-)	(+)	Reference
1 (I)	RA	LA	LL
2 (II)	RA	LL	LA
3 (III)	LA	LL	RA

Electrode Placement with 3-Lead Sets! (MCL_1 and MCL_6 Configurations)



Select **Lead I** for monitoring the MCL_1 configuration. Electrodes need to be moved or switched according to the following instructions. As you will notice, you must attach lead wires to areas of the chest that do not coincide with the electrode labels (that is, that do not coincide with the RA, LA and LL labels).

- White(RA) electrode - place directly below the clavicle and near the left shoulder.
- Black(LA) electrode - place on the 4th intercostal space at the right sternal border.
- RED(LL) electrode - place on the left midaxillary line at the 5th intercostal space.

Note—This modified lead placement allows monitoring of the MCL_6 lead. Simply select **Lead II** on the monitor for MCL_6.

Recommended ECG Lead Placement for Surgical Patients

The placing of the ECG leads will depend on the type of surgery that is being performed. For example, with open heart surgery the electrodes may be placed laterally on the chest or on the back.
In this case you will no longer be monitoring the standard leads.

In the operating room artifacts can sometimes affect the ECG waveform due to the use of ES (electro-surgical) equipment. To help reduce this you can place the electrodes on the right and left shoulders, the right and left sides near the stomach, and the chest lead on the left side at mid-chest. Avoid placing the electrodes on the upper arms otherwise the ECG waveform will be too small.

Warning

- **To protect against the hazard of burns when using high frequency surgical equipment in the OR, only the OR orange lead sets should be used (part numbers can be found in the Accessories section of this chapter). With this lead set, respiration cannot be measured. To avoid triggering unnecessary RESP alarms in this situation, it is possible to configure the RESP parameter to be Off when the system is switched on. This setting is made in the special Configuration Mode.**
- **All specified patient lead cables are protected against the effects of the discharge of a defibrillator.**

Caution

- When using ES equipment, never place an electrode near the grounding plate of the ES device, as significant interference with the ECG signal occurs.

  The electrodes should be approximately equidistant from an axis joining the ES knife and the ES grounding plate.

- Do not apply leads directly to the external wall of the heart.

Respiratory Monitoring Setup

How Respiration is Measured

The system measures respiration from the amount of thoracic impedance between two ECG electrodes. The change of impedence between the two electrodes, (due to the thoracic movement), produces a respiratory waveform on the screen.

For respiratory monitoring you do not need additional electrodes but the placing of electrodes is important. If the patient is using the thoracic muscles you can use the electrode placement as shown on page 14-19.

Some patients, due to their clinical condition, expand their chest laterally causing a negative intrathoracic pressure. In these cases it is best to place the two respiratory electrodes laterally in the right midaxillary and left lateral chest areas at the maximum point of breathing movement to optimize the respiratory waveform.

Note—Respiratory monitoring is not recommended for patients who are very active as this can cause false alarms to occur.

Note—Implantable pacemakers which are minute ventilation rate-adaptive can occasionally interact with the impedance measurement of cardiac monitors causing the pacemakers to pace at their maximum programmed rate.

Checklist for Respiratory Monitoring

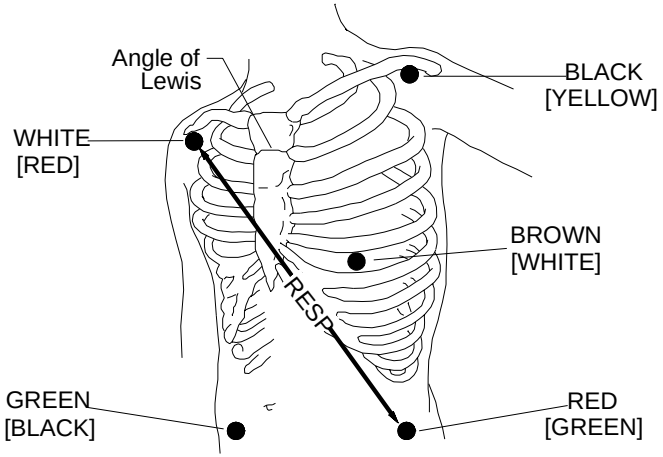
1. Plug the patient cable into the ECG/RESP module.
2. Prepare the patient's skin prior to placing the electrodes.
3. Attach snap or clip to the electrodes and attach the electrodes to the patient as described above.
4. Switch on the monitor (if not already switched on).

Placing the Electrodes for Respiratory Monitoring

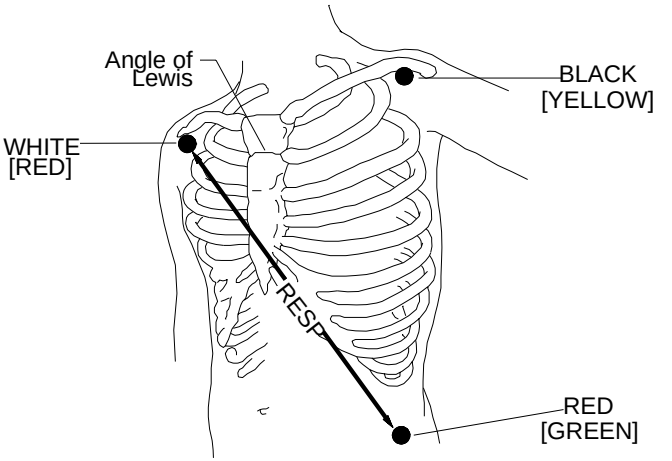
Note—Position the White (Red) and Red (Green) electrodes diagonally to optimize the respiration waveform. Avoid the liver area and the ventricles of the heart in the line between the respiratory electrodes so as to avoid cardiac overlay or artifacts from pulsating blood flow.
This is particularly important for neonates.

Note—**EASI™**: Respiratory monitoring **is** also possible with the the EASI™ placement shown in "Electrode Placement with a 5-Lead Set for EASI™ 12-lead." on page 14-33.

Electrode Placement with a 5-Lead Set



Electrode Placement with a 3-lead Set



Note—Respiration can only be monitored with an ICU ECG cable set, not with an OR ECG cable set. This is because of the higher internal impedance of the OR cable set, required for use if electro-surgery is being performed.

ECG/RESP with Analog Respiration Output

Option C01 of the M1002A/B ECG/RESP Module provides an analog respiration output signal for use with external devices. A standard BNC cable is required to connect the device to the output socket situated at the top left of the module.

Note—Avoid accidental disconnection of the BNC cable by locking it into the socket. Always turn the connector clockwise.

Note—The BNC Cable must not exceed 4 meters (13 feet) in length.

Note—Always keep the cable away from working space.

Caution

The module provides an output signal only. Do not attempt to input any other signal or data into the BNC output socket.

ECG Adjustments

Information about the following ECG adjustments is provided on the proceeding pages:

- Changing the lead
- Adjusting the waveform size
- ECG waveform settings
- Changing the filter bandwidth
- Changing the QRS detection mode
- Adjusting the QRS detection level
- Adjusting the alarm limits
- Changing the alarm parameter

Changing the Lead

A 5-lead set is optional for the System. This gives you a choice of leads for the first 2 channels: I, II, III, aVR, aVL, aVF, V, MCL1. The third channel displays one of the V leads, V_1, V_2, V_3, V_4, V_5, or V_6.

Note—**EASI™:** The EASI™ software gives you a choice of leads for all 3 channels : I, II, III, aVR,aVL, aVF, V_1, V_2, V_3, V_4, V_5, V_6.

With a 3-lead set, (1 channel only), all the lead labels are displayed on the screen but only leads I, II, or III can be processed.

If you choose one of the other leads it will cause an INOP.

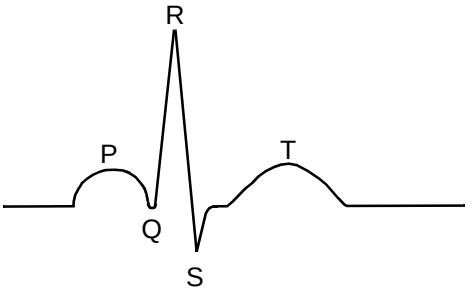
You cannot use a 3-lead set with the EASI™ option. If you try to use a 3-lead set with the EASI™ option, the prompt “EASI ECG requires 5 electrodes” will be issued.

If you are not receiving a good ECG waveform and the electrodes are securely placed, you should try changing the lead in which you are monitoring.

Characteristics of a Good Signal

Normal QRS complex

- Tall and narrow with no notches (for a good HR measurement).
- R-wave should be tall.
- Pacer pulses should be smaller than the R-wave height.
- T-wave should be less than the R-wave height (for a good HR measurement)
- P-wave should be much smaller than the T-wave.



Switching between EASI and Standard leads

In the Change Lead Task Window of each channel you can also switch between EASI and Standard lead placement:

Procedure

1. Press **Confirm** to change to standard lead placement (if EASI is active) or to EASI lead placement (if standard is active). To cancel the procedure, press **Change Lead**.

2. You will be prompted to change the electrode placement. After performing the change, press **Confirm**.

3. Monitoring will be interrupted for 15 seconds and will then resume with the new setting.

Adjusting the Waveform Size

If either autoadjust or autosize ECG wave settings is selected (in Configuration mode), an automatic size adjustment will be performed in the following situations:

- after power on
- after the module has been plugged in, or a lead has been off for longer than 60 seconds
- between 7 and 15 seconds after lead change.

When the ECG wave has been adjusted, the gain is frozen.

You can also manually change the size of the ECG waveform by entering the Adjust Size Task Window.

This Task Window also enables you to set the waveform to a specific size in order to get a calibrated ECG wave recording of 10 mm/mV. Two wave sizes, x1 or x2, are available. Select the wave size shown in the table for your recorder and its sector size in order to get a calibrated 10 mm/mV recording.:

Recorder	Sector size	Wave Size
M1116A/B Module Recorder	40 mm 20 mm	x1 x2
M1117A Bedside Recorder **(CMS Only)**	50 mm 25 mm	x1 x2
Central Recorder	40 mm and 50 mm	x1

Note—Pressing the **Adjust Size** key changes the size of this individual channel. Pressing the **Confirm** key changes the size of all three channels simultaneously. For viewing and recording multilead ECG, the size and filter of channel 1 is used for all leads of the multilead ECG.

Note—**EASI™:** If you are using EASI™, you cannot adjust the gain at the ECG Out using the **Adjust Size** key.

Note—On touch-operated monitors, you can use the arrow buttons below the size bar to adjust the size of the ECG waveform.

Indication for Adjusting the Size

If the system is in manual mode and the pace pulse is the same size or larger than the R-wave, you can select a lead that produces a smaller pace pulse, or you will need to change the size of the QRS complex so that the R-wave is larger than the pace pulse otherwise the pace pulse could also be counted and this will double the heart rate count.

Notes—

- If you get an INOP caused by pacemaker activity the message `Pace pulses too large - reduce size of ECG-CH1` is displayed in the status line. Reduce the size of ECG-CH1 slowly until the status message is removed or select a lead that produces a smaller pace pulse.

ECG Waveform Settings

There are four possible configuration settings which control the size and the position of the ECG wave. The settings must be selected in a special *Configuration Mode* by your biomedical engineering department, or the Agilent Service Engineer.

Autoadjust

This is the factory default. The size of the wave is automatically adjusted to fit inside the channel. The position of the wave is optimized so that the middle of the wave occupies the middle of the channel, unless ST monitoring is switched on. In this case the wave is not centered.

Autosize

The size of the wave is automatically adjusted to fit inside the channel, without changing position.

Gain x 1

The size of the wave is not automatically adjusted. It is always displayed with a gain of x1. (The amplitude of the wave is magnified by 1000.)

Gain x 2

The size of the wave is always displayed with a gain of x 2. (The amplitude of the wave is magnified by 2000.).

Changing the Filter Bandwidth

The filter bandwidth refers to a measure of electrical frequencies contained within an electrical signal. Depending on the measurement conditions, you may want to change the ECG's filter to remove some of these electrical frequencies. The System offers a choice of filter bandwidth settings:

- Filter
- Monitor
- Diag

These settings can be selected by pressing the **Filter/Mon/Diag** key.

Indications for Changing the Filter Bandwidths

- *Filter* - use if signal is distorted. The filter bandwidth reduces interference to the signal. In the operating room the filter reduces the artifact and interference from electrosurgical units. In normal monitoring situations the filter may suppress the QRS complexes too much. It is important to remember that using the filter bandwidth is not a replacement for good skin prep.

  If the monitor is configured for the O.R. and it is in monitor or diagnostic mode, it will automatically switch to filter mode during episodes of electro-surgical interference (ESU). It will return to its original setting once the interference stops.

- *Monitor* - use in normal monitoring situation. The monitoring bandwidth filters out artifacts which may cause false alarms.

- *Diag* - use when diagnostic quality is required. The diagnostic bandwidth allows the monitor to display an unfiltered ECG wave. This enables the clinician to detect changes in the ECG, for example, R-wave notching and ST segments.

A letter indicating the filter bandwidth is shown next to the HR numeric. **F** is filter, **M** is monitoring, and **D** is diagnostic.

When ST monitoring is ON, the low end bandwidth for *diag, monitor* and *filter* always defaults to a lower value of 0.05 Hz. This enables the clinician to detect changes in the ECG, for example, discrete elevation or depression of S-T segments. When ST monitoring is switched OFF, the bandwidth automatically returns to the previously selected filter, monitoring or diagnostic bandwidth.

Note—For viewing or recording multilead ECG, the bandwidth setting for channel 1 is used for all leads of the multilead ECG.

Note—**EASI™:** For EASI™ 12-lead ECG, the same bandwidth setting is used for all leads of the ECG.

Changing the QRS Detection Mode

You have a choice of auto or manual modes:

- In **auto** mode the QRS complexes are detected automatically.
- In **manual** mode the QRS detection level appears on the screen as a horizontal line across the ECG wave. This enables you to see exactly what is causing the heart rate counter to count.

These two detection modes are available for adult, pediatric and neonatal non-paced and paced patients.

Indications for Changing Mode

Auto Mode - use in normal monitoring situation.
Manual Mode - use in exceptional cases if the monitor miscounts the heartrate. If arrhythmia monitoring is assigned, the monitor automatically switches to Auto mode.

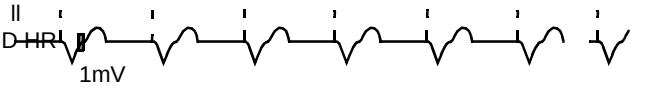
Warning

In manual mode you may have to readjust the QRS detection level if the waveform size or the shape of the QRS complex has changed.

Paced Patients vs Non-Paced Patients

In the **non-paced** patient mode no pace pulses are expected and no pace pulse rejection occurs.

In **paced** patient mode the pace pulses are annotated with a small dash on the screen, as shown in the figure below:



Auto/Manual pacing cannot be adjusted when arrhythmia channels are assigned or an arrhythmia computer is being used. The arrhythmia function cannot recognize which paced mode has been selected in the Monitor. For this reason, whenever arrhythmia is assigned you have to reselect paced mode. If you are using the Agilent Information Center (M3150A/M3153A), you select paced mode in the Admit Window. If you are using CCM (M2300), you have to select the paced mode in the arrhyth functns Task Window at either the monitor or the Central Station. After arrhythmia has been assigned during the use of an arrhythmia computer, the Monitor stays in “Paced Patient” mode.

If heartrate is counted irregularly or there are too many (unaccountable) pacer marks on a paced patient monitored in “Paced Patient” mode, do not use the instrument for further patient monitoring. Contact the hospital biomedical engineer.

Warning

- Beats with a pacer spike within the QRS complex may not be detected by the System's QRS detector.
- The paced/non-paced selection should be based on your specific patient situation - “paced mode” should be used for paced patients, and “non-paced mode” used for non-paced patients. Using the non paced mode with paced patients may result in pace pulses being counted as regular QRS complexes which could prevent an asystole alarm from being activated.

Adjusting the QRS Detection Level Manually

The QRS detection level only needs to be adjusted if the monitor is in manual mode - If the monitor is in auto mode, the QRS complexes are detected automatically.

Note—Ventricular fibrillation alarms will function in both automatic **and** manual modes.

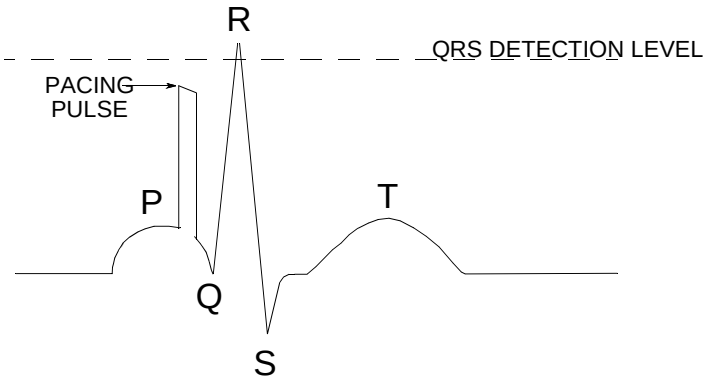
Non-Paced Patients

Set the QRS detection level at a location where it is guaranteed to cross the QRS complex.

Paced Patients

The pace pulse in manual mode is set to a fixed size on the display. This enables you to increase the size of the ECG wave independently and thus set the QRS detection level above the pace pulses so that only the QRS complex is causing the heart rate counter to count. An example of incorrect and correct positioning of the QRS Detection Level is shown in the diagram below.

Correct Positioning of the QRS Detection Level



Changing Alarm Parameter

In some situations it may be impossible to derive an accurate HR from an ECG, for instance because of excessive ECG artifact or because of inability to place electrodes on a patient with burns. If a pulsatile pressure is being monitored (pressure or pleth), you can choose PULSE as the alarm parameter.

Adjusting the Alarm Limits

You can set the heart rate alarm limits according to the individual patient's clinical condition.

The high rate alarm setting is also important in QRS detection. You should not set the upper limit too high otherwise it may cause the heart rate counter to miscount. Set the limit no higher than 20 beats per minute higher than the heart rate, taking into account the variability.

The alarm limits that you set are shared by the HR/PULSE parameters, but only one of these parameters can be in active alarm function.

Warning

Red alarms for Asystole, V. Fib. and Brady will not occur with Pulse selected as the active alarm function. If Pulse is selected, the following status message is displayed on the Agilent CMS: *"ECG Alarms Off. To switch on, select HR."*

As both numerics are displayed on the screen, the parameter that has not been chosen as the alarm parameter will have a 🔕 sign next to the parameter label.

Switching ECG Parameter Alarms On/ Off

ECG parameter alarms can be switched on/off, like any other parameter. If, however, arrhythmia is assigned to the bedside and all alarms are switched off (the **Suspend** key has been pressed), then if you go into the ECG Task Window, the **On/Off Alarms** softkey is hollow and there is a 🔕 sign beside the ECG alarm bar and HR reading.

Changing Brady Limit

If the alarm source for HR is ECG, you can set a red brady alarm for neonates and pediatrics. When the patient's HR falls below the low alarm limit, a yellow alarm is activated. If it then falls below the brady limit a red alarm is activated.

When you go into the HR Alarm Adjust Task Window, in neonatal or pediatric mode, you will see the brady alarm limit displayed above the HR low alarm limit. For example, the low alarm limit may be 100 and the brady limit 80. If the HR falls below 100, a yellow alarm is activated. If it then continues to fall below 80, a red alarm is activated.

The difference between the HR lower alarm limit and the brady alarm limit can be set in a special *Configuration Mode* by your biomedical engineering department. For example, you may want a lower alarm limit of 80 with a brady alarm limit of 70 (Brady Limit Diff =10). You can even set the brady alarm limit to be the same as the lower alarm limit. In this case, you would always see a red low heart rate alarm.

A brady alarm delay time can also be set in this special *configuration mode*. This defines the amount of time the HR needs to be below the brady limit, before a red alarm is activated. For example, if the delay time is set to 3 seconds, the HR has to remain below the brady limit for 3 seconds before a red alarm is activated. Choosing a short brady delay time (for example, less than 3 seconds) may increase the probability of issuing false brady alarms.

Tone Modulation

If tone modulation is configured, the pitch of the QRS tone is related to the SpO_2 level. If the SpO_2 level drops, the QRS tone becomes lower.

The QRS tone is derived from the alarming parameter, which can be configured as *either* HR *or* pulse in the "Adjust Alarms" Task Window. If the numerics for the alarming parameter are set to "Off" when the monitor is switched on, there will be no QRS tone and therefore no tone modulation is possible.

If the alarm parameter source goes into INOP, the modulated QRS tone does not stop. Instead, it is derived from PLETH, if the PLETH parameter is on.

Note—Tone modulation is selected in a special Configuration Mode, by your biomedical engineering department. You can have tone modulation configured as either "Off", "Standard" or "Enhanced":

Standard: The tone decreases by a small amount for each drop in the SpO_2 level. (This is equivalent to that used in *NELLCOR*® equipment.)

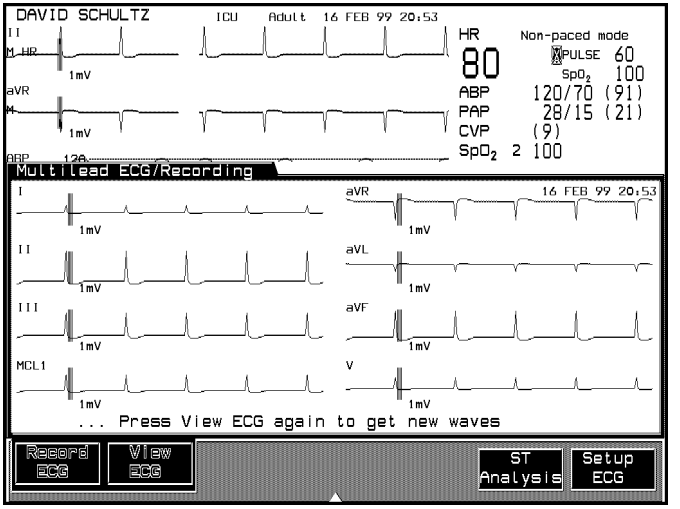
Enhanced: The tone decreases more dramatically for each drop in the SpO_2 level, and is therefore easier to recognize.

Multilead ECG Display and Recording

The Multilead ECG capability allows you to view and record a snapshot of 8 ECG leads.

For multilead ECG viewing and recording, you will need to use a 5-lead ECG cable.

The size and filter bandwidth of channel 1 (ECG-CH1) is used by the system as a reference if the remaining channels have differing size and filter bandwidth settings. For example, if the size or filter bandwidth for channels 2 and 3 are different to that of channel 1, the system will change the size or filter bandwidth of channels 2 and 3 to correspond to channel 1 for the multilead procedure. After the multilead procedure, the original settings will be returned



EASI™ 12-lead ECG Display, Printing and Recording

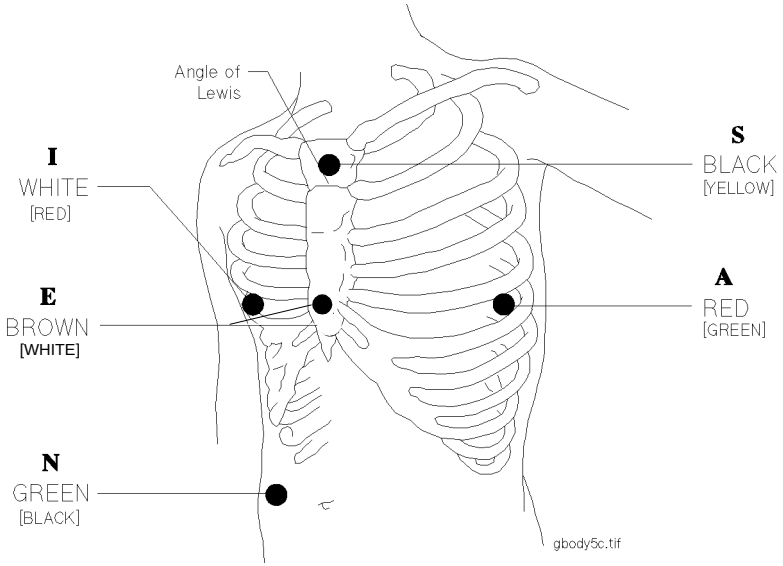
Note—In the USA, EASI™ 12-lead ECG is only for use on adult and pediatric patients.

The optional EASI™ 12-lead ECG capability allows you to view and record or record a snapshot of 12 ECG leads.

For EASI™ 12-lead ECG viewing and recording, you will need to use a 5-lead ECG cable. The electrode placement for EASI™ is given below.

Note—You must select the EASI™ lead placement in the ECG Configuration Task window for this placement to work.
When EASI™ lead placement is selected, "EASI" is shown beside the 1mV calibration bar on the ECG wave in channel 1.

Electrode Placement with a 5-Lead Set for EASI™ 12-lead.



Note—Great care must be taken to place the electrodes as accurately as possible for the best quality EASI™ measurements.

- S - Black [IEC: Yellow] (LA) electrode - place on the upper sternum.
- E - Brown [IEC:White] (V) electrode - place on the lower sternum at the level of the fifth intercostal space.

- I - White [IEC: Red] (RA) electrode - place on the right midaxillary line at the same level as the E electrode.
- A - Red [IEC: Green] (LL) electrode - place on the left midaxillary line at the same level as the E electrode.
- Green [IEC: Black] (REF) electrode - place anywhere.

If the electrode placement shown is not possible on your patient (because of plasters or therapeutic equipment), the E and S electrodes can be moved in parallel to the patient's right, but this move should be kept as small as possible.

If the electrode placement shown is not possible due to pulmonary problems, the A and I electrodes can be moved up or down in parallel. Moving the electrodes down produces better measurements than moving them up.

Note—Respiratory monitoring is also possible with the the EASI™ placement. Respiration is measured between the I and A electrodes.

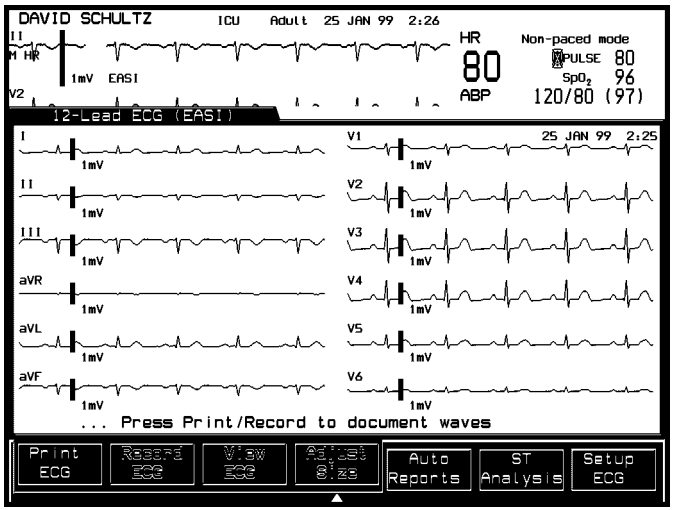
To View a 12-Lead ECG

1. Press **Capture 12-Lead** in the Procedures task window,

   or

1. **12-Lead ECG** in the ECG Main Task window (channel 1).
2. Press **View ECG** to view/preview the 12-lead snippets.

Example of a 12-lead ECG display



3. You can change the size using the **Adjust Size** softkey or the up and down arrows. (Pressing the key changes the size of the 1mV calibration bar for the first channel. The waves change size 1 second after you have finished adjusting the calibration bar.)

Press **Print ECG** in the 12-lead Task window to print the 12-lead snippets to the local or central printer.

Press **Record ECG** in the 12-lead Task window to record the 12-lead snippets on a central or local recorder.

Note—Use diagnostic bandwidth for the optimal signal definition. Due to network transmission restrictions, the bandwidth printed on a central recorder is of reduced resolution.

The same filter bandwidth is used by the system for all channels. The 12 lead snippets are all the same size. The initial size is set in the EASI™ ECG Configuration Task Window in Configuration Mode.

Adjust the size to "x2" to get 1cm/mV on the printout.

You cannot adjust the size of the waves after you have printed them. If you need to change the size of the waves, you should capture the 12-leads again.

Scheduled or Triggered 12-Lead Reports

Press **Auto Reports** in the 12-lead Task window.

The type of alarm that triggers a report as well as the kind of report (printer or recorder) can be set up in the EASI™ Configuration Task Window in Configuration Mode. You can select between

- No Reports.
- Reports On Alarm, triggered by ST alarms, or ST & HR alarms. The type of alarm that triggers a report can be set in the EASI™ ECG Configuration Task Window. Reports generated by an ST & HR alarm have a  symbol, reports for an ST alarm have an  symbol.
  Arrhythmia alarms will also generate a 12-lead printout if you select ST & HR alarms.
- Scheduled reports, which can be at any multiple of half an hour between a half an hour and 48 hours (0.5, 1.0, 1.5, 2.0,...48). Scheduled reports are marked with a  symbol.
- All, which selects the scheduled reports you have set and any reports triggered by an ST or ST&HR alarm.

EASI™ Configuration

In the ECG configuration in configuration mode, you must first select EASI™ lead placement. Then, in addition to the normal parameters for the ECG, there are a number of parameters just for the 12-lead.

- The 12-lead sequence lets you choose between normal and Cabrera order for the display, printing and recording of the 12-lead snippets.
  Normal order displays the lead snippets as follows:

I	V_1
II	V_2
III	V_3

aVR	V_4
aVL	V_5
aVF	V_6

Cabrera order displays the lead snippets as follows::

aVL	V_1
I	V_2
-aVR	V_3
II	V_4
aVF	V_5
III	V_6

Note—The 12-lead snippets on the recorder are paired so that you can cut the strip up and stick them on a sheet to get the Normal or Cabrera order given above.

- You can select the size of the 12-lead window as large or normal. The large window will cover all of the real-time traces on the screen. The normal window leaves space for 1 full trace above the task window.
- The next settings are for the automatic EASI™ reports, as described in “Scheduled or Triggered 12-Lead Reports” on page 14-36. Here you can select
  - Whether the report is generated for alarms, at scheduled times, for alarms and on schedule, or no reports at all.
  - Whether the alarm reports are triggered by ST or ST & HR alarms. HR alarms are selected automatically for monitors with no ST functionality.
  - The time interval between scheduled reports.

  - Whether alarm reports are output to the printer or recorder.
  - Whether scheduled reports are output to the printer or recorder.

- 12-lead on SDN is set to "Off". This parameter is for future use.

  Note—Only one precordial-lead can be transmitted on SDN.

- Set the initial size for the 12-lead snippets to
  - AutoAdj for a best fit.
  - GainCH1 to use the gain for channel 1 for all snippets.
  - Gain x1 sets all snippets to 0.5cm/mV.
  - Gain x2 sets all snippets to 1cm/mV.

  Note—The same gain applies to all 12 leads.

Respiration Adjustments

Changing the Respiration Detection Mode

The monitor counts the respiration using one of two modes, auto or manual.

In auto mode the monitor counts the respiration and adjusts the detection level automatically depending on waveform height, presence of cardiac artifact and absence of valid breaths. The auto mode is used in the following situations:

- When breathing is spontaneous with or without Continuous Positive Airway Pressure (CPAP).
- With ventilated patients, (except Intermittent Mandatory Ventilation - IMV).
- When the Respiration Rate (RR) does not approach the Heart Rate (HR).

In manual mode you set the detection level for counting the respiration. It is important to remember that if the depth of breathing changes the detection level may require adjustment. The manual mode should be selected in the following situations:

- When the RR approximately equals the HR.
- When the respiration is weak, heart activity, or movements of the chest wall caused by the heart, can cause artifacts. (In this situation, adjust electrode placement to improve the signal. Take special care when adjusting EASI™ placement - see “Electrode Placement with a 5-Lead Set for EASI™ 12-lead.” on page 14-33).

Adjusting the Respiration Detection Level

In manual mode the Respiration Detection Level is shown as a horizontal line across the respiratory waveform. Each downward stroke of the waveform which crosses the detection line is counted as a respiration.

The manual mode is more sensitive than the auto mode to any impedance changes, including artifact. You should check the waveform on the screen to ensure that it represents the patient's breathing pattern.

Caution

- If you move the detection level towards the waveform's baseline, the monitor is more likely to detect impedance changes due to cardiac activity. If apnea occurs in this situation the monitor might falsely interpret cardiac activity as respiratory activity and not detect the apnea.

  The apnea alarm would *not* be activated.

  You would remain unaware of this critical patient condition.

- Switching the RESP alarms OFF, also has the effect of switching the **apnea** alarms OFF.

ECG and RESP Alarm and INOP Messages

ECG Alarm Messages

The Heart Rate alarm messages are rated in order of severity:

***	Red
**	Yellow
	INOP message

Alarm tone = a single chime repeated every second.
INOP tone = a single beep repeated every 2 seconds.
Alarm limits are dependent on patient's condition.

Physiological Alarms

Alarm Message	Condition	Visual Indication	Audible Indication
***ASYSTOLE[1]	The interval between two QRS complexes has exceeded 4 seconds.	HR numeric (=0) blinks. Red alarm lamp.	Alarm tone
***VENT FIB[1]	The heart is fibrillating. Only in adult configurations.	HR numeric blinks. Red alarm lamp.	Alarm tone
***BRADY 60<80[1], [2]	HR has dropped below the selected Brady limit.	HR numeric blinks. Red alarm lamp.	Alarm tone
**HR 160>150	HR has exceeded the high alarm limit.	HR numeric blinks. Yellow alarm lamp.	Alarm tone
**HR 90<100	HR has dropped below the low alarm limit.	HR numeric blinks. Yellow alarm lamp.	Alarm tone

[1]If PULSE is the HR numeric source, there is no ASYSTOLE, VENT FIB or BRADY red alarm.

[2]Brady alarms will only be generated in neonatal or pediatric mode.

Technical Alarms

INOP messages appear when the monitor cannot measure or process signals properly. This could be due to patient-related or equipment-related problems but you must always check the patient's condition first. The INOP message is accompanied by an audible alarm which can be silenced with the **Silence/Reset** key.

Equipment-Related INOPS

INOP Message	Condition	Visual Indication	Audible Indication
LEADS OFF	Not all the required leads are attached or electrodes have been displaced.	HR numeric displays -?-.	INOP tone
LEADS OFF XX	Single electrode from lead XX detached.	If INOP occurs in channel 1, HR numeric displayed as -?-. After 10 seconds lead in channel 2 switches to channel 1 so that heart rate counter can operate. HR numeric displayed as normal.	INOP tone
LEADS OFF (EL.X)	Single electrode from lead E, S, or I is detached (EASI™ lead set).	A non-standard ECG signal is shown in channel 1, the HR numeric is derived. Channels 2 and 3 show baseline. ST is disabled.	INOP tone at beginning.
ECG/RESP UN PLUGGED	ECG/RESP module switched on and has been un-plugged from the rack.	HR numeric displays -?-.	INOP tone
ECG EQUIP MALF	Malfunction in the ECG hardware.	HR numeric displays -?-.	INOP tone

RESP Alarm Messages

Physiological Alarms

Alarm Message	Condition	Visual Indication	Audible Indication
***APNEA	RESP has exceeded the preset apnea alarm limit.	RESP numeric (=0) blinks. Red alarm lamp.	Alarm tone
**RESP 25>20	RESP has exceeded the high alarm limit.	RESP numeric blinks. Yellow alarm lamp.	Alarm tone
**RESP 6<8	RESP has dropped below the low alarm limit.	RESP numeric blinks. Yellow alarm lamp.	Alarm tone

Patient-Related INOPS

INOP Messages	Condition	Visual Indication	Audible Indication
RESP ERRATIC	Poor contact between the electrode and skin or excessive patient movement.	? next to RESP label.	None

Equipment-Related INOPS

INOP Message	Condition	Visual Indication	Audible Indication
ECG/RESP UN PLUGGED	ECG/RESP module switched on and un-plugged from the rack.	RESP numeric displays -?-.	INOP tone
RESP LEAD OFF	RESP lead fallen off, or electrode detached, or patient cable unplugged.	RESP numeric displays -?-.	INOP tone
RESP EQUIP MALF	Malfunction in the RESP hardware.	RESP numeric displays -?-.	INOP tone

Parameter Settings Transfer

Warning

Make sure that the ECG placement (Standard or EASI™) selected on the monitor to which you are transferring, and your patient's electrode placement are the same.

The following settings can be transferred with ECG and ECG/RESP modules that have a *T* on the front. For more information on Parameter Settings Transfer, refer to "*Parameter Settings Transfer*" in Chapter 3.

Setting Name	Meaning
Standard Lead on CH1 / CH2	Selected ECG lead
EASI™ Lead on CH1 / CH2 / CH3	Selected ECG lead
Paced Mode	Patient paced / non paced
Alarm parameter	Heart rate or pulse rate alarm source
Alarm limits	Heart / Pulse and respiration rate alarm limits
Apnea time	Apnea delay time

Note—**EASI™:** Both the EASI™ settings and the standard settings are transferred.

Accessories and Ordering Information

Note—All Agilent patient lead cables are protected against the effects of the discharge of a defibrillator.

Trunk Cables

Note—You cannot use 3-lead cables with the EASI™ option.

3-lead

AAMI:	M1500A - Trunk cable (2.7m)
	M1540C - Trunk cable (0.4m)
IEC:	M1510A - Trunk cable (2.7m)
	M1550C - Trunk cable (0.4m)

3-lead One Piece Cables

AAMI:	M1970A - OR (1.9m)
	M1972A - ICU (Snap, 1.9m)
IEC:	M1980A - OR (1.9m)
	M1981A - ICU (Grabber, 1.9m)

5-lead

AAMI:	M1520A - Trunk cable (2.7m)
	M1560A - Trunk cable (0.4m)
IEC:	M1530A - Trunk cable (2.7m)
	M1570A - Trunk cable (0.4m)

5-lead One Piece Cable

AAMI:	M1975A - OR (2.5m)
	M1977A - ICU (Snap, 2.5m)
IEC:	M1985A - OR (2.5m)
	M1986A - ICU (Grabber, 2.5m)

If you are using EASI™ lead placement, replace the standard lead-placement label on the cable with the appropriate EASI™ Label.

Since these Agilent cables were designed specifically for your Agilent V24 and V26 Monitor, we recommend the use of only Agilent cables and leadsets for optimum monitor performance.

Note—The following listed accessories are not shipped with every instrument. Contact your Agilent sales representative for details.

Accessories

	3 lead	**5 lead**
combiner block	M1501A	M1502A
cable organizer (standard and OR cables)	M1503A	M1504A
cable organizer (unshielded cables)	M1505A	M1506A
bedsheet clip	M1509A	M1509A

OR Lead Sets

Note—You cannot use 3-lead cables with the EASI™ option.

Lead Sets (Orange)	**Grabber OR 0.7m**
3-lead U.S.	M1601A
3-lead Europe	M1611A
5-lead U.S.	M1621A
5-lead Europe	M1631A

Shielded Lead Sets

Note—You cannot use 3-lead cables with the EASI™ option.

Lead Sets (Grey)	Snap Std 0.7m	Grabber Std 0.7m
3-lead U.S.	M1605A	M1603A
3-lead Europe	M1615A	M1613A
5-lead U.S.[1]	M1625A	M1623A
5-lead Europe[1]	M1635A	M1633A

[1]The limb lead on 5-lead sets are 1.6m.

Radioluscent Lead Sets

Lead Sets (Black)	Miniclip 0.91m
5-lead	M1649A[1]

[1]With color rings for AAMI and Europe

Electrodes

Neonatal	Pediatric	Adult
40476	13950	40489
40478	13951	40493
13952		13941
13953		13942
		M2202A

ECG/RESP Performance Specifications

For safety and environmental specifications, please refer to the *Monitor Installation and Patient Safety* Chapter 10.

ECG

Cardiotach

Adult Range	15 to 300 bpm
Pedi/Neo Range	15 to 350 bpm
Accuracy	±1% of range
Resolution	1 bpm
Sensitivity	>= 200 µV peak

Pace Pulse Detection:

- 100 µs pulse width amplitude greater than 3 mV
- 50 µs pulse width amplitude greater than 5 mV

Pace Pulse Rejection:

- Meets the requirements for AAMI EC 13-1993 Standards for cardiac monitors (automode).

Filter Bandwidths

Mode	Adult	Pediatric / Neonatal
Diagnostic Mode	0.05 to 130 Hz [a]	0.5 to 130 Hz[a]
Monitoring Mode	0.5 to 40 Hz	0.5 to 60 Hz
Filter Mode	0.5 to 20 Hz	0.5 to 20 Hz

a. The M1001B and M1002B have a bandwidth of 0.05Hz to 150Hz.

ECG Output

Signal Gain: 640 to 6400 depending upon display gain

Full Scale Display: $6.4V_{pp}$

Gain Error Constant deviation <20%

Baseline Offset <180mV + ECG offset

Signal Delay: <30ms[a]

a. ECG Output Signal Delay range for ECG and ECG/RESP modules:
All ECG and ECG/RESP modules **without** a *P* on the front have a signal delay of <20ms
All ECG and ECG/RESP modules **with** a *P* on the front have a signal delay of <30ms

Warning

EASI™ 12-Lead: If you are using EASI™, the signal gain is fixed at 3400. You cannot adjust the gain at the ECG Out using the Adjust Size .
Certain defibrillators may double trigger on the R-wave and T-wave, depending on the size and shape of the signal.
Use an alternative lead which does not double trigger, or change to non-EASI mode for cardioversion procedures.

Warning

⚠ Defib Your ECG/Defibrillator combination is configured to detect R waves from a high lead ECG signal. According to the specifications defined by AAMI the peak of the synchronized defibrillator discharge should be delivered within *60msec* of the peak of the R wave.

The Agilent M1001A/B and M1002A/B ECG modules meet the AAMI specifications, however your biomedical engineer should verify that your ECG/Defibrillator combination does not exceed the recommended maximum delay of 60msec.

ECG Output Impedance

Tip (ECG & Marker)	2.6kΩ (typically)
Ring (ECG only)	2.2kΩ (typically)

Marker Input Requirements

Signal Type	0 to -12V (source < 7kΩ)
Current	1mA
Falltime	<100µs
Duration	>4ms

Alarms

	Adult	Pediatric	Neonatal
HR Alarm Limit Range	15 to 250 bpm	15 to 300 bpm	15 to 300 bpm
Bradycardia Alarm Limit Range	not applicable	20 to 295 bpm	40 to 295 bpm

Adjustment: Steps of 5bpm

High/Low delay: 10 seconds according to AAMI EC 13-1993 standards.

Asystole:

- no detected beat within 4 seconds
- alarm within 3 seconds after this criterion is met according to AAMI EC 13-1993 standards.

INOP Alarms: Triggered if the offset potential rises above 500mV or leads off.

Miscellaneous

Baseline Recovery	Less than 1 second after defibrillation
Display Update	2 seconds nominal.

RESP

Respiration Rate

Adult/Pedi Range: 0 to 120 rpm

Neonatal Range 0 to 180 rpm

Accuracy ± 1 rpm at 60 rpm

Resolution 1 rpm

Alarm

	Adult/Pedi	Neonatal
High Alarm Limit	10 to 100 bpm	30 to 150 bpm
Low Alarm Limit	0 to 95 bpm	0 to 145 bpm

Adjustment Steps of 1 under 20 rpm
Steps of 5 above 20 rpm.

RESP Alarm Delay *If limit is between 0 and 20 rpm:*
As soon as value goes below limit setting.
If limit is above 20 rpm:
10 seconds after limit exceeds limit setting.

Apnea Alarm Delay
- Range of 10 to 40 seconds.
- Adjustment in Steps of 5 seconds.
- No detected breath within the adjusted apnea delay time.

Alarm 2 seconds after this criterion is met.

INOP Alarms: Triggered if the impedance rises above 2 kΩ or leads off.

Miscellaneous

Bandwidth 0.3 to 2.5 Hz (- 6 dB)

Noise	Less than 25 mΩ (input reference).

ECG/RESP with Analog Respiration Output Performance Specifications (CMS Only)

Output Range	-3.5V to +3.5V
Amplitude	1.0V/Ω change of transthoracic impedance
Offset	0.0V ±1V
Delay	<90ms
Polarity	Rising (positive) edge at inspiration
Load Capacitance	<100nF
Load Resistance	>1kΩ
Ground	Floating, isolated
Connector	BNC

Output Delay

Actual delay of the respiration output signal depends upon the respiration rate. When used with a critical timing device, careful evaluation of the device's compatibility is essential.

Cable Specification

Proper operation of the analog output is only guaranteed if the interface cable meets the following specifications:

BNC Cable Length	<4m
Impedance	<60mΩ/m
Capacitance	<400pF/m

Care and Cleaning

Patient Cables and Leads

Clean cables after each use as follows:

1. Remove any adhesive used to secure the electrodes to the patient and wipe off any remaining electrolyte from the electrodes. (If adhesive tape residue has to be removed, use a plaster remover solution or the Scholl Mfg. Co. Double seal tape remover. Acetone, alcohol, ammonia, chloroform or other strong solvents are not recommended, because they will eventually damage the vinyl cabling.)

2. Sponge cables with warm water and soap, or another suitable cleaning solution, and dry. Do not immerse them in water.

3. Check each cable for corrosion, cracks and deterioration.

Do not autoclave cables or electrodes or heat them above 75°C (167°F). If the metal surfaces become tarnished, they may be cleaned with any cleaner which does not leave a residue. Do not use any metallic abrasive such as steel wool. The cables should be stored in an environmental temperature between -20°C to 75°C (-68°F to 167°F). They should be hung up or laid flat to prevent damage to the cable.

ST Segment Monitoring

In this section you will find information on setting up ST segment monitoring, adjusting alarm limits, and troubleshooting.

If you have problems with the monitoring (for example, an INOP message appears on the screen), you will find information on alarms and INOPs on page 12-53.

For a list of the parameter settings related to ST segment monitoring that are stored inside the ECG and ECG/RESP modules with a *T* on front, turn to page 12-55.

To find specific information check either the contents list at the front of the user guide or the alphabetical index at the back.

Warning

This application provides ST level change information; the clinical significance of this ST level change information should be determined by a physician.

ST Segment Monitoring with EASI™

Using EASI™, ST monitoring can be done on multiple V-leads.[1]

Note—If an electrode falls off, the monitor shows a non-standard lead (that is, one of the 3 EASI™ vectors) labelled "ECG" until the electrode is reattached.
No ST analysis is possible in this time, and ST analysis is switched off automatically.

1. Assessment of EASI derived 12-Lead ST measurements is recommended for patients that meet the following requirements:

Ages: 33 to 82
Heights: 147 to 185 cm (58 to 73 in)
Weights: 53 to 118 kg (117 to 261 lb)
Height-to-Weight Ratios: 1.41 to 2.99 cm/kg (0.25 to 0.54 in/lb)

Introduction to ST Segment Monitoring

The ST segment monitoring for System measures the elevation or depression of the ST segment on up to three leads of a patient's ECG.

The corresponding ST measurements:

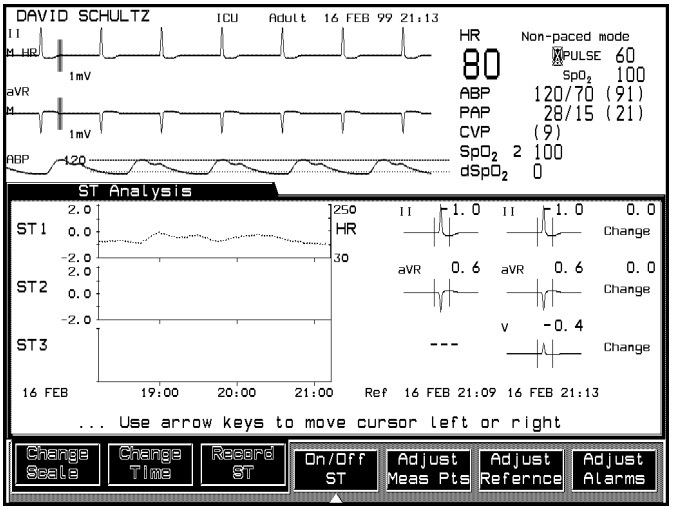
- are presented as numerics on the Standard Display. These ST values are as follows:
  ST 1 is the ST measurement from the channel 1 ECG lead.
  ST 2 is the ST measurement from the channel 2 ECG lead.
  ST 3 is the ST measurement from the channel 3 ECG lead.
- are shown graphically in the ST Analysis Task Window, an integrated display of current ST values and waveforms, HR and ST trends, reference ST values and waveforms, and net change
- are available in Vital Signs and Graph Trends displays and reports in Patient Data
- can be recorded with reference beats at the bedside or at a central recorder. Recordings made at the Patient Information Center do not include reference beats.

ST Analysis is accessed through the ECG Channel 1 Task Window, or through **Procedures** . The ST Analysis Task Window provides quick access to information needed to make an initial assessment of the significance of ST changes.

In the left side of the window, up to three ST trends are shown, with the HR trend graphed in the ST1 plot area. Trends can be scaled at ±1.0, ±2.0, ±5.0, or ±10.00 mm; the current scale is displayed in the box above the **Change Scale** softkey label. The trend time span choices are 1, 3, 6 or 12 hours for the standard database, 1 or 3 hours with high resolution storage; the span for the current trends is noted in the box above the **Change Time** label. The bar cursor provides a mechanism for retrieving stored values for display in the *cursor spot* on the right side of the window.

In the right side of the window, the current or recalled ST complexes are displayed in the cursor spot at the right. To their left in the *reference spot* the reference set of complexes for use in analysis is displayed. Up to 242 sets of realtime algorithm outputs (ST values, beats and measurement points) can be trended and recalled. The default reference beat can be updated to any of the stored values.

The net change between the current and reference values is listed at the extreme right of the Task Window.



The arrow keys can be used to move the cursor to different time columns within the trend area. On touch-operated systems, the arrow buttons below the trends can be used to perform the task of the arrow keys. Alternatively, the trend area can be directly selected by touch or mouseclick. This will bring up the ST strored for the selected time.

Operation Notes

- ST measurements are not performed on ventricular or A-V sequential paced beats. ST measurements are performed on atrially paced beats.
- Arrhythmia and pulse monitoring are fully compatible with ST segment monitoring.

- Usually VPBs do not affect the accuracy of the ST segment measurement. However, rhythms that are primarily ventricular can cause incorrect ST measurements.
- If you are using a touchscreen, selecting the trend area will bring up the ST segment stored for that particular time.

Note—The System automatically marks the following ST-related adjustments as events in Patient Data:

- Whenever an ECG lead is changed.
- Whenever ST parameter measurement points are changed.

You can review the ST adjustment markers on the Graphs Display. The label is "ST" or, if part of a graphs group, "ST Adjust". See "*Marking and Reviewing Events*" in Chapter 8 for more information.

Data Transfer

ST Analysis functions are available during transfers to the M1235A Data Transfer Module, but they are deactivated during a transfer to the monitor.

ST trends of transferred data can be viewed in the ST Analysis Task Window and in the Vital Signs and Graphs Trends screens accessible under the **Trends/Calcs** key. Transferred values are indicated by a "T" on the trend time line. However, ST waveforms are not transferred; thus transferred measurements cannot be used as the reference beat.

ST Segment Monitoring Setup

- Standard Lead placement:
  - ECG channel 1 should display a good cardiotach lead. This is typically lead II.
  - ECG channel 2 should display a good lead for monitoring the ST level. This is typically aVF.
  - ECG channel 3 is always lead V, which is typically V_5 for monitoring the ST level.
- EASI™ Lead placement:
  - ECG channel 1 should display a good cardiotach lead. This is typically lead II.
  - ECG channel 2 should display a good lead for monitoring the ST level. This is typically V_2.
  - ECG channel 3 is always lead V, which is typically V_5 for monitoring the ST level.

Notes—

- If monitoring with only one lead, choose the lead where both beat detection and ST segment evaluation are possible. If monitoring with two leads, leads II and V_5 are typically chosen. Remember, the number of ECG channels that you *monitor* is independent of the number that you *display*. For example, you can turn on ECG-CH1, CH2, and CH3 (and thus monitor three ST parameters) but display only ECG-CH1.
- When you turn an ST parameter on, the monitor automatically adjusts the low end of the bandwidth (filter, monitor, or diagnostic) to 0.05 Hz, the diagnostic quality needed for ST monitoring. There is no change to the high end of the bandwidth. When you turn ST monitoring off, the monitor automatically returns to the original low end of the selected bandwidth.

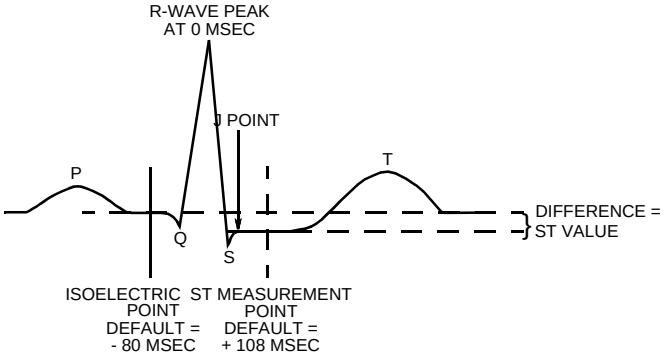
- If the monitor is configured to switch to the filter bandwidth during ESU interference, you will get an ST INOP (Cannot Analyze STx) during ESU interference. When the ESU interference stops, the low end of the bandwidth range automatically changes back to.05 and ST monitoring resumes.

ST Segment Measure-ment Points

The ST measurement for each QRS complex is the vertical *difference* between where two measurement points on the wave:

The **isoelectric point** provides the baseline for the measurement.

The **ST point** provides the other measurement point.



You can adjust both measurement points. Your monitor is configured so that you set the ST Point in reference to:

the R-wave peak.
or
the J Point, which is the transition between the QRS and the ST segment.

Note—The ST measurement point may need to be adjusted if the patient's heart rate or ECG morphology changes significantly. As you move the cursor, the ST values at the right of the ST Measurement Points Task Window are updated to show the effects of moving the cursors. These values may differ from those in the Standard Display, since the Standard Display ST values are only updated every 15 seconds.

Waveform Storage/ Recall

Up to 242 sets of ST beats can be stored, each with up to three channels of data. After 242 sets of data are stored, the database replaces the oldest entry with new data. The duration and frequency of storage is dependent on the frequency of parameter storage in Patient Data. If patient data is being collected every 12 seconds, ST wave storage occurs at 1 minute intervals. If patient data is collected once per minute, ST storage occurs at 5 minute intervals. During an ST alarm, wave storage is once per minute. All stored waves are cleared after a discharge procedure, when the monitor is turned off for more than 3 hours, or when monitoring mode is reset.

Adjusting the Reference

Setting the reference values enables you to select new or temporary reference beats. When ST analysis is begun, the second valid beat is selected as the default reference beat and is displayed in the reference spot. Any trended beat can then be compared with the reference. You can change the reference in the Adjust Reference Task Window.

In addition, any trended beat can be used as a temporary reference, without affecting the saved reference. A temporary reference remains in effect until you change it or you leave the Task Window. A temporary reference can be retained as the saved reference.

If the monitor is turned off for more than 3 hours, the saved reference will be reset to the second valid ST beat after restart. The reference is also reset whenever the ST or ISO point is changed.

Saved Reference	the stored reference beat (This may be the default beat, or a trended beat selected by the user.)
Temp Reference	a trended beat selected by the user and displayed in the reference spot on a temporary basis for analysis
Change Reference	a way for the user to replace the default reference with a temporary reference complex

Adjusting the Alarm Limits

Each ST parameter has its own alarm limit. The alarm is triggered when the value of the ST parameter exceeds its alarm limit for more than 1 minute. The alarm will be a yellow alarm.

Turning ST alarms on or off affects all of the ST parameters. (If you need to disable alarms for an individual parameter, adjust the alarm limits so that reaching an alarm condition is virtually impossible.)

Caution

When more than one ST parameter is in alarm, only one alarm message is displayed.

Note—The displayed scales for ST alarm limits (in the Adjust ST Alarms and Alarm Limits Task Windows, and in Vital Signs and Graph Trends) are pre-configured to ±1, ±2, ±5, or ±10 mm. However, the actual range you can set ST alarms within is -9.8 to +9.8 mm.

ST Alarm and INOP Messages

The ST alarm messages are rated in order of severity:

** Yellow

INOP

Alarm tone = a single chime repeated every second.

INOP tone = a single beep repeated every 2 seconds. Alarm limits are dependent on patient's condition.

The alarm and INOP messages are listed below, with the "x" representing ST1, ST2, or ST3.

Physiological Alarms

Alarm Message	Condition	Visual Indication	Audible Indication
**STx -1.2<-1.0	ST below the low alarm limit	ST numeric blinks. Yellow alarm lamp.	Alarm tone
**STx 1.3>1.0	ST above the high alarm limit	ST numeric blinks. Yellow alarm lamp.	Alarm tone

ST Alarm Limit Ranges

-9.8mm to +9.8mm

Technical Alarms

INOP messages appear when the monitor cannot measure or process signals properly. This could be due to patient- related or equipment-related problems but you must always check the patient's condition first. Some INOP messages are accompanied by an audible alarm which can be silenced with the **Silence/Reset** key.

Patient-Related INOPS

INOP Message	Condition	Visual Indication	Audible Indication
ERRATIC STx	The variation between measured ST values exceeded the limits for valid data.	STx numeric displays -? -	None
ST PACED BEATS	The algorithm recognizes an unacceptable number of paced beats. This could be caused by an exceptionally noisy ECG signal.	STx numeric displays -? -	None
CANNOT ANALYZE STx	The algorithm cannot generate a valid value (e.g., noisy ECG) and none of the above conditions apply.	STx numeric displays -? -	None

Equipment-Related INOPS

INOP Message	Condition	Visual Indication	Audible Indication
NO STx SOURCE	The channel of ECG corresponding to this ST parameter is off.	STx numeric displays -? -	INOP tone *
STx OVERRANGE	The algorithm calculated a value $\geq$ 25 mm or $\leq$ -25 mm	STx numeric displays -? -	INOP tone *

*If the Unit Type for the Configuration Set is OR, there is no INOP tone.

Parameter Settings Transfer

The following settings related to ST Segment Monitoring can be transferred with ECG and ECG/RESP modules that have a *T* on the front. For more information on Parameter Settings Transfer, refer to "Parameter Setting Transfer," Chapter 3.

Setting Name	Meaning
Alarm limits	Heart/Pulse and respiration rate alarm limits
ISO points	Isoelectric measurement point
ST points	ST measurement point

Performance Specifications

ST Segment

Measurement Range

Measurement Range	-25.0 mm to 25 mm
Resolution Range	± 0.1 mm at highest ECG gain (50 mm/mV)
Intermediate Resolutions	± 0.1 mm at 40 mm/mV ± 0.1 mm at 20 mm/mV ± 0.3 mm at 10 mm/mV
Leads	First and second channels selectable from I, II, III, aVR, aVF, aVL, MCL1, V. Third channel is V.

Measurement Points

Measurement Points	Referenced to peak of QRS complex or set 60/80 ms from the user-selected J-point
Measurement Resolution	4 ms
Isoelectric Point Range	-460 ms to 460 ms from QRS peak
ST Point Range	-380 ms to 460 ms from QRS peak
J-Point Range	-460 ms to 460 ms from QRS peak.

Alarms

Range	-9.8 mm to 9.8 mm
Adjustment	Steps of 0.2 mm
Alarm delay	1 minute after the value exceeds the set limit value
INOP Alarms	Refer to Patient and Equipment related INOP tables.

Miscellaneous

Median Value	Updated every 15 seconds
Automatic Annotation	Measurement point changes and lead changes
Manual Annotation	Available to user using Events A to D.

15
Noninvasive Blood Pressure Module Section

This chapter describes to the M1008B* pressure module. (With the exception of information relating to neonatal measurements, this chapter is also valid for the M1008A pressure module.) This chapter provides information on setting up blood pressure monitoring and troubleshooting. It includes the following sections:

Blood pressure measurements determined with this device are equivalent to those obtained by intraarterial devices, within the limits prescribed by the American National Standard for Electronic or Automated Sphygmomanometers.

*Licensed under one or more of the following U.S. patents: numbers 4 349 034, 4 360 029, 4 546 775, 4 543 962.

Introduction to the Noninvasive Blood Pressure Parameter Module

- The Noninvasive Blood Pressure (NBP) module measures the blood pressure using the **oscillometric** method.
- The M1008B NBP module can be used on adults, pediatrics and neonates.
- There are three modes of measurement available: manual, automatic and stat. Each mode displays the systolic, diastolic and mean blood pressure.

  In the *manual* mode, only one measurement is taken.

  In the *automatic* mode, the measurement is repeated. You can configure the repetition time to be one of the following:

  1, 2, 2.5, 3, 5, 10, 15, 20, 30, 45, 60, 120 minutes.

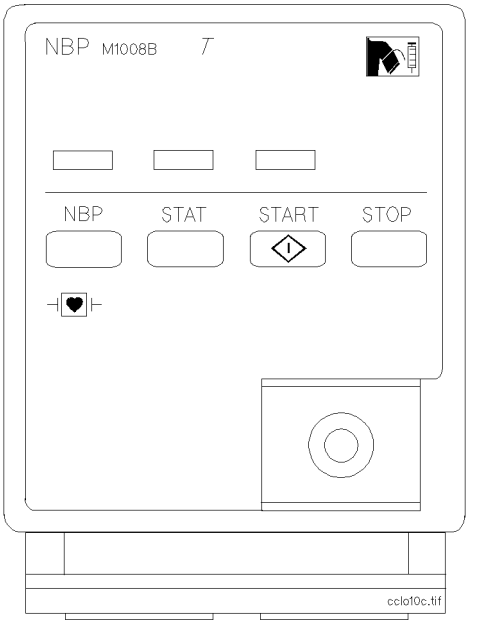
  The *stat* mode, measures the blood pressure as many times as possible over a five minute period. This mode uses a faster measurement procedure.
- In all three of these modes, an estimation of the systolic pressure is displayed before the end of the measurement, except for the very first measurement.
- The “Venous Puncture” function inflates the cuff to a configurable pressure in order to prevent venous backflow, leading to a swelling of the veins to aid the application of a venous line.

Warning

- **You must not perform noninvasive blood pressure measurements on patients with sickle-cell disease or any condition where skin damage has occurred or is expected.**
- **Use clinical judgement to decide whether or not to perform automatic blood pressure measurements on patients with severe blood clotting disorders, because of the risk of hematoma in the limb wearing the cuff.**
- **Ensure that the correct configuration set is selected when performing measurements on pediatric and neonatal patients. Using an incorrect configuration set can endanger patient safety because of the higher pressure level which should not be applied on pediatric and neonatal patients.**

- The front of the module has four keys:
  - NBP key for parameter setup, a light will appear above the key when you are in the Setup Task Window.
  - STAT key for starting a measurement in stat mode, a light will appear above the key when this mode is active.(Note that the **Stat NBP** key in the NBP Task Window has the same function as this key.)
  - START key for starting:
    a. A manual measurement
    b. An automatic measurement sequence.
  - The light above the START key blinks during a manual or automatic measurement sequence. A continuously illuminated light indicates that the NBP module is set to take automatic measurement sequences.(Note that the **Start NBP** key in the NBP Task Window has the same function as this key.)
  - STOP key for stopping an NBP measurement. When you press this key, the NBP cuff deflates immediately. Auto or Stat

measurement procedures are cancelled. If required, you must restart these procedures. (Note that the **Stop NBP** key in the NBP Task Window has the same function as this key.)



The Noninvasive Blood Pressure Module (M1008B)

The settings are transferred with NBP modules that have a *T* on the front. For more information on Parameter Settings Transfer, refer to “Parameter Settings Transfer” on page 15-13.

 indicates that the module supports the venous puncture function.

 indicates that the module is designed to have special protection against electric shocks (particularly regarding allowable leakage currents), and is defibrillator proof.

 is the symbol for starting a procedure.

NBP Measurement Setup

Warning

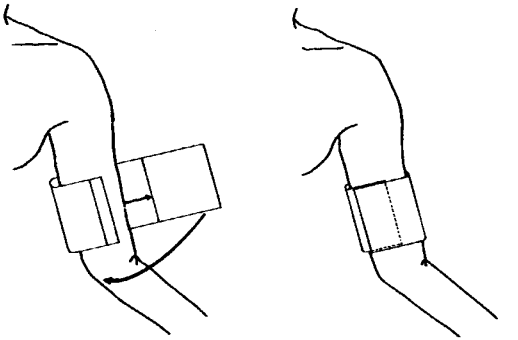
- **Before starting a measurement, verify that you have selected a configuration appropriate for your patient (adult, pediatric or neonate.)**
- **Do not apply the cuff to a limb that has an intravenous infusion or catheter in place. This could cause tissue damage around the catheter when the infusion is slowed or blocked during cuff inflation**

Caution

- All specified cuffs may be used during electrosurgery.
- All specified cuffs and the NBP pressure module are protected against the effects of the discharge of a defibrillator.
- During defibrillation, the NBP values may be temporarily interrupted or distorted. After defibrillation, the monitor will continue to monitor as before; the operating mode and user settings are not affected

1. Check that the NBP module is inserted in the rack.
2. Plug the air tubing into the module and switch on the system.
3. Apply the blood pressure cuff to the patient's arm or leg following the instructions below.
   - Ensure that the cuff is completely deflated.

– Apply the appropriate sized cuff to the patient - ensure that the ⌀ (ARTERIA ⇩for neonatal cuffs) is over the appropriate artery. Ensure that the cuff is not wrapped tightly around the limb. Excessive tightness may cause discoloration and eventual ischemia of the extremities.



Note—The width of the cuff should be within a range of 37% to 47% of the limb circumference. The inflatable part of the cuff should be long enough to encircle at least 80% of the limb. The wrong size of cuff can cause erroneous readings.

– Check that the edge of the cuff falls within the range marked <-->, (on disposable cuffs this is a blue line without arrows). If it does not, use a larger or smaller cuff that fits better.

4. Connect the cuff to the air tubing. The limb used for taking the measurement should be placed at the same level as the patient's heart. If this is not possible you should apply the following corrections to the measured values:

   – If the cuff is placed higher than the heart level, add 0.75 mmHg (0.10 kPa) to the displayed value for each centimeter difference, or 1.9 mmHg (0.25 kPa) for each inch difference.

   – If the cuff is placed lower than the heart level deduct 0.75 mmHg (0.10 kPa) from the displayed value for each centimeter difference, or 1.9 mmHg (0.25 kPa) for each inch difference.

5. Press the “START” key on the front of the module for auto or manual measurement and press “STAT” for stat measurement, or enter the measure NBP task window.

   – If you are in doubt about the accuracy of any reading(s), check the patient's vital signs by an alternative method **before** checking the functioning of the monitor.

Warning

Prolonged series of non-invasive blood pressure measurements in Auto mode may be associated with purpura, ischemia and neuropathy in the limb wearing the cuff. When monitoring a patient, examine the extremities of the limb frequently for normal color, warmth and sensitivity. If any abnormality is observed, stop the blood pressure measurements immediately.

You can configure your monitor to generate a prompt tone when the NBP measurement is complete. This is done in a special *configuration mode* by your biomedical engineering department or the Agilent Service Engineer.

Notes on NBP Module

- The following inflation limits have been implemented in the NBP module to ensure patient comfort:

  – In manual and automatic modes for adults, the cuff inflates to 165mmHg (22.0kPa) on the initial measurement, and to 25mmHg (3.3kPa) above the last systolic measurement on all subsequent measurements. In stat mode for adults, the cuff inflates to 165mmHg (22.0kPa) on the initial measurement, and to 15mmHg (2.0kPa) above the last systolic measurement on all subsequent measurements.

  – In manual and automatic modes for pediatrics, the cuff inflates to 125mmHg (16.7kPa) on the initial measurement, and to 20mmHg (2.7kPa) above the last systolic measurement on all subsequent measurements.
  In stat mode for pediatrics, the cuff inflates to 125mmHg (16.7kPa) on the initial measurement, and to 15mmHg (2.0kPa)

above the last systolic measurement on all subsequent measurements.

– In manual, automatic, and stat modes for neonates, the cuff inflates to 100mmHg (13.3kPa) on the initial measurement, and to 15mmHg (2.0kPa) above the last systolic measurement on all subsequent measurements.

Warning

The initial pressure inflation value must be reset in one of the following ways before monitoring a new patient:

- **Press the STOP key on the front of the module.**
- **Press Discharg Patient and Confirm.**

If you fill in the "Discharg Patient" screen, the old (previous patient's) NBP readings will also be deleted from the display.

- Old NBP readings are deleted from the display under the following conditions:
  - If you are in manual mode, old NBP readings are deleted after one hour.
  - If you are in automatic mode, old NBP readings are deleted after the repetition time has elapsed.
  - The old NBP reading is deleted after pressing **Discharg Patient** → **Confirm** .
  - When the NBP parameter is switched off then on again (*either* in the "Parameters On/Off" Task Window, *or* by removing the NBP module from the rack then re-inserting it).
- When using smaller sizes of cuffs the inflation may occur in a series of surges but this does not affect the quality of the measurement.
- In automatic mode, if you start a manual measurement by pressing the "START" or "STAT" key on the front of the module, the next automatic measurement will be timed from the last automatic measurement.
- An NBP yellow alarm will disappear from the display after the **Silence/Reset** key is pressed. This is true for latching and non-latching alarms.

- The number of NBP readings plotted (see “Viewing Graph Trends” in Chapter 8) depends on the number of values stored. Usually, every value is plotted and up to 96 readings can be stored for 24 hours (or 48 hours if purchased and configured).
- The performance specifications and tolerance of this product are established using Agilent-supplied accessories and supplies. Non-Agilent-supplied accessories and supplies may corrupt the performance of the equipment. Agilent assumes no liability for poor performance or injury caused by non-Agilent-supplied accessories and supplies.

Venous Puncture

The “Venous Puncture” function is an NBP function that inflates the cuff to a configurable pressure in order to prevent venous backflow, leading to a swelling of the veins to aid the application of a venous line. The cuff can be deflated by the user, or deflates automatically after a fixed time, depending on the patient category.

The venous puncture is only possible using the newer NBP modules with the venous puncture symbol on the front.

NBP Setup Task Window

There is a **Venous Puncture** softkey in the NBP Setup Task Window that is active if:

- the NBP module supports venous puncture (has the venous puncture symbol on the front), and
- there is no measurement running

When you press this key, the cuff inflates to a configurable pressure for a fixed maximum time (both dependent on the patient category).

Patient Category	Configurable Pressure Range	Factory Default Pressure	Maximum Time
Adult	20-120 mmHg	60 mmHg	170 s
Pediatric	20-80 mmHg	40 mmHg	170 s
Neonatal	20-50 mmHg	30 mmHg	85 s

While the cuff is inflated

- The indication “VP” appears next to the numeric.
- The time stamp beside the numeric shows the remaining venous puncture time (the time until the cuff deflates automatically).
- “VeniPunc” and “Venous Puncture mode active” appear in the NBP task window.
- The **Stat NBP** and **Start NBP** softkeys are inactive (no NBP measurements are possible during venous puncture).

The venous puncture can be ended and the cuff deflated at any time by pressing **Venous Puncture** again, or by pressing **Stop NBP**.

Note—Performing a venous puncture while automatic NBP measurements are being made suspends the automatic measurements for the duration of the venous puncture inflation and for three minutes afterwards.

Note—Pressing **Stop NBP** to end a venous puncture will also stop any automatic measurement. Press **Start NBP** to restart automatic measurements.

Parameter Settings Transfer

The following settings can be transferred with NBP Modules that have a *T* on the front. For more information on Parameter Settings Transfer, refer to "*Parameter Settings Transfer*," Chapter 3.

Setting Name	Meaning
Auto / Man	Measurement mode automatic / manual
Repetition time	Time between two measurements
Alarm parameter	Sys, dia, or mean pressure
Alarm limits	Sys, dia, and mean alarm limits

NBP Alarm and INOP Messages

The NBP alarm messages are rated in order of severity:

** Yellow

INOP message

Alarm tone = a single chime repeated every second.
INOP tone = a single beep repeated every two seconds.
Alarm limits are dependent on patient's condition.

Physiological Alarms

Alarm Message	Condition	Visual Indication	Audible Indication
**NBP 160 >150	NBP above high alarm limit for systolic, diastolic, or mean pressure.	NBP numeric blinks. Yellow alarm lamp.	Alarm tone
**NBP 90 < 100	NBP below low alarm limit for systolic, diastolic, or mean pressure.	NBP numeric blinks. Yellow alarm lamp.	Alarm tone

Technical Alarms

These occur when the monitor cannot measure or process signals properly, due to patient or equipment-related problems. Always check the patient's condition first. The INOP message is accompanied by an audible alarm which can be silenced with the **Silence/Reset** key.

If an automatic measurement is interrupted by an INOP, you must rectify the situation which caused the INOP to avoid reoccurrence. Even when this is done, the INOP message will be displayed until:

- the next automatic measurement is made (only for NBP INTERRUPTED or NBP MEASURE FAILED INOPs), or
- you initiate a manual measurement, or
- you press the STOP key on the NBP module before a new automatic or manual measurement is made, or
- by switching off the parameter.

Patient-Related INOPS

INOP Message	Condition	Visual Indication	Audible Indication
CUFF NOT DEFLATED[1]	Cuff pressure does not decrease within time limit.	NBP numeric displays -?-. Prompt message in Task Window. Cuff deflates.	INOP tone
NBP CUFF OVERPRESS[1]	Cuff pressure increases above overpressure safety limits.	NBP numeric displays -?-. Prompt message in Task Window. Cuff deflates.	INOP tone

[1]INOP must be reset manually.

Note—These two INOP alarms cannot be switched off by using the **Suspend Alarms** softkey, or the parameter alarm softkeys or the **Suspend** hardkey. If they occur and the main alarms are switched off, the main alarms are automatically switched back on. If they occur and the parameter alarms are switched off, the parameter alarms are automatically switched back on.

Patient-Related INOPS

INOP Message	Condition	Visual Indication	Audible Indication
NBP INTERRUPTED	The preset maximum time for inflation[1], deflation[2] or total measurement[2] has been exceeded.	NBP numeric displays -?-. Prompt message in Task Window.	INOP tone
NBP INCORRECT CUFF[1]	This occurs if the instrument cannot measure with this cuff in the patient category selected	NBP numeric displays -?-. Prompt message in Task Window.	INOP tone
NBP MEASURE FAILED[2]	If no measurement values are derived (for instance because blood pressure very low).	NBP numeric displays -?-. Prompt message in Task Window.	INOP tone

[1]INOP must be reset manually.

[2]INOP will remain displayed until the next manual or automatic measurement is made.

Equipment-Related INOPS

INOP Message	Condition	Visual Indication	Audible Indication
NBP UN-PLUGGED[1]	Main Alarms switched on, NBP module switched on and the module un-plugged.	NBP numeric displays -?-.	INOP tone
NBP EQUIP MALF[1]	The rubber tube to the cuff may be kinked, or there is a malfunction in the NBP module.	NBP numeric displays -?-. Prompt message in Task Window.	INOP tone

[1]INOP must be reset manually.

Measurement Limitations

The oscillometric measurement has some limitations according to the patient's condition. The measurement looks for a regular arterial pressure pulse; in those circumstances where the patient's condition makes this hard to detect, the measurement becomes unreliable and measurement time increases. The user should be aware that the following conditions can interfere with the measurement method, making the measurement unreliable or longer to derive. In some cases the patient's condition will make the measurement impossible.

Patient Movement: Measurements may be unreliable or may not be possible if the patient is moving, shivering, these activities may interfere with the detection of the arterial pressure pulses. In addition, the measurement time will be increased.

Heart Rate Extremes: Measurements cannot be made at a heart rate of less than 40 bpm and greater than 300 bpm.

Heart-lung Machine: Measurements will not be possible if the patient is connected to a heart-lung machine.

Cardiac Arrhythmias: Measurements will be unreliable or may not be possible if the patient displays cardiac arrhythmias causing an irregular heart beat. The measurement time will be increased.

Pressure Changes: Measurements will be unreliable or may not be possible if the patient's blood pressure is changing rapidly over the period of time during which the arterial pressure pulses are being analyzed to obtain the measurement.

Severe Shock: If the patient is in severe shock or hypothermia, measurements will be unreliable since reduced blood flow to the peripheries will cause reduced pulsation of the arteries.

Obese Patients: A thick layer of fat surrounding a limb tends to dampen oscillations coming from the artery, and stops them from reaching the cuff. Accuracy may be lower than normal.

Accessories and Ordering Information

Reusable Blood Pressure Start-up Kits

Agilent Part No	Contents
40400A	Contains 3 cuffs: - Pediatric - Adult - Adult Large Arm
40400B	Contains 5 cuffs: - Infant - Pediatric - Adult - Adult Large Arm - Adult Thigh
Long-Life Reusable Cuff Kits	
M1577A	Contains 4 cuffs: - Infant - Pediatric - Small adult - Adult
M1578A	Contains 4 cuffs: - Small adult - Adult - Large adult - Adult Thigh
M1579A	Contains 6 cuffs: - Infant - Pediatric - Small adult - Adult - Large adult - Adult Thigh

Reusable Blood Pressure Cuffs

Agilent Part No.	Contents	Limb Circumference	Bladder Width	Tubing
40401A	Infant Cuff	10 - 18 cm	7 cm	
40401B	Pediatric Cuff	18 - 25 cm	9.3 cm	M1598A/B (1.5m)
40401C	Adult Cuff	25 - 33 cm	12.3 cm	or
40401D	Adult Large Arm	33 - 41 cm	15.3 cm	M1599A/B (3m)
40401E	Adult Thigh	41 - 49 cm	18 cm	
Long-life Reusable Cuffs				
M1571A	Infant cuff	10 - 15 cm	5.5 cm	M1598A/B (1.5m)
M1572A	Pediatric cuff	14 - 21.5 cm	8 cm	or
M1573A	Small adult cuff	20.5 - 28 cm	10.5 cm	M1599A/B (3m)
M1574A	Adult cuff	27 - 35 cm	13 cm	
M1575A	Large adult cuff	34 - 43 cm	16 cm	
M1576A	Adult thigh cuff	42 - 54 cm	20 cm	
A protective cap can be ordered for the reusable cuffs: Agilent Part No. 40401-60090.				

Caution

Always follow the specific instructions delivered with the cuff if this is possible. This information may be more recent than the information given here.
The information given in this chapter is intended as a guideline if the individual cleaning instructions are not available.

Cuffs for Neonates/Infants for Single Patient Use

Agilent Part No.	Size	Limb Circumference	Bladder Width	Tubing
M1866A[a]	1	3.1 - 5.7 cm	2.2 cm	
M1868A [a]	2	4.3 - 8.0 cm	2.8 cm	M1596A/B (2.5m)
M1870A[a]	3	5.8 - 10.9 cm	3.9 cm	or
M1872A[a]	4	7.1 - 13.1 cm	4.7 cm	M1597A/B (3m)

a. contains 20 cuffs

Cuffs for Adults/Pediatrics for Single Patient Use

Agilent Part No.	Size	Limb Circumference	Bladder Width	Tubing
M1874A	Infant	10 -15 cm	5.5 cm	
M1875A	Pediatric	14 - 21.5 cm	8 cm	M1598A/B (1.5m)
M1876A	Small Adult	20.5 - 28 cm	10.5 cm	
M1877A	Adult	27 - 35 cm	13 cm	or
M1878A	Large Adult	34 - 43 cm	16 cm	
M1879A	Adult Thigh	42 - 54 cm	20 cm	M1599A/B (3.0m)

Performance Specifications

For safety and environmental specifications, please refer to the *Monitor Installation and Patient Safety* Chapter 10.

NBP

Measurement and Repetition Times

The table below shows the typical measurement time for a patient with a HR of > 60 bpm.

	Adult / Pediatric	Neonatal
Auto Mode	30 seconds	25 seconds
Stat Mode	20 seconds	17 seconds
Maximum (M1008A/B)	100 seconds	60 seconds
Maximum (M1008B "Veni")	175 seconds	87 seconds

Auto Mode Repetition Times:

1, 2, 2.5, 3, 5, 10, 15, 20, 30, 45, 60 or 120 minutes

Note—The beginning of an NIBP measurement can be synchronized with the monitor's real-time clock to start at full time intervals. This configuration can be made in Configuration mode by your biomedical engineer or your Agilent service engineer.

Stat Mode Cycle Time:

5 minutes

Measurement (Validation):

Complies with ANSI/AAMI SPIO-1987 in relation to mean error and standard deviation, when compared to intra arterial measurements in a representative patient population.

Measurement Range

	Adult Mode	Pediatric Mode	Neonatal Mode[a]
Systolic	30 to 270 mmHg (4 to 36 kPa)	30 to 180 mmHg (4 to 24 kPa)	30 to 130 mmHg (4 to 17 kPa)
Diastolic	10 to 245 mmHg (1.5 to 32 kPa)	10 to 150 mmHg (1.5 to 20 kPa)	10 to 100 mmHg (1.5 to 13 kPa)
Mean	20 to 255 mmHg (2.5 to 34 kPa)	20 to 160 mmHg (2.5 to 22 kPa)	20 to 120 mmHg (2.5 to 16 kPa)
Heart Rate Range	40 to 300 bpm (40 to 220 bpm for M1008A module)		

a. does not apply for M1008A Module

Alarms

Range	Adult Mode	Pediatric Mode	Neonatal Mode[a]
Systolic	30 to 270 mmHg (4 to 36 kPa)	30 to 180 mmHg (4 to 24 kPa)	30 to 130 mmHg (4 to 17 kPa)
Diastolic	10 to 245 mmHg (1.5 to 32 kPa)	10 to 150 mmHg (1.5 to 20 kPa)	10 to 100 mmHg (1.5 to 13 kPa)
Mean	20 to 255 mmHg (2.5 to 34 kPa)	20 to 160 mmHg (2.5 to 22 kPa)	20 to 120 mmHg (2.5 to 16 kPa)
Overpressure Limit	Max. 300 mmHg (40 kPa) > 2 sec	Max. 300 mmHg (40 kPa) > 2 sec for modules supporting the Venous Puncture function Max. 200 mmHg (26.7 kPa) > 2 sec for other modules	Max. 150 mmHg (20 kPa) > 2 sec

a. does not apply for M1008A Module

Alarm Parameters	Systolic or Diastolic or Mean
Adjustment	Steps of 2 mmHg (0.5 kPa) for 10 to 30 mmHg range (1.5 to 4 kPa) Steps of 5 mmHg (1 kPa) steps for all other ranges.

Care and Cleaning

The Non-Invasive Blood Pressure Module

Caution

- **Avoid compression or restriction of the rubber tubes to the cuffs.**
- **Water or cleaning solution must not enter the connector on the front of the module, as this could damage the equipment:**
  - **When cleaning the NBP module, wipe around the connector socket, not over it.**
  - **When the reusable cuff is not connected to the module, or is being washed, always fit the cap to the end of the rubber tube. This helps prevent accidental entry of liquid into the tubing, which could then be sucked into the module.**

The Reusable Blood Pressure Cuff

The cuff can be disinfected by immersion in decontamination solutions, but remember to remove the rubber bag if you use this method. The cuff should not be dry cleaned.

The cuff can also be machine-washed or hand-washed, although the latter method will prolong the service life of the cuff. Before washing, remove the rubber bag and, for machine-washing, close the Velcro fastening. Allow the cuff to dry thoroughly after washing, then reinsert the rubber bag.

To replace the bag in the cuff, first place the bag on top of the cuff so that the rubber tubes line up with the large opening on the long side of the cuff (figure 1). Now roll the bag lengthwise and insert it into the opening on the long side of the cuff (figure 2). Hold the tubes and the cuff and shake the complete cuff until the bag is in position. Thread the rubber tubes from inside the cuff, out under the internal flap and through the small hole.

The Disposable Blood Pressure Cuff

Disposable cuffs are intended for one-patient use only. Do not use the same cuff on different patients. Do not sterilize or autoclave disposable cuffs. Disposable cuffs can be cleaned using soap solution to control infection.

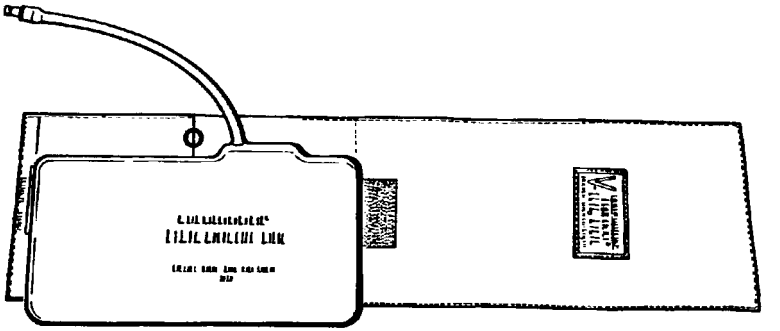


Figure 1

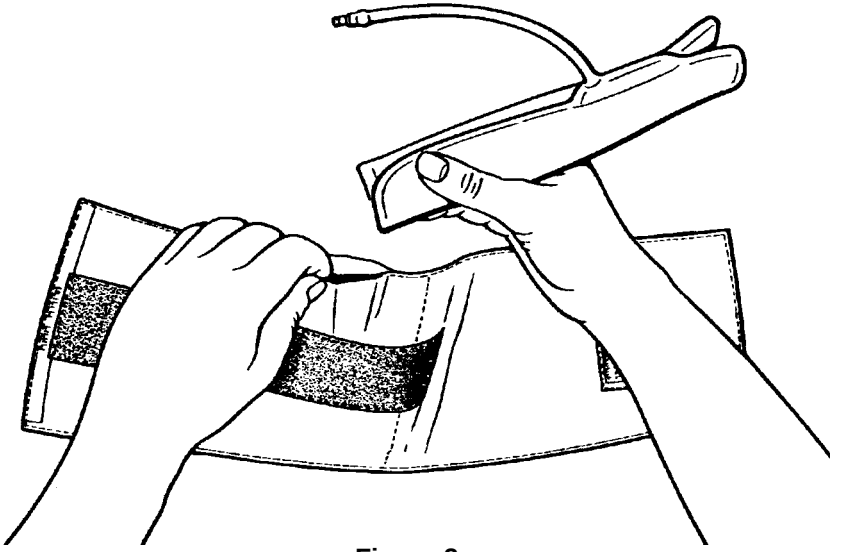


Figure 2

16
SpO_2/PLETH Module Section

This chapter describes the SpO_2/PLETH Module. It contains the following sections:

Introduction to the SpO_2/PLETH Parameter Module

What does it Measure?

The SpO_2/PLETH parameter measures the functional arterial oxygen saturation. That is, the percentage of oxygenated hemoglobin in relation to the sum of oxyhemoglobin and deoxyhemoglobin. If, for example, a total of 97% of the hemoglobin molecules in the red blood cells of the *arterial* blood combine with oxygen, then the blood has an oxygen saturation of 97%. The SpO_2 numeric on the monitor will read 97%. The SpO_2 numeric indicates the percentage of hemoglobin molecules which have combined with oxygen molecules to form oxyhemoglobin. The SpO2/PLETH parameter can also provide a pulse rate signal and a plethysmogram wave.

The SpO_2 measurement signal also provides quantitative information about the pulsatile arterial blood flow, called the *perfusion indicator*. It is directly related to the amount of blood perfusion at the transducer site and displayed as a digital value. This value typically lies between 0.5 and 1 for neonates and 1 and 5 for adults. Changes in the perfusion indicator result from changes in the blood flow, but should not be interpreted as a direct measurement. It is recommended as a quality measurement of how strong the SpO_2 signal is.

Notes—

- Agilent has adopted the convention of referring to this parameter as SpO_2. **SaO_2** is the term used to indicate the oxygen saturation of arterial blood. **SpO_2** is the term used to indicate the oxygen saturation of arterial blood **as measured by pulse oximetry**.
- The patient size setting of the monitor is used to optimize the calculation of the SpO2, Perfusion and Pulse numerics. Therefore it is highly recommended to check the correct patient size setting (adult/pediatric and neonatal) before using the SpO2 measurement.
- In case of very low pulse rates or strong arrhythmia, the pulse rate may differ from the heart rate calculated from ECG.

How the SpO_2/ PLETH Parameter Works

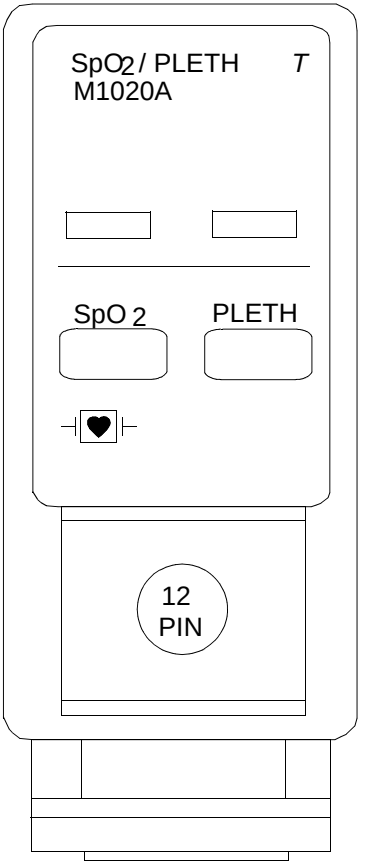
- The oxygen saturation is measured using the pulse oximetry method. This is a continuous, noninvasive method of measuring the arterial hemoglobin oxygen saturation. It measures how much light, sent from light sources on one side of the transducer, travels through patient tissue (such as a finger or an ear), to a receiver on the other side.
- The amount of light getting through depends on many factors, most of which are constant, such as tissue or venous blood). However one of the factors, the blood flow in the arterioles, varies with time - because it is pulsatile. This measurement principle is used to derive all the SpO_2 -related measurements.
- The SpO_2 PLETH parameter delivers 3 measurements:-
  - **Oxygen saturation of the arterial blood** - The measurement of light absorption during a pulsation.
  - **PLETH waveform and pulse rate signal** - The detection of the pulsations themselves.
  - **Perfusion indicator** - The scaled ratio between two different light absorbing volumes (one varies with time and one is constant).
- The pulse rate and SpO_2 value are displayed as numerics on the Standard Display. The PLETH waveform can also be displayed on the Standard Display. The perfusion indicator is labelled as “PERF”. It can also be displayed on the Standard Display, when set to “On” in the Numerics On/Off Task Window.

Warning

The presence of dysfunctional hemoglobins such as Hb-CO or Met-Hb, or dye dilution chemicals can influence the oxygen saturation value measured by pulse oximetry.

The front of the module has two keys:

- The SpO_2 key for parameter setup, a light will appear above the key when you are in the setup.
- The PLETH key for parameter setup, a light will appear above the key when you are in the setup.



The SpO_2/Pleth Module

Caution

Radiated field strengths above 0.5 V / m may cause incorrect measurements. Therefore, it is recommended to avoid the use of electrical radiating equipment in close proximity to the patient monitor.

Dual SpO_2/ PLETH Measure-ments (Agilent CMS only)

If you have the appropriate system installed in your unit, you can measure arterial oxygen saturation at two separate locations on the body using two SpO_2 modules. The second SpO_2 channel provides an independent set of SpO_2/PLETH measurement results with full alarming, trending and recording capability.

Notes—The second SpO_2 channel

- does not provide QRS tone modulation
- cannot be selected as SpO_2 parameter for OxyCRG presentation
- is not transferred over the Agilent Network
- is not displayed in the SvO_2 Task Window, neither as a numeric nor as a trend curve.

The difference between the two saturation measurements is automatically derived when measureing two SpO_2s simultaneously and is displayed as 'dSpO_2'. The numeric can be displayed on the main screen, trended and recorded. This "difference" numeric has no alarming capability and is not transferred over the Agilent Network.

SpO_2/PLETH Measurement Setup

1. Check that the SpO_2/PLETH module is inserted in the rack.
2. Switch on the system.

Note—**(Agilent CMS only)**: If two SpO_2/PLETH modules are present, the system automatically allocates the SpO_2 channels as follows:

a. If the system is switched on when SpO_2 modules are already in the rack, the SpO_2 module located furthest left in the rack will be the first SpO_2 channel.

b. If you insert the SpO_2 modules into the rack after you switch on the system, the first SpO_2 module that is inserted in the rack will be the first SpO_2 channel, regardless of its location.

We recommend you insert the module for the first SpO_2 channel further left in the rack than the second module. This avoids an automatic reallocation of channel numbers after a power failure or after switching off and on again.

3. Select the correct type and size of transducer.
4. Prepare the transducer (disposable and semi-disposable only):
   - *Disposable*:

     remove protective backing.
   - *Semi-disposable*:
     apply a new adhesive wrap and new adhesive dots to the transducer.
5. Attach the transducer to the appropriate part of the patient's body. The procedure for each type of approved Agilent Technologies transducer is described in detail in Appendix C.
6. Attach the transducer cable to the module, either directly or via an adapter cable.

Screen Display

The SpO_2 numeric is displayed if:

- the SpO_2 parameter is switched on
- the SpO_2 numeric is switched on in the “Numerics On/Off” Task Window.

The PLETH wave must be selected for display for it to appear on the screen.

If PLETH is selected as the pulse source, the pulse numeric displayed on screen is derived from the PLETH wave.

Note—The PLETH waveform is set either to *Perfusion* or *SpO_2 SQI Mode*. These settings control the way the PLETH wave is adjusted for display on the screen, and are selected in configuration mode by the Agilent Service Engineer or the hospital biomedical engineer.

Warning

- **When the specified NELLCOR® transducers are used, the application must be consistent with the manufacturer's own guidelines.**
- **Prolonged, continuous monitoring may increase the risk of changes in skin characteristics, such as irritation, reddening, blistering or pressure necrosis, particularly on neonates and on patients with impaired perfusion and varying or immature skin morphology. Specific attention must be given to sensor site inspection for changes in skin quality, proper optical path alignment and attachment. Check the application site at regular intervals and change the site if any compromise in skin quality should occur. More frequent checking may be required due to an individual patient's condition.**
- **Setting the high SpO_2 alarm limit to 100% is equivalent to switching off the high alarm limit. High oxygen levels may predispose a premature infant to retrolental fibroplasia. Therefore the upper alarm limit for oxygen saturation must be carefully selected in accordance with accepted clinical practices.**

- **If the INOP suppression of SpO2 while measuring NIBP on the same arm is configured on, detection of a critical patient status such as sudden pulse loss or hypoxia may be postponed by up to 60 seconds.**

Notes—

- The PLETH waveform is set either to *Perfusion* or *SpO2 SQI Mode*. These settings control the way the PLETH wave is adjusted for display on the screen, and are selected in configuration mode by the hospital biomedical engineer. See page 14-9 for more details about these settings.
- The SpO_2 alarm delay built into the system is ten seconds. That means that the monitor generates an alarm if the averaged numeric value on the display stays beyond the alarm limit for more than 10 seconds.

Tone Modulation

If tone modulation is configured, the pitch of the QRS tone is related to the SpO_2 level. If the SpO_2 level drops, the QRS tone becomes lower.

Tone modulation can be switched on and off in the SpO_2 Task Window, where the current status (on or off) is also shown. From the SpO_2 Task Window you can also enter the Volume Control Task Window to change the volume of the QRS tone, if necessary.

The QRS tone is derived from the alarming parameter, which can be configured as *either* HR *or* pulse in the “Adjust Alarms” Task Window. If the numerics for the alarming parameter are set to "Off" when the monitor is switched on, there will be no QRS tone and therefore, no tone modulation is possible.

If the alarm parameter source goes into INOP, the modulated QRS tone does not stop. Instead, it is derived from PLETH, if the PLETH parameter is on.

Tone modulation is selected in a special *Configuration Mode*, by your biomedical engineering department. You can have tone modulation configured as either “Off”, “Standard” or “Enhanced”:

Standard The tone decreases by a small amount for each drop in the SpO_2 level. (This is equivalent to that used in *NELLCOR*® equipment.)

Enhanced The tone decreases more dramatically for each drop in the SpO_2 level, and is therefore easier to recognize.

SpO_2 Alarm Limits

The following alarm settings are adjustable in Monitoring Mode in the SpO_2 Adjust Alarms task window by using the **Low Limit** and **High Limit** softkeys (or the arrow keys for the Desat Alarm):

Alarm	Application Area	Averaging Trigger Time Adjustments
High ALarm Limit	OR and ICU	N / A
Low Alarm Limit	OR and ICU	N / A
Desaturation Alarm Limit	ICU	N / A
High Alarm Trigger Time	ICU	If enabled in Configuration Mode[a]
Low Alarm Trigger Time	ICU	If enabled in Configuration Mode[a]
Desaturation Alarm Trigger Time	ICU	If enabled in Configuration Mode[a]
Averaging Time	ICU	If enabled in Configuration Mode[a]

a. This setting is made by either your biomedical engineering department or the Agilent Service Engineer

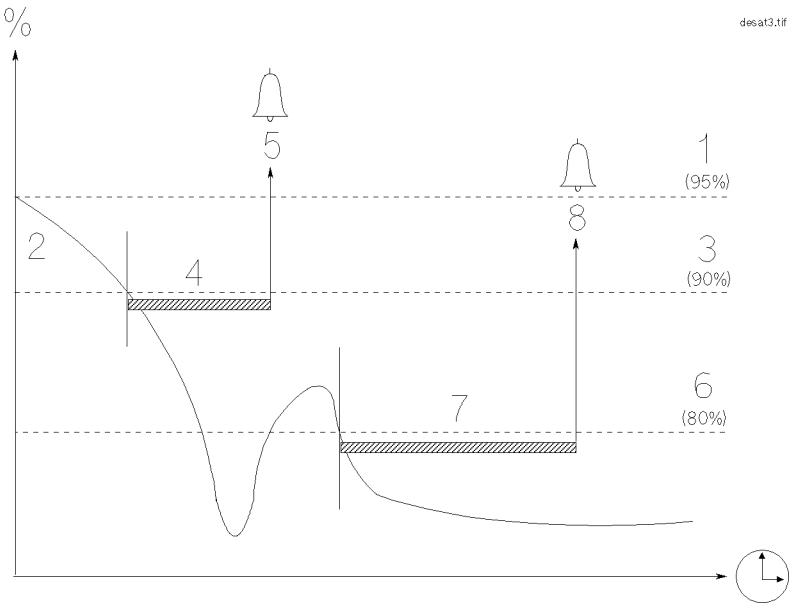
High Alarm Limit — If a patient's SpO_2 values rise above the high alarm limit, a **yellow** alarm is activated e.g **SpO_2 97>95.

Low Alarm Limit — If the patient's SpO_2 values fall below the low alarm limit a **yellow** alarm is activated e.g **SpO_2 88<90.

Desaturation Alarm Limit — If the patient's SpO_2 values fall below the desaturation alarm limit, a **red** alarm is activated e.g ***DESAT 78<80. The desaturation alarm limit must be set equal to, or lower than the low alarm limit.

Note—If the SpO_2 Desat or Low Alarm Limit is set below 50 % the following prompt message is displayed:
SpO_2 Alarm Limit < 50%. Check Settings

Escalating SpO_2 Situations



(1) High Limit *e.g (95%)*

(2) Current average SpO2.

(3) Low Limit *e.g (90%)*

(4) Low Limit Trigger Time *e.g (5 sec)*.

(5) SpO_2 has exceeded Low Alarm Trigger Time. Yellow Low Limit Alarm is activated.

(6) DESAT Limit *e.g (80%)*

(7) DESAT Trigger Time *e.g (10 sec)*.

(8) SpO_2 has exceeded DESAT Trigger Time. Red DESAT Alarm is activated (replaces previous Yellow Alarm).

Trigger Times

The SpO_2 trigger time for the high, low and desaturation alarms can be set to a value in the range from 0 to 30 seconds. This defines the amount of time that the average SpO_2 value needs to be above or below the alarm limits before an alarm is activated. For example, if the delay time has been set to 10 seconds then the SpO_2 value has to remain above or below the alarm limit for 10 seconds before an alarm is activated.

High Alarm Trigger Times: Shorter trigger times give a fast response to sudden High SpO_2 levels whereas longer trigger times suppress announcing shorter High SpO_2 levels.

DESAT and Low Alarm Trigger Times: Shorter trigger times give a fast alarm response to sudden SpO_2 drops whereas longer trigger times suppress announcing shorter SpO_2 drops.

The setting selected is also valid for a second SpO2 channel, if present.

Averaging Time

The SpO_2 value displayed on the monitor always represents an average SpO_2 value. This value is then compared against the set High, Low and Desaturation alarm limits.

The average value is calculated from the sum of SpO_2 values generated during a 5 (*fast*), 10 (*medium*) or 20 (*slow*) second averaging time.

- The *fast* setting uses a five second averaging time. This is useful for situations where an extremely fast measurement is required, and very little patient motion is expected.
- The *medium* setting uses a 10 second averaging time. This can be used in most clinical situations, where the amount of patient motion should be relatively low.
- The *slow* setting uses a 20 second averaging time. This setting will be least affected by patient motion, and so is most useful in situations where the patient is unavoidably active.

The setting selected is also valid for a second SpO_2 channel, if present (Neonatal CMS and selected Anesthesia CMS models only).

Note—The total alarm delay time is equal to the sum of *the delay caused by averaging* plus *the Trigger Time*. The maximum delay caused by averaging is equal to the set averaging time, namely 5, 10 or 20 seconds.

NBP Alarm Suppression

The "SpO_2/PLETH NON-PULSATILE" INOP is triggered when the SpO_2 sensor no longer detects arterial blood pulsation. When monitoring NBP and SpO_2 from the same limb, the inflation of the NBP cuff would normally trigger this alarm.

Warning

If the NBP INOP suppression of SpO2 while measuring NIBP on the same arm is configured on, detection of a critical patient status such as sudden pulse loss or hypoxia may be postponed by up to 60 seconds.

However with the Agilent CMS, V24 and V26 monitors, there is a characteristic drop in pulsation, due to a cuff inflation, the SpO_2/PLETH NON-PULSATILE INOP is suppressed for up to 35 seconds. The original SpO_2 measurement is displayed during this time, until new pulsations are detected and a new measurement can be made. This NBP Alarm Suppression setting can be set to "On" in a special Configuration Mode by your biomedical engineering department or the Agilent Service Engineer.

Testing the Alarm

The SpO_2 alarm function can be tested manually:

Step 1. Connect an SpO_2 transducer and make sure the SpO_2 measurement is switched on (See "Parameters On/Off on page 3-33)

Step 2. Select a high limit below 100% (e.g. 99%)

Step 3. Switch on test signals (See "The Test Signals Function" on page 3-58)

The test signal will simulate an SpO_2 value of 100% and an ****SpO_2 100>99** alarm condition will be generated.

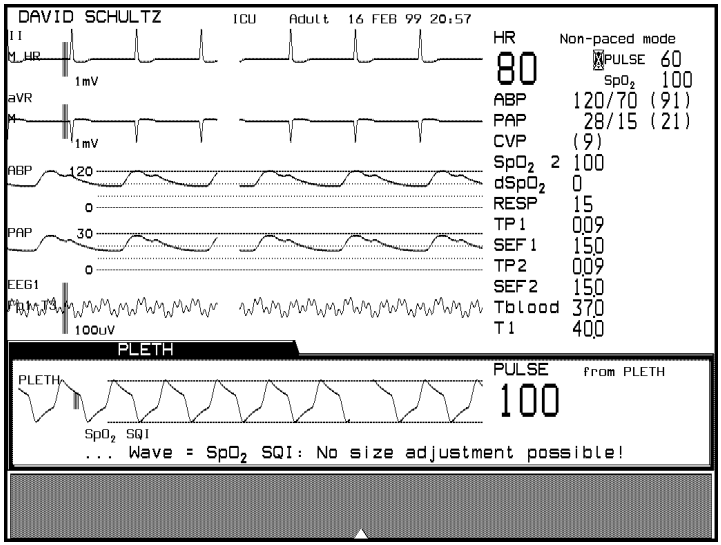
Adjustment of the PLETH wave.

There are two settings which control the appearance and behavior of the PLETH wave. These settings are called *Perfusion*, and *SpO_2-SQI Mode* (SpO_2 Signal Quality Indicator). *SpO_2-SQI* is the factory default. These are accessible in Configuration Mode, by the hospital biomedical engineer.

The *Perfusion Indicator* (if configured) functions independently from the selected wave presentation and gives additional information about arterial blood perfusion.

SpO_2 SQI Mode

Module Setup --> **Pleth**



The size of the wave is continuously adjusted automatically, and represents the quality of the signals that make up the SpO_2 measurement. It cannot be adjusted manually. If the SpO_2 signal and perfusion of the patient are good, and the selection of the transducer and application site is correct, the PLETH wave fills the channel between the grid lines. In this optimum case, the perfusion indicator reading is typically greater than 1. If the signal quality becomes weak, the PLETH wave size becomes progressively smaller, and the perfusion indicator reading typically falls below 1. This indicates lower, but still acceptable, confidence in the SpO_2 reading.

If the PLETH wave becomes smaller than the bar beside the SQI label and the perfusion indicator reading is typically 0.3 or less, the SpO_2 readings tend to vary and have to be interpreted carefully.

If the signal quality degenerates further, the INOP message "SpO_2 Non Pulsatile" appears, and the PLETH wave becomes a flat line.

A poor quality SpO_2 signal is *not* related to low hemoglobin saturation levels. It may be caused by inadequate peripheral circulation in the area of the transducer, an old or unsuitable transducer, or an inadequately applied transducer.

If the size of the PLETH wave starts to decrease:

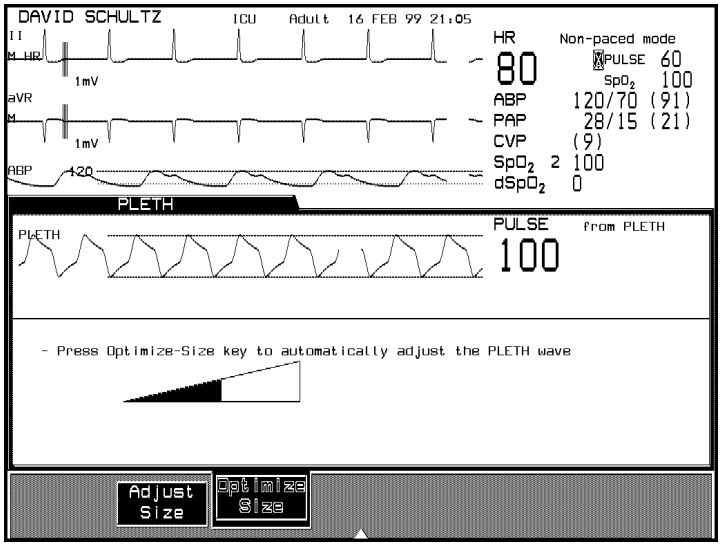
- Check that the transducer is appropriate for the patient. Select a new one if necessary.
- Inspect the application site and relocate the transducer to an area with better peripheral circulation if appropriate.
- Check that the transducers are correctly applied. (See Appendix C for details).

On extremely poorly perfused patients it may be impossible to significantly improve the SpO_2 signal quality by these means.

If the wave size is between optimum and the bar indicator, the SpO_2 signal is still sufficient to provide a reliable measurement.

Perfusion Mode

Module Setup --> **Pleth**



In the following three situations, the size of the PLETH wave is automatically adjusted for 60 seconds so that it fits between the grid lines.

- When the power is turned on, if an SpO_2/ PLETH module is present with a transducer connected *and* applied to the patient.
- After a transducer is connected to the SpO_2/PLETH module.
- Whenever the **Optimize Size** key in the PLETH Task Window is pressed.

Any subsequent change in the size of the PLETH wave during patient monitoring is caused by a change in the peripheral perfusion at the application site of the transducer. In addition, the perfusion indicator provides more precise digital information about significant perfusion changes.

In *Perfusion* setting, the size of the PLETH wave is *not* related to the quality of the SpO_2 signal.

The automatic adjustment period can be stopped by pressing **Adjust Size**. The size of the PLETH wave can then be manually adjusted by pressing either **Adjust Size** again, or the  and  keys.

To help you choose which mode is right for you, consider the advantages and disadvantages of each, as summarized below:-

Summary of Modes

Perfusion Mode	
Advantages:	Changes in wave size reflect changes in perfusion at the transducer site.
Disadvantages:	Needs manual adjustment to the wave size after significant changes in perfusion. Size of wave unrelated to SpO_2 signal quality. Gives no aid to transducer application/ selection.
SpO_2 SQI Mode	
Advantages:	No manual wave size adjustment needed. Wave size indicates signal strength of SpO2 measurements.
Disadvantages:	Wave size does not reflect changes in perfusion.

Notes—

- If you have chosen PLETH as your PULSE source, you can choose PULSE as your alarm parameter.
- If the SpO_2/PLETH module is unplugged from the rack, or PLETH is switched off, and Pulse is the alarm source, an INOP message “NO PULSE SOURCE” is displayed on the screen.
- Remember that HR/PULSE share the same alarm limits.

SpO_2/PLETH Alarm and INOP Messages

Remember- setting the high SpO_2 alarm limit to 100% is equivalent to switching off the high alarm. The SpO_2 and PLETH alarm messages are rated in order of severity:

*** Red
** Yellow
INOP message

Alarm tone = a single chime repeated every second.
INOP tone = a single beep every 2 seconds. Alarm limits are dependent on patient's condition.

Note—**(Agilent CMS only):** All Physiological and Technical (INOP) Alarms related to the second SpO_2/PLETH channel during SpO_2 monitoring are indicated separately, for example: ***SpO*$_2$ *2 80<85*. The messages may be shortened to enable the "2" indication to be included.

Physiological Alarms

Alarm Message	Condition	Visual Indication	Audible Indication
***DESAT 70<80	SpO_2 below the desaturation alarm limit[a]	SpO_2 numeric blinks. Red alarm lamp.	Alarm tone
**SpO_2 80<85	SpO_2 below the low alarm limit.	SpO_2 numeric blinks. Yellow alarm lamp.	Alarm tone
**SpO_2 98>94	SpO_2 alarm limit exceeded.	SpO_2 numeric blinks. Yellow alarm lamp.	Alarm tone
**PULSE 120>100	High alarm limit exceeded.	PULSE numeric blinks. Yellow alarm lamp.	Alarm tone
**PULSE 50<60	Pulse below low alarm limit.	PULSE numeric blinks. Yellow alarm lamp.	Alarm tone

a. This alarm is not available for OR applications.

Pulse Rate Alarms are only active if PULSE is selected as the alarm parameter.

Technical Alarms

INOP messages appear when the monitor cannot measure or process signals properly. This could be due to patient- related or equipment-related problems but you must always check the patient's condition first. The INOP message is sometimes accompanied by an audible alarm which can be silenced with the **Silence/Reset** key.

Patient-Related INOPS

INOP Message	Condition	Visual Indication	Audible Indication
SpO_2 NON-PULSATILE	Pulse is too weak or not detectable.	SpO_2 numeric displays -?-.	INOP tone
SpO_2 NOISY SIGNAL	Excessive patient movement or electrical interference are causing irregular pulse patterns.	SpO_2 numeric displays -?-.	INOP tone
SpO_2 LIGHT INTERF.	Level of ambient light is so high that the SpO_2 transducer cannot measure SpO_2 or pulse rate. **Or** transducer/adapter cable is damaged.	SpO_2 numeric displays -?-.	INOP tone
SpO_2 ERRATIC	Erratic SpO_2 measurements, often due to a faulty transducer.or Invalid SpO_2 measurements; often due to the transducer being incorrectly positioned.	SpO_2 numeric displays -?-.	INOP tone
PLETH NOISY SIGNAL	Patient movement or electrical interference are causing irregular pulse patterns.	Pulse numeric displays -?-*.	None
PLETH LIGHT INTERF	Level of ambient light is so high that the SpO_2 transducer cannot measure pulse rate.	Pulse numeric displays -?-.*	INOP tone

INOP Message	Condition	Visual Indication	Audible Indication
PLETH NON-PULSATILE	Pulse is too weak or not detectable.	Pulse numeric displays -?-*.	None.
PLETH REDUCE SIZE	Transducer displaced or increased pulse strength after automatic wave fixing. Press **Optimize Size** softkey in PLETH Task Window to restore the PLETH wave.	PLETH wave appears as a flat line above the gridlines.*	None

*These messages are only derived when PLETH is selected as the pulse source.

Note—The PLETH parameter has no alarm capabilities.

Equipment-Related INOPS

INOP Message	Condition	Visual Indication	Audible Indication
SpO_2 UN-PLUGGED	SpO_2/PLETH module switched on and un-plugged from the rack.	SpO_2 numeric displays -?-.	INOP tone
SpO_2 NO TRANSDUCER	SpO_2/PLETH transducer disconnected.	SpO_2 numeric displays -?-.	INOP tone
SpO_2 EQUIP MALF	Malfunction in the SpO_2/ PLETH module hardware.	SpO_2 numeric displays -?-.	INOP tone
SpO_2 TRANSD MALF	SpO_2 transducer is defective.	SpO_2 numeric displays -?-.	INOP tone
PLETH UN-PLUGGED	SpO_2 switched off, PLETH switched on and module un-plugged from the rack.	Pulse numeric displays -?-*.	INOP tone
PLETH NO TRANSDUCER	SpO_2 switched off, PLETH switched on and transducer disconnected.	Pulse numeric displays -?-*.	INOP tone
PLETH EQUIP MALF.	SpO_2 switched off, PLETH switched on **And** Malfunction in the SpO_2/ PLETH module hardware.	Pulse numeric displays -?-*.	INOP tone
PLETH TRANSD MALF	SpO_2 transducer is defective.	Pulse numeric displays -?-*.	INOP tone

*Only if PLETH is the pulse rate source.

Parameter Settings Transfer

The following settings can be transferred with SpO_2/PLETH modules that have a *T* on the front. For more information on Parameter Settings Transfer, refer to Chapter 3.

Setting Name	Meaning
Alarm limits	High and low alarm limits

Measurement Limitations

Refer to this section on problem situations if you have difficulty getting a signal or obtaining accurate measurements.

1. Distortion, such as ambient light, motion, perfusion or incorrect sensor placement may affect the accuracy of the derived measurements. See Appendix C for details.

2. The measurement depends on the pulsatile nature of blood flow in the arteries and arterioles; with the following conditions arterial blood flow may be reduced to a level at which accurate measurements cannot be made:

   – shock
   – hypothermia
   – use of vasoconstrictive drugs
   – anemia.

   An "SpO_2 NON-PULSATILE" message will appear on the display, if the pulsations are undetectable. You can use the perfusion indicator as a quality measurement of how strong the SpO_2 signal is, based on the information in the table below:-

SpO_2 Measurability

Perfusion Indicator	SpO_2 Measurability
Below 0.3	Marginal; frequent technical alarms
Between 0.3 and 1	Acceptable; sufficient arterial pulses can be identified for reliable readings.
Greater than 1[1]	Optimal; all arterial pulses can be identified. Minimal interference from movement artifacts.

[1]The optimum range may not be fully reached in neonatal applications due to weaker signals.

3. The measurement also depends on the absorption of particular light wavelengths by the oxyhemoglobin and reduced hemoglobin. If other substances are present which absorb the same wavelengths, they will cause a falsely high, or falsely low SpO_2 value to be measured. For example:

   – carboxyhemoglobin
   – methemoglobin
   – methylene blue
   – indocyanine green*
   – indiocarmine*

*These chemicals are used in dye dilution cardiac output calculations.

4. Very high levels of ambient light can also affect the measurement; an "SpO_2 LIGHT INTERF." message will appear on the display. The measurement quality can be improved by covering the transducer with suitable non see-through material.

SpO_2/PLETH Performance Specifications

For safety and environmental specifications, please refer to the *Monitor Installation and Patient Safety* Chapter 10.

SpO_2

Measurement

Wavelength Range	600 to 1000 nm
Emittedf Light Energy	≤ 5 mW
Measurement Range:	0 to 100%
Accuracy M1190/1/2A:	1 SD, 70% to 100%: ± 2.5%
Accuracy M1193/5A:	1 SD, 70% to 100%: ± 3%
Accuracy M1194A:	1 SD, 70% to 100%: ± 4%
Accuracy NELLCOR ®[a]	1 SD, 80% to 100%: ± 3%
Numerics:	Averaging of detected beats within 5 second (fast), 10 second (medium), or 20 second (slow) time intervals.
Display Update Period	Typical: 2 seconds Maximum: 30 seconds With NBP INOP Suppression: 60 seconds

a. Nellcor Sensors are: M1901A/B, M1902A/B, M1903A/B, M1904A/B, M1905A, M1906A, M1907A

Temperature Range

Operating:	10 to 37ºC (50 to 98.6ºF)
Storage:	-40 to 70ºC (-40 to 158ºF)

Humidity

Operating (non condensing):	95% RH max. at 37ºC (98.6ºF)
Storage:	95% RH max. at 65ºC (150ºF)

Alarms

Adjustment:	Steps of 1%
Adult	
High Range:	51 to 100% SpO_2
L*ow Range:*	50 to 99% SpO_2
Desaturation Range	50% to Low Limit Value
Pediatric/Neonatal	
High Range:	31 to 100% SpO_2
Low Range:	30 to 99% SpO_2
Desaturation Range:	30% to Low Limit Value
Alarm Criterion:	N seconds after the SpO_2 value exceeds the set **High**, **Low** or **Desaturation** alarm limit value, where N is in the range 0-30 seconds.
Alarm:	within 2 seconds after this criterion is met.
INOP Alarms:	Refer to Patient and Equipment related INOP tables.

PLETH

Measurement

Pulse Rate Range:	30 to 300 bpm
Accuracy:	± 1%
Resolution:	1 bpm
Wave Setting Time:	3 seconds

Alarms

High and Low Range:	30 to 250 bpm (Adult)
High and Low Range:	30 to 300 bpm (Pedi/Neo)
Adjustment:	Steps of 5 bpm
Alarm Criterion:	10 seconds after the value exceeds the set limit value
Alarm:	within 2 seconds after this criterion is met
INOP Alarms:	Refer to Patient and Equipment related INOP tables.

Care and Cleaning

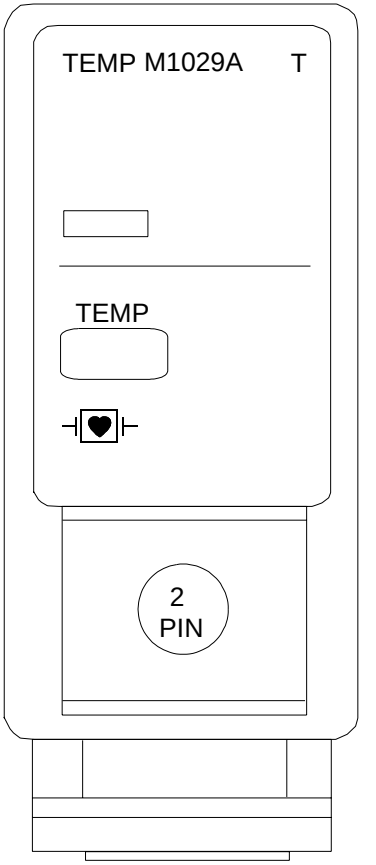
Please refer to Appendix D "SpO_2 Transducer Information" for information on care and cleaning.

17
Temperature Module Section

This chapter provides information on setting up temperature monitoring and measuring temperature differences. It includes the following sections:

Introduction to the Temperature Parameter Module

- If more than one temperature module is being used, a temperature difference can be derived.
- The front of the module has one key marked TEMP. This key is for parameter setup. A light appears above the key when you are in setup.



The Temperature Module

Note—The “T” on the front of the module indicates that this module transfers parameter settings from one monitor to another.

Temperature Measurement Setup

1. Check that the TEMP module is inserted in the rack.
2. If you are using disposable temperature probes you need to plug the temperature cable into the module and then connect the probe to the cable. With a reusable temperature probe you can plug the probe directly into the module.
3. Attach the temperature probe(s) securely to the patient.
4. Switch on the system.

Note—If your monitor has Parameter Settings Transfer set ON, you can select "*T*" modules that have stored settings.

Temperature Module Labeling

Temperature module labeling can be handled in two different ways by your Agilent CMS, V24 and V26 monitor:

Either 1. The label you select for a Temperature module is kept with the module. This means that a module which is labeled “Tskin” will remain “Tskin” after you move it to another slot, or even if you move it to another monitor.

Or 2. The Temperature module labels are allocated by the monitor according to its default settings. This means that the label may change from one rack position to another, or if the sequence that the modules are inserted in the rack is changed.

This behavior is dependent upon a “Parameter Settings Transfer” setting which is made in a special *Service Mode* by your biomedical engineering department.

Situation “1.” above corresponds to Parameter Settings Transfer ON.

Situation “2.” corresponds to Parameter Settings Transfer OFF.

Note—Labeling for the Pressure module is handled in the same way as the Temperature module.

Parameter Settings Transfer details relating to labeling are provided on the following pages.

Labeling with Parameter Settings Transfer ON

If you set Parameter Settings Transfer ON, Temperature module labels are kept with the modules. The label only changes if:

- you change it in the Temperature Task Window.
- you reset all parameter settings to their default values. This happens when you change Configuration Sets or operating modes.

Label Tracking Messages

Message	Condition	Action Required
Identical label in rack position *R-P* and *R-P*	Two modules with the same label have been plugged into the rack: *R* is the number of the rack, (1=integral rack, 2=first satellite rack,...) *P* is the slot number in that rack, (1=slot on left, 8=slot on right).	Change the label on one of these modules, or replace one of them with a module that has a different label.
Check label and settings	No settings are stored in the module, **or** the settings are incorrectly stored, **or** the module label is not one of the pre-configured labels in the monitor.	Check/change the label and settings in the parameter Task Window.

Labeling with Parameter Settings Transfer OFF

If you set Parameter Settings Transfer OFF, the module labels are allocated by the monitor each time they are plugged-in. This can happen in the following two ways:

1. When the monitor is switched ON, the Temperature modules are numbered in ascending order from left to right in the rack.
2. During monitoring, if the Temperature modules are removed from the rack, the first one to be replaced will be T1, the second will be T2 and so on. They are numbered according to the order they are put back in the rack. Their physical position in the rack is irrelevant.

If a temperature module is removed, and another temperature module is put in its slot, the monitor recognizes the change. The prompt message

"Check label and settings''

appears. The message will disappear if you enter a Temperature Task Window.

Temperature Labels Available

Label	Meaning
T1 to Tn*	standard label
Tskin	skin temperature
Tcore	core temperature
Trect	rectal temperature
Tnaso	nasopharyngeal temperature
Tesop	esophageal temperature
Tart	arterial temperature
Tven	venous temperature

*The number of temperature labels depends on the monitor and option you have purchased

Notes—

- If you unplug and then replug temperature modules, check their labels and settings. These may change.
- Reposition the temperature modules *one at a time.*
- Only information relating to temperature labels T1, T2, T1-T2 and TBlood will be broadcast over the Agilent patient care system, and appear at the Central Station.
- If you choose temperature labels different from these, data (such as trend information) will only appear on the bedside monitor.
- The color of a temperature numeric is linked to the temperature module number (T1 to T4), **not** the temperature label. Therefore,

the color of a temperature numeric does not change when a new label is assigned to the module.

Measuring Temperature Differences

There are various clinical situations where the measurement of two temperatures and the difference between them are important. For example:

1. The difference in temperature between a patient and their environment - for example, a neonate in an incubator. The temperature gradient will indicate how well the neonate is maintaining its body temperature.

2. The difference in temperature between two parts of the same patient's body - for example, toe and core temperature in a post cardiac surgery patient. The temperature gradient will indicate the state of the peripheral circulation.

You need to have more than one temperature module in the rack. Depending on the model, you will have the capability of measuring up to four temperatures, therefore, the number of temperature differences you can measure depends on the number of temperature modules you are using. The softkeys will be labeled Diff 1 and Diff 2 in the Parameters Selection Window. The temperature difference on the display is accurate to 0.1°C.

Getting into the Diff Temperature Task Window

1. Press the hard key **Module Setup** .
2. Move the line of highlighting in the Selection Window to the line which includes **Diff 1** or **Diff 2** and press the appropriate softkey.

Selecting Labels for Diff Temperatures

In the table below is a list of the labels as shown on the display for diff temperatures.

Label	Meaning
T1-T2 (T4)*	standard labels
Tsk	skin temperature
Tco	core temperature
Tre	rectal temperature
Tar	arterial temperature
Tna	nasopharyngeal temperature
Tes	esophageal temperature
Tve	venous temperature
Tbl	blood temperature

*Agilent CMS only

Note—These labels are shortened versions of the standard temperature labels as they will combine together to form the labels for temperature differences, for instance Tsk-re.

Parameter Settings Transfer

The following settings can be transferred with temperature modules that have a *T* on the front. For more information on Parameter Settings Transfer, refer to “Parameter Settings Transfer, Chapter 3."

Setting Name	Meaning
Alarm limits	Temperature alarm limits
Site label	Temperature site label

Temperature Alarm and INOP Messages

The Temperature alarm messages are rated in order of severity:

** Yellow
INOP messages

Alarm tone = a single chime repeated every second.
INOP tone = a single beep repeated every 2 seconds. Alarm limits are dependent on the patient's condition.

Physiological Alarms

Alarm Message	Condition	Visual Indication	Audible Indication
**<T1> 39>38	High alarm limit exceeded.	<T1> numeric blinks. Yellow alarm lamp.	Alarm tone
**<T1> 35<36	Temperature below low alarm limit.	<T1> numeric blinks. Yellow alarm lamp.	Alarm tone

Technical Alarms

INOP messages appear when the monitor cannot measure or process signals properly. This could be due to patient-related or equipment-related problems but you must always check the patient's condition first. The INOP message is accompanied by an audible alarm, which can be silenced with the **Silence/Reset** key.

Patient-Related INOPS

INOP Message	Condition	Visual Indication	Audible Indication
<T1> OVERRANGE	Temperature out of the range<-1°C or >45 °C.	<T1> numeric displays -?-.	INOP Tone

Equipment-Related INOPS

INOP Message	Condition	Visual Indication	Audible Indication
<T1> UN-PLUGGED	TEMP module switched on and has been unplugged from the rack.	<T1> numeric displays -?-.	INOP tone
<T1> NO TRANSDUC	TEMP probe disconnected from the module.	<T1> numeric displays -?-.	INOP tone
<T1> EQUIP MALF	Malfunction in the temperature hardware.	<T1> numeric displays -?-.	INOP tone

Accessories and Ordering Information

Reusable Temperature Probes

		Application	Additional Information
General Purpose Temperature Probes	21075A/B	Adult esophageal and rectal temperature measurements.	Probes are very rugged. They feature a vinyl tip and lead.
Small Flexible Vinyl Temperature Probes	21076A/B	Pediatric esophageal and rectal temperature measurements.	Both probes feature cuvette temperatures and vinyl tip and sheath. Pediatric rectal probe can be used for long term monitoring on adults because it is more comfortable.
Tubular Temperature Probes	23001A 23002A	Cardiac output probes - dye and ice bath	Static temperature probes to measure cardiac output using dyes (23001A) or ice bath and syringes (23002A). Probes can also be placed under the arm to give axilla temperature.
Attachable Surface Temperature Probes	21078A/B	Can easily be taped to the skin to give surface temperature readings.	

Disposable Temperature Probes

	Agilent Product Number	Size	Application	No per box
General Purpose Temperature Probes	M1837A 21090A	9FR 12FR	Used to measure core temperature at esophageal, rectal or nasopharyngeal sites.	20/box
Skin Temperature Probes	21091A		Non-invasive probes for measurements at axilla, chest, under shoulders or between skin and heating blanket.	20/case
Esophageal Stethoscope Temperature Probes	M1838A 21093A 21094A 21095A	9FR 12FR 18FR 24FR	Used to measure heart and breath sounds along with esophageal temperature.	20/box
Foley Catheter Temperature Probes	M1839A M1840A 21096A 21097A	8FR 10FR 16FR 18FR	Used to measure temperatures in surgical situations requiring bladder drainage. Temperature can be monitored for as long as Foley is in place.	10/box

Cables

21082A extension cable for disposable probes (3.0 m)
21082B extension cable for disposable probes (1.5 m)

Performance Specifications

For safety and environmental specifications, please refer to the *Monitor Installation and Patient Safety* Chapter 10.

Temperature

Measurement

Measurement Range:	-1 to 45°C
Resolution:	0.1°C
Accuracy:	± 0.1°C
Diff. Temperature:	± 0.1°C
Average Time Constant:	Less than 10 seconds
Test Temperature:	40°C ± 0.1°C
Display Update:	2 seconds nominal.

Alarms

Alarm Limit Range:	-1 to 45°C
Adjustment:	Steps of 0.1°C (T > 35 °C) Steps of 0.5°C (T < 35 °C)
Alarm Delay:	< 30 seconds after the value exceeds the set limit value.
INOP Alarms:	Refer to Patient and Equipment related INOP tables.

Care and Cleaning

Reusable Temperature Probes|

1. The temperature probe should not be heated above 100°C (212°F). It should only be subjected briefly to temperatures between 80°C (176°F) and 100°C (212°F).

2. The probe must not be sterilized in steam.

3. Only detergents which do not contain alcohol should be used for disinfection.

4. To clean the probe, hold the tip with one hand and with the other using a moist lint-free cloth rub the probe down in the direction of the connector.

Note—If you are using the disposable temperature probes these must not be re-sterilized or reused.

18
CO_2 Module and Sidestream Module Section

This chapter provides information on mainstream and sidestream Carbon Dioxide (CO_2) monitoring. It includes the following sections:

Introduction to the CO_2 and Sidestream Modules

The M1016A CO_2 module is a carbon dioxide measurement unit designed to be used with intubated adult, pediatric or neonatal patients in the operating room, ICU or NICU environment. The M1015A sidestream module is designed for use with the M1016A to provide a solution for long-term intubated pediatric or adult patients weighing more than 7 kg in the operating room or ICU environment. The modules, in conjunction with the M1460A transducer, provide two methods of measuring the partial pressure of carbon dioxide in the patient's airway. From this, the end tidal carbon dioxide ($ETCO_2$) is derived. $ETCO_2$ is the peak CO_2 value measured at the end of expiration. The $ETCO_2$ measurement uses a technique based on the absorption of infrared radiation by some gases. It indicates changes in:

- The elimination of CO_2.
- The delivery of O_2 to the lungs.

The CO_2 module on its own, or in conjunction with the sidestream module provide the system with an $ETCO_2$ value, a CO_2 waveform, and the following additional values:

- Inspired Minimum CO_2 ($IMCO_2$) - the smallest value sensed during inspiration (displayed as a numeric).
- Airway Respiration Rate (AWRR) - the number of breaths per minute (displayed as a numeric).
- The uncorrected instantaneous CO_2 value - displayed in Calibration Mode.

Sidestream and Mainstream CO_2 Measure-ment

There are two CO_2 measurement methods:

- Mainstream M1016A (CO_2 module).
- Sidestream M1015A (CO_2 sidestream module).

Note—You cannot measure both sidestream and mainstream CO_2 at the same time. In patient monitoring mode, the system automatically recognizes the placement of the CO_2 transducer on the sidestream

module and switches to sidestream mode on the Agilent CMS, V24 or V26 monitor display. The system automatically switches back to mainstream mode when the CO_2 transducer on the sidestream module is removed. Please refer to the section for further details.

Caution

- **If operating under conditions according to the EMC-standard 60601-1- 2 (Radiated Immunity 3 V/m), field strengths above 1 V/m may cause erroneous measurements, if the frequency is in the range of 28 to 38 MHz. Therefore it is recommended to avoid the use of electrically radiating equipment in close proximity to CO_2 measurements.**
- **Fast power line transients (bursts) may cause temporary degradation of the displayed CO_2 wave and numeric. However, the plug-in module will not be damaged and will self-recover after the transient is over.**

Mainstream Measurement

The **mainstream** method measures the CO_2 present in the endotracheal tube. The transducer is placed on an airway adapter, which is fitted within the respiratory tube near the patient's mouth.

Sidestream Measurement

The **sidestream** method has a pump which draws expired patient gas at a flow rate of 100ml/min along a gas sampling tube attached to the patient's main breathing circuit and the sidestream module.

Note—The sidestream module can *only* be used when the M1016A **CO_2** module is present.

The CO_2 transducer is connected to the sidestream module, not to the airway adapter in the patient's breathing circuit.

Warning

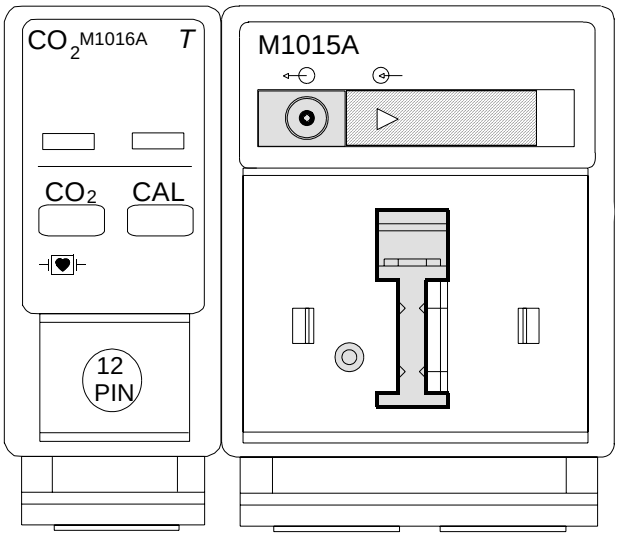
- **Danger - explosion hazard - sidestream measurement should not be used in the presence of flammable anesthetics such as:**
  - **Flammable anesthetic mixture with Air.**
  - **Flammable anesthetic mixture with Oxygen or Nitrous Oxide.**
- **CO_2 should not be measured in the presence of aerosolized pharmaceuticals.**

CO_2 Module Setup Keys

The front of the CO2 module has two keys:

- The CO_2 key for parameter setup; a light appears above the key when you are in setup mode.
- The CAL key to enter calibration mode. When you are in calibration mode a light appears above the key and the CO_2 CAL Task Window is displayed.

Note—The parameter setup and calibration modes cannot be accessed via the sidestream module. When using the sidestream method, these modes can only be accessed via the CO_2 module.



The CO_2 Module and the Sidestream Module

CO_2 and Sidestream CO_2 Measurement Setup

1. Ensure that the CO_2 module and, if applicable, the sidestream module are in the rack.

2. Switch on the system.

3. If you are using **mainstream** measurement place the transducer on the patient's airway adapter and attach the connector to the CO_2 module. If you are using **sidestream** measurement place the transducer on the sidestream module, and attach the connector to the CO_2 module. The message CO_2 `SENSOR WARMUP` is shown on the Standard Display until the transducer reaches operating temperature.

Caution

The message "`CO2 SENSOR WARMUP`" is shown on the Standard Display to indicate that the sensor is warming up. When the message disappears from the Standard Display, a calibration can be performed, although subsequent CO_2 measurements will have a slightly reduced accuracy due to the short warmup time. If a cold sensor is plugged into the CO_2 module or placed on the sidestream module, waiting a total of 20 minutes before performing a calibration ensures that subsequent measurements have the maximum possible accuracy.

4. Perform an accuracy check using the calstick and if necessary calibrate the transducer. Refer to the Calibration Procedure described in this section. Always use the Calstick that is attached to the transducer cable.

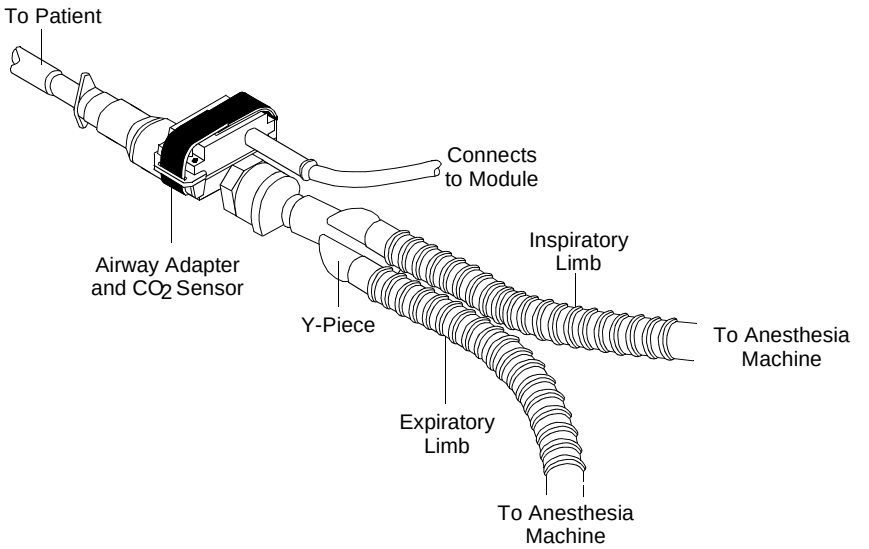
Notes—

- Always calibrate the transducer when it is moved from one module to another.
- When the transducer remains connected to the module, perform an accuracy check at least once a day. If the sensor doesn't pass the accuracy check, calibrate.
- Once the CO_2 transducer is calibrated, the calibration data is maintained in the module. Therefore, if you unplug the module and plug it into another monitor with the same transducer connected, no calibration is required.

When you are in calibration mode, the CO_2 Module is not able to monitor a patient.

Mainstream Setup

5. If you are using **mainstream** CO_2 measurement only, refer to the diagram below to attach the transducer to the patient's breathing circuit.



CO 2 Transducer and Breathing Circuit

Warning

Support the transducer and Airway Adapter to prevent stress on the endotrachial tube.

- Snap the transducer onto the Airway Adapter and place it in the patient's breathing circuit between the endotracheal tube and the Y-piece.
- The accuracy of the transducer depends on its operating temperature. The INOP message `CO2 SENSOR WARMUP` is displayed until the transducer is at operating temperature.

Sidestream Setup

6. If you are using **sidestream** CO_2 measurement refer to the diagram on page 16-11 to attach the transducer to the patient's breathing circuit.

- If you are using the M1460A transducer, please attach the transducer clamp (M1015-41201) to the transducer prior to use with the sidestream module. Attach the transducer to the sidestream module; it clicks into place. If necessary, roll up the excess transducer cabling into a coil and use the cable tie to hold the cabling in place.
- Fit the bacterial filter (part number 13904A) to the Gas Sample Tube using a twisting action.

Warning

Use only the recommended Gas Sample Tubes (Product Numbers 13901A or 13905A). Agilent Technologies disclaims all responsibility if other types of tubing are used. Discard any tubes which are kinked, since these could cause an occlusion. Use a bacterial filter at all times to protect both the patient and the module.

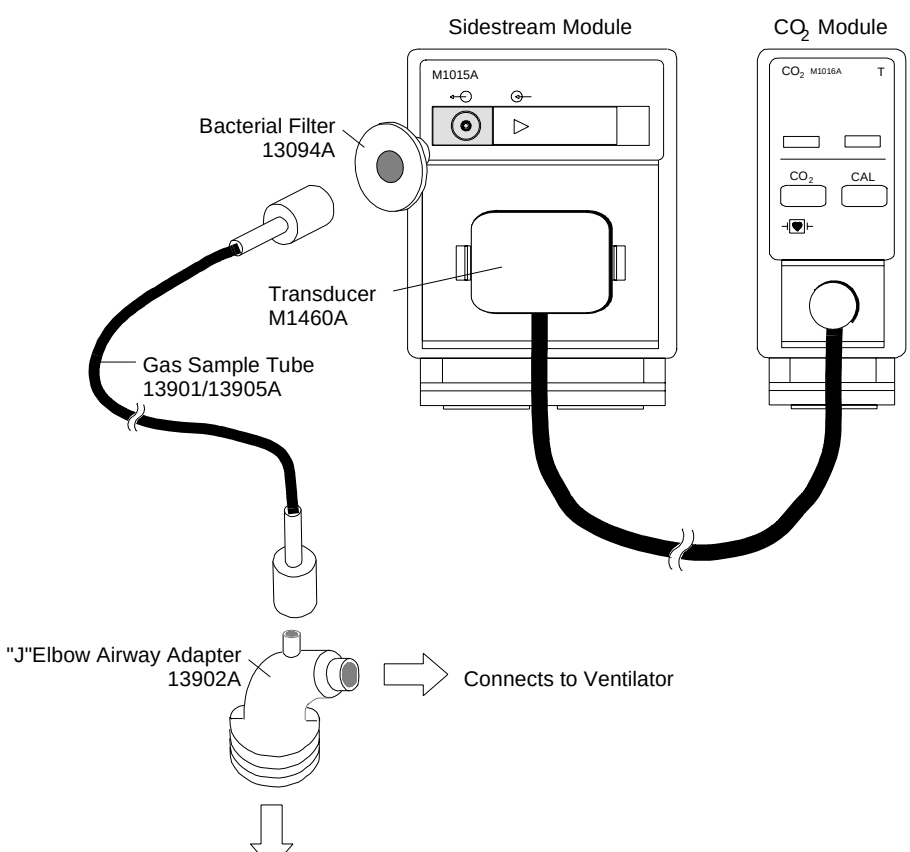
- Connect the Gas Sample Tube and filter to the sidestream module; slide back the door and use a twisting action to fit the filter tightly in place and to ensure leaks are prevented.
- Connect the Gas Sample Tube to the patient via a "J" (elbow) adapter.

Note—If you are using the 13905A Gas Sample Tube, ensure that the end with the **braided** surface is attached to the "J" (elbow) adapter, and that the end with the **smooth**, polyethlene surface is connected to the filter and sidestream module.

When both the CO_2 module and the sidestream module are plugged in, one of the following messages is displayed on the left side of the waveform line in Standard Display mode to tell you which measurement method is being used:

Sidestream Measurement Waveform Messages

Message	Description
MAIN	Mainstream measurement (transducer attached to patient's main airway).
SIDE	Sidestream measurement (transducer connected to sidestream module).
ZERO	Sidestream sensors reading zero. This occurs immediately at each cold or warm start, then after half an hour, and subsequently every 2 hours for 2-3 seconds while in monitoring mode.
OFF	Sidestream pump switched off. CO_2 not being measured at all.



Sidestream Module, CO_2 Transducer and Breathing Circuit

Note—The bacterial filter provided by Agilent Technologies must be attached to the module end of the gas sample tube. It is not designed for use at the patient end of the tube.

Sidestream Pump Operation

The sidestream module contains a pump which draws expired patient gas along the gas sampling tube for analysis and measurement by the CO_2 transducer and CO_2 module.

The pump is automatically switched on when the sidestream module is placed in the rack, the transducer attached and the monitor ready for use.

Sidestream Off

The Sidestream measurement automatically switches itself off when:

- There is no CO_2 monitoring for 1 hour. AND
- The transducer is attached to the sidestream module.

The following messages indicate that the pump is off:

- The waveline becomes blank.
- The standard display message reads ⍓;`CO2 SIDESTRM OFF`.
- The waveform message reads `OFF`.
- The waveform numerics read -?-.

To restart the measurement do the following:

1. Ensure that the transducer is placed on the sidestream module.
2. Press the CO_2 key on the CO_2 module. The CO_2 task window is displayed on the monitor
3. If the **Restart Sidestrm** softkey is highlighted, press it once to restart the Sidestream CO_2 measurement.

Note—If Sidestream is already switched on, the **Restart Sidestrm** key is not available for selection in the CO_2 task window. It appears as a "hollow" key. If no sidestream module is present in the module rack the **Restart Sidestrm** softkey is not displayed.

N_2O, O_2 and Environmental Corrections

The CO_2 absorption is influenced by the temperature and by water vapor in the patient's breath. These influences are corrected automatically.

The CO_2 absorption is further influenced by barometric pressure and by other gases in the mixture. You can make corrections to compensate for these influences in the following ways:

- An adjustment for barometric pressure is made during installation of the monitor by entering the altitude of operation. This setting is made in *Service Mode* by your biomedical engineer or the Agilent Service Engineer.
- **(Agilent CMS only)**: When an FIO_2 module is in use, the O_2 value from this module is used to correct for O_2.
- **(Agilent CMS only)**: If an FIO_2 module is not in use the system uses correction values of 45% O_2 and 55% N_2 or 55% N_2O.
- For other inspired O_2 concentrations use the information below to correct for CO_2:
  - You can select to have the value corrected for two different compositions of breathing gases:
    - If the gas mixture contains N_2, O_2 and CO_2 (ICU), you must select N_2O OFF.
    - If the gas mixture contains N_2O, O_2 and CO_2 (OR) you must select N_2O ON.

O_2 Correction Values (in mmHg)

CO2 Reading in mmHg	Correction Values			
	N_2O ON		N_2O OFF	
	21% O2	75% O_2	21% O2	75% O2
30	-1.1	+1.3	-0.4	+0.7
40	-1.6	+1.9	-0.5	+0.9
60	-2.6	+3.1	-0.8	+1.5
80	- 3.8	+4.6	-1.1	+2.1
100	-5.1	+6.3	-1.5	+2.6

To adjust the CO_2 value displayed on the monitor, use the table above to:

Example

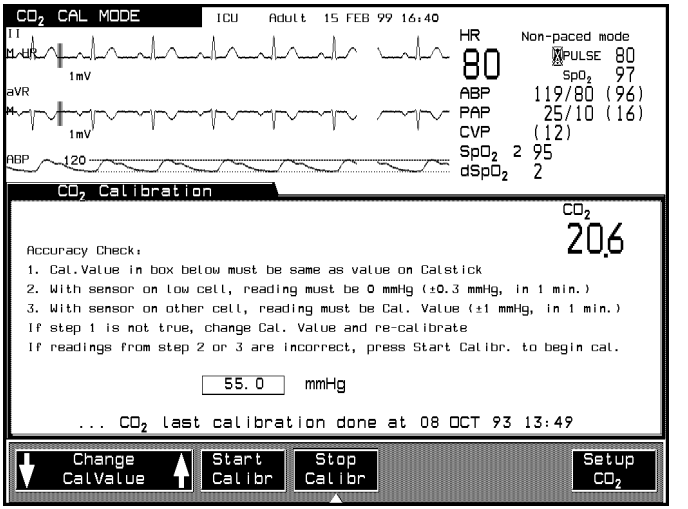
1. Select the column for your N_2O correction settings.	N_2O ON
2. Select the O_2 concentration for your patient's environment.	75% O_2
3. Select the CO_2 reading from the first column in the table which is closest to the displayed value on the monitor.	Display = 38mmHg Table = 40mmHg
4. Read the correction value from the table.	+1.9
5. Add this correction value to the displayed value on the monitor.	1.9 + 38mmHg

Example

6. This gives you the corrected CO_2 value.	39.9mmHg

Calibration

Module Setup --> **CO2** --> **Calibr. CO2**



You can also enter the Calibration mode by pressing the CAL key on the front of the module.

When you initiate a calibration the system enters CAL mode and the CO_2 alarms are disabled. The CAL LED on the front of the module is illuminated and the message CO2 CAL MODE is displayed in the INOP message field. The date and time of the last successful calibration is also displayed.

If the transducer has not been connected to a module, allow it to warm up until the message CO2 SENSOR WARMUP leaves the system message field.

To check whether a calibration procedure is necessary, the following accuracy check can be done. If the check fails, then calibration is required.

Accuracy Check

Check that the calstick value displayed in the box on the screen is the same as that indicated on your calstick.

- If the calstick value displayed is the same as the value indicated on your calstick, do the following:

  1. Place the transducer on the low cell (labelled 0.0 mmHg). The reading on the display should be within ±0.3 mmHg within 1 minute.

  2. Place the transducer on the high cell. The reading should be within ±1 mmHg of the value on the calstick within 1 minute.

  If either of the readings are out of range, press **Start Calibr.** to recalibrate the transducer. Follow the calibration procedure described in this section.

  If both readings are inside the given ranges, calibration is not required. Press **Setup CO2** to return to the CO_2 Task Window, or press **Main Screen** to return to the Main Screen.

- If the calstick value displayed does **not** match the value indicated on your calstick, do the following:

  1. Use the softkeys **↓Change Cal Value↑** to set the correct value. (Each time you press the key, the value is adjusted by 0.1 mmHg.)

  2. Press **Confirm** . You will then enter the CAL Task Window. Follow the calibration procedure described in this section.

Notes—

- The calstick value is only stored after a successful calibration. Hence, if you have changed the cal value, you must do a calibration.

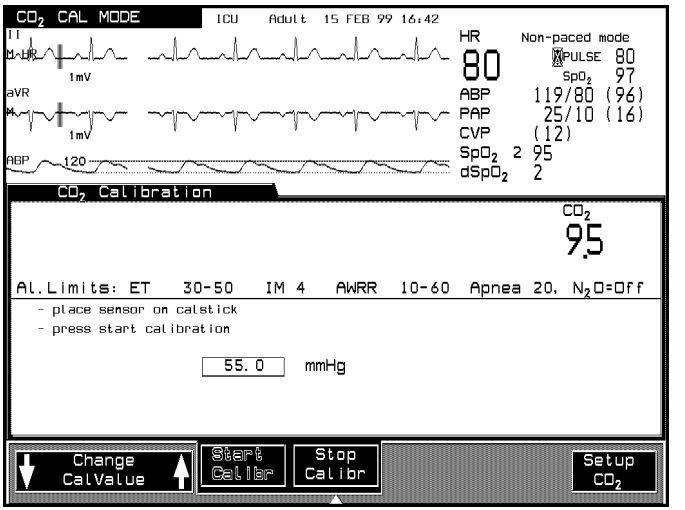
- The calstick value is given in mmHg and is entered as mmHg, even if you have selected the kPa option.

Calibration Procedure

Module Setup → **CO2** → **Calibr. CO2** → **Start Calibr.**

or

Module Setup → **CO2** → **Calibr. CO2** → **↓Change Cal Value ↑** → **Confirm**



1. When you enter the CAL Task Window, you are prompted to:

   - `Place sensor on calstick`
   - `Press Start Calibr.`

   Place the transducer onto either calstick cell and then press the softkey **Start Calibr.** .

   The first part of the calibration takes place. This is indicated by the message `CO2 CAL1 running`.

2. If an error occurs during the calibration procedure the system displays the message `CO2 CAL1 error` and you are prompted to:

   - `Check whether sensor is securely in position on calstick`
   - `Start calibration again`

Repeat step 1 of this procedure.

3. When the first part of the calibration has successfully completed (this takes up to 5 minutes), the message `CO2 CAL1 done` is displayed and you are prompted to:

   - `Place sensor on other cell`
   - `Press Start Calibr.`

   Place the transducer on the other calstick cell then press the softkey **Start Calibr.** .

   The second part of the calibration takes place. This is indicated by the message `CO2 CAL2 running`.

4. If an error occurs during the calibration procedure the system displays the message `CO2 CAL2 error` and you are prompted to:

   - `Check whether sensor is placed on other CAL cell`
   - `Start calibration again`

   Repeat step 3 of this procedure.

5. When the second calibration has successfully completed (this takes up to 5 minutes), the message `CO2 CAL done` and the date and time of this successful calibration are displayed.

6. With the transducer on the high cell, check that the CO_2 value you get matches the calstick value to within $\pm$1.0 mmHg ($\pm$0.15 kPa) within 1 minute.

7. When the calibration is complete, to exit CAL mode and return to normal monitoring, press **Main Screen** . The CAL LED is switched off and you return to the Main Screen.

Notes—

- During the calibration procedure you can return to the Main Screen by pressing **Main Screen** . The calibration continues but the Calibration Task Window is removed from the display.
- When the first part of the calibration is complete, you are prompted: `CO2 CAL1 done - start CAL 2`.
- When the second part of the calibration is complete, the message: `CO2 CAL done` is displayed.
- To return to the Calibration Task Window press the hardkey **Module Setup** then the softkeys **CO2** and **Calibr. CO2** , or press the CAL key on the front of the module.

CO_2 Alarm and INOP Messages

The CO_2 alarm messages are rated in order of severity:

*** Red

** Yellow

INOP message

Alarm tone = a single chime repeated every second.
INOP tone = a single beep repeated every 2 seconds.
Alarm limits are dependent on patient's condition.

Physiological Alarms

Alarm Message	Condition	Visual Indication	Audible Indication
**$ETCO_2$ 55>50	$ETCO_2$ above high alarm limit.	$ETCO_2$ numeric blinks. Yellow alarm lamp.	Alarm tone
**$ETCO_2$ 25<30	$ETCO_2$ below low alarm limit.	$ETCO_2$ numeric blinks. Yellow alarm lamp.	Alarm tone
**$IMCO_2$ 5>4	$IMCO_2$ above high alarm limit.	$IMCO_2$ numeric blinks. Yellow alarm lamp.	Alarm tone
**AWRR 45>40	AWRR above high alarm limit.	AWRR numeric blinks. Yellow alarm lamp.	Alarm tone
**AWRR 5<8	AWRR below low alarm limit.	AWRR numeric blinks. Yellow alarm lamp.	Alarm tone
***APNEA	Apnea - no breath detected in the selected delay time.	AWRR numeric (=0) blinks, $ETCO_2$ numeric is blank, $IMCO_2$ shows instantaneous CO_2 value. Red alarm lamp.	Alarm tone

The alarm limit ranges are as follows:

Alarm	Range
$ETCO_2$ High alarm	20 to 100 mmHg (2 to 14 kPa)
$ETCO_2$ Low alarm	10 to 95 mmHg (1 to 13 kPa)
$IMCO_2$	2 to 20 mmHg (0.3 to 3 kPa)

AWRR High Alarm Limit Ranges

Adult & Ped.	10 to 100 rpm
Neonatal	30 to 150 rpm

AWRR Low Alarm Limit Ranges

Adult & Ped.	0 to 95 rpm
Neonatal	0 to 145 rpm

APNEA Delay Value

Adult & Pediatric & Neonatal	10 to 40 s

Sidestream Measurement

AWRR In all cases 10 to 100 rpm

Technical Alarms

INOP messages appear when the monitor cannot measure or process signals properly. This could be due to patient-related or equipment-related problems but you must always check the patient's condition first. The INOP message is accompanied by an audible alarm which can be silenced with the **Silence/Reset** key.

INOP Messages

INOP Message	Condition	Visual Indication	Audible Indication
CO_2 UNPLUGGED	Module switched on and unplugged from rack. Silencing the alarm switches the parameter off.	CO_2 wave disappears, numerics display -?-.	INOP tone
CO_2 EQUIP MALF	Malfunction in the transducer or module.	CO_2 wave disappears, numerics display -?-.	INOP tone
CO_2 NO TRANSDUCER	Transducer not connected. Silencing the alarm switches the parameter off. If the transducer is replaced, the new transducer must be calibrated.	CO_2 wave disappears, numerics display -?-.	INOP tone

INOP Message	Condition	Visual Indication	Audible Indication
CO_2 FAILED CAL	Calibration aborted due to power failure, unstable signal during calibration or transducer being placed on the wrong Cal cell.	CO_2 wave and AWRR numeric are valid, other numerics are questionable (?).	None
CO_2 SENSOR WARM UP	The transducer has not reached operating temperature.	$ETCO_2$, AWRR and $IMCO_2$ numerics questionable (?).	None
CO_2 CAL RUNNING	The CO_2 calibration is running.	CO_2 wave set to zero, numerics display -?-.	None
CO_2 CAL MODE	CAL mode is set but the calibration has not been initiated.	CO_2 wave is set to zero, instantaneous CO_2 valid, other numerics display -?-.	None
CO_2 CHECK CAL	CO_2 value <-2 mmHg, >150 mmHg.	AWRR, $ETCO_2$ and $IMCO_2$ numerics displayed as -?-.	None
CO_2 OVERRANGE	$ETCO_2$ > 90 mmHg, therefore no scale is available to display the wave.	Wave display clipped at 90 mmHg.	None
CO_2 REDUCE SIZE	$ETCO_2$ > 60 mmHg in 40 mmHg wave scale. Selecting the 60 mmHg scale will enable the full wave to be displayed.	Wave display clipped at 60 mmHg.	None

INOP Message	Condition	Visual Indication	Audible Indication
CO_2 OCCLUSION	**Sidestream** sample flow rate < 50ml/min due to failure in pump system, tubing or filter to patient, or low flow (50-80ml/min) continues for more than 10 minutes.	CO_2 wave zero, numeric display -?-.	INOP tone
CO_2 SIDESTRM MALF	**Sidestream** malfunction in the transducer or module.	CO_2 wave zero, numerics display -?-.	INOP tone
CO_2 LOW FLOW	**Sidestream** flow between 50-80ml for 10 mins. CO_2 values may not be accurate.	CO_2 wave and AWRR numeric are valid, other numerics are questionable (?).	None
CO_2 SIDESTRM OFF	**Sidestream** module not drawing gas.	CO_2 wave disappears, numerics display -?-.	INOP tone

Note—If the `CO2 OCCLUSION` message appears, first check the following:

- The filter is not blocked.
- The Gas Sample Tube is not kinked

If there are no problems with these accessories, please consult your biomedical engineer as there may be a fault with the module.

When the `ZERO` message is displayed in **Sidestream** mode, the absolute barometric pressure is measured. If the barometric pressure measured differs by more than 50mmHg from the original altitude settings made in Service Mode, the following message will be displayed: `Abs. barometric pressure out of range`

If this message appears, consult your biomedical engineer.

Parameter Settings Transfer

The following settings can be transferred with CO_2 modules that have a *T* on the front. For more information on parameter settings transfer, refer to “Parameter Settings Transfer,” Chapter 3.

Setting Name	Meaning
Scale	Selected CO_2 scale
Calibration values[1]	Transducer calibration values
Alarm limits	$IMCO_2$, $EtCO_2$, and AWRR alarm limits
Apnea time	Apnea delay time

[1]Calibration values are transferred when Parameter Settings Transfer is ON *or* OFF.

Accessories and Ordering Information

M1460A Airway CO_2 Transducer with Calstick

M1465A Airway Reusable Adapter (Adults)

14363A Airway Reusable Adapter (Pediatric)

13901A Nafion® Gas Sample Tube - 2.4m (Sidestream)

13905A Hybrid Gas Sample Tube (Sidestream)

13902A “J” (elbow) Airway Adapter - 15mm (Sidestream)

M1612A Straight Airway Adapter (Sidestream)

M1015-41201 Transducer Clamp (M1460A only)

M1614A Cable Tie

13904A Bacterial Filter (Sidestream)

M1015-40001 Exhaust Tube (Sidestream).

Note—The above listed accessories are not shipped with every instrument. Contact your Agilent sales representative for details.

Performance Specifications

For safety and environmental specifications, please refer to the *Monitor Installation and Patient Safety* Chapter 11.

Note—A hazard analysis according to IEC 601-1-4 has been performed in the hardware and software development process.

CO_2/ssCO_2

All readings comply with the conditions on BTPS (Body Temperature Pressure Saturated). This corresponds to 37ºC body temperature, 95% relative humidity and 47mmHg pH_2O. The formula for calculation is as follows:

pCO_2 (mmHg) = CO_2 vol% * (P_{abs} - 47) / 100

with:
pCO_2 = partial pressure
vol% = gas concentration
P_{abs} = absolute pressure

Measurement — Mainstream CO_2 Measurement

	$ETCO_2$	**$IMCO_2$**	**AWRR**
CO_2 Measurement (mainstream)			
Range	-4 to 150 mmHg (-0.5 to 20 kPa)	-4 to 150 mmHg (-0.5 to 20 kPa)	0 to 150 rpm
Accuracy	0 to 40 mmHg $\pm$ 2.2 mmHg[1] (0 to 5.33 kpa $\pm$ 0.29 kPa) 40 to 76 mmHg $\pm$ 5.5% (5.33 to 10.1 kpa $\pm$ 5.5%)	0 to 40 mmHg $\pm$ 2.2 mmHg[1] (0 to 5.33 kpa $\pm$ 0.29 kPa) 40 to 76 mmHg $\pm$ 5.5% (5.33 to 10.1 kpa $\pm$ 5.5%)	$\pm$2 rpm

[1]Accuracy at 37°C gas temperature and 47 mmHg for H_2O (BTPS)

.

Stability	± 1 mmHg over 7 day period
SystemResponse Time	<125 ms (for step from 10 to 90%)
Temperature Range (Operating)	0 to 55°C (32 to 131°F)
Temperature Range (Storage)	-40 to 70°C (-40 to 158°F)
Warm-up Time	20 minutes

Sidestream CO_2 Measurement

All sidestream measurements and alarms are subject to a delay of 2 seconds.

	$ETCO_2$	$IMCO_2$	AWRR
Sidestream CO_2 Measurement			
Range	-4 to 150 mmHg (-0.5 to 20 kPa)	-4 to 150 mmHg (-0.5 to 20 kPa)	0 to 100 rpm
Accuracy	0 to 40 mmHg $\pm$3.3 mmHg[1] (0 to 5.33 kpa $\pm$ 0.29 kPa) 40 to 76 mmHg $\pm$ 7.5% (5.33 to 10.1 kpa $\pm$ 7.5%)	0 to 40 mmHg $\pm$3.3 mmHg[2] (0 to 5.33 kpa $\pm$ 0.29 kPa) 40 to 76 mmHg $\pm$ 7.5% (5.33 to 10.1 kpa $\pm$ 7.5%)	$\pm$ 2 rpm

[1]Accuracy at 37°C gas temperature and 47 mmHg for H_2O (BTPS). Valid for AWRR of < 40 rpm at I:E ratio of 1:1

[2]Valid for AWRR of < 40 rpm at I:E ratio of 1:1.

Stability	± 1 mmHg over 7 day period
Rise Time	< 330 ms (for step from 10 to 90%)
Delay Time	2 seconds
SystemResponse Time	13901A: <2270 ms 13905A: <2330 ms
Temperature Range (Operating)	10 to 45°C (50 to 117°F)
Temperature Range (Storage)	-40 to 70°C (-40 to 158°F)
Warm-up Time	20 minutes
Sample Flow Rate	100 ml/minute ± 10 ml/minute

O_2/N_2O Correction Errors:

	O_2 Correction Error	**N_2O Correction Error**
Automatic O_2 Correction (from FIO_2)	$< \pm$ 1% (actual O_2 10 - 100%)	$< \pm$ 1% (N_2O - 100% O_2)
Manual O_2 Correction	$< \pm$ 3% (actual O_2 20 - 70%)	$< \pm$ 6% (actual N_2O 30 - 80%)

Alarms

Alarm	$ETCO_2$	$IMCO_2$	AWRR
High Range[1]	20 to 100 mmHg (2 to 14 kPa)	2 to 20 mmHg (0.3 to 3 kPa)	*Adult/Pedi*: 10 to 100 rpm *Neo:* 30 to 150 rpm
Low Range[1]	10 to 95 mmHg (1 to 13 kPa)	not applicable	*Adult/Pedi:* 0 to 95 rpm *Neo:* 0 to 145 rpm
Criterion	15 seconds after the value exceeds the set limit value	15 seconds after the value exceeds the set limit value	*High/Low Limit (> 20 rpm):* 10 seconds after the value exceeds the set limit value *Low Limit (0 to 20 rpm):* 2 seconds after the value exceeds the set limit value
Delay	2 seconds after this criterion is met	2 seconds after this criterion is met	2 seconds after this criterion is met

[1]Accuracy: ±1mmHg

APNEA Delay Values:

Adult, Pediatric, Neo 10 to 40 s

Note—The alarm tone characteristics of the Agilent CMS are not as specified in EN475. This is mainly due to three factors:

- Standardized alarm tones would not allow differentiation between the alarms of different instruments.
- The time between two alarm tones specified by EN475 is too long for ICU applications
- Alarm tones of a monitor should be consistent with those of the central station and other monitors on the same network. Therefore, alarm tones have been standardized within Agilent.

Care and Cleaning

CO_2 Transducer

The performance of the transducer does not degrade with use. Other than normal care and cleaning the transducer requires no regular maintenance.

Note—Moving parts are contained within the CO_2 transducer housing. Take care not to strike the housing against hard surfaces.

Dropping the transducer onto such a surface may cause permanent internal damage.

1. Wipe the transducer and cable with warm soapy water, Alconox, 70% isopropyl alcohol, or 3% hydrogen peroxide and dry.

   Do not submerge for prolonged periods of time, or allow the connector end of the cable to be immersed in water. Do not use ultrasonic cleaning, as this process may weaken the adhesive bonds. Do not use bleach on the calstick.

2. Periodically check each item for cracks or deterioration.

For more aggressive cleaning:

1. Clean the transducer with a soft brush and on the following disinfecting agents prepared according to the manufacturer's recommendations:
   - LpH®
   - Cidex®
   - Metricide 28®
   - Commercial bleach, 1:10 dilution with water
   - Edisonite®
   - Mucocit-P 2000®
   - Sagrotan K®

2. Rinse with water and soak the transducer in one of the above solutions for 20 minutes.

3. Rinse with warm water and dry.

Note—If you must remove adhesive tape residue from the cable Double Seal tape remover such as that produced by Scholl Mfg. Co. Inc. is effective and causes minimum damage if used sparingly

Sterilization of the CO_2 Transducer

Use the following procedure to sterilize the transducer to a sterility assurance level of 10-3. This level of sterility assurance applies to the transducer and the cable. The calstick and connector exterior can be cleaned with the listed disinfectants listed on the previous page.

1. Wipe the transducer with 70% isopropyl alcohol.
2. Soak the transducer for 10 minutes in Cidex or Metricide 28 prepared according to the manufacturer's recommendations.
3. Rinse in water, wipe and air dry.
4. Soak the transducer in one of the following solutions according to the solution manufacturer's recommendations.
   - Cidex
   - Metricide 28
5. Rinse the transducer in sterile water and air dry.
6. Follow hospital procedure for maintaining sterile equipment.

Note—Do not immerse the connector end of the cable. Do not autoclave, gas sterilize or heat the transducer or cables to temperatures above 55ºC (103ºF).

Cleaning the Reusable Airway Adapters

The airway adapter can be cleaned by immersing in a warm, soapy solution for 5 minutes, brushing, and then rinsing with clean water.

If mucous has collected, a longer soaking may be necessary. An overnight soaking will not harm the airway adapter.

1. Immerse in warm, soapy water.
2. Carefully brush the inside and between the windows using the small bristle brush (or equivalent - pipe cleaners or cotton swabs might also be helpful) provided.

3. When the debris has been removed from both inside and outside, rinse the adapter with clean water and air dry.

4. Sterilize.

Note—Do not use abrasive cleaning materials as you would damage the windows. Do not use ultrasonic cleaning as this could weaken the bonds holding the windows in place.

Handling Precautions: Handle with care; repeated dropping could damage or loosen the windows.

Sterilization of the Reusable Airway Adapters

Sterilize the adapter before reusing (use hospital recommended procedures for autoclaving or ethylene oxide sterilization). The following provides some guidelines. The effectiveness of all sterilization procedures should be confirmed by the user.

Autoclaving of the Reusable Airway Adapters

Do not use temperatures greater than 126°C (265°F).

Ethylene Oxide Sterilization

Follow the operating instructions provided by the manufacturer of the gas sterilizer with these reminders.

1. Clean as described in the Cleaning section to remove surface contamination.

2. Dry carefully to avoid formation of toxic ethylene glycol during ethylene oxide sterilization.

3. Use ethylene oxide/freon mixture as the sterilant (12% ethylene oxide with 88% freon 12).

Caution

When sterilizing, the sterilizer temperature must not exceed 54.4°C (130°F). Temperatures exceeding this limit could affect the reliability of the item or damage the components. Maximum gas pressure should not exceed 6 PSI (310 mmHg) for up to six hours.

4. At the end of the sterilization cycle, use vacuum(-26 inches of mercury) for 5 to 15 minutes to expel the residual gas.

Bacterial Filter

The bacterial filter is for single patient use only.

Nafion® Gas Sample Tube (2.4m)

For the cleaning procedure of the Nafion® gas sample tube, you will need the following:

- Distilled water
- Citric Acid mix (concentration of 35g/100ml)
- Container - large enough to submerge the tube in the citric acid
- Syringe (50ml).

Procedure:

1. Flush the tube with 50ml of distilled water to clean out debris that may have collected in the tube.
2. Flush the tube with 50ml of the citric acid mix.
3. Soak the tube in the citric acid mix for 20 minutes. Ensure that the tube is completely submerged during this time.
4. Flush the tube again with 50ml of the citric acid mix.
5. Flush the tube with 200ml (minimum) of distilled water to remove any remaining citric acid mix from the tube.
6. Blow air through the tube using an air-filled syringe to remove any remaining water from the tube.
7. Leave the tube to dry for a minimum of 1 hour before re-use.

19
FIO_2 Module Section
(Agilent CMS only)

In this section you will find information on the fractional inspired oxygen (FIO_2) measurements and setting up FIO_2 monitoring. You will also find information on calibrating the FIO_2 transducer in this section. It includes the following sections:

Introduction to the FIO_2 Module

What does it Measure?

The FIO_2 module measures the inspired oxygen concentration. The value is displayed on the screen as a numeric.

How the FIO_2 Parameter Works

The inspired oxygen concentration is measured using the polarographic method.

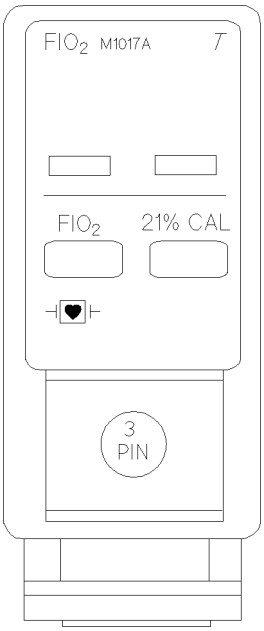
1. The transducer comprises an anode and cathode protected by a gas permeable membrane. A specific polarisation voltage is applied between the anode and cathode. O_2 passing through the membrane results in an output current at the cathode proportional to the amount of O_2. The current is measured and the fraction of oxygen in the gas is derived.
2. The transducer is placed in the inspired pathway of a ventilated patient. In neonatal applications the transducer can be placed in the incubator to measure environmental oxygen concentration.
3. The FIO_2 transducer must be stabilized (polarized) to make accurate measurements.

Note—To ensure that the transducer is available for immediate use, always leave the transducer connected to the module. If the transducer remains connected to the module, an internal battery maintains stabilization for up to four days, even if the module is removed from the rack or the monitor is turned off.

- The front of the module has two keys:
  The FIO2 key for parameter setup, a light will appear above the key when you are in the setup.

  The CAL key to start the 21% O_2 Calibration. When the calibration is started a light will appear above the key.

FIO_2 Module



FIO2 Measurement Setup

1. Check that the FIO_2 module is inserted in the rack.
2. Switch on the system.
3. Attach the transducer to the module.
   When the transducer is connected to the module stabilization begins, the time taken to reach stabilization depends upon the circumstances. Recommended stabilization times are given in the following table.
4. Perform either the 21% or the 100% calibration procedure described on page 18-7.
   - The advantage of the 100% calibration is that you can leave the oxygen sensor in the T-Piece and then change the gas mixture to 100% O_2. (The time to purge the system depends upon the flow rate and the volume of the system).
   - You should perform the calibration on a polarized, stable transducer.
   - The FIO_2 transducer should be calibrated every 8 hours, when the transducer is moved from one module to another or when the module is moved from one monitor to another.
   - When you are in calibration mode the CAL LED on the front end of the module is illuminated, the FIO_2 module is not in patient monitoring mode and FIO_2 alarms are disabled.
5. Attach the transducer to the patient's breathing circuit.
   Refer to the following illustration.

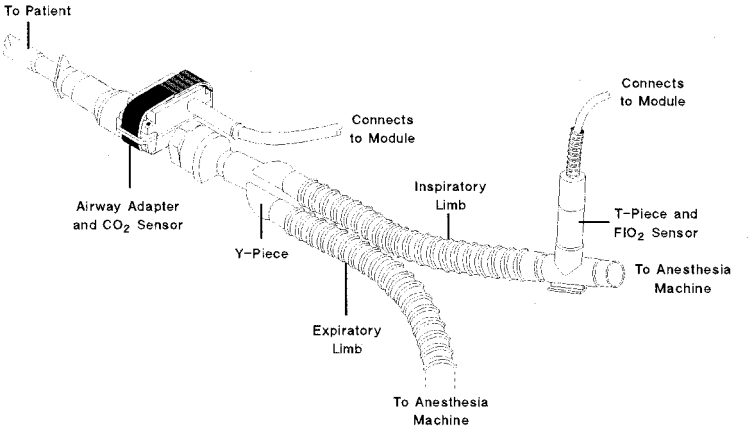
– You should fit the transducer in the T-Piece, then insert the T-Piece into the inspiratory limb of the patient's breathing circuit.

FIO2 Stabilization Times

Condition	Recommended Stabilization Time	
Sensor connected to module for more than 15 minutes and module in rack and power on.	None.	
Sensor connected to module for more than 15 minutes and module not in rack or power off.	1 minute.	If power has been off longer than 4 days, stabilize for 2 hours.
Sensor disconnected from module.	15 minutes.	Sensor remains stable for up to 16 hours. If it has been disconnected for a longer period, stabilize for 2 hours.
Electrolyte has been replaced.	2 hours.	
New transducer or new membrane.	4 hours.	

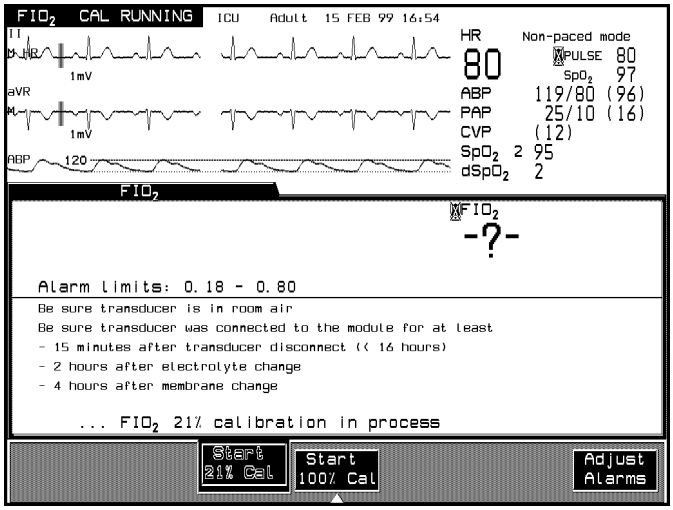
FIO_2 Measurement Setup

FIO_2 Transducer and Breathing Circuit



FIO_2 Calibration Procedure

Module Setup --> **FIO2**



When you initiate a calibration the system enters CAL mode.

The FIO_2 alarms are disabled and the FIO_2 value is displayed as - ? - (invalid). The CAL LED on the front end of the module is illuminated. The transducer must be stabilized before you commence the calibration.

Calibration in 21% O_2

1. Remove the transducer from the T-Piece and expose it to room air. Press the softkey **Start 21% Cal**
   The calibration takes place. This is indicated by the message `FIO2 21% calibration in process`.
2. If the transducer does not settle within 30 s of starting the calibration, the calibration is stopped, a prompt tone is sounded and the system displays the message `FIO2 calibration error (unstable signal)`.
   If the values measured during calibration are out of range a prompt tone is sounded and the system displays the message `FIO2`

`calibration error (signal out of range)`.
In both instances the CAL LED on the front of the module is switched off, a ? appears next to the FIO_2 numeric and you are prompted:
`-check whether transducer is in room air`
`-check membrane`
`-check whether electrolyte has to be changed`
You should check the transducer as prompted and repeat step 1.

3. When the calibration has been successfully completed the CAL LED is switched off and the message `FIO2 calibration done` is displayed.
4. To return to the Main Screen press **Main Screen**

Note—The 21% calibration can also be started using the CAL key on the frontend of the module. When you have removed the transducer from the T-Piece, and exposed it to room air, press the CAL key for at least 1 second. The Calibration Task Window is not displayed but the message `FIO2 CAL RUNNING` appears in the INOP field, and the messages `FIO2 21% calibration in process`, and `FIO2 calibration done` are displayed in the system message field. If the calibration is unsuccessful, the message `FIO2 calibration error` is displayed.

Calibration in 100% O_2

1. Leave the transducer in the T-Piece. Change the gas to 100% O_2, the time to purge the system depends on the flow rate and the volume of the system. Press the softkey **Start 100% Cal** . The calibration takes place. This is indicated by the message `FIO2 100% calibration in process`.
2. If the transducer does not settle within 30 s of starting the calibration, the calibration is stopped, a prompt tone is sounded and the system displays the message `FIO2 calibration error (unstable signal)`.
   If the values measured during calibration are out of range a prompt tone is sounded and the system displays the message `FIO2 calibration error (signal out of range)` and the INOP message `FIO2 FAILED CAL`.
   In both instances the CAL LED on the front of the module is switched off, the FIO_2 numeric is invalid and you are prompted:
   `-check whether transducer is in 100% oxygen`
   `-check membrane`

`-check whether electrolyte has to be changed`
You should check the transducer as prompted and repeat step 1.

3. When the calibration has successfully completed the CAL LED is switched off and the message `FIO2 calibration done` is displayed.
4. To return to the Main Screen press **Main Screen**

Note—When the dry 100% O_2 is used as the calibration gas, the FIO_2 value will depend on whether the measured gas is wet or dry: For dry gas measurements, the actual FIO_2 value is equal to the measured value. With wet gas, the actual FIO_2 value is approximately 10% less than the measured value.

FIO_2 Alarm and INOP Messages

The FIO2 alarm messages are rated in order of severity:

***	Red
**	Yellow
	INOP message

Alarm tone (red) = a single chime repeated every second.
Alarm tone (yellow) = a single chime repeated every 2 seconds.
INOP tone = a single beep repeated every 2 seconds.

Alarm limits are dependent on patient's condition.

Physiological Alarms

Alarm Message	Condition	Visual Indication	Audible Indication
**FIO2 0.90>0.80	High alarm limit has been exceeded.	FIO_2 numeric blinks. Yellow alarm lamp.	Alarm tone
**FIO2 0.20<0.25	FIO_2 below low alarm limit.	FIO_2 numeric blinks. Yellow alarm lamp.	Alarm tone
***FIO2 LOW OXYGEN	FIO_2 below 0.18.	FIO_2 numerics blink. Red alarm lamp.	Alarm tone

Technical Alarms

INOP messages appear when the monitor cannot measure or process signals properly. This could be due to equipment-related problems but you must always check the patient's condition first. The INOP message is accompanied by an audible alarm which can be silenced with the **Silence/Reset** key.

INOP Messages

INOP Message	Condition	Visual Indication	Audible Indication
FIO2 UNPLUGGED	Module switched on and unplugged from rack. Silencing the alarm switches the parameter off.	FIO2 numeric displays - ?-.	INOP tone
FIO2 EQUIPM MALF	Internal test or offset values out of range or transducer lead C cable break or transducer not delivering sufficient current.	FIO2 numeric displays - ?-.	INOP tone
FIO2 NO TRANSDUCER	Transducer not connected or transducer lead cable A or B cable break or transducer current too high.	FIO2 numeric displays - ?-.	INOP tone
FIO2 FAILED CAL	Signal out of range or it drifts during calibration.	FIO2 numeric displays - ?-.	INOP tone
FIO2 CAL RUNNING	The 21% or 100% calibration is running.	FIO2 numeric displays - ?-.	None

FIO_2 Alarm and INOP Messages

INOP Message	Condition	Visual Indication	Audible Indication
FIO2 OUT OF RANGE	FIO2 <0.10, >1.10 due to incorrect calibration, old transducer in need of recalibration or a defective transducer.	FIO2 numeric displays -?-.	INOP tone
FIO2 CHECK CAL	Transducer not calibrated since last start or calibration failed.	FIO2 numeric displays -?-.	None
FIO2 BATTERY ?	Module battery is not loaded or is defective, therefore the transducer may not be polarised immediately after switch on. After some time the transducer will polarize.	FIO2 numeric questionable.	None

Parameter Settings Transfer

The following settings can be transferred with FIO_2 modules that have a *T* on the front. For more information on Parameter Settings Transfer, refer to"*Parameter Settings Transfer*" in Chapter 3.

Setting Name	Meaning
Calibration values	Transducer calibration values
Alarm limits	FIO_2 high and low alarm limits

Accessories and Ordering

15203A O_2 Transducer

15203AH Monitoring Kit, contains:
adult Conductive T-piece, neonatal/pediatric Conductive T-piece, neonatal Transducer membrane set and transducer gel.

15202AH-K03 Transducer membrane set and Transducer gel (59ml)

15202AH-K04 Conductive T-piece for adult applications

15200AH-K05 Conductive T-piece for neonatal applications.

Performance Specifications

For safety and environmental specifications, please refer to the *Installation and Patient Safety* Chapter 10.

FIO_2 Performance Specifications

Warm-up Time

Polarized Sensor:	< 1 minute
Non-Polarized Sensor:	< 2 hours
After Membrane Change:	< 4 hours.

Measurement Range and Alarms

Measurement Range:	0.10 to 1.10
High Limit Range:	0.25 to 1.10
Low Limit Range:	0.18 to 0.90
Alarm Criterion:	<= 13 seconds after value exceeds the limit setting
Alarm:	within 2 seconds after this criterion is met.

Miscellaneous

Accuracy after Calibration:	at 100% O_2: <± 1.5% O_2, 21% O_2: <± 2.5% O_2
Resolution:	0.01
Battery Backup:	> 4 days.

Care and Cleaning

FIO_2 Module

The FIO_2 module contains a NiCad battery. To ensure this battery remains charged, always keep the module plugged into the rack with the monitor switched on.

For details regarding the care and cleaning of the FIO_2 Transducer and Airway Adapter refer to 15203A Oxygen Transducer Operating Guide.

Note—DO NOT autoclave the transducer.

20
Pressure Module Section

This chapter provides information on invasive pressure monitoring and troubleshooting for the following Plug-in Modules: M1006A, M1006A with Analog Output (Option C01), M1006B, and the M1006B with Analog Output (Option C01). It includes the following sections:

Notes—

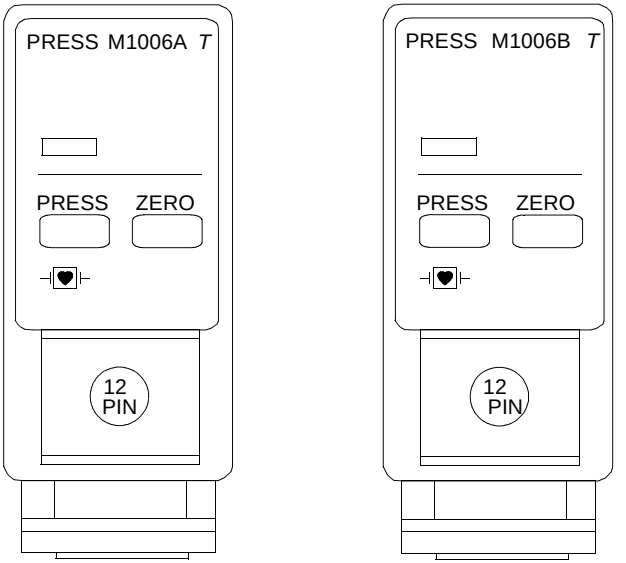
- The 1290A (40µV/V/mmHg) transducer can only be used with the M1006A module.

  A flat line and a "-?-" will be displayed on the main screen when using this transducer with all other pressure modules.

- The procedures described in this section apply to all four pressure modules, unless otherwise specified in the text.

Introduction to the Pressure Plug-in Module

- You can select any pulsatile pressure that is being monitored to be the source of the PULSE rate numeric.
- The pressure measurements can be displayed in mmHg or kPa. This is selected in Configuration mode, and can be changed by your hospital biomedical engineer or an Agilent service engineer.
- The front of the module has two keys:
  - The PRESS key for parameter setup, a light will appear above the key when you are in the setup.
  - The ZERO key. Press this until the message “zero in process” appears.



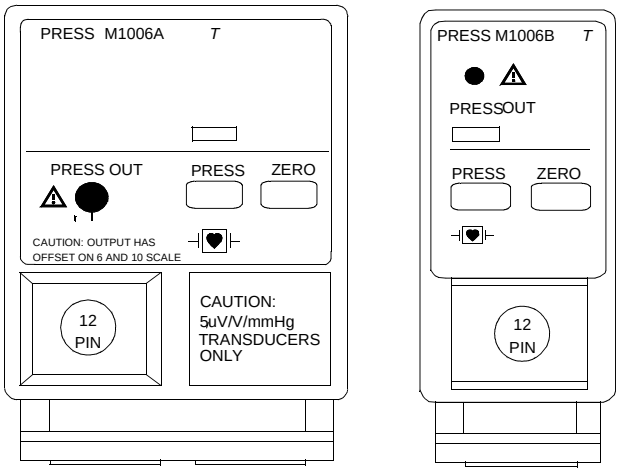
Pressure Modules M1006A and M1006B

Note—The “T” on the front of the module indicates that this module transfers parameter settings from one monitor to another.

Intra-Aortic Balloon Pump Pressure Module

Option C01 of Pressure Modules M1006A and M1006B provides a pressure analog output signal for use with an intra-aortic balloon pump (IABP).

Note—Only use IEC 601-1 approved intra-aortic balloon pumps for application with these modules where IEC standards apply.



optco1ab.tif

Pressure Modules M1006A & M1006B with Option C01

Note—The "T" on the front of the module indicates that this module transfers parameter settings from one monitor to another.

Note—The ⚠ symbol indicates a source of danger. Please read manual carefully.

In order to provide an arterial pressure waveform to the IABP for synchronization, connect the pump cable to the PRESS OUT phone jack socket (an adapter cable is provided for the M1006B with pressure analog output).

Caution

- **The PRESS OUT jack output on the M1006A module (with #C01) has a 150mV offset on 6 mmHg or 10 mmHg scales. Do not use these scales with an IABP on this module.**
- **The pressure analog output signal is 1V/100 mmHg on both the M1006A and M1006B modules.**

Warning

Do not attempt defibrillation unless the pump cable is connected at both ends or disconnected entirely. Improper connections can disrupt synchronization and cause inaccurate data.

The signal to the balloon pump stops when:

- **the Test Signals are active (30 seconds of test waves displayed) when you press:**

  Monitor Setup → Test Signals

- **the System is in Demo, Configuration, or Service Mode.**

Caution

During defibrillation, the pressure values may be temporarily interrupted or distorted. After defibrillation, the Agilent CMS will continue to monitor as before; the operatiing mode and user settings are not affected.

Pressure Measurement Setup

1. Check that the PRESS module is inserted in the rack.
2. Plug the pressure cable into the module and check that the monitor is switched on.

Caution

For the M1006A with Analog Output (Option C01) and M1006B with Analog Output (Option C01), and the M1006B Pressure Modules:

- **Only use transducers with an input sensitivity of 5µV/V/mmHg.**
- **Don't use the 1290A (40µV/V/mmHg) transducer with the M1006B. The input sensitivity of this transducer is not compatible with the Module.**

Note—The M1006A is compatible with 1290A.

3. Prepare the pressure line and transducer by flushing through the system with the solution to be infused. Ensure that the system is free of air bubbles.
4. Connect the patient catheter to the pressure line making sure that there is no air present in the catheter or line. If air bubbles appear in the pressure line, flush through the system again with the solution to be infused.
5. If you are using an infusion pressure cuff with the pressure line, attach the pressure cuff to the fluid to be infused and inflate it according to your Standard Hospital Procedure, then start the infusion.
6. Position the transducer so that it is level with the heart, approximately midaxillary line.

7. Zero the transducer. You can do this by pressing the ZERO key on the front of the module until the message “zero in process” appears, or by getting into the Zero Xducer Task Window.

8. Calibrate the transducer. The procedure is described in detail in Appendix B “Calibrating the Pressure System”. Calibrate the instrument *either* whenever a new transducer is used, *or* as frequently as dictated by your Hospital Procedures Policy.

Note—If your monitor has Parameter Settings Transfer set ON, you can select “*T*” modules that have stored settings.

Note—Radiated field strengths above 0.7 V /m may cause erroneous measurements at various frequencies. Therefore it is recommended to avoid the use of electrical radiating equipment in close proximity to the patient monitor.

Zeroing the Transducer

Points to Remember

Turn off patient stopcock before you start the zero procedure.

- The transducer must be vented to atmospheric pressure before the zero procedure.
- Zero procedure should be performed before starting the monitoring and at least once a day.
- The transducer should be placed level with the heart, approximately mid-axillary line.
- There are three ways to zero the transducer; either press the ZERO key on the front of the module until the message “zero in process” appears, or get into the Zero Xducer Task Window via the Parameters Selection Window or via the setup key on the front of the pressure parameter module.
- A message UNABLE TO ZERO <P1>* is displayed if the monitor is not able to zero due to:
  - A pulsatile wave.
  - >±200mmHg. pressure to the transducer.
  - monitor being in test mode.
  - transducer being defective

* Or whichever pressure label is being used.

Warning

- **If the pressure alarms are turned on, they are automatically turned off during this procedure, while the message "zero in process" appears on the screen. This is true whether the procedure is performed via a Task Window, or via the ZERO key on the parameter module. On completion of the procedure the alarms remain off for a further 30 seconds to allow time for the stopcocks to be turned back to the monitoring positions.**
- **It is the responsibility of the user to ensure that a zero procedure has recently been done on the transducer, otherwise there will be no recent, valid zero value for the instrument to use.**

Notes—

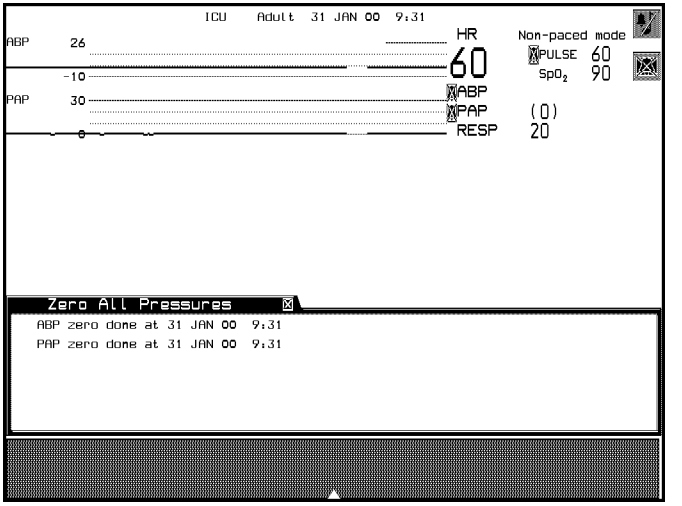
- If you require information about mercury calibration of the pressure module, see Appendix B.
- If intracranial pressure (ICP) is being monitored, it is not necessary to perform a zero procedure. The zero and pressure values are stored in the pressure module and will automatically be used. (this is not dependent on Settings Transfer.)

Zeroing all pressures

In a situation where several pressures are monitored, it is also possible to zero all pressures simultaneously. To zero all pressures:

1. Press **Procedures** followed by the **Zero AllPress** softkey - the Zero All Pressures Task Window will open up and remind you to close the transducers to the patient, open them to the atmosphere, and to adjust the transducers' level.
2. Press **Confirm** to begin the zero procedure.

After the zero procedure the completion prompts will be displayed in the Zero all Pressures Task Window (see example below).



Warning

Before using the Zero All Pressure control to zero all active pressures, make sure that all invasive pressure transducers are vented to atmospheric pressure. As the Zero All Pressures control zeroes all connected pressures, a non-pulsatile pressure such as CVP could otherwise be inadvertently zeroed, which would lead to wrong pressure readings.

Changing the Wave Scale

One out of eight alternative wave scales, ranging from 6 to 240, can be selected from the Set Up Task Window. An additional “Optimum” scale can be selected, which automatically calculates a “best fit” scale to suit the size of the incoming wave. Once calculated, the scale remains frozen, until **Optimum** or the **Confirm** key is pressed.

Pressure Module Labeling

Pressure module labeling can be handled in two different ways by your monitor:

Either The label you select for a Pressure module is kept with the module. This means that a module which is labeled ABP will remain ABP after you move it to another slot, or even if you move it to another monitor.

Or The Pressure module labels are allocated by the monitor according to its default settings. This means that the label may change from one rack position to another, or if the sequence that the modules are inserted in the rack is changed.

This behavior is dependent upon a "Parameter Settings Transfer" setting which is made in a special *Service Mod*e by either your biomedical engineering department, or the Agilent service engineer.

Situation "1." above corresponds to Parameter Settings Transfer ON.

Situation "2." corresponds to Parameter Settings Transfer OFF.

Note—Labeling for the Temperature module is handled in the same way as the Pressure module.

Parameter Settings Transfer details relating to pressure module labeling are provided on the following pages.

Labeling with Parameter Settings Transfer ON

If you set Parameter Settings Transfer ON, Pressure module labels are kept with the module. The label only changes if:

- you change it in the Pressure Task Window.
- you reset all parameter settings to their default values.

This happens when you change Configuration Sets or operating

Labeling Messages

Message	Condition	Action Required
Identical label in rack position *R-P* and *R-P*	Two modules with the same label have been plugged into the rack: *R* is the number of the rack, (1=integral rack, 2=first satellite rack,...) *P* is the slot number in that rack, (1=slot on left, 8=slot on right).	Change the label on one of these modules, or replace one of them with a module that has a different label.
Check label and settings	No settings are stored in the module, **or** the settings are incorrectly stored, **or** the module label is not one of the preconfigured labels in the monitor.	Check/change the label and settings in the parameter Task Window.

Labeling with Parameter Settings Transfer OFF

With Parameter Settings Transfer OFF, there are two ways in which the modules can be allocated labels:

1. When the monitor is switched ON, the pressure modules are numbered in ascending order from left to right in the rack.

2. During monitoring, if the pressure modules are removed from the rack, the first one to be replaced will be PRESS 1, the second will be PRESS 2 and so on. They are numbered according to the order they are put back in the rack. Their physical position in the rack is irrelevant.

If a pressure module is removed, and another pressure module is put in its slot, the instrument recognizes the change. The prompt message `Check label and settings` appears. The message will disappear if you enter the Pressure Task Window.

Note—Whenever you unplug then replug pressure modules, check their labels and settings, as they may change. Reposition Pressure modules *one at a time.*

Pressure Labels Available

Label	Definition
P1-Pn*	Non-specific pressure labels
ABP	Arterial Blood Pressure
ART	Arterial Blood Pressure
Ao	Aortic Pressure
PAP	Pulmonary Artery Pressure
CVP	Central Venous Pressure
RAP	Right Atrial Pressure
LAP	Left Atrial Pressure
ICP	Intracranial Pressure
UAP	Umbilical Arterial Pressure
UVP	Umbilical Venous Pressure

*The number of pressure labels depends on the monitor and option purchased.

Notes—

- Information relating to pressure labels P5, P6, UAP, and UVP will not be broadcast over the Agilent patient care system and will not appear at the Central Station. This information will only appear on the bedside monitor.
- The color of a pressure wave or numeric is linked to the pressure module number (P1 to P6), **not** the pressure label. Therefore, the color of a pressure wave or numeric does not change when a new label is assigned to the module.
- When you have selected PRESS as your PULSE source, you can choose PULSE as your HR/PULSE alarm parameter.
- If the PRESS module you have selected as PULSE source is unplugged from the rack or switched off (via the Parameters On/Off Task Window) and PULSE is the HR/PULSE alarm source, an INOP message “NO PULSE SOURCE” will be displayed on the screen.

Pulmonary Artery Wedge Pressure Measurement (CMS only)

The Pulmonary Artery Wedge Pressure (PAWP) is an important diagnostic measurement because it enables the clinician to assess a patient's cardiac function and manage his treatment accordingly. The value of the PAWP will be affected by:

- Fluid status
- Myocardial contractility
- Valve and pulmonary circulation integrity

The measurement is obtained by using a balloon-tipped pulmonary artery flotation catheter introduced into the pulmonary artery. The wedge position is reached when the catheter is advanced into one of the smaller pulmonary arteries.

In the "wedge" state the inflated balloon occludes the artery which it is in. The pressure receptor in the catheter can only record pressure changes which occur in front of the occlusion. That is, even though the catheter is in the right side of the heart the receptor records pressure changes transmitted back through the pulmonary circulation from the left side of the heart.

Pulmonary Wedge Pressure = left ventricular end diastolic pressure (preload)

The pressure transducer connected to the pulmonary artery flotation catheter records changes in the intrathoraic pressures that occur throughout the respiration cycle. Therefore, the most accurate values of PAWP are obtained at the end of the respiration cycle when the intrathoraic pressure is fairly constant.

The PAWP value most often used in clinical practice is the mean of the PAWP values recorded.

It is useful to see the respiration waveform as a reference when assessing the PAWP waveform, to ensure constant measurement timing relative to the respiratory cycle.

Measuring Wedge Pressure

1. It is advisable to monitor CO2 using the CO2 module or RESP using the ECG/RESP module so that you have a reference waveform to compare with the wedge waveform. (SSCO2 cannot be used as a reference waveform due to the slight timing delay caused by this measurement method).

Notes—

- The PAWP parameter is automatically switched off if no valid PAWP measurement is available. This happens under the following conditions:
  - 24 hours after tha last PAWP measurement,
  - after changing Configuration-Set or operating mode,
  - after admitting a new patient, or
  - after the monitor has been switched off for more than one minute
- To make a PAWP measurement, the pressure label **must** be PAP. If the PAP parameter is switched OFF, or the pressure label changed a message ... *No PAP detected to start wedge measurement* ... will appear on the screen.

Warning

While performing the wedge procedure the pressure alarms for Pulmonary Artery pressure alarms for Pulmonary Artery Pressure are switched OFF. A appears next to the PAP numeric.

2. To measure the wedge pressure, press the hardkey **Procedures** then press **Wedge** . This takes you to the Acquire Wedge Task Window.

3. While in the Acquire Wedge Task Window, the trace speed for the PAP wave is set at 6.25 mm/s and the trace is moving trace. The pressure scale remains unchanged. If a zero procedure needs to be performed a -?- appears next to the PAP numeric and the prompt *Check transducer and PAP zero* is displayed in the Acquire Wedge TAsk Window. Either press the ZERO key on the front of the

module, or perform the zero procedure. Re-enter the procedure by pressing the hardkey **Procedures** then **Wedge**.

4. If no wedge waveform is detected when the balloon is inflated, the procedure must be stopped manually by pressing the **Stop Trace** softkey.

5. To start a new measurement, press the softkey **Continue Trace**. The procedure must then be stopped manually by pressing the **Stop Trace** softkey.

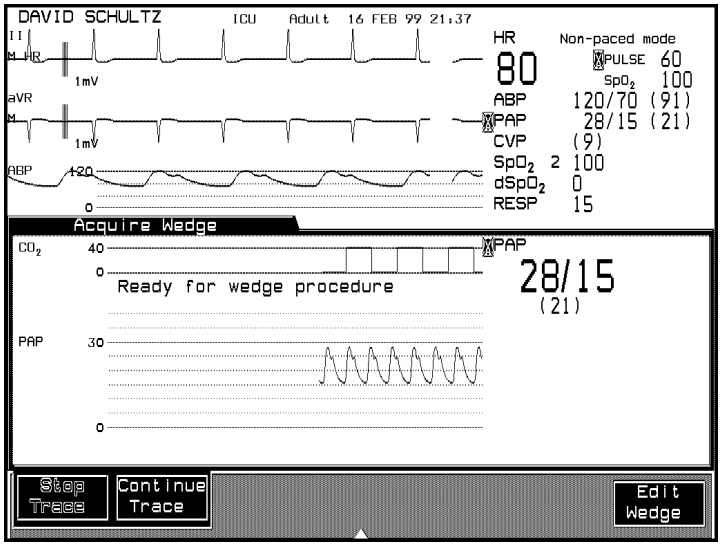
6. To complete the measurement press the **Edit Wedge** softkey. This takes you to the Edit Wedge Task Window.

7. In the Edit Wedge Task Window you can record the waveform, edit the PAWP value and store the PAWP value.

Starting the Procedure

Prepare and check the pressure line according to your Hospital Procedures Policy then enter the Wedge Task Window as follows.

Procedures → **Wedge**



Note—If the PAP waveform is in the Optimum Scale prior to the Wedge Procedure, it is possible that after wedging the catheter, the resulting pressure waveform will fall below the lower scale. In this case, the wedge waveform will not be displayed or recorded properly. For this reason, you may wish to switch out of Optimum Scale before performing a wedge procedure.

1. Inflate the balloon when prompt message “Ready for wedge procedure” appears. The waveform changes from the PAP to the PAWP wave and the message “. . . . Wedging . . . “ will appear. The measurement takes approximately 12 seconds, on completion the PAWP waveform display is frozen and the message “ . . . Ready for balloon deflation . . . “ appears.

2. If it is necessary to start a new measurement, press the **Continue Trace** softkey. During the ensuing measurement the prompt message *Press Stop Trace to freeze waves* appears. The new

measurement must be stopped manually using the **Stop Trace** softkey.

If no wedging waveform is detected, the message . . . . *Wedging* . . . will not appear. Stop the measurement by pressing the **Stop Trace** softkey.

3. Deflate the balloon when prompt message *Ready for balloon deflation* appears in the Task Window. The screen will be frozen. Press **Edit Wedge** to obtain the next Task Window.

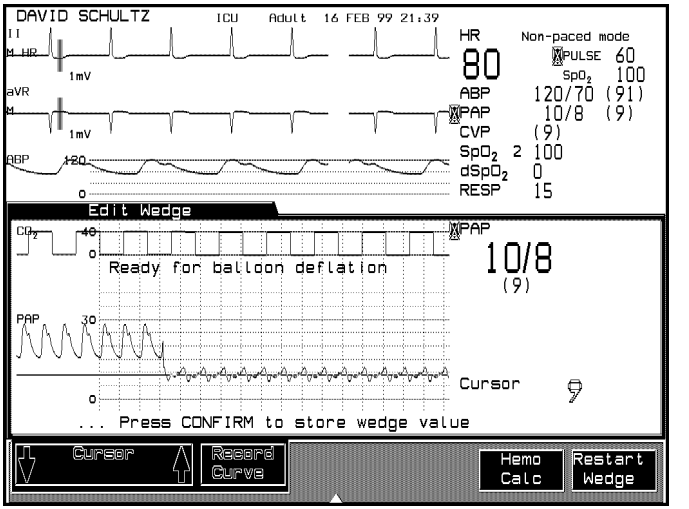
Warning

Balloon inflation time must be the minimum possible that is compatible with obtaining an accurate measurement.

Finishing the Procedure

Procedures → **Wedge** → **Edit Wedge**

Procedures → **Wedge** → **Stop Trace** → **Edit Wedge**



1. A horizontal line (cursor) appears in the PAWP waveform in the position of the mean value for PAWP. A numeric value for PAWP

appears on the screen, entitled cursor. If a previous value is stored, it is also shown along with the time.

2. Move the cursor up or down using the **Cursor** softkeys if you want to alter the position of the cursor within the PAWP waveform.

3. Press the hardkey **Confirm** when the cursor is in the correct position. The chosen value is then stored as PAWP. A numeric value for PAWP is displayed, along with a message showing the time that the value was stored.

   a. Press **Record Curve** softkey to record the PAWP waveform and, if displayed, the CO_2 or the RESP waveform on to a recorder. (The CO_2 waveform has priority over the RESP waveform). While the recording is in progress, no other operation is possible in the Wedge Task Window.

   b. Press **Restart Wedge** softkey if you want to take another measurement.

   c. Press **Hemo Calc** to enter the Hemodynamic Calculation Task Window.

   d. Press **Main Screen** hardkey to return to the Main Screen.

Note—Prompt messages regarding the status of the Recorder are displayed in the status line, not in the Edit Wedge Task Window.

The PAWP numeric will be displayed on the Standard Display Screen for up to 24 hours. After 24 hours or when a new patient is admitted the PAWP value is removed from the Standard Display.

Situations to Avoid

There are three situations which may occur during long term monitoring of the pulmonary artery pressure and during wedge measurements which are potentially dangerous to the patient:

1. Persistent Balloon Inflation
When performing manual measurements, the balloon must only be inflated for the minimum time that is compatible with obtaining an accurate measurement. Prolonged inflation of the balloon can cause pulmonary hemorrhage, infarction or both.

2. Drifting Catheter
The pulmonary artery flotation catheter may drift into the wedge position without inflation of the balloon. You will notice that the pulmonary artery pressure waveform assumes a wedged appearance. Take appropriate action, in line with standard procedures, to correct the situation.

3. Over-inflated Balloon
This is very dangerous for the patient because:

- The pulmonary artery could be accidently ruptured.
- The wedge value derived will not reflect the patient's hemodynamic state, but will merely reflect the pressure in the catheter or balloon.

This situation can be recognized if the PAWP (mean) is greater than the PAP (systolic).
Deflate the balloon.
Report the incident immediately to the appropriate senior personnel.

Cerebral Perfusion Pressure Measurements (CMS only)

Application Information

1. Cerebral Perfusion Pressure is defined as the difference between the mean systemic and the mean intracranial pressure: CPP=mean ABP (ART,Ao) - mean ICP.

2. **Parameter On**
   In order to derive CPP, you **must** be monitoring and obtaining valid numerics for ICP and a preselected arterial pressure.
   The factory default for CPP is OFF. The parameter switches ON *manually* or *automatically*.

   – *Manually*:
   When the user switches the parameter ON in the Parameters On/Off Task Window.
   – *Automatically*:
   When the monitor detects the first valid preconfigured arterial and intracranial pressure numerics.

3. **Parameter Off**
   The parameter switches off *manually* or *automatically*.

   – *Manually*:
   When the user switches the parameter OFF in the Parameters On/Off Task Window
   – *Automatically*
   When either of the pressure sources are switched off, or their modules are unplugged, the monitor waits one minute for the pressure sources to be recovered. If they are not recovered within one minute, the CPP parameter is switched off. If the pressure sources are recovered later, the CPP parameter is switched back on.

4. **Transducer levelling**
   When monitoring the intracranial pressure, it is **essential** to position the transducer at the same level as the catheter tip.

   When the patient is lying down, the transducer is positioned at the level of the mid-axilliary line, since the skull and heart are at the

same height.
When the patient is sitting up, the transducer should either be attached to the patient's head, or mounted at the same level as the patients head.

Pressure Alarm and INOP Messages

Flush/ Sample Detection

Flush and sample pressure line situations imply a non-physiological pressure rise to values above 200 mmHg for a short time. However, this is sufficient to derive unwanted pressure alarms.

The pressure algorithm includes flush/sample detection logic. The flush/ sample detection extracts evidence of flush or sample events from the pressure wave and the pressure beat detector.

In case of a detected flush or sample event no pressure alarms will be processed and an INOP will be issued.

Alarms

The Pressure alarm messages are rated in order of severity:

*** Red

** Yellow

INOP message

Alarm tone= a single chime repeated every second.
INOP tone = a single beep every 2 seconds.
Alarm limits are dependent on patient's condition.

Physiological Alarms

Alarm Message	Condition	Visual Indication	Audible Indication
***<P1> Disconnect	Occurs if the mean pressure is continuously less than 10 mmHg (1.3 kPa). The alarm is not active if the maximum scale reading is less than 45 mmHg (4.5 kPa).	<P1> numeric blinks. Red alarm lamp	Alarm tone
**<P1> 185>180	High alarm limit exceeded.	<P1> numeric blinks. Yellow alarm lamp.	Alarm tone

Alarm Message	Condition	Visual Indication	Audible Indication
**<P1> 90<100	Pressure below low alarm limit.	<P1> numeric blinks. Yellow alarm lamp.	Alarm tone
**PULSE 120>100	High alarm limit exceeded.	PULSE numeric blinks. Yellow alarm lamp.	Alarm tone
**PULSE 50<60	Pulse below low alarm limit.	PULSE numeric blinks. Yellow alarm lamp.	Alarm tone
**CPP 140>130 (CMS only)	CPP above high alarm limit	CPP numeric blinks. Yellow alarm lamp	Alarm tone
**CPP 40<50 (CMS only)	CPP below low alarm limit	CPP numeric blinks. Yellow alarm lamp	Alarm tone

Pulse Rate Alarms are only active when Pulse is selected as the alarm parameter. > **Pressure Alarm Limits Range** = -40 to 360 mmHg.
CPP Alarm Limits Range = current displayed arterial pressure range.

Technical Alarms

INOP messages appear when the monitor cannot measure or process signals properly. The INOP message is accompanied by an audible alarm which can be silenced with the **Silence/Reset** key.

Patient-Related INOPS

INOP Message	Condition	Visual Indication	Audible Indication
<P1> REDUCE SIZE	The pressure wave is larger than the scale. You will need to increase the scale.	<P1> numeric display is normal.	None

INOP Message	Condition	Visual Indication	Audible Indication
<P1> NOISY SIGNAL*	The beat detector finds a pulse rate above 300bpm(adult) or 350bpm(neonatal).	PULSE numeric displays -?-.	INOP tone
<P1> NON-PULSATILE*	The pressure being monitored is non-pulsatile.	PULSE numeric displays -?-.	INOP tone.

*These INOP messages can only be derived when a pressure is selected as the pulse source.

Equipment-Related INOPS

INOP Message	Condition	Visual Indication	Audible Indication
<P1> UN-PLUGGED	Pressure module switched on and un-plugged from the rack.	<P1> numeric displays -?-.	INOP tone
<P1> NO TRANSDUCER	No transducer connected to the module.	<P1> numeric displays -?-.	INOP tone
<P1> EQUIP MALF	Malfunction in the pressure hardware.	<P1> numeric displays -?-.	INOP tone
<P1> ZERO + CHECK CAL	Occurs when new transducer attached to monitor, or when the power is off for longer than one minute and settings transfer is off.	<P1> numeric displays -?-.	None
<P1> OVERRANGE	Measured pressure >361 mmHg <-41 mmHg.	<P1> numeric displays -?-.	INOP tone
<P1> ARTIFACT	A flush or sample event has been detected. Pressure alarms are suppressed for the duration of this event.	? is displayed in front of <P1> numeric	None
“CPP CHECK SOURCES”	Occurs for one minute if either the arterial or the intracranial pressure sources are switched off, or the front end modules are removed.	CPP numeric displays -?-.	INOP tone
“CPP CHECK UNITS”	Occurs if two pressure sources have different units.	CPP numeric displays -?-.	None

Parameter Settings Transfer

The following settings can be transferred with Pressure Modules that have a *T* on the front. For more information on Parameter Settings Transfer, refer to Chapter 3.

Setting Name	Meaning
Label	Catheter site label for module
Scale[1]	Selected pressure scale
Alarm parameter	Sys, Dia, or Mean pressure
Alarm limits	Sys, Dia, and Mean limits
Zero calibration[2]	Transducer offset correction values
Mercury calibration[2]	Gain correction values

[1]If the scale is set to “optimum”, the scale is recalculated once the module is plugged on.
[2]If the site label is ICP, the zero and calibration values are transferred when Parameter Settings Transfer is ON *or* OFF.

Accessories and Ordering Information

Pressure Monitoring Accessories

1290C J06	Quartz transducer (5 µV/V sensitivity)
1295CK-020	Pack of 20 disposable pressure domes for 1290C
1295CK	Pack of 60 disposable pressure domes for 1290C
1292C	Holder for the 1290C pressure transducer
M1567A(*)	Single line disposable sensor kit (20)
M1568A(*)	Double line disposable sensor kit (20)
M1634A(*)	Adapter cable for disposable sensor kit

* Available in EU/EFTA countries only.

Warning

Disposable pressure transducers are not to be reused.

Performance Specifications

For safety and environmental specifications, please refer to the Monitor Installation and Patient Safety Chapter 10.

Invasive Pressure

Scales and Ranges

Scale	Range (mmHg)	Scale	Range (kPa)
240	-40 to 360	32	-5.3 to 48
180	-30 to 270	24	-4 to 36
120	-20 to 180	15	-2.5 to 22.5
60	-10 to 90	6	-1 to 9
30	-5 to 45	3	-0.5 to 4.5
18	-3 to 27	2.4	-0.4 to 3.6
10	-25 to 25	1	-2.5 to 2.5
6	-15 to 15	0.8	-2.0 to 2.0

Optimum Scale: 400 mmHg (53.5 kPa) maximum range
30 mmHg (4.2 kPa) minimum range

Calstair: 0, 6, 10, 18, 30, 60, 120, 180 mmHg
0, 0.8, 1, 2.4, 3, 6, 15, 24 kPa.

Alarms

Range:	-40 to 360 mmHg
Adjustment (mmHg):	Steps of 2 mmHg -40 to 30 mmHg range Steps of 5 mmHg 30 to 360 mmHg range
Adjustment (kPa):	Steps of 0.5 kPa -5.0 to 4.0 kPa range Steps of 1.0 kPa 4.0 to 48.0 kPa range.
Alarm Criterion:	8 seconds after the value exceeds the set limit.
Disconnect Alarms:	triggered if the mean pressure falls below 10 mmHg for more than 8 seconds. Alarm not active if the max. scale reading is less than 45 mmHg.
Alarm:	within 2 seconds after these criteria are met.
INOP Alarms:	Refer to the patient and equipment related INOP tables.

Pulse Rate Specifications

Measurement Range:	25 to 300 bpm (Adult) 25 to 350 bpm (Pedi/Neo)
Accuracy:	$\pm$ 1% full range
Resolution:	1 bpm
Alarm Limit Range:	30 to 250 bpm (Adult) 30 to 300 bpm (Pedi/Neo)
INOP Alarms:	Triggered if the signal is non pulsatile or noisy.

Analog Pressure Output Specifications (M1006B #C01)

(@ CAL 200 mmHg)

Output Range:	*-0.4 V to 3.6 V*
Output Level:	*1 V / 100 mmHg*
Accuracy:	*± 3% full scale*
Offset:	*± 30 mV*
Resolution:	*8 Bit (@ 5 V range)*
Signal Delay	*20 ms.*

Miscellaneous

Display Update:	2 seconds nominal
Frequency Response:	dc to 12.5 Hz or 40 Hz
Zero Adjustment:	± 200 mmHg (± 26 kPa) Range ± 1 mmHg (± 0.1 kPa) Accuracy Less than 0.1 mmHg/°C (0.013° kPa/°C) Drift.

Care and Cleaning

Pressure Transducer Cleaning

After the pressure monitoring operation is complete, remove the tubing and the dome from the transducer and wipe the transducer diaphragm with water. The transducer and cable can be cleaned by soaking and/or wiping with soap and water or cleaning agents such as those listed below:

Cetylcide®	Wavicide-01®
Wescodyne®,	Cidex®
Lysol®,	Vesphene®

Do not immerse the connector in any liquid. After cleaning, dry the transducer thoroughly before storing. Slight discoloration or temporary increase of surface stickiness of the cable should not be considered abnormal. If adhesive tape residue must be removed from the transducer cable, double seal tape remover (The Scholl Mfg.Co.) is effective and will cause a minimum of damage to the cable if used sparingly.

Acetone, Alcohol, Ammonia and Chloroform, or other strong solvents are not recommended because over time the vinyl cabling will be damaged by these agents.

Note—If you are using disposable transducers or domes these must not be re-sterilized or re-used.

Sterilization

Liquid Chemical Sterilization

Remove obvious contamination using the cleaning procedure described previously. Select a sterilant that your hospital or institution has found to be effective for liquid chemical sterilization of operating room equipment, and one that does not damage the materials listed in the table on page 11-30. Buffered gluteraldehyde (e.g. Cidex or Hospisept) has been found to be effective. Do not use quaternary cationic

detergents such as zephiran chloride. If the whole unit is to be sterilized, immerse the transducer but not the electrical connector into the sterilant for the recommended sterilizing period. Be sure that the dome is removed. Then rinse all transducer parts except the electrical connector with sterile water or saline. The transducer must be thoroughly dried before storing.

Gas Sterilization
For more complete asepsis, use gas sterilization.

- Remove obvious contamination using the cleaning procedure described previously. To inhibit the formation of ethylene glycol when ethylene oxide gas is used as the sterilant, the transducer should be completely dry.
- Follow the operating instructions provided by the manufacturer of the gas sterilizer.

Caution

For gases other than 12% /88% ethylene oxide/freon 12 mixture, consult gas manufacturer for compatibility with component materials of this transducer.

The sterilizer temperature must not exceed 70°C (158°F); plastics in the pressure transducer may deform or melt above this temperature.

Transducer Component Material

Transducer component	Material
transducer housing	glass-filled polyester
sensor	fused quartz
sensor adhesives	silicone rubber, RTV
cable insulation	polyvinyl chloride
strain reliefs	Neoprene rubber
connector shell	glass-filled polyester
connector insert	glass-filled nylon, gold-plated pins
cover seal	silicone rubber
screws	stainless steel

21
Cardiac Output Module Section

This chapter provides information on setting up cardiac output monitoring, and troubleshooting. It includes the following sections:

Introduction to Cardiac Output Parameter Module

Cardiac output measurements can be performed using either the conventional right heart thermodilution or the transpulmonary thermodilution method.

Right Heart Thermo-dilution

- Right Heart measurement is possible with any version of the Cardiac Output parameter module.
- You can select to have room temperature or iced injectate using either the flow through system or individual syringes of injectate.
- You can perform up to six measurements before editing the average cardiac output (C.O.) and cardiac index (C.I.). If you perform more than six measurements before editing the result, the oldest measurement will be deleted.
- There is an audio prompt and screen message that tells you when to inject.
- The start time next to the cardiac output numeric is *one minute* earlier than the time of the first measurement in a series of measurements. This is done so that valid PAP and CVP values can be accessed for hemodynamic calculations.

Note—The Cardiac Output Parameter Module is only supported by specific Agilent V24 and V26 configurations.

Trans-pulmonary Thermo-dilution (Agilent CMS only)

- The Transpulmonary Thermodilution method requires the **M1012A Option C10** Cardiac Output Module.
- **Option C10** is Agilent's implementation of Pulsion Medical Systems PiCCO™ method, which offers the following additional features:
  - Measurement of Cardiac Output (C.O.), Intrathoracic Blood Volume (ITBV) and Extravascular Lung Water (EVLW)[1] using transpulmonary thermodilution.
  - Measurement of Continuous Cardiac Output (CCO), Stroke Volume (SV), Systemic Vascular Resistance (SVR) and Stroke Volume Variation (SVV) by means of Pulse Contour analysis of the arterial blood pressure waveform.

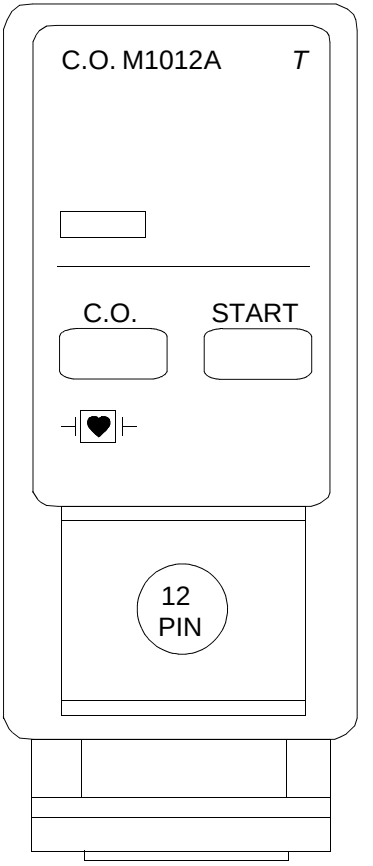
Notes—

- The catheter used determines the method of measurement. Only if no catheter is connected to the Cardiac Output Interface Cable, the additional softkey **Change Method** appears in the Setup C.O. Task Window. You can use this key to switch between Right Heart and Transpulmonary Thermodilution. However, if the catheter used does not match the selected method, the selection will automatically be changed to match the catheter.
- The Transpulmonary Thermodilution Method is **not** supported by the Agilent V24 and V26 monitors.
- PiCCO™ is a trademark of Pulsion Medical Systems AG.

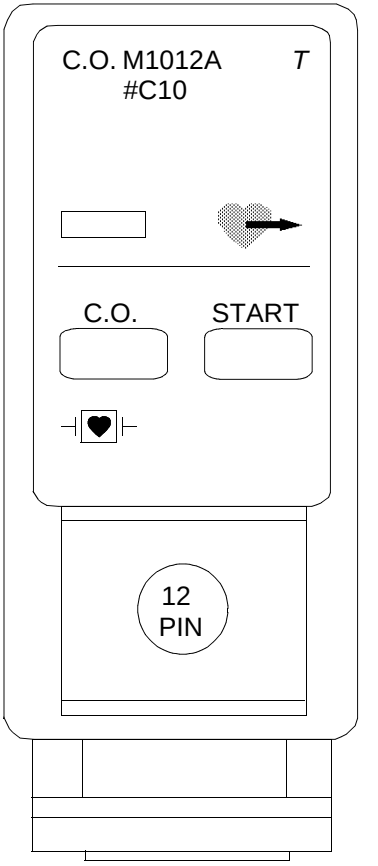
1. EVLW is not available in U.S.A.

The front of the module has two keys:

- C.O. key for parameter setup. A light will appear above the key when you are in setup.
- START can be used to enter the C.O. Measurement Task Window and to start a C.O. measurement instead of the softkey **Start C.O.** .



The Cardiac Output Module



The Cardiac Output Module - Option C10

Cardiac Output Measurement - Right Heart Thermodilution

Setup Checklist

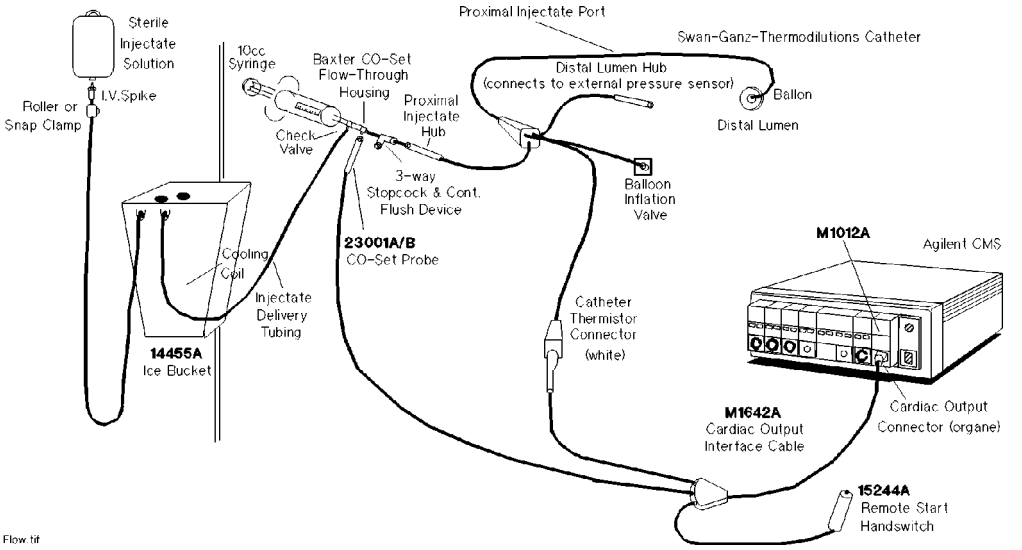
1. Check that the C.O. module is inserted in the rack.
2. Switch on the system.
3. Plug the C.O. interface cable into the module.
4. Attach the injectate probe connector, catheter thermistor connector and remote start switch connector (if you are using a remote switch) to the appropriate parts of the cardiac output interface cable.
5. Enter the Setup C.O. Task Windows and if necessary change the computation constant to the one appropriate to the catheter, volume of injectate and temperature used.
6. Enter the Measure C.O. Task Window and start the measurement.
7. Inject the injectate when prompted to do so.
8. Repeat steps 6 and 7 if you require more measurements.
9. On completion of the measurements edit the values by entering the Edit C.O. Task Window.

Warning

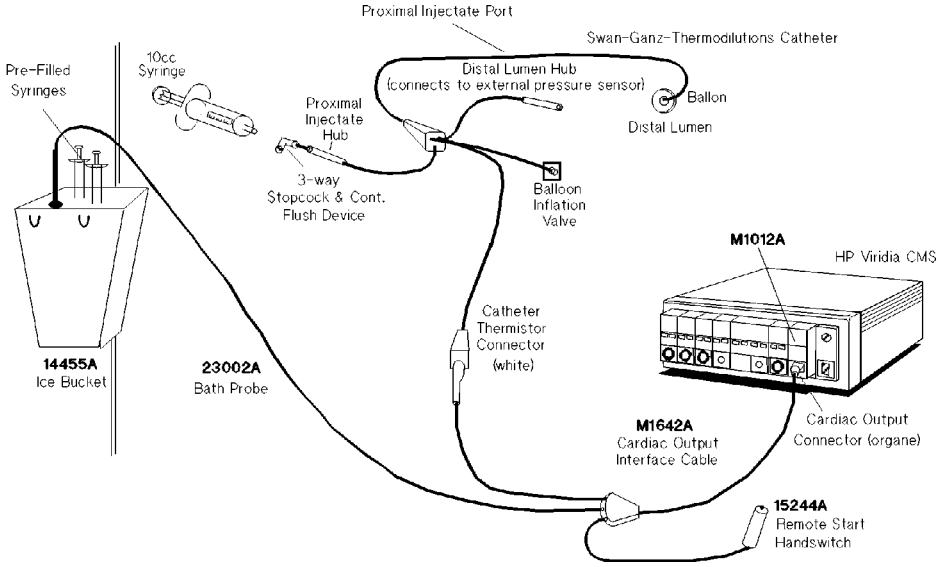
•Make sure that the computation constant for the measurement is appropriate to the catheter used.

• Do not use the Cardiac Output Interface Cable in MRI applications.

The procedure is described in detail on the following pages.



C.O. Measurement Set-up for Flow Through Method (typical only)



C.O. Measurement Set-up for Bath Method (typical only)

Adjusting the Computation Constant

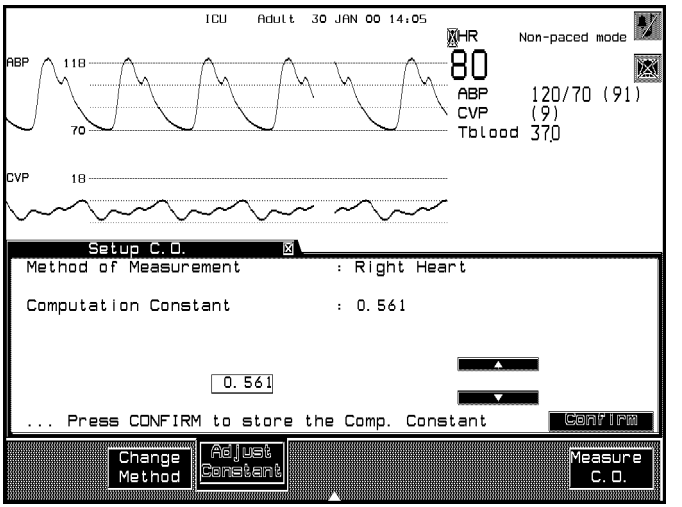
There is one Task Window in the Cardiac Output setup in which you can change the computation constant.

Refer to the manufacturer's instructions of the catheter you are using for the computation constant corresponding to the injectate volume and temperature you are using.

Module Setup --> **C.O.** --> **Setup C.O.** *or*

Procedures --> **C.O.** --> **Setup C.O.** *or*

C.O. Key on the module



1. Adjust the computation constant by pressing either the **Adjust Constant** softkey, or by using the arrow keys.
2. Press the **Confirm** hardkey to store the computation constant.
3. Press the softkey **Measure C.O.** to enter the Measurement Task Window.

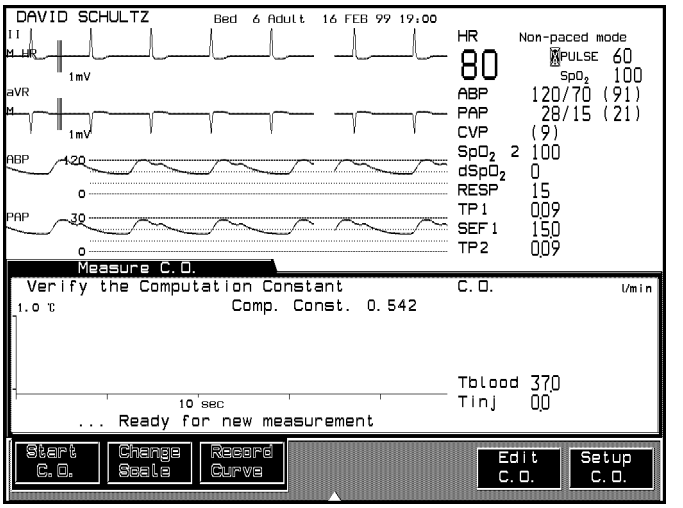
Getting into the C.O. Measure-ment Task Window

- You can get into the C.O. measurement Task Window by 5 different methods:
  - via the Monitoring Procedures Selection Window.
  - via the Module Setup Selection Window.
  - by pressing the START key on the front of the parameter module.
  - by using a remote start switch.
  - by pressing the **Measure C.O.** softkey when you are in the Setup C.O. or Edit C.O. Task Windows.
- In this section each adjustment or measurement starts in the Measure C.O. task window.

Caution

During the cardiac output measurement procedure the blood temperature alarms are inactive. This is indicated by a sign next to the temperature numeric. Making alarms inactive during this procedure prevents false alarms. The alarms are automatically reactivated when you have completed the measurement procedure.

Measuring the Cardiac Output



You are in the first C.O. measurement Task Window. A message "...Ready for new measurement" will appear on the screen.

1. Press **Start C.O.** in the Task Window or **Start** on the module and wait for an audible tone and prompt message "...Inject now!" to appear on the screen. To ensure the greatest measurement accuracy, use an injectate volume of 10 cc if not contra-indicated by the patient's condition.

   At the end of the measurement the thermodilution curve, cardiac output, index values and curve alerts (if necessary) are displayed and a message will appear "...Wait before starting new measurement" (If the "Inj. low temp." is configured ON in Configuration Mode, the value of the lowest injectate temperature detected during measurement is displayed for approximately 30 seconds next to the Tinj value in the C.O. measurement Task Window.)

2. A prompt message "...Ready for new measurement" will then appear on the screen. Press **Start C.O.** for the next measurement.

Notes—

- If a “Tinj off scale” prompt message appears, the Tinjectate is out of the range -1°C and 27°C. Cool down or heat up the injectate or change the injectate solution and repeat the measurement.
- The time taken for the “...Ready for new measurement” prompt message to appear is dependent on the clinical condition of the patient.
- It is strongly recommended that you wait at least 1 minute (or longer depending on the patient's clinical condition) before starting the next measurement.

Continue to repeat this procedure until you have completed the measurements you want to perform. You can perform a maximum of 6 measurements before editing (selecting which curves should be used for the averaging calculation).

After the sixth measurement is performed, a message will be displayed stating that no more curves can be stored in the memory. If you perform additional measurements:

- If any of the curves in the memory have already been deleted in the Edit C.O. Task Window, these will be the first to be replaced, starting with the oldest.
- If there are six curves already stored in memory, the oldest measurement will automatically be deleted, when a 7th curve is stored.

There are two other softkeys in the Measure C.O. Task Window:

- **Change Scale** - By using this softkey you can change the scale of the curve. There are four choices; 0.25ºC, 0.5°C, 1.0°C to 2°C. The smaller the temperature scale the larger the curve.
- **Record Curve** - By using this softkey you can record the cardiac output thermodilution curve onto a recorder.

Curve Alert Messages

Curve alert messages appear in the Measure C.O. Task Window, if the thermodilution curve appears abnormal.

A '?' appears next to the cardiac output numeric in the Edit C.O. Task Window if any of these messages appear.

1. Noisy Baseline
   Interference may be caused if the patient is on a ventilator.

2. Excessive Baseline Drift
   May occur if the patient is recovering from open heart surgery. If the patient was cooled down for surgery and is in the process of regaining normal body temperature when the measurement is made, this curve alert message might appear.

3. Unsteady Baseline
   There is a noisy baseline, *and* thermal baseline drift.

4. Multiple Peaks
   Caused by faulty injection technique.

5. Abnormal Decay Time
   May be caused by low cardiac output. Calculated value for cardiac output may not be accurate.

6. Very Long Curve
   The decay time of the curve is longer than 15 seconds.

7. Very Short Curve
   Decay time of the curve is less than 0.5 seconds. (If there is a noisy baseline, part of the baseline might be mistaken for a thermodilution curve, giving this message.) Calculated value for cardiac output may not be accurate.

8. Irregular Curve
   Any combination of curve alert messages 4 to 7.

9. Delayed Injection
   Injection is given more than 15 seconds after **Start C.O.** is pressed. Calculated value for cardiac output may not be accurate.

10. Injectate Temperature too High

The difference between the blood and injectate temperatures is less than 8°C. The calculated value for cardiac output may not be accurate.

Task Window Prompt Messages

Task Window prompt messages appear in the Measure C.O. Task Window if the C.O. measurement has to be terminated.

1. `Curve Below Baseline, measurement terminated`
   The curve drops below the baseline. This may be caused by thermal baseline drift. No C.O. value calculated.

2. `Excessive Curve Height, measurement terminated`
   The curve exceeds the upper limit. This may be caused by an injectate that was too cold. No C.O. value calculated.

Warning Messages

Warning messages give users important information or warnings.

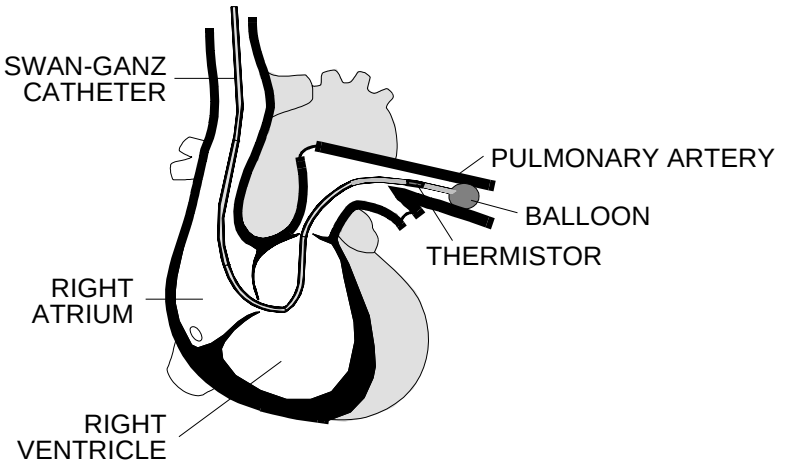
- `Next measurement erases first curve`
  Six thermodilution curves are stored by the monitor. This is the maximum that it can hold. If another measurement is made, the oldest deselected thermodilution curve is erased. If no curves have been deselected in the Edit C.O. Task Window, the oldest valid thermodilution curve is erased.

- `Verify the Computation Constant`
  This message appears when a new catheter is plugged in, or when the computation constant has been changed and the **Confirm** key has not been pressed. The message disappears when the **Start C.O.** softkey is pressed.

- `Previous Comp. Constant replaced`
  This message appears when you plug in a new C.O. module which has an internally stored computation constant which is different from the current one. The new computation constant is read from the C.O. module, and it replaces the current one. The message disappears when the **Start C.O.** softkey is pressed.

Measuring the Blood Temp-erature

- The key for the blood temperature will be labeled Tblood in the Module Setup Selection Window. It is only active when the cardiac output module is in use.
- The blood temperature is measured by the thermistor situated in the distal end of the flotation catheter in the pulmonary artery. (See the diagram below).
- During the measurement procedure the temperature is displayed in the bottom right corner of the cardiac output measurement Task Window, along with the temperature of the injectate.
- If you are measuring more than one temperature you can also derive temperature differences.
- You can set alarm limits for the blood temperature by entering the Tblood Task Window.



Editing the Cardiac Output Measure-ment

The Edit Task Window displays up to six measurements with the measurement number under the curve and the C.O. value above the curve. If there is a question mark before the value it means it is a questionable result. The cause of this could be due to one of the following:

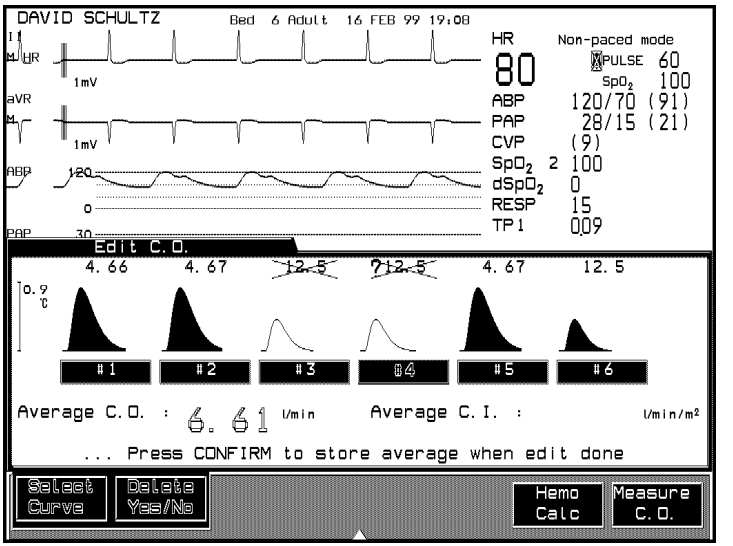
noisy baseline (interference on baseline)
thermal baseline drift
very long curve
very short curve
multiple peaks
delayed injection
injectate temperature too high
abnormal decay time

You can select the measurements to be edited. An average is calculated for the remaining measurements and stored when **Confirm** is pressed. The average of multiple thermodilution measurements should be used for therapy decisions. There are two other softkeys in this Task Window:

Hemo Calc - Press this softkey to enter the Hemocalculation Task Window. The calculations can only be performed on the averaged cardiac output. If you forget to store the average and then try to enter the Hemo Calc Task Window, the message: “Average has not been stored” will appear on the screen. Press the **Hemo Calc** softkey again, if you still want to enter the Task Window.

Measure C.O. - This softkey returns you to the measurement Task Window to enable you to perform another set of measurements.

Module Setup --> **C.O.** --> **Edit C.O.**



Procedure for Editing Cardiac Output

1. Press the softkey **Select Curve** .

   a. Move the highlighting through the curves.

   b. When you have selected a curve, press **Delete Yes/No** to include or exclude it from the average.

   c. The curves you have selected to include will be filled.

   d. The numerics of the curves you have selected to exclude will be crossed through.

2. When you have selected the curves for the average press **Confirm** . The average value and the time (1 minute earlier than the time of the first measurement) are stored. The curves are erased when you leave the Edit Cardiac Output Task Window.

3. Press **Measure C.O.** if you want to perform more measurements or press **Hemo Calc** to get into the Hemodynamic Task Window or press **Main Screen** to return to the Main Screen.

Cardiac Output Measurement - The PiCCO Method

Introduction

The PiCCO™ method is a combination of the transpulmonary thermodilution technique and blood pressure waveform analysis. The transpulmonary thermodilution technique requires a central venous line and an arterial catheter placed in one of the bigger systemic arteries e.g. the femoral or the axillary artery to measure Cardiac Output (C.O.), Intrathoracic Blood Volume (ITBV) and Extravascular Lung Water (EVLW)[1]. The injectate is injected through the central venous line. Transpulmonary Thermodilution C.O. is used to calibrate the Continuous Cardiac Output (CCO) derivation by means of Pulse Contour Analysis.

Notes—

- The transpulmonary thermodilution and the CCO measurement require a special arterial catheter from Pulsion Medical Systems. Only use these specified catheters and make sure that only the specified puncture locations for this catheter are used.
- The arterial thermodilution catheters can only be used for transpulmonary thermodilution measurements with the M1012A Option C10 C.O. Parameter Module.

Setup Checklist

1. Check that the C.O. module Option C10 is inserted into the rack
2. Switch on the system
3. Plug the C.O. interface cable into the module
4. Attach the flow-through injectate probe connector, catheter thermistor connector and remote start switch connector (if you are using a remote switch) to the appropriate parts of the cardiac output interface cable.
5. If you want to measure CCO , set up the pressure measurement. Make sure to select the correct pressure source in the CCO Task

1. EVLW is not available in USA.

Window. Please refer to the *Pressure Module Section* of this manual for details on the pressure measurement setup.

6. Enter the Setup C.O. Task Window and check the catheter constant. If it is not automatically detected, change the catheter constant to the one appropriate to the arterial catheter used .
7. Enter Injectate Volume.
8. Select the injectate temperature probe type in use.
9. Enter the Measure C.O. Task Window and start the measurement
10. Inject the injectate when prompted to do so.
11. Repeat steps 9 and 10 if you require more measurements.
12. On completion of the measurements edit the values by entering the Edit C.O. Task Window.
13. Calibrate Continuous Cardiac Output

Warning

•Make sure that the arterial catheter constant for the measurement is appropriate to the catheter used.

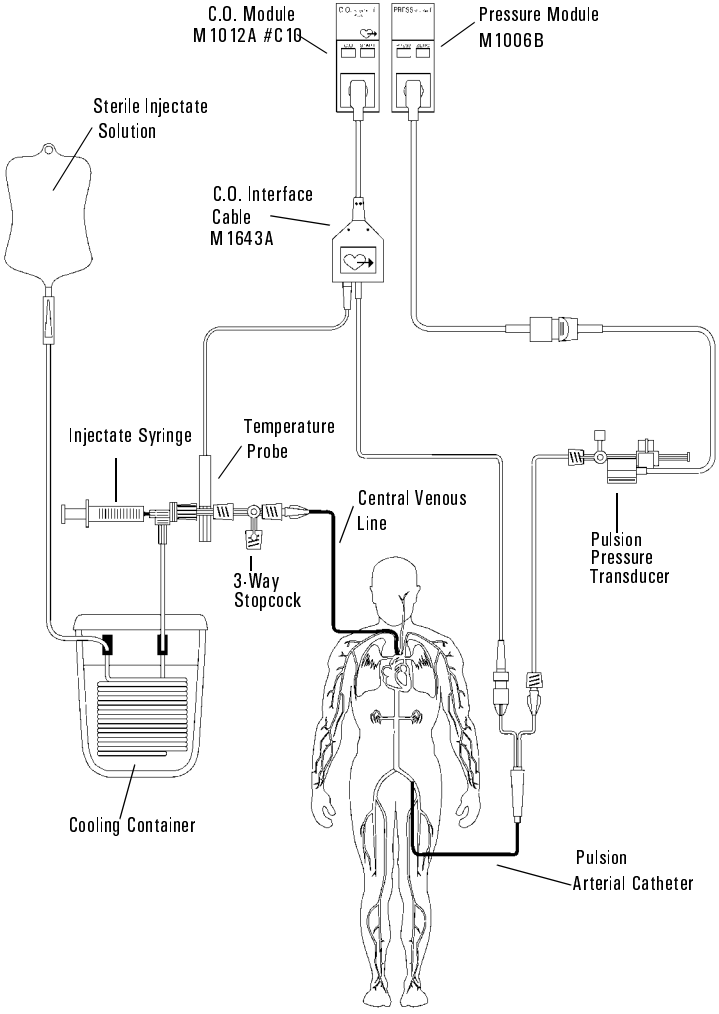
•Do not perform transpulmonary thermodilution measurements on patients undergoing IABP treatment.

•Accuracy of the CCO measurement and all the derived values may be influenced by patients with valve diseases or artificial valves.

•Do not use the Cardiac Output Interface Cable in MRI Applications

• Do not use a femoralis catheter when it is contra indicated e.g. with patients who have an aorta plastic.

Setup - Transpulmonary Thermodilution and CCO



Notes—

- The arterial catheter must be placed and fixed properly.
- The CCO measurement requires a minimally dampened invasive pressure setup. Please make sure that there are no air bubbles in the pressure line or dome and use only specified accessories.

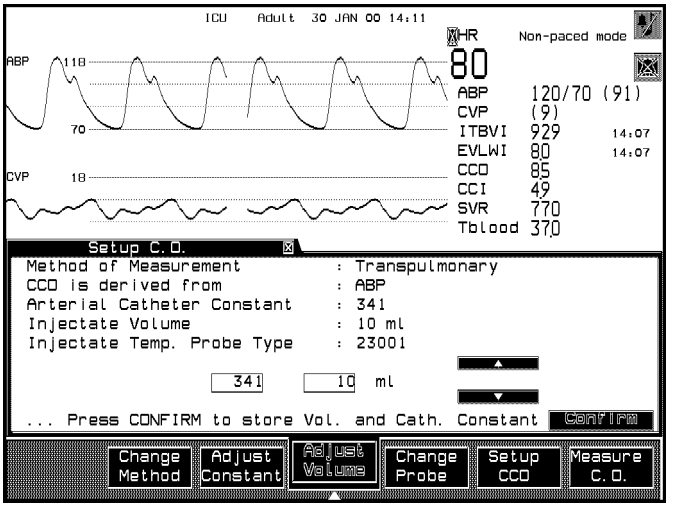
Adjusting the Arterial Catheter Constant and the Injectate Volume

Depending on whether the arterial catheter is recognized by the module software or not, you may have to adjust the catheter constant. In addition, the injectate volume needs to be entered. Both adjustments are made in the Setup C.O. Task Window.

Module Setup --> **C.O.** --> **Setup C.O.** *or*

Procedures --> **C.O.** --> **Setup C.O.** *or*

C.O. on the Module

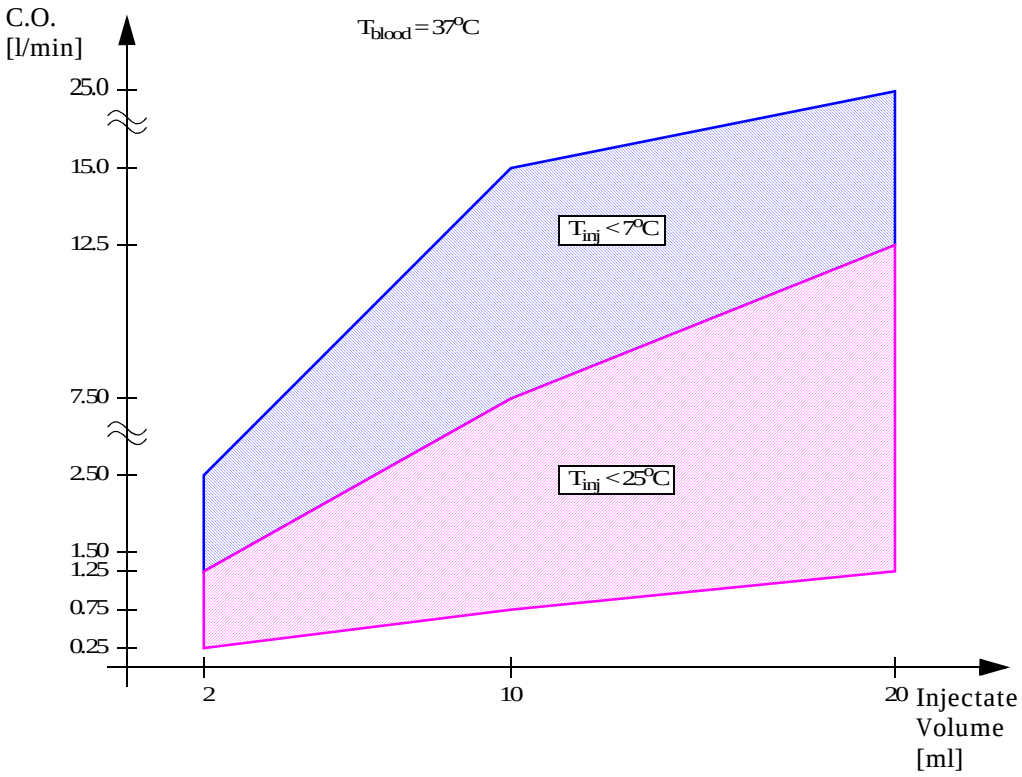


1. If the catheter is recognized by the module software, the arterial catheter constant is automatically selected and displayed. If the catheter is not recognized, adjust the catheter constant by pressing either the **Adjust Constant** softkey or by using the arrow keys.
2. Adjust the injectate volume by pressing either the **Adjust Volume** softkey or by using the arrow keys.
3. Press the **Confirm** hardkey to store the catheter constant and the injectate volume.
4. Select the Injectate Temperature Probe type in use by using the **Change Probe** key.

5. Press the softkey **Measure C.O.** to enter the Measurement Task Window.

Injectate Temperature and Volume

The following graphic is a guideline on which injectate volume should be used based on the injectate temperature and the patient's cardiac output.



The dilution of injectate is also influenced by the extravascular tissue. The Extravascular Thermovolume Index (ETVI) is a quality indicator which quantifies this influence. ETVI is calculated based on the patient's body weight and only applies to the current single transpulmonary thermodilution measurement. For patients with high ETVI values, the accuracy of the transpulmonary thermodilution measurement may be reduced. It is recommended to use a higher injectate volume and/or colder injectate in these patients based on the following table.

Patient Weight	Cold Injectate		Room Temp. Injectate	
	ETVI < 10	ETVI ≥ 10	ETVI < 10	ETVI ≥ 10
< 3 kg	2 ml	2 ml	3 ml	Use cold injectate
< 10 kg	2 ml	3 ml	3 ml	
< 25 kg	3 ml	5 ml	5 ml	
< 50 kg	5 ml	10 ml	10 ml	
< 100 kg	10 ml	15 ml	15 ml	
≥ 100 kg	15 ml	20 ml	20 ml	

Notes—

- If no weight is entered, no ETVI value will be calculated
- Make sure that the injectate volume displayed by the monitor is equal to the injectate volume used
- The use of injectate with a temperature less than 12ºC lower than the blood temperature may cause incorrect values for the thermodilution and CCO calibration.
- Reduced injectate volume or higher injectate temperature may reduce the specified accuracy

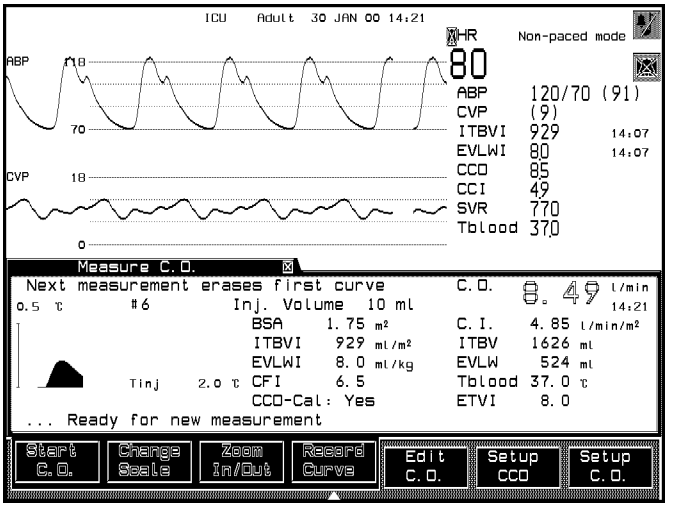
Getting into the C.O. Measure-ment Task Window

- You can get into the C.O. measurement Task Window by 5 different methods:
  - via the Monitoring Procedures Selection Window
  - via the Module Setup Selection Window
  - by pressing the START key on the front of the parameter module
  - by using a remote start switch
  - by pressing the **Measure C.O.** softkey when you are in the Setup C.O., Edit C.O. or Setup CCO Task Windows
- In this section each adjustment or measurement starts in the Measure C.O. task window.

Caution

During the cardiac output measurement procedure the blood temperature alarms are inactive. This is indicated by a sign next to the temperature numeric. Making alarms inactive during this procedure prevents false alarms. The alarms are automatically reactivated when you have completed the measurement procedure.

Measuring the Cardiac Output



You are in the first C.O. measurement Task Window. A message "...Ready for new measurement" will appear on the screen.

1. Press **Start C.O.** in the Task Window or **Start** on the module and wait for an audible tone and prompt message "...Stable baseline, inject now!"[1] to appear on the screen. To ensure measurement accuracy, use the recommended injectate volume and temperature (See "Injectate Temperature and Volume" on page 21-21).

   At the end of the measurement the thermodilution curve, cardiac output, index values, ITBV and EVLW[2] values and curve alerts (if necessary) are displayed and a message will appear "...Wait before starting new measurement" . In addition, the status of the data regarding CCO calibration is displayed in the CCO-Cal status line. The table on the following page lists the possible situations. Please refer to the Continuous Cardiac Output section of this chapter for further details.

1. See "Task Window Prompt Messages" on page 21-13 for details on other prompt messages.
2. EVLW not available in USA

CCO-Cal Status	Condition	CCO Calibration Data available for this Thermodilution?
yes	A proper pressure signal for CCO was available during the thermodilution measurement.	yes
quest.	A pressure signal for CCO was available, but it was disturbed during the thermodilution measurement.	yes
no	There was no proper pressure signal available for CCO during the thermodilution measurement.	no

2. A prompt message "...Ready for new measurement" will then appear on the screen. Press **Start C.O.** for the next measurement.

Notes—

- If a “Tinj off scale” prompt message appears, the Tinjectate is out of the range -1°C and 27°C. Cool down or heat up the injectate or change the injectate solution and repeat the measurement.
- The time taken for the “...Ready for new measurement” prompt message to appear is dependent on the clinical condition of the patient.
- It is strongly recommended that you wait at least 1 minute (or longer depending on the patient's clinical condition) before starting the next measurement.

Note—All measurements should be conducted within 15 minutes. Older measurements “expire” for CCO calibration.

Continue to repeat this procedure until you have completed the measurements you want to perform. You can perform a maximum of 6 measurements before editing (selecting which curves should be used for the averaging calculation).

After the sixth measurement is performed, a message will be displayed stating that no more curves can be stored in the memory. If you perform additional measurements:

- If any of the curves in the memory have already been deleted in the Edit C.O. Task Window, these will be the first to be replaced, starting with the oldest.
- If there are six curves already stored in memory, the oldest measurement will automatically be deleted, when a 7th curve is stored.

There are three other softkeys in the Measure C.O. Task Window:

- **Change Scale** - By using this softkey you can change the scale of the curve. There are four choices; 0.25ºC, 0.5°C, 1.0°C to 2°C. The smaller the temperature scale the larger the curve.
- **Record Curve** - By using this softkey you can record the cardiac output thermodilution curve onto a recorder.

- **Zoom In/Out** - By using this softkey you can switch between a compressed curve display and the original resolution curve.

Curve Alert Messages

Curve alert messages appear in the Measure C.O. Task Window, if the thermodilution curve appears abnormal.

A ?' appears next to the cardiac output numeric in the Edit C.O. Task Window if any of these messages appear.

1. Noisy Baseline
   Varying blood temperature baseline drift during the C.O. measurement which could not be compensated.

2. Excessive Baseline Drift
   May occur if patient is recovering from open heart surgery. If the patient was cooled down for surgery and is in the process of regaining normal body temperature when the measurement is made, this curve alert message might appear.

3. Small signal, more indicator required
   The peak of the Transpulmonary Thermodilution curve was below 0.1ºC. The user should either use more injectate volume and/or lower injectate temperature.

4. Injectate Temperature too High
   The difference between the blood and injectate temperatures is less than 12ºC. The calculated value for cardiac output may not be accurate.

5. High ETVI, more indicator recommended
   The patient's ETVI value is too high. The accuracy of the transpulmonary thermodilution measurement may be reduced. The user should either use more injectate volume and/or lower injectate temperature.

6. Disturbed Injection
   The injection should be performed quickly and with a steady pressure. Shaking or unsteady pressure could cause this alert message to appear.

7. `Check Injectate Temperature Probe Type`
   The injectate temperature probe type is set to M1646 but the recorded T_{inj} signal is uncharacteristic for this type of probe. The probe may be defective or the incorrect probe type may be selected.

Task Window Prompt Messages

Task Window prompt messages appear in the Measure C.O. Task Window if the C.O. measurement has to be terminated.

1. `Curve Below Baseline, measurement terminated`
   The curve drops below the baseline. This may be caused by thermal baseline drift. No C.O. value calculated.

2. `Excessive Curve Height, measurement terminated`
   The curve exceeds the upper limit. This may be caused by an injectate that was too cold. No C.O. value calculated.

3. `Unstable Baseline, injection not recommended`
   The baseline is unstable. It is recommended to wait with the injection until the baseline is stable. If this does not occur within a reasonable time, injection is possible but the accuracy of the measured values may be reduced.

4. `Excessive Baseline Drift`
   No measurement is possible. Measured values are incorrect.

Warning Messages

Warning messages give users important information or warnings.

- `Next measurement erases first curve`
  Six thermodilution curves are stored by the monitor. This is the maximum that it can hold. If another measurement is made, the oldest thermodilution curve is erased.

- `Previous C.O. Setup Data replaced`
  This message appears when you plug in a new C.O. module which has internally stored C.O. Setup Data which is different from the current one. The new C.O. Setup Data is read from the C.O. module, and it replaces the current data. The message disappears when the **Start C.O.** softkey is pressed.

- `Verify the C.O. Setup Data`
  This warning will be displayed when a new Transpulmonary Thermodilution catheter is plugged or when the C.O. Setup data has been changed and the **Confirm** key is not pressed.
- `Start will erase unconfirmed CCO cal data`
  This warning will be displayed if AutoCal is configured off and the Edit C.O. Task Window is closed before CCO Calibration is confirmed.
- `Invalid Pressure, CCO cal not possible`
  This warning ia caused by a poor or invalid pressure signal, e.g. because pressure was not zeroed.

Measuring the Blood Temperature

- The key for the blood temperature will be labeled Tblood in the Module Setup Selection Window. It is only active when the cardiac output module is in use.
- The blood temperature is measured by the thermistor situated in the distal end of the catheter in or near the aorta.
- During the measurement procedure the temperature is displayed in the bottom right corner of the cardiac output measurement Task Window.
- If you are measuring more than one temperature you can also derive temperature differences.
- You can set alarm limits for the blood temperature by entering the Tblood Task Window.

Editing the Cardiac Output Measure-ment

The Edit Task Window displays up to six measurements with the measurement number under the curve and the C.O. value above the curve. If there is a question mark before the value it means it is a questionable result. The cause of this could be due to one of the following:

noisy baseline (interference on baseline)
excessive baseline drift
small signal
injectate temperature too high
high ETVI
disturbed injection

You can select the measurements to be edited. An average is calculated for the remaining measurements and stored when **Confirm** is pressed. The average of multiple thermodilution measurements should be used for therapy decisions. Averages are also calculated for EVLW[1], ITBV and CFI. The averaged data can then be used to calibrate Continuous Cardiac Output (CCO). There are three other softkeys in this Task Window:

Hemo Calc - Press this softkey to enter the Hemocalculation Task Window. The calculations can only be performed on the averaged cardiac output. If you forget to store the average and then try to enter the Hemo Calc Task Window, the message: "Average has not been stored" will appear on the screen. Press the **Hemo Calc** softkey again, if you still want to enter the Task Window.

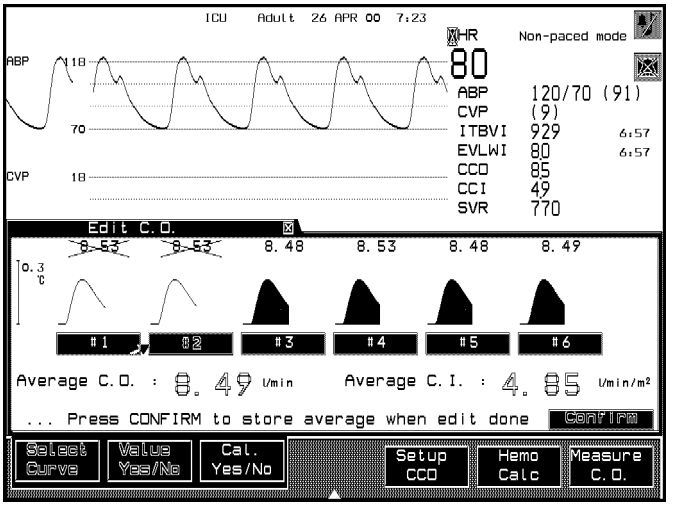
Note—Due to different averaging mechanisms, the calculated values shown in the Hemo Calc Task Window may differ slightly from the corresponding continuously calculated values shown in the CCO Task Window and stored as a trend.

Measure C.O. - This softkey returns you to the measurement Task Window to enable you to perform another set of measurements.

Setup CCO - This softkey brings you to the Setup CCO Task Window where you can view the Continuous Cardiac Output values.

1. EVLW not available in USA

To enter the Edit C.O. Task Window, press the following key sequence:
Module Setup --> **C.O.** --> **Edit C.O.**



Procedure for Editing Cardiac Output

1. Press the softkey **Select Curve** .

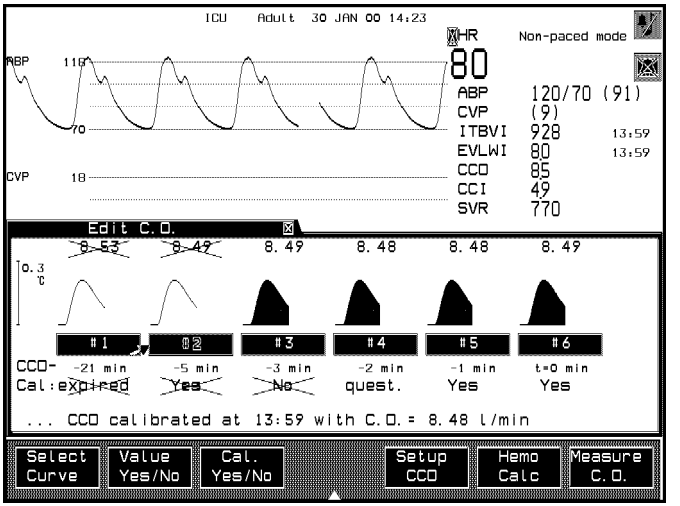
   – Move the highlighting through the curves.

   – When you have selected a curve, press **Value Yes/No** to include or exclude it from the average.

   – The curves you have selected to include will be filled in and highlighted.

   – The numerics of the curves you have selected to exclude will be crossed through.

2. When you have selected the curves for the average press **Confirm** . The average value and the time (1 minute earlier than the time of the first measurement) are stored and Continuous Cardiac Output (CCO) is calibrated.



Note—It is recommended to perform a CCO calibration every 8 hours or when the hemodynamic condition of the patient has changed.

Note—If AutoCal is configured off, CCO must be calibrated manually. See *Calibrating Continuous Cardiac Output manually* below for details.

3. Press **Measure C.O.** if you want to perform more measurements or press **Hemo Calc** to get into the Hemodynamic Task Window or press **Main Screen** to return to the Main Screen.

Calibrating Continuous Cardiac Output manually

1. In the Edit C.O. Task Window, press the softkey **Select Curve** .
   - Move the highlighting through the curves.
   - When you have selected a curve, press **Cal Yes/No** to include or exclude a curve from CCO calibration.
2. When you have selected the curves for calibration press **Confirm** . The average value and the time are displayed and stored. The curves are erased when you leave the Edit Cardiac Output Task Window.

Notes—

- If you do not confirm the calibration for CCO, the calibration data will be lost as soon as a new single measurement is performed.
- CCO calibration data from a single transpulmonary thermodilution, which is derived more than 15 minutes before the last valid thermodilution, will not be used.[1]

Warning

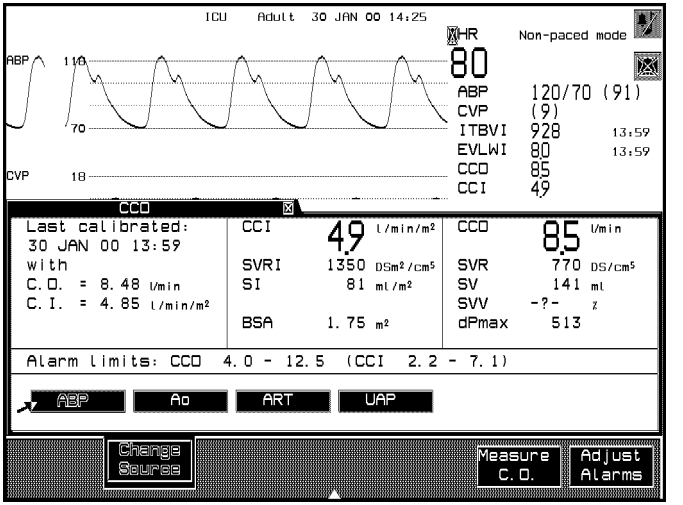
CCO calibration is patient-specific. When using Settings Transfer, make sure that the correct CCO calibration is used. When in doubt or if another patient is monitored, perform a new CCO calibration first.

1. If AutoCal is configured to *off* the 15 minute limitation can be overridden, provided the patient's hemodynamic condition has not changed.

Continuous Cardiac Output

To obtain Continuous Cardiac Output (CCO) values a calibration with Transpulmonary Thermodilution is required and the arterial pressure signal has to be measured during the Transpulmonary Thermodilution. CCO is calculated by performing a Pulse Contour Analysis on the arterial blood pressure wave.

The values for CCO and Systemic Vascular Resistance (SVR) are calculated on a continuous basis and can be viewed in the CCO Task Window. CCO values are calculated on a beat-to-beat basis and then averaged over a 12-second timeframe. To enter the CCO Task Window press **Setup CCO** in the Measure C.O. Task Window.



Note—If there is no valid CVP value available, CVP = 0 mmHg is assumed for the continuous SVR calculation and a '?' is displayed before the SVR label. The values for SVR and SVRI displayed in the Hemo Calc Task Window, may differ from those displayed in the CCO Task Window.

The **Change Source** key allows you to select the pressure source for CCO Calculation.

Stroke Volume Variation (SVV)

Stroke Volume Variation (SVV) is presented as the change in stroke volume (in percent) calculated by the mean difference between the highest and the lowest stroke volume divided by a calculated mean stroke volume over the last 30 seconds. SVV is calculated according to the following formula:

$$\mathbf{SVV = (SV_{max} - SV_{min}) / SV_{mean}}$$

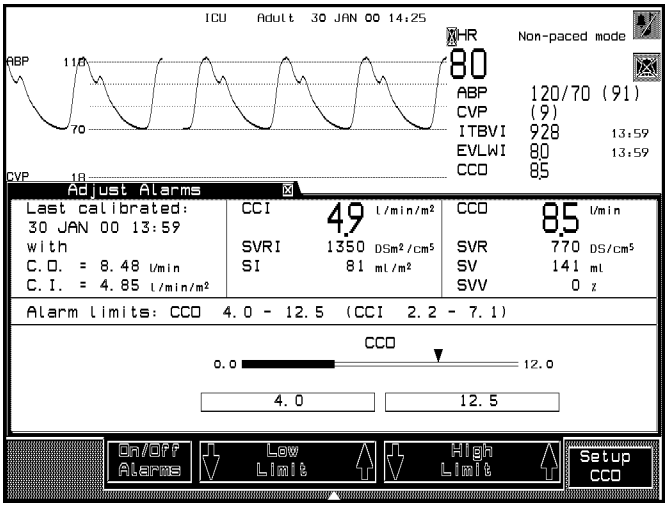
SV_{max} = mean value of maximum stroke volumes of the last 30 sec.
SV_{min} = mean value of minimum stroke volumes of the last 30 sec.
SV_{mean} = mean value of stroke volumes over the last 30 sec.

In mechanically ventilated patients, the SVV mainly depends on the intravascular volume of the patient. Big variations in stroke volume, induced by mechanical ventilation, is an indication of insufficient intravascular volume relative to the applied intrathoracic pressures. Thus, SVV allows a rough estimation of the vascular volume status. When high SVV is detected, it is recommended to perform a thermodilution measurement to quantify the volume status by measuring the ITBV.[1]

1. Preisman S., Pfeiffer U., Liebermann N., Perel A.: *Single Thermodilution monitoring of global end-diastolic volume, intrathoracic blood volume and extravascular lung water. Intensive Care Med. 23: 651-657, 1997*

Adjusting Alarm Limits for CCO

The Alarm Limits for CCO can be adjusted in the Adjust Alarms Task Window. To access the Adjust Alarms Task Window press **Adjust Alarms** in the CCO Task Window.



Note—If BSA is available, the corresponding alarm limits will be shown as CCI values. This is for information purposes only. Alarming does not occur on CCI values but only on absolute CCO values.

C.O. Alarm and INOP Messages

The alarm messages are rated in order of severity:

** Yellow

INOP message

Alarm tone = a single chime repeated every two seconds.
INOP tone = a single beep repeated every 2 seconds.
Alarm limits are dependent on the patient's condition.

Physiological Alarms

Alarm Message	Condition	Visual Indication	Audible Indication
**CCO 4.0 < 5.0	Continuous Cardiac Output is below alarm limit.	CCO Numeric blinks. Yellow alarm lamp.	Alarm tone
**CCO 11.0 > 10.0	Continuous Cardiac Output is above alarm limit	CCO Numeric blinks. Yellow alarm lamp.	Alarm tone
**Tblood 39.0>38.0	High alarm limit exceeded.	Tblood numeric blinks. Yellow alarm lamp.	Alarm tone
**Tblood 35.0<36.0	Temperature below low alarm limit.	Tblood numeric blinks. Yellow alarm lamp.	Alarm tone

Technical Alarms

INOP messages appear when the monitor cannot measure or process signals properly. This could be due to patient- related or equipment-related problems but you must always check the patient's condition first. The INOP message may be accompanied by an audible alarm which can be silenced with the **Silence/Reset** key.

Equipment-Related INOPS

INOP Message	Condition	Visual Indication	Audible Indication
C.O. UN-PLUGGED	C.O. module switched on and has been un-plugged from the rack.	Tblood numeric displays -?-. If available, CCO, CCI, SVR, SVRI numerics display -?-	INOP tone
Tblood NO TRANSDUC or CCO/Tblood NO Transduc	No transducer attached to the module. Catheter disconnected.	Tblood numeric displays -?-. If available, CCO, CCI, SVR, SVRI numerics display -?-	INOP tone
C.O. EQUIP MALF	Malfunction in the C.O. hardware	Tblood numeric displays -?-. If available, CCO, CCI, SVR, SVRI numerics display -?-	INOP tone
CCO NOT SUPPORTED	The user has changed from a transpulmonary catheter to a right heart catheter. CCO is not supported.	CCO, CCI, SVR and SVRI numerics display -?-	INOP tone
CCO NO ABP	The pressure source selected for pulse contour calculation for CCO is not available.	CCO, CCI, SVR and SVRI numerics display -?-	INOP tone
CCO ABP INVALID	The pressure for pulse contour calculation for CCO is not valid (e.g. no transducer, no Zero-Cal.)	CCO, CCI, SVR and SVRI numerics display -?-	INOP tone
CCO NO CAL	No valid calibration for CCO	CCO, CCI, SVR and SVRI numerics display -?-	none

INOP Message	Condition	Visual Indication	Audible Indication
CCO BAD PRESS SIGN	The pressure for pulse contour calculation for CCO cannot be analyzed (e.g. unexpected wave form).	CCO, CCI, SVR and SVRI numerics display -?-	INOP tone
CCO CHECK CAL	CCO calibration is older than 8 hours	A '?' is displayed before the CCO, CCI, SVR and SVRI numerics.	none
SVR MISSING CVP	No valid CVP available at the moment. CVP is assumed to be 0 mmHg for the continuous SVR calculation.[1]	A '?' is displayed before the SVR and SVRI numerics.	none

1. With the HemoCalc package, a correct SVR value can be calculated by manually entering a CVP value.

Patient-Related INOPS

INOP Message	Condition	Visual Indication	Audible Indication
Tblood OVERRANGE	Tblood out of range 17°C - 43°C.	Tblood numeric displays -?-.	INOP tone
CCO PULSE OVERRANG	The pulse rate of the pressure used for pulse contour calculation for CCO is below 30 bpm or above 240 bpm.	CCO, CCI, SVR and SVRI numerics display -?-	INOP tone
CCO PRESS OVERRANG	The pressure values used for pulse contour calculation for CCO are below 0 mmHg or above 300 mmHg.	CCO, CCI, SVR and SVRI numerics display -?-	INOP tone
CCO OVERRANGE	The measured CCO is out of reporting range.	CCO, CCI, SVR and SVRI numerics display -?-	INOP tone

Errors in Measurement

Right Heart Measurement

- Physiological Reasons

  Patient movement during the procedure
  Anxious patient
  Variations in cardiac rate and rhythm
  Variation of Cardiac Output due to mechanical ventilation
  Cardiac abnormality (for example, incompetent valves)
  Shock

- Catheter Related Errors

  Balloon inflated during measurement
  Catheter not positioned properly
  Damaged catheter

- Injection Errors

  Use of the wrong catheter injection port
  Poor timing of injection
  Incorrect or unsuitable volume of injectate
  Unsuitable injectate temperature

- Instrument Errors

  Incorrect computation constant
  Instrument failure

Trans-pulmonary Thermo-dilution

- Physiological Reasons

  Patient movement during the procedure
  Anxious patient
  Variations in cardiac rate and rhythm
  Cardiac abnormality (for example, incompetent valves)
  Shock

- Catheter Related Errors

  Catheter not positioned properly
  Damaged catheter

- Injection Errors

  Poor timing of injection
  Incorrect or unsuitable volume of injectate
  Unsuitable injectate temperature

- Instrument Errors

  Incorrect arterial catheter constant
  Instrument failure

Continuous Cardiac Output

- Physiological Reasons

  Patient with valve disease or artificial valves
  Significant change in hemodynamic condition of the patient

- Setup Errors

  Incorrect Pressure Source selected
  Air bubbles in pressure line or dome

- Catheter Related Errors

  Catheter not positioned in specified locations
  Unsuitable catheter used

Parameter Settings Transfer

The following settings can be transferred with C.O. modules that have a *T* on the front. For more information on Parameter Settings Transfer, refer to *"Parameter Settings Transfer"*, Chapter 3.

M1012A C.O. Module or M1012A Option C10 Module

Setting Name	Meaning
Computation constant[1]	Swan Ganz catheter constant
Tblood alarm limits	Blood temperature alarm limits

[1]The computation constant is always transferred regardless of whether Parameter Settings Transfer is ON or OFF.

M1012A Option C10 C.O. Module only

Setting Name	Meaning
Catheter Constant[1]	Last manually entered arterial catheter constant
Injectate Volume[1]	Injectate Volume last used
Injectate Temp. Probe Type[1]	Type of Injectate Temperature Probe last used.
CCO alarm limits	Continuous Cardiac Output alarm limits
CCO Calibration Data	• pCCO Calibration for calculation of CCO, SVR, etc. via Pulse Contour Analysis • Date and Time of CCO Calibration • C.O. value used for CCO Calibration • BSA at time of CCO Calibration • selected arterial pressure source

1. This setup data is always transferred regardless of whether Parameter Settings Transfer is ON or OFF

Accessories and Ordering Information

Right Heart Measure-ment

- Catheters
  Baxter 831HF75 or compatible catheters.
- C.O. Interface Cables
  M1642A 2.7 meter cable
  M1643A 2.4 m + 2.4 m cable
- Injectate Probes
  23001A (2.4m) injectate temp. probe (reusable)
  23001B (0.5m) injectate temp. probe (reusable)
  23002A ice bath temp. probe (reusable)
  Injectate Flow Through Sensor Housing: Baxter CO-Set (w/ 23001A/B)
- Accessories
  14455A set of ice buckets
  15244A remote handswitch

Trans-pulmonary Thermo dilution

- Catheters
  - Arterial Catheter
    PV 2014L16 (4F, 16cm, w/ Lumen)
    or compatible catheters from PULSION
  - Venous Catheter
    Any central venous access w/ deadspace volume less than 1.25 ml
- C.O. Interface Cables
  M1643A 2.4 m + 2.4 m cable

- Injectate Probes
  23001A (2.4m) injectate temp. probe (reusable)
  23001B (0.5m) injectate temp. probe (reusable)
  M1646A injectate temp. probe[1]
  Injectate Flow Through Sensor Housing:
  Baxter CO-Set (w/ 23001A/B)
  PULSION PV 4046 (w/ M1646A)[1]

- Pressure Transducer Kits (PULSION)
  PV 8003 (30 cm pressure line)
  PV 8010 (100 cm pressure line)
  PV 8015 (150 cm pressure line)

- Pressure Interface Cable for disposable Pressure Transducer
  PULSION PMK 206

- Accessories
  14455A set of ice buckets
  15244A remote handswitch

1. not available in the U.S.A.

Performance Specifications

For safety and environmental specifications, please refer to the *Monitor Installation and Patient Safety* Chapter 10.

Cardiac Output Measurement

Cardiac Output (Right Heart)		*Cardiac Output Range:*	0.1 to 20.0 l/min
	Instrument Specification:[1]	*Cardiac Output instrument accuracy:*	± 3% or 0.1 l/min
		Cardiac Output repeatability accuracy:	± 2% or 0.1 l/min
	System Specification	*Cardiac Output instrument accuracy:*	± 5%.or 0.1 l/min
		Cardiac Output repeatability accuracy:	± 3% or 0.1 l/min
Cardiac Output (Transpulmonary)		*Cardiac Output Range:*	0.1 to 25.0 l/min
	Instrument Specification:[1]	*Cardiac Output instrument accuracy:*	± 4% or 0.15 l/min
		Cardiac Output repeatability accuracy:	± 2% or 0.1 l/min
	System Specification	*Cardiac Output instrument accuracy:*	± 5% or 0.2 l/min
		Cardiac Output repeatability accuracy:	± 3% or 0.1 l/min
Blood Temperature		*Blood Temperature Range:*	17 to 43°C

Injectate Temperature	*Injectate Temperature Range:*	0 to 27°C
EVLW	*EVLW[2] Range*	10 to 5000 ml
	Standard Deviation	10% or 1 ml/kg
ITBV	*ITBV Range*	50 to 6000 ml
	Accuracy	± 10% or 30 ml
	Repeatability	± 5% or 20 ml
CCO	*CCO Range*	0.1 to 25.0 l/min
	Standard Deviation	10% or 0.3 l/min
	Display Update:	2 seconds nominal

1. Electrical
2. EVLW not available in the USA

Cardiac Output Alarms

Tblood Alarms:

Alarm Limit Range:	17 to 43°C
Adjustment:	Steps of 0.1°C (T > 35 °C) Steps of 0.5°C (T < 35 °C)
Alarm Criterion:	8 seconds after the value exceeds the set limit value.
Alarm:	within 2 seconds after this criterion is met.

CCO Alarms:

Alarm Limit Range:	0.1 to 25.0 l/min
Adjustment:	Steps of 0.1 l/min (CCO < 10.0 l/min) Steps of 0.5 l/min (CCO > 10.0 l/min)
Alarm Criterion:	8 seconds after the value exceeds the set limit value
Alarm:	within 2 seconds after this criterion is met

INOP Alarms: Refer to Patient and Equipment related INOP tables.

Curve Warnings: Refer to the Curve Alert Messages section in this chapter.

Care and Cleaning

General Cleaning of the System

Please refer to the *Maintenance* Chapter of this manual for general cleaning guidelines for the system.

C.O. Interface Cable

Please refer to the C.O. Interface Cable instruction sheet for details on care and cleaning.

22
VueLink Module Section

This chapter provides information on setting up the VueLink module, changing VueLink module settings and troubleshooting. It includes the following sections:

Introduction to the VueLink module

The VueLink module is used to connect an external device (such as a ventilator, gas analyzer, anesthesia machine or stand alone parameter monitor) to the monitor. Information from this device can then be displayed, recorded and trended and calculated on the system.

There are five different VueLink module options:

Auxiliary	for connecting external stand alone parameters to the monitor.
Ventilator	for connecting ventilators to the monitor.
Gas Analyzer	for connecting gas analyzers to the monitor.
Anesthesia Machine	for connecting anesthesia machines to the monitor.
Auxiliary Plus	for connecting external multi-parameter measurement devices to the monitor.

The operation of each module option is similar. In this section, the *Ventilator* module option is described; variations between the different module options are detailed where necessary.

VueLink modules fall into two basic types:

- **Type A:** Those that can use up to 1 wave and 2 numerics for further processing within the monitor.
- **Type B:** Those that can use up to 2 waves and 6 numerics for further processing within the monitor.

Each module option is a fixed type, as shown in the following table:

Option:	**Aux**	**Ventil.**	**Gas Analyzer**	**Anes. Machine**	**Aux. Plus**
Type:	**A**	**B**	**B**	**B**	**B**
Waves	1	2	2	2	2
Numerics	2	6	6	6	6

The number of VueLink modules you can plug into your system at one time depends on the model of system you have ordered.

Features

The following features are provided by the VueLink module:

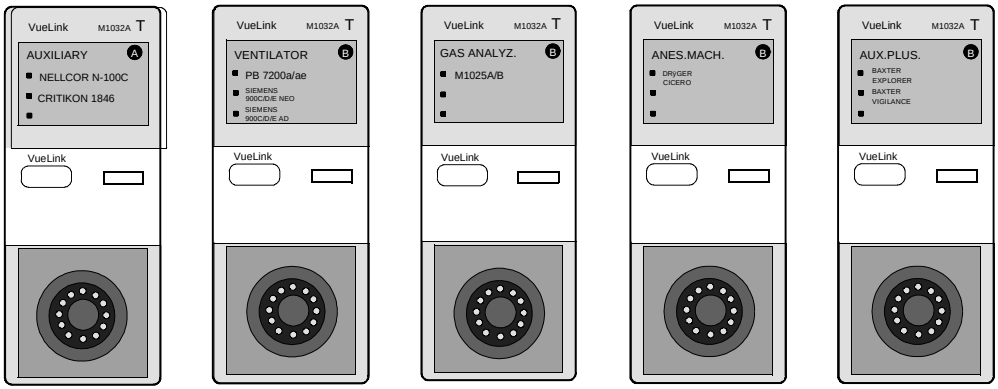
- Each module can be easily switched between up to three external devices.
- External device alarms are supported (visual only).
- Up to eight free configurable analog inputs are available.
- Up to two waveforms and six numerics can be used for display, trending and recording.
- Up to two VueLink modules can be plugged into the system at once.
- **(Agilent CMS only)**: Optional display and storage of up to 3 types of Respiratory Loops. Please refer to Ventilator Interfaces and Respiratory Loops chapter for further details on Respiratory Loops.
- **(Agilent CMS only)**: More than one VueLink module can be plugged into the system at once. The number of modules depends upon the model of Agilent CMS you have ordered.

Notes—

1. If you have more than one VueLink module plugged into the system at once, the “Parameter Settings Transfer” setting in Service Mode should be set ON. This ensures that the system can differentiate between the different VueLink modules you have plugged in. (Note that the “Parameter Settings Transfer” setting also has an effect on Temperature and Pressure module labeling.)

2. The signal labels used on the monitor may be different from those used on external devices. Refer to Appendix D for details of signal labels and their meanings.

- The front of the VueLink module has one key, and up to three labels:
  - The key is for setup. A light will appear beside the key when you are in setup.
  - The labels contain the names of the devices to which your VueLink module can be connected. The device which you have presently selected has a light beside it.



Caution

Do not apply voltages greater than ±12V to the VueLink module front connector. Input voltages exceeding ±12V may damage the module.

Note—The device names on the labels are not the same on all VueLink modules. The labels on your module contain only the names of the devices for which your particular VueLink module has been configured.

VueLink Module Setup

1. Check that the VueLink module is inserted into the module rack of the system.
2. Ensure that the correct device name is selected on the front of the module (there is a light next to the selected device name).
   - The procedure to select a different device for connection to the VueLink module is described in “Selecting a Different Device.”
3. Connect the external device to the VueLink module with the appropriate cable.
4. Check that the external device is switched on.

Caution

Selection of an incorrect device can lead to unpredictable or inoperative system behavior. Therefore, exercise care in selecting the device name.

If an incorrect device is selected:

1. Switch off the external device.
2. Ensure that the correct device name is selected on the front of the VueLink module.
3. Complete the VueLink setup procedure.

Adjustments to VueLink Module Settings

VueLink Module Task Windows

The Task Windows shown in this section are **example** Task Windows. The Task Windows you see on your monitor may differ from these examples in the following ways:

- The example Task Windows shown are for a *Ventilator* VueLink module option. If you have a *Gas Analyzer*, *Auxiliary*, *Anesthesia Machine* or *Auxiliary Plus* module option, the words Gas Analyzer, Auxiliary, Anesthesia Machine or Auxiliary Plus will be present at the top of the Task Windows.
- The device names and signal names which appear in the Task Windows on your system may differ from those shown in the example Task Windows in this chapter. This is dependent upon the VueLink module option you have, and its configuration.

VueLink Module Softkeys

The softkeys that represent the VueLink module (accessed by pressing the **Module Setup** hardkey) are labeled as follows:

Ventilator:	**VENTILTR**
Gas Analyzer:	**GAS ANALYZER**
Anesthesia Machine:	**ANESTH MACHINE**
Auxiliary:	**AUXn parameter**

Auxiliary Plus: **AUXPLUSn parameter**

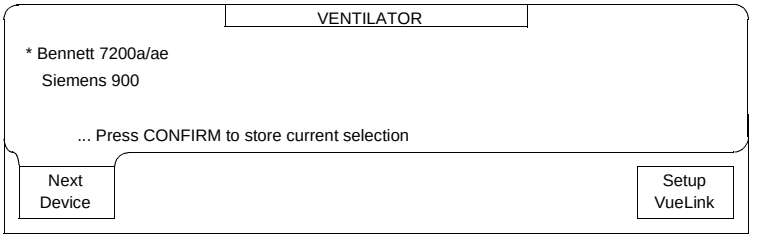
where:
n is an identification number.

parameter is the name of the parameter which the auxiliary device monitors.

However, it is recommended that you press the **VueLink** setup key on the front of the relevant VueLink module to enter the Task Windows. This avoids any confusion if more than one module with the same option is plugged into the system.

Selecting a Different Device

VueLink --> **Select Device**



Procedure For Selecting a Different Device

1. The Task Window contains the names of the devices which can be connected to your VueLink module. The softkey **Next Device** is highlighted. Move the highlighting to the name of the device which you have connected.

2. Press **Confirm** to store the selection.

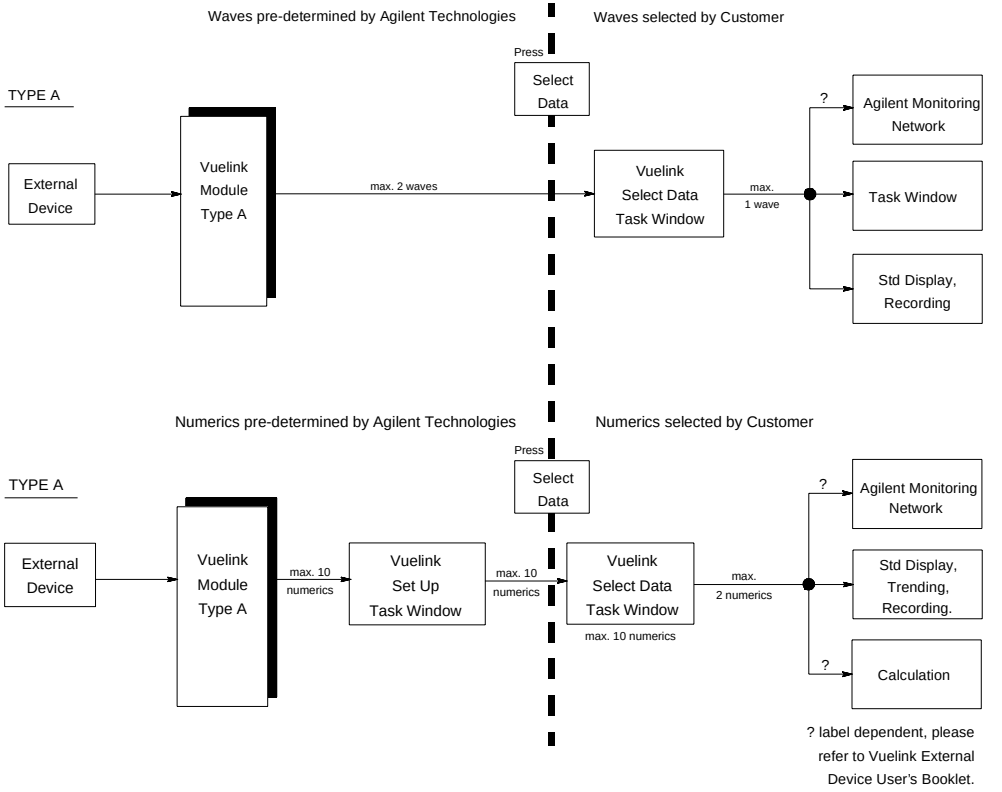
3. The message
   `Please wait. Preparing operation.`
   appears on the display.

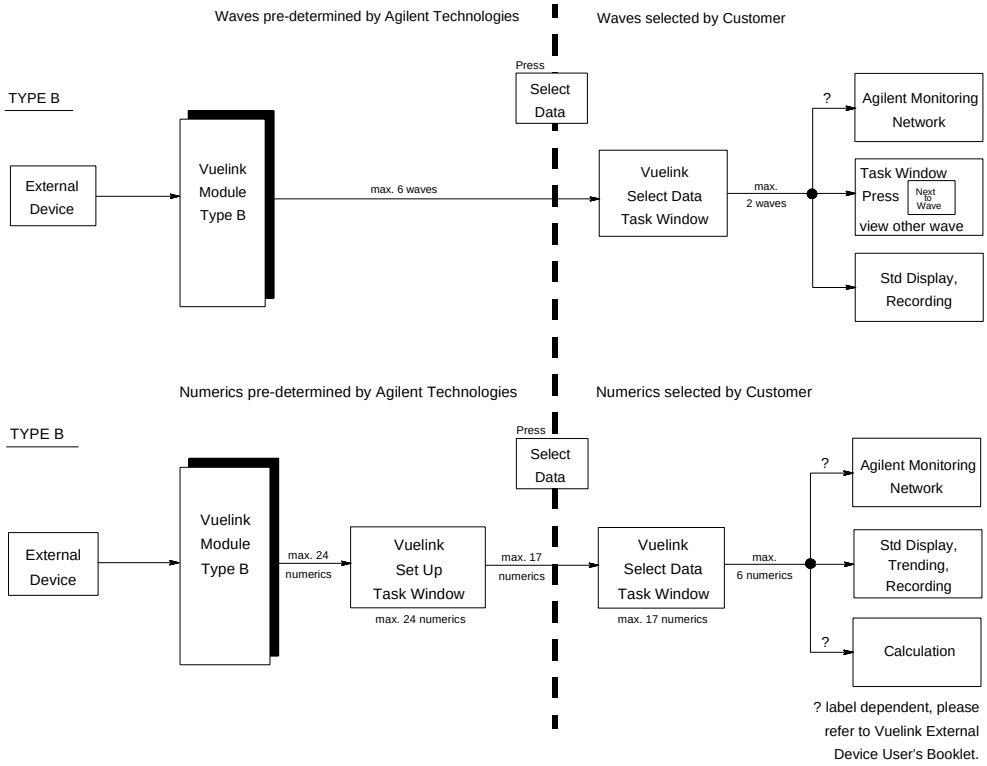
   When the selection is confirmed, the message
   `Switched to new device`
   is displayed. The asterisk denotes the current selection.

If you now want to make adjustments to the settings, or view device data, press **Setup VueLink** . If you want to return to the Main Screen, press **Main Screen** .

General Wave and Numeric Information

The number of waves and numerics available on the monitor depends on the type of module. The rules which apply to type A modules (Auxiliary Devices) and type B modules (Ventilator, Gas Analyzer, Anesthesia Machine and Auxiliary Plus) follow:

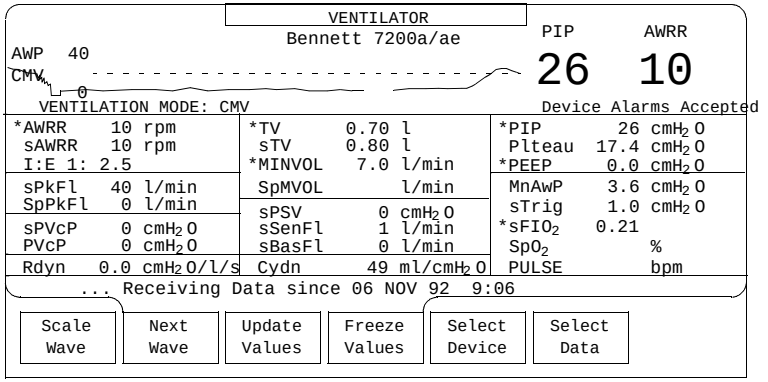



Waves pre-determined by Agilent Technologies
Waves selected by Customer
TYPE B
External Device
Vuelink Module Type B
max. 6 waves
Press
Select Data
Vuelink Select Data Task Window
max. 2 waves
?
Agilent Monitoring Network
Task Window
Press
Next to Wave
view other wave
Std Display, Recording
Numerics pre-determined by Agilent Technologies
Numerics selected by Customer
TYPE B
External Device
Vuelink Module Type B
max. 24 numerics
Vuelink Set Up Task Window
max. 24 numerics
max. 17 numerics
Press
Select Data
Vuelink Select Data Task Window
max. 17 numerics
max. 6 numerics
?
Agilent Monitoring Network
Std Display, Trending, Recording
?
Calculation
? label dependent, please refer to Vuelink External Device User's Booklet.

Viewing Waves and Numerics

VueLink

Setup Task Window



Procedure for Viewing Waves and Numerics

You are now in the Setup Task Window.

The upper part of the Setup Task Window contains the current device's name, the first wave (if any) of the device and any numerics associated with that wave.

The lower part of the Setup Task Window contains the most important numerical information received by the VueLink module. Selected numerics are indicated by an asterisk (*). (These numerics are then available for trending and displaying.) A status line below the numerics tells you the date and time that the VueLink module started to receive information from the external device.

- Press **Next Wave** to view the next available wave. (This key will only be present if more than one wave is available from the external device.)
- Press **Freeze Values** to hold the numerics frozen (the 2 sets of numerics aligned with the waveforms do not freeze). The numerics can then be updated again by pressing **Update Values** .

Notes—

- A message in the upper part of the Setup Task Window, to the right of the displayed wave, tells you how the alarms from the external device are being handled by your system. One of the following three messages is displayed:

`Device Alarms Ignored`	This message indicates that your system is configured to *ignore* alarms from the external device.
`Device Alarms Accepted`	This message indicates that your system is configured to *accept* alarms from the external device.
`No Alarms Available`	This message indicates that **either** the external device has its alarm capability switched off, **or** that the system cannot receive alarm signals from the external device at all.

The free analog device driver replaces the message; `Device Alarms Accepted` with one of the following alarm messages:

*Alarm Severity: ***RED*	This message indicates that your system is configured to activate a red alarm
*Alarm Severity: **YELLOW*	This message indicates that your system is configured to activate a yellow alarm.

The setting to *ignore* or *accept* external device alarms is made in a special *Configuration Mode*, either by your biomedical engineering department, or the Agilent service engineer. (See Chapter 3 "*Configuring the System*" for more details on Configuration Mode.)

- The softkey **Select Data** may not be present in the Setup Task Window, as the key is not used with certain external devices.

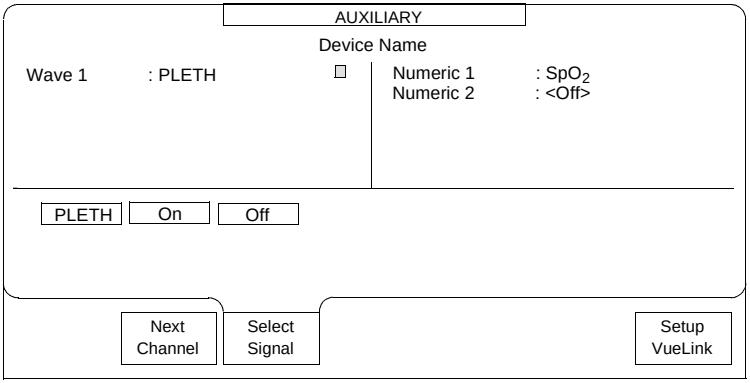
Caution

- If the alarm severity is configured to Yellow, a yellow alarm will be generated *only* if the Vuelink module has been plugged into an Agilent CMS Release G or later or an Agilent V24 or V26 Release A.0 or later.
- If a Vuelink module with this configuration is plugged into a Agilent CMS or Agilent V24 from a previous release (prior to Release G or A.0), a Red alarm will be generated, regardless of the alarm severity configuration.

Selecting Waves and Numerics

VueLink --> **Select Data**

Type A Select Data Task Window



Wave Selection

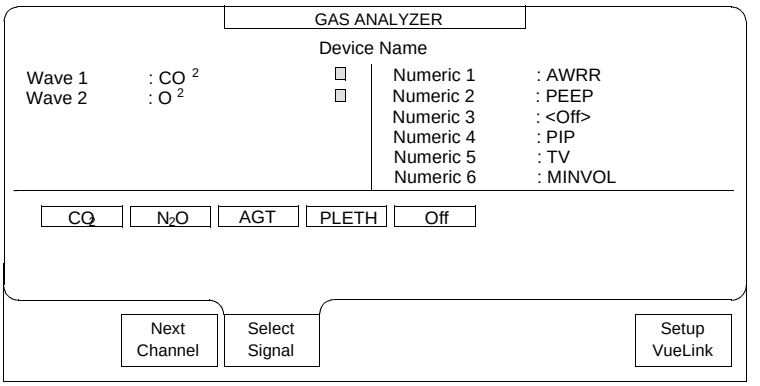
A maximum of 2 waves are available for selection in the Task Window. Up to 1 of these waves can then be **selected** for standard display and recording. The wave label determines whether it is also available on Agilent patient care system. Please refer to specific device specifications for more information.

Numeric Selection

A maximum of 10 numerics are available for selection in the Task Window. Up to 2 of these 10 numerics can then be **selected** (*) for standard display, trending and recording. The numeric label determines whether these are also available on Agilent patient care system. Please refer to specific device specifications for more information.

Note—The Agilent patient care system features for each numeric only apply if the numeric is **selected** for standard display, trending and recording. If the numeric is only visible in the Setup Task Window, it will **not** be available on Agilent patient care system.

Type B Select Data Task Window



Wave Selection

A maximum of 6 waves are available for selection in the Task Window. Up to 2 of these waves can then be **selected** (*) for standard display and recording. The wave label determines whether the waves are also available on Agilent patient care system. Please refer to specific device specifications for more information.

Numeric Selection

A maximum of 24 numerics are visible in the Setup Task Window. Up to 17 of these 24 numerics are **selectable** in the Select Data Task Window for standard display, trending and recording and up to 6 of these 17 numerics can be **selected** (*) simultaneously. The numeric label determines whether these numerics are also available on Agilent patient care system. Please refer to specific device specifications for more information.

Note—The Agilent patient care system and calculation features for each numeric only apply if the numeric is **selected** for standard display, trending and recording. If the numeric is only visible in the Setup Task Window, it will **not** be available on the Agilent patient care system or for calculation.

Procedure for Selecting Waves and Numerics

Note—The wave and numeric selections for certain external devices cannot be changed during monitoring. (The softkey **Select Data** is not present when these devices are connected to the VueLink module). The selections for these devices are pre-set in a special *Configuration*

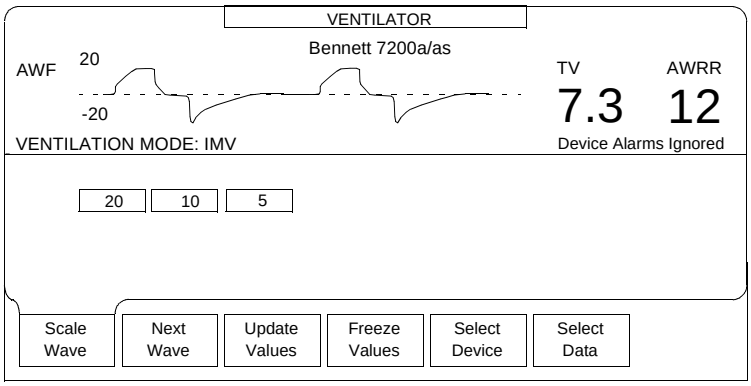
Mode by either your biomedical engineering department, or the Agilent service engineer.

1. The softkey **Next Channel** is highlighted. Move the highlighting to select a channel (wave or numeric).
2. Press **Select Signal** and then move the highlighting to the signal you want to place in your selected channel.
3. Press **Next Channel** to move on to the next channel you want to setup.
4. Repeat list item2 and list item 3 for each wave and numeric you want to change.
5. Press **Setup VueLink** if you want to return to the Setup Task Window. If you want to return to the Main Screen screen, press **Main Screen**.

Note—Changing the waves and numerics which are assigned to each channel will affect the setup of the main screen, trending and recorder.

Changing Wave Scale

VueLink --> **Scale Wave**



Procedure for Changing Wave Scale

- Three choices of wave scale are available for most waves. The exact scaling depends upon the wave selected. (For unscaled waves, the selection labels are **Gain X1**, **Gain X2**, and **Gain X4**).
- In some cases, for example if the zero line of the selected wave is not in the display range, the **Scale Wave** softkey is hollow, and the scale cannot be changed.

1. Move the highlighting to select a new scale.
2. Select another softkey if you want to make more adjustments, or press **Main Screen** to return to the main screen.

VueLink Module Alarm and INOP Reporting from the External Device

It is possible to interface alarms and INOPs sent from the External Device. You can configure your system at installation to either **ignore** or **accept** alarms and inops generated by the external devices connected to the VueLink module. No changes can be made to the alarm reporting condition during monitoring.

For information about alarms sent from external devices, refer to the user documentation of the relevant external device.

Alarms Ignored

If your system is configured to **ignore** external device alarms, no alarms and inops from the external devices will be displayed on the screen. This is indicated by the message “Device Alarms ignored'' or “No Alarms Available” in the Setup Task Window.

Alarms Accepted

If your system is configured to **accept** external device alarms, then **visual** alarm messages from the external devices can be displayed on the screen. **Audible alarms are not sounded on the bedside monitor**.

Notes on Alarms

- External device alarms are **always** non-latching on the monitor.
- If external device alarms refer to numerical values currently displayed on the screen, these numerics will blink as long as the alarm condition persists.
- Device specific alarms are transmitted over the Agilent patient care system to central stations. Audible and visual alarms **are** announced on the central stations.

Notes on Inops

- INOP messages are only announced for the signals that are **selected** on the monitor.
- For an external device INOP, the numerics on the monitor are replaced by the -?- numeric, and waves show a baseline.

- Devices with analog outputs such as the Nellcor N-100C may show a ““0'"” instead of the -?- numeric.
- Inops messages from the External Device are not accompanied by an audible alarm by the bedside monitor.

Alarm symbols

The following symbols precede certain parameter labels, to indicate the external device alarm *status* (whether the alarms are switched **on** or **off** at the external device):

This symbol indicates that your system is configured to accept external device alarms, **but** the alarms are switched **off** at the external device.

! This symbol indicates that the alarm status of this external parameter is **unknown**.

VueLink Module Alarm and INOP Reporting from the System

Alarms

The VueLink module itself does **not** generate any alarms.

INOP Messages

INOP messages appear when the monitor cannot process signals properly. This could be caused by connection or configuration problems with the external device or the VueLink module. If you have a problem with the VueLink module, you can use the INOP messages to solve the problem. INOP messages are accompanied by an audible alarm that can be silenced with the **Silence/Reset** key.

Certain status messages that appear at the top of the display can also be used to identify problems with the VueLink module. These messages are listed after the INOPs.

VueLink Module INOPs

INOP Message	Condition	Audible Indication
VueLnk-*X*[1] UN-PLUGGED	The VueLink module has been unplugged from the rack, or the whole rack has been disconnected. Silencing this INOP switches the parameter OFF.	INOP tone
VueLnk-*X*[1] EQU. MALF	Malfunction in the VueLink module. If this message appears repeatedly, the module must be replaced.	INOP tone
VueLnk-*X*[1] NO CONFIG	The VueLink module has not been configured during installation. The installation process should be completed by either your biomedical engineering department or the Agilent service engineer.	INOP tone
<VueLink option>[2] CHECK SETUP	No information was received from the external device. The device may be switched off or disconnected.	INOP tone

INOP Message	Condition	Audible Indication
<VueLink option>[2] CHECK CONFIG	The wrong external device has been selected on the VueLink module, or the external device has not been correctly setup, or the wrong cable has been used to connect the device to the VueLink module.	INOP tone
<VueLink option>[2] CHECK CABLE	No cable or the wrong cable connected to the VueLink module {silencing this INOP switches the parameter OFF}, or incorrect device selected.	INOP tone

[1] "X" indicates the module type (A or B).

[2]<VueLink option> can be one of: AUXn, VENT, GAS-AN, AN.MACH. or AUXPLUSn. Inop abbreviations may differ slightly depending on device category. Please refer to the External Device User's Booklet for exact inop message.

Status messages that indicate a problem with a plug-in module in a particular slot can appear at the top of the display. For example:
`Currently ignored module in rack position 1.8`
The slot is identified in the message using two numbers:

The first number indicates the rack, (1=integral rack, 2=first satellite rack,...).

The second number indicates the slot in that rack, (1=slot on left, 8=slot on right).

Therefore, in the example message above, the indicated module is plugged into the integral rack, in the slot on the extreme right.

If you see such a message on the display, and the module indicated is a VueLink module, refer to the following table for a possible cause and suggested action.

VueLink Module Status Messages

Message	Possible cause	Suggested Action
`Unrecognized module in rack position` *`R.P.`*	The module in the indicated slot is unknown to the system. This indicates a malfunction in the VueLink module.	Replace the VueLink module in the indicated slot.
`Too many modules of the same type connected. Currently ignored module in rack position` *`R.P.`*	Only a certain number of type A or type B VueLink modules can be plugged in at the same time. Refer to the start of this section for more details.	Remove VueLink modules from the system as necessary.

23
$S\bar{v}O_2$ Module Section
(Agilent CMS only)

In this section you will find information on the mixed venous oxygen ($S\bar{v}O_2$) measurements and setting up $S\bar{v}O_2$ monitoring. You will also find information on calibrating the $S\bar{v}O_2$ transducer in this section. It includes the following sections:

Introduction to the $S\bar{v}O_2$ Plug-in Module

What does the Module Measure?

The $S\bar{v}O_2$ module measures the percentage of mixed venous oxygen saturation continuously and invasively using a *fiber optic* catheter. The catheter usually combines the C.O. and $S\bar{v}O_2$ measurements . The $S\bar{v}O_2$ parameter label is always shown as Sv02 on the screen. The catheter is routed via the right side of the heart into the pulmonary artery.

How Does the SvO_2 Measurement Work?

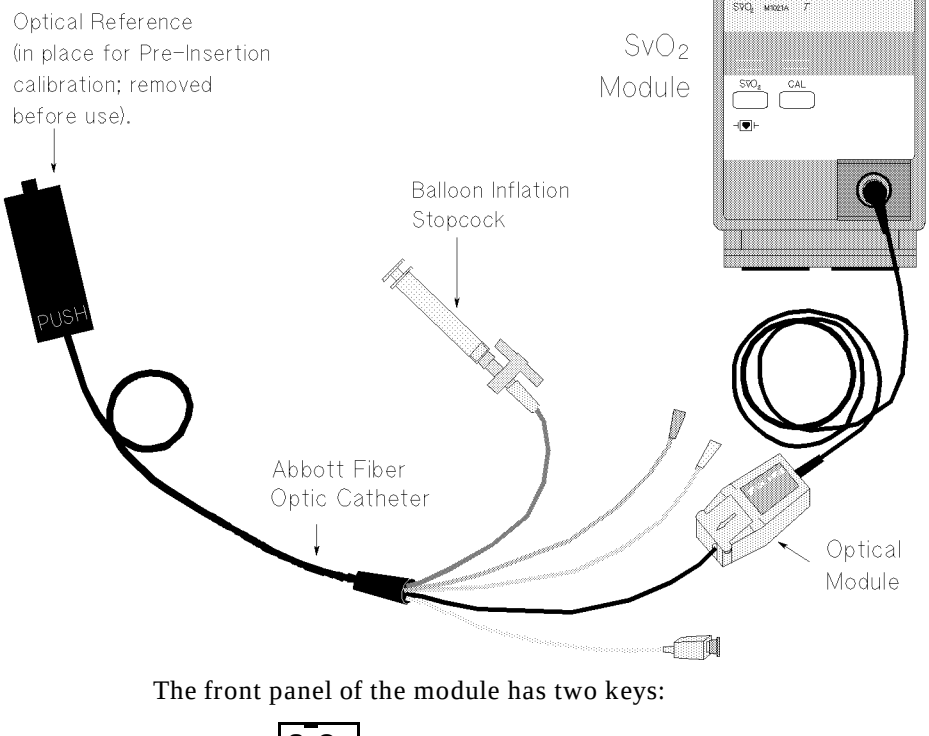
The measurement is based on the progressive change in the color of the blood, from scarlet to purple as oxygen saturation decreases. Light of different selected wavelengths illuminates the blood. The amount of light reflected is dependent on the blood's color, indicating the oxygen saturation.

An Optical Module generates light at 3 different wavelengths that shine down the fiber optic filament of the catheter into the blood. The light reflected in the blood is converted into an electrical signal by the Optical Module. The electrical signal is processed in the $S\bar{v}O_2$ Plug-in Module.

The following equipment, supplied by Agilent Technologies and Abbott Critical Care Systems, is required for the $S\bar{v}O_2$ measurement:

- Agilent CMS
- M1021A $S\bar{v}O_2$ module
- Abbott fiber optic catheter. (A complete list of all compatible fiber optic catheters can be found in "Accessories and Ordering" on page 23-16).
- Abbott 50131-04 Optical Module (Abbott recommend that a stability test of the Optical Module is carried out every month.

Please refer to the Abbott Operating Manual or Agilent Service Manual for further details).

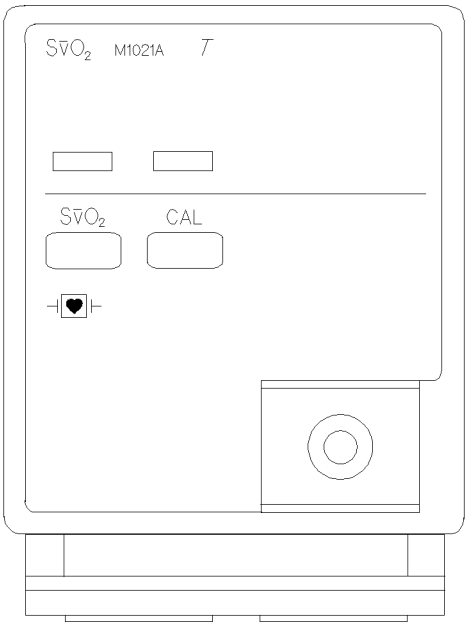


The front panel of the module has two keys:

The **SvO2** key for parameter setup. A light will appear above the key when you are in any of the $S\bar{v}O_2$ Task Windows.

The **CAL** key to enter the Calibration Task Window. A light will appear above the key when you are in the Calibration Task Window, or when a calibration procedure is running.

The $S\bar{v}O_2$ Module



$S\bar{v}O_2$ Main Task Window

To access the $S\bar{v}O_2$ Task Window, Press:

SvO2 Set-up key on the Plug-in Module

or

Module Setup → **SvO2**

The $S\bar{v}O_2$ Task Window displays:

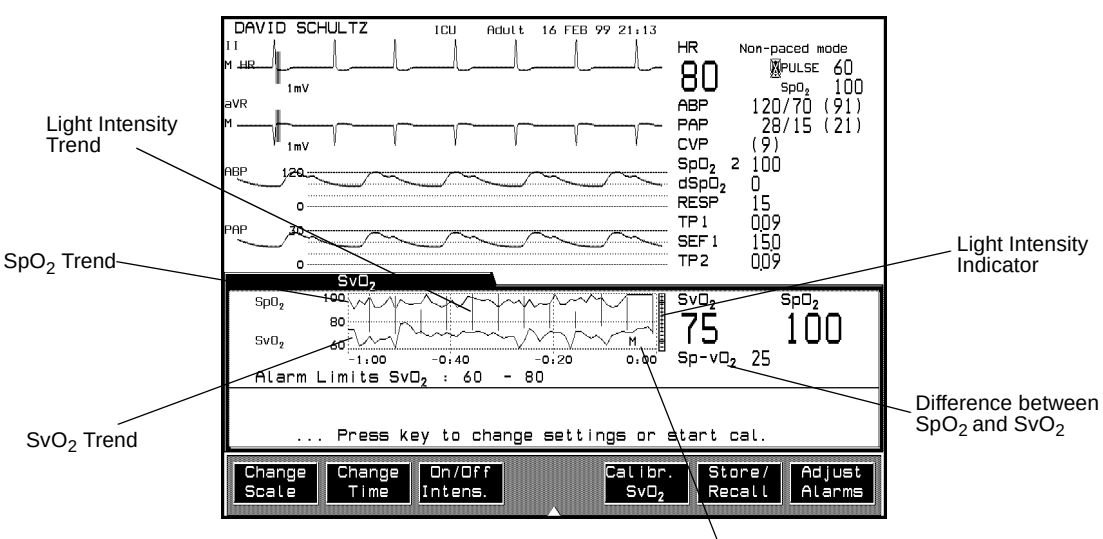
- $S\bar{v}O_2$ numeric (as a percentage)
- $S\bar{v}O_2$ graphical trend
- Light intensity trend (displayed as vertical bars)
- Annotations (indicating calibration or application conditions).
- Light Intensity Indicator

If SpO_2 is also being monitored by the Agilent CMS, the following SpO_2 information is automatically displayed:-

- SpO_2 numeric (as a percentage)
- SpO_2 graphical trend

- Difference between SpO_2 and $S\bar{v}O_2$ values

$S\bar{v}O_2$ Main Task Window



The following annotations can appear in the $S\bar{v}O_2$ Task Window:

R:	Calibration successful
F:	Calibration failed
I:	In-Vivo calibration started
L:	Light intensity calibration
M:	Merge file (Data has been recalled from the Optical Module)
P:	Pre-insertion calibration started
Q:	C.O. (Cardiac Output) measurement.

Setting up the SvO_2 Equipment for Use

The following procedures are required to set up the $S\bar{v}O_2$ equipment:

1. Preparation of the catheter
2. Pre-insertion calibration

3. Insertion of the catheter

- A light intensity calibration must be performed after proper positioning is achieved following catheter insertion, or if the existing readings are in doubt.
- An in-vivo calibration must be performed, if the catheter has been placed in a patient *without* performing a pre-insertion calibration.

For all procedures:

1. The Optical Module (Abbott 50131-04) must be connected to the $S\bar{v}O_2$ Module.

2. The $S\bar{v}O_2$ Module must be plugged into the Agilent CMS.

Note—The Optical Module (Abbott 50131-04) must be warmed-up prior to any calibration procedure. The "WARM UP"" message disappears from the screen after 1 minute. For best accuracy however, Abbott recommends that the Optical Module is warmed up for 15 minutes. Please refer to the instructions label on the Optical Module.

1. Preparation of the Catheter

Note—Please refer to the *Instructions for Use* on the catheter packaging.

Note—Don't use the catheter if the packaging is damaged.

1. Remove outer wrapping from catheter tray to uncover optical connector.

2. Place the Optical Module on the catheter tray in the space provided and open the lid.

3. Place the optical connector into the Optical Module (with **TOP** facing upwards) and close the lid.

The set up is now ready for pre-insertion calibration.

2. Pre-insertion Calibration

1. Please ensure that the tip of the catheter is still in the optical reference. Press the **CAL** key on the module, or the **Calibr SvO2** softkey in the main Setup Task Window to obtain the Calibration Task Window.

2. Press **Pre-Ins Calibr** followed by **Confirm**. (A "P'" is placed on the Event Line in the Task Window).

After approximately 1 minute the message
`... SvO2 cal. completed - cath. ready for insertion`
is displayed, (an "R" is placed on the Event Line) indicating that the catheter is *ready* for insertion.

Note—After the calibration has been completed, check the display regularly for the INOP message
`SvO2 CAL FAILED`
If this INOP appears, repeat the pre-insertion calibration before inserting the catheter.

3. Insertion of the Catheter

1. Remove the inner cover of the catheter tray.
2. Remove the catheter tip from the optical reference. Check the catheter's proper operation (for example: checking the balloon tip and thermistor).
3. Prepare and insert the catheter in accordance with standard hospital practice.

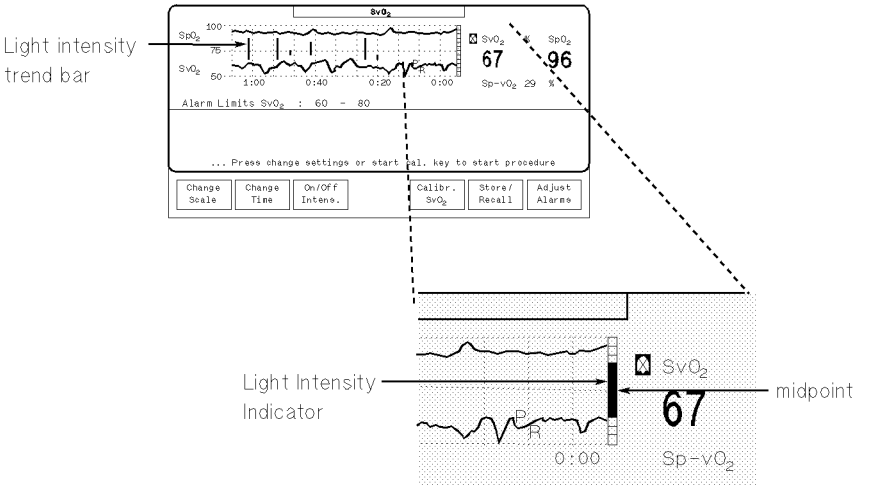
Note—If the catheter is placed in the patient without performing the pre-insertion calibration, an in-vivo calibration **must** be performed once the catheter is in place.

Light Intensity Calibration

When the catheter is positioned properly, the light intensity indicator displayed in the $S\bar{v}O_2$ Calibration Task Window must be at least 2 small divisions above the midpoint, as shown in the diagram below.

A light intensity calibration must be performed after proper positioning is achieved following catheter insertion, or if the existing readings are in doubt.

The light intensities recorded during the displayed time period are also shown on the screen in the form of light intensity trend bars. This information can be used for troubleshooting purposes.



From the $S\bar{v}O_2$ Calibration Task Window:

Press **Light Calibr** , then **Confirm**

Calibration is complete after a few seconds.

In-Vivo Calibration

An in-vivo calibration must be performed:

- If the catheter is placed in a patient *without* performing a pre-insertion calibration.
- If the SvO2 CAL FAILED INOP is displayed.
- When the catheter has been placed in the patient for 24 hours.

For the in-vivo calibration, ensure that the following conditions apply:

- Proper positioning of the catheter in the patient.
- Patient has a relatively stable oxygen saturation.
- The light intensity indicator displayed in the $S\bar{v}O_2$ Calibration Task Window is at least 2 small divisions above the midpoint.

1. Prepare to draw a blood sample from the patient.

2. From the $S\bar{v}O_2$ calibration Task Window, press **In-Vivo Calibr** followed by **Confirm**.
3. Draw off about 2ml and discard.
4. Draw a blood sample from the distal port of the catheter and flush the line according to standard hospital practice.
5. Obtain laboratory analysis of the sample using direct measurements.
6. Compare the results with the stored value displayed on the monitor in the $S\bar{v}O_2$ calibration Task Window.
7. If there is a difference of more than 4% between the stored value and the laboratory value, use **↓Change CalValue↑** to adjust the stored value.
8. Press **Accept CalValue** after making the adjustment. You can press **In-Vivo Calibr** to re-adjust the stored value.
9. Press **Confirm** to store the calibration data.

SUMMARY - Calibrating the $S\bar{v}O_2$ module

	Pre-Insertion	Light Intensity	In-Vivo
When to perform cal:	Prior to **all** insertions (if not possible, In-Vivo calibration **must** be conducted).	After proper positioning is achieved following catheter insertion, or if the existing readings are in doubt.	After insertion if no Pre-Ins Calibration *or* Disconnected from optical module *or* In place for 24 hours *or* Fiber optic cables damaged *or* Suspect readings

SUMMARY - Calibrating the $S\bar{v}O_2$ module

	Pre-Insertion	Light Intensity	In-Vivo
Before you start:	Connect the catheter to the Optical Module and ensure that the catheter tip is in the optical reference.	Position catheter so that light intensity indicator is at least 2 small divisions above the midpoint.	Be ready to start drawing blood sample within 12 seconds of *Confirming* the In-Vivo calibration.
Approximate duration:	1 minute	5 seconds	Time to obtain lab value
Indicator on event line:	P, then R or F	L, then R	I, then R
Calibration failure:	1. Check connections and ensure that the catheter tip is in the optical reference, then repeat: 2. Replace catheter and repeat: 3. Replace Optical Module and repeat	Reposition catheter, then repeat.	Adjust if difference of more than 4% from blood sample.

Data Storage and Recall in the Optical Module

When the $S\bar{v}O_2$ Plug-in Module is in use, up to the last 15 minutes of data can be stored and recalled from the Optical Module. This function allows you to transfer and reconnect a patient to another $S\bar{v}O_2$ Module or Abbott's Oximetrix 3 SO_2/CO Computer, without having to go through a complete set-up procedure.

The Optical Module can store the following:

- 15 minutes of $S\bar{v}O_2$ or SaO_2 readings from the Abbott Oximetrix 3 Monitor.
- Most recent average Cardiac Output
- Most recent calibration data.

Note—The Optical Module does not store the measurement label. Therefore, if the Optical Module was previously connected to Abbott's Oximetrix 3 Monitor, the System cannot determine if the stored data represents $S\bar{v}O_2$, or SaO_2.

Note—The Optical Module does not store the patient's name. For this reason, please ensure that the Optical Module is always moved with the patient, so that the data is not mixed with data from another patient. Stored data is not cleared if a patient is discharged from the monitor. Therefore, data from the previous patient may be stored in the Optical Module.

Data Storage and Recall can be initiated from the $S\bar{v}O_2$ Task Window by pressing **Store/Recall** to enter the Store/Recall Task Window, followed by **Store Data** → **Confirm** to store data.

To recall data, press **Recall Data**

Alarms and INOP Messages

The $S\bar{v}O_2$ alarm messages are rated in order of severity:

** Yellow

INOP message

Alarm tone = a single tone repeated every second
INOP tone = a single beep repeated every 2 seconds.

Physiological Alarms

Alarm Message	Condition	Visual Indication	Audible Indication
**SvO_2 90>80	$S\bar{v}O_2$ above high alarm limit	$S\bar{v}O_2$ numeric blinks. Yellow alarm lamp	Alarm tone
**SvO_2 50<60	$S\bar{v}O_2$ below low alarm limit	$S\bar{v}O_2$ numeric blinks. Yellow alarm lamp	Alarm tone

To avoid the occurence of false and INOP alarms during the pre-insertion calibration and insertion of the catheter into the patient, alarms are automatically suspended during the pre-insertion calibration and for up to 3 minutes after the catheter tip is removed from the optical reference.

After 3 minutes or after a light intensity calibration, the monitor automatically re-activates the alarm state prior to the pre-insertion calibration.

Technical Alarms

INOP messages appear when the monitor cannot measure or process signals properly. If the INOP message is accompanied by an audible alarm, it can be silenced with the **Silence/Reset** key.

The following table describes the INOP messages that can occur when using the $S\bar{v}O_2$ parameter.

INOP Messages

INOP Message	Condition	Visual Indication	Audible Indication
SvO_2 UN-PLUGGED	Parameter switched on and $S\bar{v}O_2$ module unplugged from the rack.	$S\bar{v}O_2$ numeric displays -?-.	INOP tone
SvO2 EQUIP MALF[a]	Malfunction in the $S\bar{v}O_2$ Module or Optical Module.	$S\bar{v}O_2$ numeric displays -?-.	INOP tone
SvO_2 CONFIGURATION	Computation Mode was set to SaO_2 using Abbott Monitor; requires return to $S\bar{v}O_2$ configuration.	$S\bar{v}O_2$ numeric displays -?-.	INOP tone
SvO_2 CONNCT OPTMOD	Optical Module disconnected during storage of data into the Optical Module.	$S\bar{v}O_2$ numeric displays -?-.	INOP tone
SvO_2 NO OPTMOD	No Optical Module connected.	$S\bar{v}O_2$ numeric displays -?-.	INOP tone
SvO_2 LOW LIGHT[b]	Optical signal levels too low.	$S\bar{v}O_2$ numeric displays -?- or numeric is displayed with ?	INOP tone with -?- display
SvO_2 UNABL TO MEAS[b]	Signal out of normal range, no $S\bar{v}O_2$ value can be obtained	$S\bar{v}O_2$ numeric displays -?-.	INOP tone
SvO_2 LIGHT INTENS[b]	Intensity changed considerably since last light intensity calibration	$S\bar{v}O_2$ numeric displays -?- or numeric is displayed with ?	INOP tone with -?- display

INOP Message	Condition	Visual Indication	Audible Indication
SvO_2 CAL RUNNING	Calibration running	$S\bar{v}O_2$ numeric displays -?- for pre-insertion calibration or valid display for in-vivo calibration.	None
SvO_2 CAL FAILED[b]	Calibration failure.	$S\bar{v}O_2$ numeric is displayed with ?	None
SvO_2 CAL REQUIRED	No valid calibration data	$S\bar{v}O_2$ numeric displays -?-	INOP tone
SvO_2 CAL MODE	Calibration complete but catheter still in optical reference block	$S\bar{v}O_2$ numeric displays -?-	None
SvO_2 WARM UP	Warm-up of optical module taking place	$S\bar{v}O_2$ numeric is displayed with ?	None
SvO_2 OPTMOD DEFECT[b]	Optical module memory defect (calibration and patient data cannot be stored for transport)	Numeric is displayed	None

a. Remove Optical Module and apply test signal (consult Agilent Representative or local Biomedical Engineering Department). If this INOP remains, replace the M1021A; if the INOP disappears, consult your local Abbott representative for information relating to the Abbott Optical Module.

b. Please refer to your Abbott Representative or documentation for information on use of the Abbott Optical Module and catheter.

Parameter Settings Transfer

The following settings can be transferred with the $S\bar{v}O_2$ module. For information on what the **optical** module stores, please refer to “Data Storage and Recall in the Optical Module” on page 23-11.

Setting Name	Meaning
Alarm limits	$S\bar{v}O_2$ high and low alarm limits
$S\bar{v}O_2$ Scale	Vertical scale for $S\bar{v}O_2$ trend
Time Scale	Time scale of $S\bar{v}O_2$ trend
Light intensity trend ON/OFF	Light intensity displayed in Task Window or not

For more information on Parameter Settings Transfer, refer to "Setting up your Monitor", Volume 1.

Accessories and Ordering

Abbott Fiber Optic Catheters

Abbott P7110-E
Abbott P7110-EH
Abbott P7110-EP-H
Abbott P7110-EP8
Abbott P7110-EP8-H
Abbott P7110-PZ8-H
Abbott P575-EH
Abbott P575-EH10CM

Optical Module

Abbott P50131-04

Please contact your local Abbott Representative, if you wish to order Abbott accessories. **They are not available from Agilent Technologies**.

Performance Specifications

For safety and environmental specifications, please refer to the *Installation and Patient Safety* chapter (Volume 1).

$\bar{S}vO_2$ Performance Specifications

Measurement

Measurement Range:	10 to 100%
Accuracy:	± 2% O_2 saturation, 1 standard deviation over 40% to 100% range (electronically validated)
Stability (System):	Drift < 2% O_2 saturation over 24 hours
Response Time:	5 seconds (10% to 90%)
Display Update:	2 seconds nominal.

Alarms

High Range:	11 to 100%
Low Range:	10 to 99%
INOP Alarms:	Refer to Patient and Equipment related INOP tables.

Care and Cleaning

Cleaning

Routine Cleaning of The 50131-04 Optical Module

The Abbott 50131-04 Optical Module has been designed to be as maintenance-free as possible.

- Always handle the Optical Module with care.
- Only use the cleaning materials listed on the Optical Module.
- Don't sterilize the Optical Module.

Care

Routine Care

The $S\bar{v}O_2$ catheter is thin and flexible, and must be treated with care. Avoid kinking, bending or grasping the catheter with forceps or a hemostat.

Damage to the fiber results in:

- low intensity light
- sudden decrease in intensity readings.

Note—Refer to the documentation provided with the fibre-optic catheter, paying special attention to the **PRECAUTIONS** section for detailed care and cleaning instructions.

Storage

Only use the sterile catheter once, then dispose it. Carefully follow the instructions on the catheter packaging before usage.

24
$tcpO_2$/$tcpCO_2$ Module Section

This chapter provides information on transcutaneous monitoring of oxygen ($tcpO_2$) and of carbon dioxide ($tcpCO_2$). It also provides information on preparing the transducer for use, and applying the transducer to the patient. This chapter includes the following sections:

Introduction to the $tcpO_2$/$tcpCO_2$ Parameter Module

What does it Measure?

The $tcpO_2$/$tcpCO_2$ module measures the partial pressure of the oxygen and carbon dioxide that diffuses *transcutaneously* (through the skin). The oxygen measurement is valid for an infant patient who is not under gas anesthesia. These partial pressures provide a measure of the oxygen and carbon dioxide levels in the blood.

How the $tcpO_2$/ $tcpCO_2$ Measurement Works

The $tcpO_2$/$tcpCO_2$ transducer heats the skin. This has the effect of increasing local blood perfusion so that oxygen and carbon dioxide can diffuse to the skin surface more easily.

The transducer contains an electrolyte solution which is held in place by two gas-permeable membranes. The oxygen and carbon dioxide that diffuses out of the skin passes through these membranes into the electrolyte solution where electrochemical reactions take place. These reactions generate electrical signals which are representative of the amounts of oxygen and carbon dioxide present. The electrical signals are measured by the module to enable the $tcpO_2$/$tcpCO_2$ values to be displayed as numerics on the standard display.

Correlation of Transcutaneous with Arterial Blood Gas Values

Transcutaneous measurements are not capable of replacing arterial blood gas monitoring. However, transcutaneous monitoring can be used to reduce the frequency of arterial sampling.

Transcutaneous values are representative of the carbon dioxide and oxygen levels in the blood. The values at tissue level will **not** be the same as those measured arterially because of the transcutaneous nature of the measurement. However, provided that the transducer is properly handled by following the procedures described in this chapter, the transcutaneous values will *correlate with* (track closely) the arterial values. For example, a drop in transcutaneous values will usually indicate that arterial values have dropped as well.

Note that transcutaneous values will not always correlate with blood samples taken from the capillary blood of the heel (*heelsticks* or *astrups*).

For information on “Correlation of transcutaneous with arterial blood gas values”, see references 5, 6 and 7 in Appendix on Analog Output)

Setting up the Module

The optimum application period for the transducer at one site on a patient is dependent on the transducer temperature and on the sensitivity of the patient's skin. Before calibrating the transducer, (see the section *Calibrating the tcpO2/tcpCO2 Transducer* in this chapter) you should adjust the transducer temperature and also set the Site Timer.

Warning

Transducer Temperature

The temperature should be selected according to the patient’s age, weight and physical condition.

Available temperatures for the transducer are 37.0°C, 41.0°C, 41.5°C, 42.0°C, 42.5°C, 43.0°C, 43.5°C, 44.0°C, 44.5°C and 45.0°C. Usually, a higher transducer temperature results in both a better correlation and also a shorter time delay between a change in arterial blood gas and its detection by the transducer. However higher temperatures also increase the risk of skin burns. A temperature between 42° and 44°C is preferred by most physicians.

Note—The $tcpO_2$ / $tcpCO_2$ module is equipped with a temperature limiter which prevents the sensor temperature from exceeding 46ºC. If the temperature limiter fails, the following INOP message is displayed on the monitor:

- tc EQUIP MALF.

Site Timer

The Site Timer helps you to guard against the risk of skin burn by ensuring that the transducer is used at one site for no longer than a predefined period. The transducer can be set to operate for any of the following time periods: 0.5, 1, 1.5, 2, 2.5, 3, 4, 5, 6, 7 or 8 hours. The selection is visible in the task window next to “`Site Time##,` and the time remaining before the Site Timer expires appears next to “`Time Left:`”.

Site time settings should be adapted to the patient's skin sensitivity.

After the selected period of time has expired, an INOP message "tcCHANGE SITE" is displayed and the INOP tone is sounded. The Monitor can be configured either to switch off the transducer heating when the Site Time has expired, or to continue monitoring. This should be set as required by your hospital's policy, either by your biomedical engineering department or by the Agilent Service Engineer.

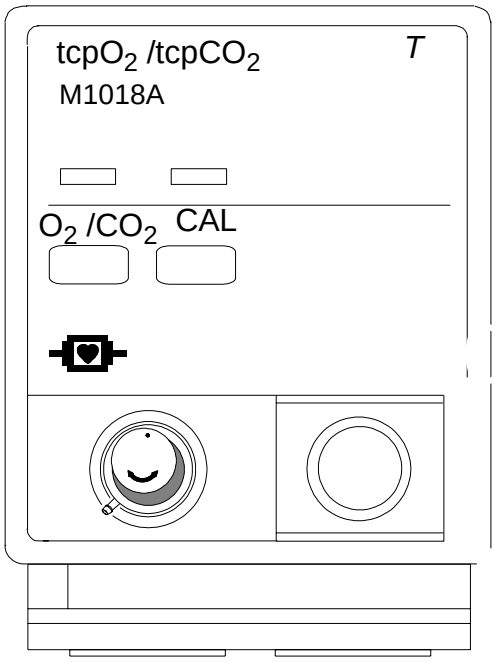
If the choice **Off** is available along with the above site times, you can choose to disable the Site Timer so that no "CHANGE SITE" reminder is displayed and the transducer monitors (and heats) indefinitely. Availability of this choice will depend on your hospital's policy and can be set by your biomedical engineering department or the Agilent Service Engineer.

Correction for $tcpCO_2$ Values

Transcutaneous pCO_2 values tend to be higher than arterial values (due to the metabolic processes of the skin and the effect of heating on the blood under the transducer). This effect can be compensated for by selecting the *Severinghaus* correction in a special *Configuration Mode* on the monitor. (This has been selected if "corr." appears under the value for $tcpCO_2$ in the Task Window - consult your biomedical engineering department or the Agilent Service Engineer if you wish to add or remove this correction.)

- The front of the module has two keys:
  - The **O2/CO2** key for parameter setup. A light will appear above the key when you are in setup.

– The CAL key to start calibration procedures.



The $tcpO_2$/$tcpCO_2$ Module

Note—The “T” on the front of the module indicates that this module transfers parameter settings from one monitor to another.

Activating the Transducer

Follow the 24 hour activation procedure if:

- the electrolyte in your transducer has dried out (this occurs when the transducer has been out of use for a long period),
- or you are about to use a new transducer (new transducers are shipped dry).

Activate by following the *Remembraning the Transducer* procedure, then leave the transducer in a safe place for 24 hours, unplugged from the module and with the cap on. Remembrane the transducer again just before carrying out the calibration procedure.

Preparing the transducer

There are three steps to preparing a transducer for application to a patient.

First, remembrane the transducer.

Then, calibrate the transducer (first checking the module settings - Site Time, Transducer Temp and Alarm Limits).

Finally, prepare a site and apply the transducer to your patient.

The procedure for carrying out these steps is described in the following three sections. Each section gives guidelines on **when** you should carry out each step. Follow the procedures carefully to ensure best results.

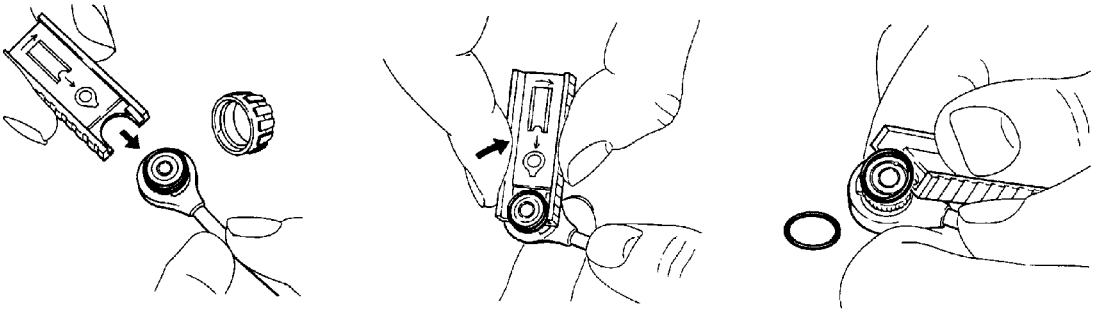
1. Remembrane the $tcpO_2$/ $tcpCO_2$ Transducer

With normal use, the membranes will last approximately 1 week before a change is required. Change the membrane on the transducer if:

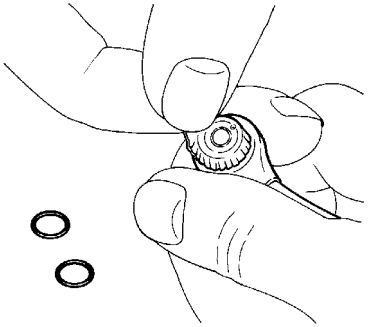
- you are about to use a new transducer,
- the transducer is to be used with a new patient,
- the membranes of the transducer are damaged (scratched or wrinkled),
- the transducer has been used for 5 days continuously,
- the transducer has been in storage for up to 28 days,
- you have a transducer which must be remembraned after activating for 24 hours (see previous page, *Activating the Transducer*), or
- calibration has failed **twice**.

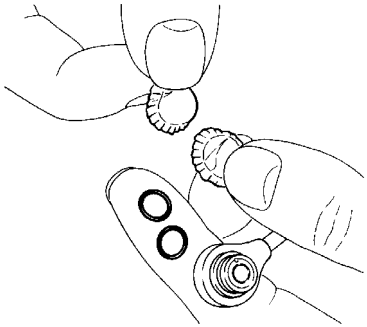
1. Check that you have the Agilent tc Accessory Kit containing an O-ring remover, absorbent paper, electrolyte solution and membrane replacers.

2. Unscrew the protection cap from the transducer, then hook the *O-ring remover* under both O-rings to remove them.

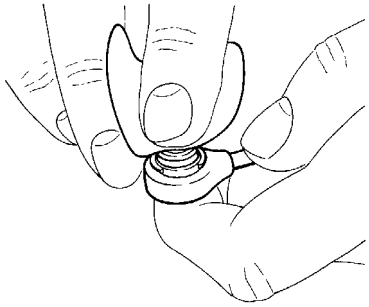


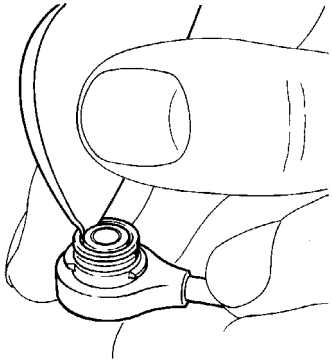
3. Remove **both** of the clear plastic membranes using your fingers.





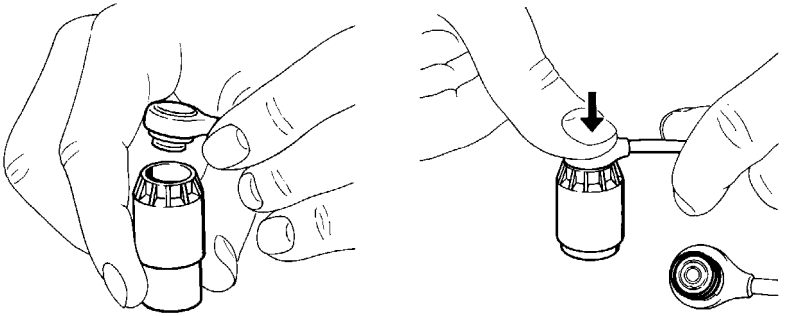
4. Clean the transducer head with *absorbent paper*. Make sure you clean the groove in the head and also the rim around the head to remove any old electrolyte - all of the old electrolyte must be removed to ensure a successful calibration and reliable measurements.





5. Apply *electrolyte solution* to the transducer head (approximately two drops). Break any air bubbles in the electrolyte using the nozzle of the solution container.

6. Press the transducer head downwards into an unused *membrane replacer* until the replacer retracts as far as it can and a *click* is heard. Discard the used replacer.



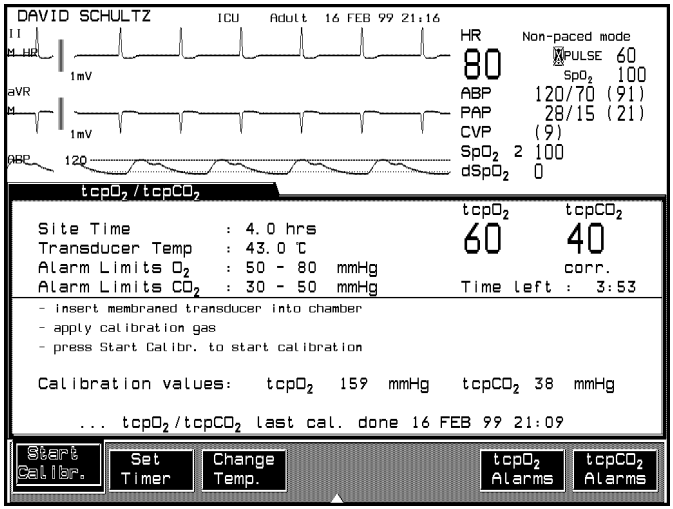
7. Remove any surplus electrolyte solution on the outside of the membranes with a soft tissue.

8. Examine the transducer carefully to ensure that the new membranes are secured by two O-rings on the transducer. If any air bubbles are visible under the membranes, repeat this procedure - air bubbles will cause incorrect readings.

Provided that you do not need to activate the transducer for 24 hours (see the section *Activating the Transducer* on page 20-7), the transducer is now ready to be calibrated and can be placed in the calibration chamber on the front of the module - see the next section.

2. Calibrating the $tcpO_2$/ $tcpCO_2$ System

Module Setup --> **tcpO2/tcpCO2**



Calibration of your $tcpO_2$/$tcpCO_2$ system is **required** if:

- you have just fitted a new membrane,
- you have just changed the transducer operating temperature, or,
- the INOP message tc CAL REQUIRD appears on the screen.

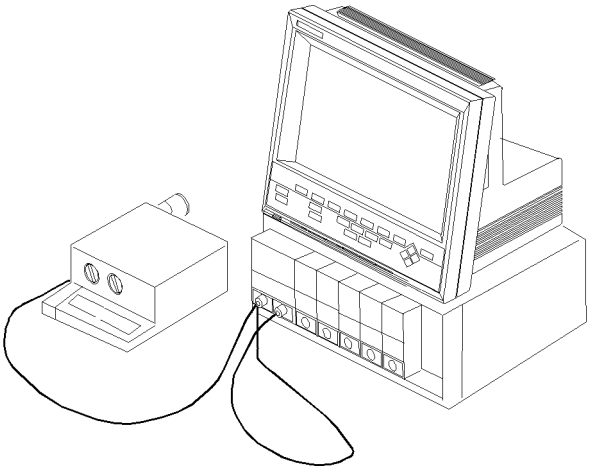
Note—To maintain accuracy, the $tcpO_2$ /$tcpCO_2$ transducer should be calibrated regularly, even if the Agilent CMS, V24 or V26 monitor does not prompt you to do so.

Calibration of your $tcpO_2$/$tcpCO_2$ system is **recommended** if:

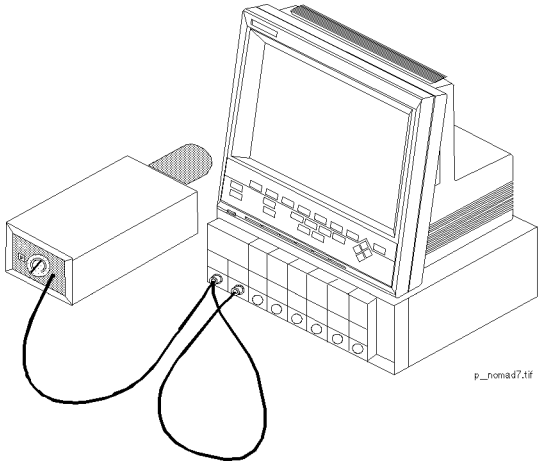
- the accuracy of the measurement is in doubt,
- you are about to start a new monitoring period, or
- you are about to change the measurement site, or
- at least six hours have elapsed since the last calibration

1. Check that you have a tcpO2/tcpCO2 module (inserted at the extreme left position in the rack for best accessibility) and an Agilent Calibration Unit (15210B). The Calibration Unit must have a gas cylinder inserted in the rear and a pressure indicator reading that is above the out-of-gas zone (*black* on 15210B and *red* on Radiometer TCC3 Calibration Unit).

2. Check that the transducer is plugged into the module and that the transducer is inserted into the calibration chamber on the front of the module (swing the flap back and insert the transducer, then swing the flap over the transducer).



Agilent V24 Monitor with 15210B Calibration Unit



Agilent V24 Monitor with Radiometer TCC3 Calibration Unit

3. Press **Module Setup**, followed by **tcpO2/tcpCO2** to bring up the $tcpO_2/tcpCO_2$ Setup Task Window. (You can also reach this screen by pressing **O2/CO2** on the front of the module.)

4. Check the module settings as displayed on the screen - Transducer Temp., Site Time and Alarm Limits. You can change any of these values by pressing the appropriate softkeys (see the Agilent CMS, V24 or V26).

5. Fit the gas tubing from the Calibration Unit into the inlet on the side of the calibration chamber (the other end of the tubing must be fitted into the Calibration Unit).

6. If you are using an 15210B Calibration Unit, turn the timer control dial on the Calibration Unit clockwise as far as you can and press **Start Calibr.** on the Monitor. If you are using a Radiometer TCC3 Calibration Unit, press the button with the green arrow on the front of the calibration unit once, then press **Start Calibr.** on the monitor.(You can also start the calibration by pressing the CAL key on the front of the module until the light above the key comes on

and a tone sounds. In addition, a calibration can be **restarted** by pressing **Start Calibr.** .)

7. Wait for "...$tcpO_2$/$tcpCO_2$ calibration running" to be replaced by "...$tcpO_2$/$tcpCO_2$ calibration complete" in the task window (the calibration process generally takes 3 to 10 minutes but may take up to 20 minutes). For 15210B Calibration Units: If the timer control dial has not reached the start position when "...$tcpO_2$/ $tcpCO_2$ calibration complete" is displayed, you can save gas by turning the dial counter-clockwise to the start position. For Radiometer TCC3 Calibration Units: If the green light on the front of the Calibration Unit is still flashing when "...$tcpO_2$/$tcpCO_2$ calibration complete" is displayed, you can save gas by pressing the button with the green arrow again.

When calibration is complete, the transducer is ready to be applied to a patient - see the next section. The Site Timer will start when you remove the transducer from the calibration chamber.

Apply the transducer to your patient as soon as possible after the "...calibration complete" message appears on the screen. If you wait longer than 30 minutes, the heat supply to the transducer is automatically switched off in order to prevent the electrolyte from drying out. This means that a new calibration will be required.

Trouble-shooting-Calibration Failure

If the calibration is unsuccessful, the message "...tcpO_2/tcpCO_2 transducer or Cal Unit malf" is displayed in the task window. In addition, the CAL FAILED INOP message for tc, tcpO_2 or tcpCO_2 appears in the upper left corner of the screen. Perform each of the following steps in the order specified until calibration is successful:

1. Check the Calibration Unit, then recalibrate, remembering to turn on the gas supply on the Calibration Unit. (If the pressure indicator reading is in the out of gas zone, there is insufficient gas in the cylinder. The gas tubing must be firmly connected to the Calibration Unit and to the calibration chamber on the module.)

2. If Step 1 is unsuccessful, check whether you need to **activate** the transducer (necessary if the electrolyte has dried out or if you have a new transducer, see page 24-6). Then remembrane the transducer ensuring that you:

   a. remove the old membranes, and
   b. clean the transducer head thoroughly.

   Then calibrate a second time.

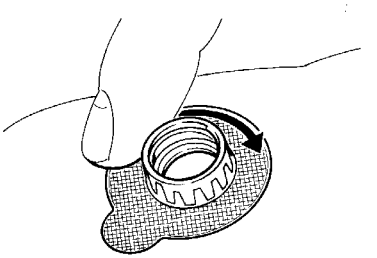
3. If Step 2 is unsuccessful, calibrate again. (A second calibration may be required in order to *stabilize* the electrochemical system in the transducer.)

4. Only if the above steps are unsuccessful (you have activated and remembraned the transducer and calibration has still failed twice), replace the transducer.

3. Applying the Transducer to the Patient

To apply the transducer to your patient, use the following procedure:

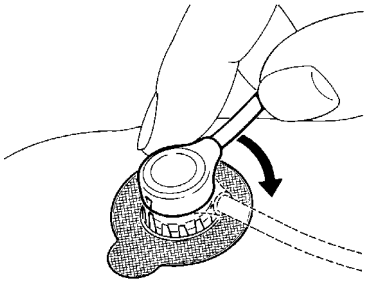
1. Check that you have the Agilent Fixation Kit containing a box of fixation rings and contact fluid.
2. Select a measuring site and clean the skin with alcohol solution. (To optimize the measurement, select a site with high capillary density and blood flow, thin epidermis and no cardiovascular disorders. Most physicians use the abdomen, chest and back.)
3. Take a *fixation ring* from the box and peel off the protection film to reveal the sticky surface.
4. Apply the fixation ring to clean and dry skin by pressing the ring onto the site with a finger, first in the center and then around the outside to ensure a good seal. (A good seal between the fixation ring and the skin is essential for good results.)



5. Place 3 to 5 drops of *contact fluid* in the center of the ring.

6. Remove the transducer from the chamber (the Site Timer on the screen will start) and align the arrow on the transducer either with or opposite the tab on the ring.

7. Turn the transducer a quarter-turn clockwise to fasten it to the ring.



8. Wait 10 to 20 minutes for readings to stabilize. (The $tcpO_2$ and $tcpCO_2$ numerics are displayed on the standard display.)

Restarting the Site Timer

- The Site Timer is automatically restarted after the transducer has been calibrated and removed from the calibration chamber (calibration is recommended whenever the site is changed).
- You can restart the Site Timer up to 2 hours after the time period has expired. (After this 2 hour period a calibration is required.) Press **Site Timer** to enter the Site Timer task window. *Confirm* your required time.

When changing the application site after a measuring period, some users leave the fixation rings in position. This allows the transducer to be quickly moved from site to site.

Note— During the initial 3 minutes of use, $tcpO_2$/$tcpCO_2$ alarms are suspended to eliminate false alarms. During this period, the "STABILIZING" INOP message is displayed for tc, $tcpO_2$ or $tcpCO_2$. After the transducer has been attached to the skin, the instrument reading will slowly assume a steady value. The reading will stabilize as soon as the measurement site is warmed up and local hyperemization is completed; usually 10 to 20 minutes for the $tcpO_2$ reading and 3 to 7 minutes for $tcpCO_2$.

The $tcpO_2$/$tcpCO_2$ Setup Task Window indicates the amount of remaining time before the Site Timer expires. At the end of the site time the INOP message "CHANGE SITE" is displayed and the INOP tone is sounded. The Monitor will switch off the transducer heating **or** will continue monitoring, depending on how the Monitor has been configured.

Warning

- **Prolonged continuous monitoring may increase the risk of undesirable changes in skin characteristics, such as irritation, reddening, blistering or burns. If the Site Timer is Off (disabled) or automatic heating switch-off has been disabled, the transducer will heat indefinitely while on a patient. Ensure that the site is changed in accordance with standard medical procedures in your hospital.**
- **Always unscrew the transducer from the fixation ring before removing the fixation ring from the skin.**

- **When defibrillating a patient, it is important to either:**
  - **remove the transducer before defibrillating, or**
  - **remembrane and calibrate the transducer after defibrillating**

Caution

All specified transducers (but not membranes) are protected against the effects of the discharge of a defibrillator.

$tcpO_2$/$tcpCO_2$ Alarms and INOP Messages

The $tcpO_2$/$tcpCO_2$ alarm messages are rated in order of severity:

** Yellow
INOP message

Alarm tone = a single tone repeated every second
INOP tone = a single beep repeated every 2 seconds.

Physiological Alarms

Alarm Message	Condition	Visual Indication	Audible Indication
`tcpO2 90>80`	$tcpO_2$ above high alarm limit	$tcpO_2$ numeric blinks. Yellow alarm lamp.	Alarm tone
`tcpO2 40<50`	$tcpO_2$ below low alarm limit	$tcpO_2$ numeric blinks. Yellow alarm lamp.	Alarm tone
`tcpCO2 60>50`	$tcpCO_2$ above high alarm limit	$tcpCO_2$ numeric blinks. Yellow alarm lamp.	Alarm tone
`tcpCO2 20<30`	$tcpCO_2$ below low alarm limit	$tcpCO_2$ numeric blinks. Yellow alarm lamp.	Alarm tone

Technical Alarms

INOP messages appear when the monitor cannot measure or process signals properly or when the measuring site is to be changed. For transcutaneous gas measurements all INOP messages except CHANGE SITE and CHECK TIME relate to equipment-related problems but you must check the patient's condition first. If the INOP message is accompanied by an audible alarm, it can be silenced with the **Silence/Reset** key.

INOP Messages

INOP Message	Condition	Visual Indication	Audible Indication
tc UN-PLUGGED	Parameter switched on and unplugged from rack. Silencing the alarm switches the parameter off.	$tcpO_2$/$tcpCO_2$ numerics display -?-.	INOP tone
tc EQUIP MALF	Malfunction in the transducer or module.	$tcpO_2$/$tcpCO_2$ numerics display -?-. Prompt message appears in task window.	INOP tone
tc NO TRANSDUC	No transducer is connected to the $tcpO_2$/$tcpCO_2$ module. Silencing the alarm switches the parameter off.	$tcpO_2$/$tcpCO_2$ numerics display -?-.	INOP tone
tc CHANGE SITE	Site Timer has timed out	$tcpO_2$/$tcpCO_2$ numerics may display -?- depending on configuration. Prompt message appears in task window.	INOP tone

INOP Message	Condition	Visual Indication	Audible Indication
tc CAL FAILED[1]	Calibration failed due to out of range or unstable signal during calibration.	$tcpO_2$/$tcpCO_2$ numerics display -?-. Prompt message appears in task window.	INOP tone
tc CAL REQUIRD	Calibration is required before applying the transducer to the patient[2]	$tcpO_2$/$tcpCO_2$ numerics display -?-. Prompt message appears in task window.	INOP tone
tc CAL RUNNING	The $tcpO_2$/$tcpCO_2$ calibration is running.	Numerics display -?-. Prompt message appears in task window.	None
tc STABILIZING	The transducer has not yet reached the selected temperature and/or skin hyperemization is not yet complete.	$tcpO_2$/$tcpCO_2$ numeric is displayed with ? to indicate that values are unstable.	None
tc CHECK TIME	Site Timer due to time out (15 minutes or less)	None	None

[1]See “Troubleshooting - Calibration Failure” earlier in this chapter or the Agilent CMS, V24 or V26 User’s Guide.

[2]Possible module or transducer malfunction if calibration in progress.

Parameter Settings Transfer

The following parameter settings can be transferred with $tcpO_2$/$tcpCO_2$ modules. For more information on Parameter Settings Transfer, refer to "*Parameter Settings Transfer*," Chapter 3.

Setting Name	Meaning
Alarm limits	$tcpO_2$ and $tcpCO_2$ high and low alarm limits
Site Time setting	Period transducer will be active at one site
Transducer temperature	Temperature to which transducer is heated

Recalibration of the $tcpO_2$/$tcpCO_2$ system is required if the module has been transferred.

Accessories and Ordering

Agilent Part No.	Equipment
15209-60010	tc Accessory Kit (O-ring remover, absorbent paper, electrolyte solution, replacement membrane)
15209-60020	tc Application Kit (4x25 disposable fixation rings, 4x20ml contact fluid)
15210-60010	Calibration Gas - 6 gas bottles
15210-64010	Calibration Gas - 6 gas bottles (Europe and Japan only)
M2205A	Replacement tubing (5 tubes)
M1918A	$tcpO_2/CO_2$ transducer
15210B	Agilent Calibration Unit.
n/a	Radiometer TCC3 Calibration Unit

Performance Specifications

For safety and environmental specifications, please refer to the *Monitor Installation and Patient Safety* Chapter 10.

$tcpO_2$ and $tcpCO_2$

$tcpO_2$ Measurement

Measurement Range:	0 to 750 mmHg (0 to 100 kPa)
Accuracy:	0 to 200 mmHg $\pm$ 2 mmHg 0 to 26.6 kPa $\pm$ 0.3 kPa
Test Signal:	60 mmHg (8.0 kPa).

$tcpCO_2$ Measurement

Measurement Range:	5 to 200 mmHg (0.7 to 26.0 kPa)
Accuracy:	5 to 100 mmHg $\pm$ 2 mmHg 0.7 to 13.3 kPa $\pm$ 0.3 kPa
Test Signal:	40 mmHg (5.3 kPa).

Alarms

$tcpO_2$ Range:	10 to 300 mmHg (1.0 to 40 kPa)
$tcpCO_2$ Range:	10 to 150 mmHg (1.0 to 20 kPa)
INOP Alarms:	Refer to Patient and Equipment related INOP tables.

Miscellaneous

Site Timer:	0.5, 1, 1.5, 2, 2.5, 3, 4, 5, 6, 7, or 8 hours (configurable: disabled). Change Site alarm when site time is expired and configurable automatic heating switch-off.
Transducer Heating:	*Available Temperatures* - 37.0°C, 41.0 to 45°C in steps of 0.5°C *Accuracy* - 0.1°C (excluding transducer) *Power Range* - 0 to 600 mW $\pm$ 10%
Correction Factor:	Automatic Siggaard-Andersen (Severinghaus) correction factor to compensate for the effect of transducer heating on $tcpCO_2$ values (configurable).

Care and Cleaning

Cleaning

Routine Cleaning

The transducer has been designed to be as maintenance-free as possible. Always handle the transducer with care and ensure that it is exposed only to the recommended materials.

When you are remembraning the transducer, simply wipe the transducer head gently with the supplied absorbent paper and then immediately apply the electrolyte solution and membranes.

Caution

- **Only use the recommended cleaning materials.**
- **Do not polish the transducer head.**
- **Do not wash the transducer head with water, alcohol or other liquids.**
- **Do not touch the transducer head surface.**
- **Do not immerse the plug.**
- **Do not autoclave the transducer.**
- **Do not heat sterilize (the transducer will not tolerate temperatures in excess of 70°C/158°F).**
- **Always pull the plug and not the cable when disconnecting the transducer from the module.**

The membrane should not require cleaning but, if necessary, it may be gently wiped with a soft cloth moistened with water. The remaining plastic-covered part of the transducer and the cable can be cleaned with a soft cloth moistened with ordinary alcohol or propylalcohol. Always clean with the protective cap screwed onto the transducer to avoid getting cleaning solution on the membranes.

Disinfection

Immerse the transducer and the cable in a 2 to 3% aqueous solution of active dialdehydes, for example Cidex®

Care

Routine Care

Refer to the *Care and Cleaning* section in Maintenance Chapter of this manual for regular maintenance information.

The $tcpO_2$/$tcpCO_2$ transducer cable is thin and flexible, and must be treated with care. Avoid kinking, bending or pulling the cable.

Storage

When not in use, insert the transducer into the calibration chamber on the front of the module.

When not in use **for more than a day**, disconnect the transducer cable from the module and protect the transducer from damage by screwing on the cap filled with a small amount of electrolyte solution. The screw cap helps prevent the transducer drying out. Remembrane the transducer before use.

When the transducer is not in use **for more than 2 weeks or is to be shipped** store the transducer dry - remove both membranes and clean the transducer head using the absorbent paper. Then screw the cap on with no electrolyte (dry storage slows down the aging of the transducer). Remember to **activate** the transducer 24 hours before use.

Disposal of Empty Calibration Gas Cylinders

1. Empty the cylinder completely by pushing in the pin of the regulator valve or by pulling out the pin of the fill wave using a tire valve stem wrench or a pair of needle nose pliers.
2. Once the cylinder is empty, either remove the valve step from the fill or regulator hole, or drill a hole in the cylinder.

Caution

Be careful to assure that the cylinder is completely empty before you try to remove the valve stem or drill the tank.

3. Write “Empty” on the cylinder and place it with your scrap metal or, if you do not collect scrap metal for recycling, dispose of the cylinder.

25
Ventilator Interfaces and Respiratory Loops (Agilent CMS only)

The Ventilator Interface and Respiratory Loops section is divided up into the following three sections:

Ohmeda Ventilator Interface Section - 7800/7810

In this section, you will find information about the interfaces to the 7800/7810 Ohmeda Ventilators and the features that they offer.

For specific information, check either the list of contents at the front of this user's guide, or the alphabetic index at the back.

Note—The Ohmeda 7800/7810 Ventilator Interface is only available with the Agilent ACMS.

Introduction to the 7800/7810 Ohmeda Ventilator Interface

The interface to the Ohmeda 7800/7810 Ventilator allows information from the ventilator to be integrated with other Agilent CMS information, making the Agilent ACMS the central source for all patient information.

The Agilent ACMS retrieves information from the Ohmeda Ventilator, which can be selected for display, trending, or recording. This selection is made in a special *Configuration Mode*, either by your biomedical engineering department, or the HP Service Engineer.

A softkey on the Agilent ACMS is provided to accept or ignore the Ohmeda Ventilator alarms, as required. All information received from the Ohmeda Ventilator is displayed in a Task Window, whether it can be used for further processing or not.

All parameters received from the Ohmeda Ventilator, except setting parameters, are available through the Agilent ACMS to other networking applications such as the Agilent Network, personal computers, and printers.

Features

The 7800/7810 Ohmeda Ventilator interface provides you with the following features:

- Real-time monitoring of the Ohmeda Ventilator's parameters and alarms.
- Trend capabilities for selected parameters.
- Ability to temporarily silence the Ohmeda Ventilator's alarms.
- Ability to accept or ignore the Ohmeda Ventilator's alarms, as required.

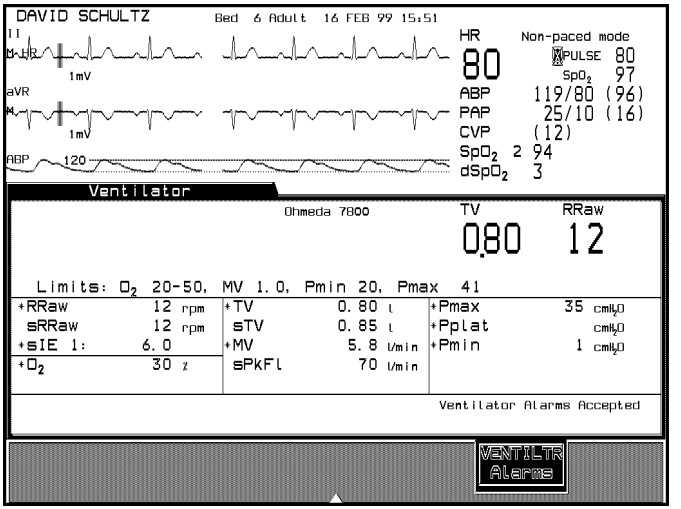
Ohmeda Ventilator Parameters and Settings

The parameters and settings are displayed in the Ventilator Setup Task Window as shown in the diagram below.

You access this task window by selecting:

- **Airway Gases/Ventilation** on the Agilent CMS control panel and
- **VENT** in the Airway Gases/Ventilation task window.

(7800/7810) Ventilator Task Window Layout



All labels that are selected for display are prefixed with an asterisk *. The numerics with the highest priority are displayed in the upper right corner of the Task Windows.

The 7800/7810 Ventilator task window displays the following information:

- The device name of the Ventilator, e.g. Ohmeda Ventilator.

- A total of 9 numerics (of which 8 can be viewed at any one time on the main display).

Operating Controls

The Ventilator task window displays the following softkeys:

Ventiltr Alarms	Selecting this softkey enables you to accept or ignore the Ohmeda Ventilator alarms during monitoring mode.

Ohmeda Ventilator Settings

The Ohmeda Ventilator settings that are retrieved from the 7800/7810 Ohmeda Ventilator are displayed in the Ventilator Task Window along with the other parameters. However, they are not shown on the real-time display and cannot be trended. The settings are made available for reference purposes.

Note—Ohmeda Ventilator alarm limits are only available as displayed values in the Ventilator Setup Task Window and cannot be adjusted from the Agilent ACMS. They can only be adjusted from the front panel controls of the Ohmeda Ventilator.

The sTV, sRRaw, and sPkFl settings correspond to front panel controls on the Ohmeda Ventilator.

Ohmeda Ventilator Signals and Labels

The Agilent ACMS retrieves the following signals from the 7800/7810 Ohmeda Ventilator.

(7800/7810) Signals and Labels

HP Label	Description	Range	Std. Display, Trend, Record	Calc.	Net-work
TV	Tidal volume	0.02 - 10.23 l	X	X	X
MV	Minute volume	0.0 - 99.9 l/min.	X		
Pmax	Peak inspired pressure	0 - 120 cm H_2O	X		
Pplat	Plateau pressure	0 - 120 cm H_2O	X		
Pmin	Minimum pressure	-20 - 120 cm H_2O	X		
O_2	Oxygen Concentration	0 - 100 %	X		
RRaw	Respiration rate	0 - 105 rpm	X		
sI:E	In/expired ratio	0.0 - 8.0 1/min	X		
sTV	Tidal volume setting	0.02 - 1.50 l			
sRRaw	Respiration rate setting	4 - 100 rpm			
sPkFl	Inspiration flow setting	10 - 100 l/min.			
	Limit Pmax high	20 - 100 cm H_2O			
	Limit Pmin high[a]	10 - 30 cm H_2O			
	Limit MV low	0 - 9.9 l/min.			
	Limit O_2 high	18 - 99 %			
	Limit O_2 low	18 - 99 %			

a. Pmin high represents the threshold for a sustained pressure.

Although most of these signals are consistent with other equipment that the Agilent ACMS supports, some of them need special consideration:

O_2	This parameter represents the O_2 concentration measured in the inspiratory (distal) portion of the breathing circuit.
Pmax	This value is the current sampled pressure during one breathing cycle.
Pmin	This is the minimum pressure measured during one breathing cycle (inspiration and expiration), including spontaneous breathing. Because spontaneous breathing can sometimes work against the ventilator, this value can also be negative.
Pplat	This value is only available when the "inspiratory pause" ventilator mode is selected.
sI:E	This is a setting, and not a measured value. The Agilent ACMS treats it as a numeric, which allows you to configure it for the real-time display and for trending.
sTV	Represents the setting on the tidal volume knob.
sRRaw	Represents the setting on the respiration rate knob.
sPkFl	Represents the setting on the inspiratory flow knob.

For a detailed description of all Ohmeda Ventilator parameters, refer to its Operation and Maintenance manual.

Ohmeda Ventilator Alarm Reporting

During installation, your biomedical engineer will have set up your system to either **ignore** or **accept** alarms generated by the 7800/7810 Ohmeda Ventilator. A **Ventiltr Alarms** softkey is provided in the Ohmeda Ventilator Task Window, which allows you to change this setting. This allows you to accept or ignore the Ohmeda Ventilator alarms during monitoring mode.

Alarms Accepted

If your system is set to **accept** the Ohmeda Ventilator alarms, then **visual** alarm messages from the Ohmeda Ventilator are displayed on the screen. **Audible alarms are not sounded on the monitor**, with the exception of the following INOP messages:

```
VENT COMMUNIC LOST

VENT COMMUNIC FAIL
```

When either of these two messages are issued, the communication between the Ohmeda Ventilator and the Agilent ACMS has failed. In this event, the Ohmeda Ventilator cannot issue an audible alarm, and this is done instead by the Agilent ACMS, which issued both an audible and a visual alarm.

The visual indication displayed by the Agilent ACMS depends on whether an alarm condition or an INOP condition occurs.

Alarm	The message is displayed in red or yellow. The numerics associated with the alarm blink.
INOP	The message is displayed in green. The numerics associated with the INOP are displayed as question marks (**-?-**).

Note—If the Ohmeda Ventilator alarms refer to numerical values currently displayed on the screen, these numerics blink as long as the alarm condition persists.

Note—If several alarms occur simultaneously, the alarm message with the highest priority is displayed. The numerics associated with all of the alarms blink.

Alarms Ignored

If your system is set to **ignore** the Ohmeda Ventilator alarms, no alarms from the Ohmeda Ventilator will be displayed on screen. This is indicated by the message

```
Ventilator Alarms Ignored
```

which is displayed in the lower right corner of Ventilator Task Window.

Note—Although no visual alarm is displayed when an INOP condition occurs, the corresponding numerics are displayed with question marks (**-?-**).

Note—When an alarm condition occurs, no visual indication is displayed except for the two messages that refer to Ohmeda Ventilator communications:

```
VENT COMMUNIC LOST
```

```
VENT COMMUNIC FAIL
```

Ohmeda Ventilator Alarm and INOP Messages

Alarms

All alarms that are generated by the 7800/7810 Ohmeda Ventilator are sent to the Agilent ACMS and, if Ohmeda Ventilator alarms are accepted, shown on the display. For more detailed information about the Ohmeda Ventilator messages, refer to the appropriate Ohmeda Ventilator operating manual.

(7800/7810) Physiological Alarms

Alarm Message	Condition	Visual Indication	Audible Indication
***APNEA	Apnea - no breath detected in the selected delay time	Red message. TV numeric (=0) blinks.	None.
**O_2 24<25	O_2 level below 25%	Yellow message. O_2 numeric blinks.	None.
**O_2 35>30	O_2 level above 30%	Yellow message. O_2 numeric blinks.	None.
**Pmax 60>45	The peak inspired pressure exceeds 45 cm H_2O.	Yellow message. Pmax numeric blinks.	None.
**MV 7.0<8.0	The minute volume is less than 8.0 l/min.	Yellow message. MV numeric blinks.	None.

INOP Messages

The INOP messages are accompanied by an audible alarm on the Ohmeda Ventilator, which you can silence for up to 30 seconds by pressing the **Silence/Reset** hardkey.

Note—INOP messages are displayed for **all** Ohmeda Ventilator signals, whether they are selected for display or not.

The following table lists these messages in order of their priority.

(7800/7810) INOP Messages

INOP Message	Condition	Visual Indication	Audible Indication
VENT COMMUNIC LOST	The Ohmeda Ventilator is disconnected or switched off.	Green message. All numerics displayed as -?-	INOP tone
VENT COMMUNIC FAIL	Data transfer failure. Interface configured incorrectly.	Green message. All numerics displayed as -?-	INOP tone
VENT EQUIP MALFUNC	Ohmeda Ventilator malfunction. For example CPU or ROM failure.	Green message. All numerics displayed as -?-	None.
VENT LOW PATIENT P	Patient disconnected from Ohmeda Ventilator	Green message.	None.
VENT SUSTAINED PR	Airway pressure exceeded sustained pressure limit for 15 seconds or more.	Green message.	None.
VENT SUB-ATMOS PR	The Ohmeda Ventilator detects airway pressure below -10 cm H_20.	Green message.	None.
VENT REVERSE FLOW	A reverse flow has been detected that exceeds the following limits: • sTV < 0.3 l - reverse flow exceeds 0.02 l. • sTV > 0.3 l - reverse flow exceeds 0.1 l.	Green message.	None.
VENT CHK O2 SENSOR	The measured oxygen level is below 5%.	Green message. O_2 numeric blinks.	None.
VENT LOW SUPPLY PR	The internally regulated supply pressure is below 152 kPa.	Green message.	None.

INOP Message	Condition	Visual Indication	Audible Indication
VENT CHK VOL SENS	Volume sensor is disconnected or defective.	MV, TV, and RRaw numerics blink.	None.
VENT Pmax LIMIT > 60	The Pmax limit is set to more than 60 cm H_2O.	Green message.	None.
VENT LOW BATTERY	The battery is insufficiently charged.	Green message.	None.
VENT CHK O2 SET	This error is displayed if you try to set an O_2 high limit equal to, or lower than, the low setting. This also applies if you try to set the low O_2 limit at less than 18%.	Green message.	None.
VENT CHECK SETTING	A combination of Ohmeda Ventilator control settings are out of range.	Numerics blink.	None.
VENT ON BATTERY	The ac power supply has failed, or is disconnected, and the Ohmeda Ventilator is running on battery.	Green message.	None.
VENT VOL STANDBY	The Ohmeda Ventilator is waiting for the first breath to activate the volume monitoring and Apnea timer.	Green message.	None.

Ohmeda Ventilator Interface Section - 7900

In this section, you will find information about the interface to the 7900 Ohmeda Ventilator and the features that it offers.

For specific information, check either the list of contents at the front of this user's guide, or the alphabetic index at the back.

Note—The Ohmeda 7900 Ventilator Interface is only available with the Agilent ACMS.

Introduction to the 7900 Ohmeda Ventilator Interface

The interface to the Ohmeda 7900 Ventilator allows information from the ventilator to be integrated with other Agilent CMS information, making the Agilent ACMS, the central source for all patient information.

The 7900 Interface provides 2 out of 3 scalable waveforms and a total of 14 numerics. This information can be selected (*in monitoring mode*) for display, trending or recording.

All parameters received from the Ohmeda Ventilator are available through the Agilent ACMS to other networking applications such as the Agilent Network, personal computers, and printers.

Features

The 7900 Ohmeda Ventilator interface provides you with the following features:

- Real-time monitoring of the Ohmeda Ventilator's parameters.
- Trend capabilities for selected parameters.
- The (optional) display and storage of up to 3 types of Respiratory Loops.
- The silencing of all ventilator alarms via a shared alarm silence key on the Agilent CMS.

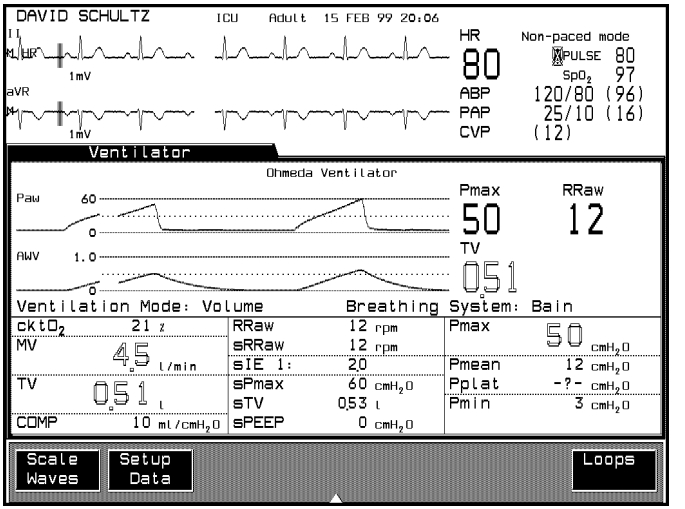
Ohmeda Ventilator Parameters and Settings

The parameters and settings are displayed in the Ventilator Setup Task Window as shown in the diagram below.

You access this task window by selecting:

- **Airway Gases/Ventilation** on the Agilent CMS control panel and
- **VENT** in the Airway Gases/Ventilation task window.

7900 Ventilator Task Window Layout



The 7900 Ventilator task window displays the following information:

- The device name of the Ventilator.
- A total of 14 numerics (of which 9 can be viewed at any one time on the main display).
- A choice of 2 out of 3 waveforms.
- The ventilation mode.

Operating Controls

In the Ventilator task window you can:

- Adjust the ventilator wave size.
- Select data for display.
- Enter the Loops task window (optional).

Adjusting the Ventilator Wave Size

Selecting the **Scale Wave** softkey enables you to select any configured wave and adjust its scale.

Selecting Data for display

Selecting the **Setup Data** softkey enables you to determine which waves and numerics should be displayed on the resting display.

Entering the Loops Task Window (optional)

Selecting the **Loops** softkey takes you into the Loops task window.

Ohmeda Ventilator Settings

The Ohmeda Ventilator settings that are retrieved from the 7900 Ohmeda Ventilator are displayed in the Ventilator Task Window along with the other parameters. The settings are made available for reference purposes.

Volume Controlled Mode

sTV	sRRaw
sI:E	sPmax
sPEEP	

Pressure Controlled Mode

sPin	sRRaw
sI:E	sPmax
sPEEP	

Ohmeda Ventilator Signals and Labels

The Agilent ACMS retrieves the following signals from the 7900 Ohmeda Ventilator.

(7900) Signals and Labels

Label		Description	Range	Std. Display, Trend, Record	Calc.	Network
Ohmeda	HP					
V_{TE}	TV	Tidal volume	0.00 - 99.99 l[a] 0 - 9999 ml [b]	X	X	X
V_E	MV	Minute volume	0.0 - 99.9 l/min.	X		
Pmax	Pmax	Peak inspired pressure	0 - 120 cmH_2O	X		
Pplateau	Pplat	Plateau pressure	0 - 120 cmH_2O	X		
Pmin	Pmin	Minimum pressure	-20 - 120 cmH_2O	X		
Pmean	Pmean	Mean Pressure	-20 - 120 cmH_2O	X		
O_2	$cktO_2$	Oxygen Concentration	0 - 110 %	X		
f	RRaw	Respiration rate	0 - 105 rpm	X		
I:E	sI:E	In/expired ratio	0.0 - 8.0 1/min	X		
V_T	sTV	Tidal volume setting	0.00 - 99.99 l[a] 0 - 9999 ml[b]	X		
Rate	sRRaw	Respiration rate setting	0 - 999 rpm	X		
PEEP	sPEEP	Positive end expiratory pressure setting	0 - 120 cm H_2O	X		

(7900) Signals and Labels

Label		Description	Range	Std. Display, Trend, Record	Calc.	Network
Ohmeda	HP					
Pinspired	sPin	Inspired pressure setting	0 - 120 cm H_2O	X		
Plimit	sPmax	Set maximum pressure	0 - 120 cm H_2O	X		
PAW	Paw	Pressure waveform	-16 - 150 cmH_2O			
	AWF	Flow waveform	-108 - 108 1/min			X
	AWV	Volume waveform	-0.25 - 2.25 1[a] -250 - 2250 ml[b]			

a. Adult and Pedi Configuration set
b. Neo Configuration set

Although most of these signals are consistent with other equipment that the Agilent CMS supports some of them need special consideration:

cktO$_2$ This parameter represents the O_2 concentration measured in the inspiratory (distal) portion of the breathing circuit.

Pmax This value is the maximum sampled pressure during one breathing cycle.

Pmin This is the minimum pressure measured during one breathing cycle (inspiration and expiration), including spontaneous breathing. Because spontaneous breathing can sometimes work against the ventilator, this value can also be negative.

Pmean This is the average pressure measured during one breathing cycle.

Pplat This value is only available when the "inspiratory pause" ventilator mode is selected.

sI:E	This is a setting, and not a measured value. The Agilent CMS treats it as a numeric, which allows you to configure it for the real-time display and for trending.
sTV	Represents the setting on the tidal volume knob.
sRRaw	Represents the setting on the respiration rate knob.
sPmax	Represents the setting on the pressure limit control knob.
sPEEP	Represents the setting on the PEEP control knob.
sPin	Represents the setting on the Pinspired control knob.
COMP	Represents the Compliance measurement which is usually measured during the ventilated breaths, using the ventilated tidal volume. It is calculated by dividing the TV by the difference of the Pmax and Pmin.

For a detailed description of all Ohmeda Ventilator parameters, refer to its Operation and Maintenance manual.

Ohmeda Ventilator Alarm Reporting

With the exception of 2 INOP messages (see Note below), the Agilent CMS does not visually or audibly announce any patient or technical alarms generated by the 7900 Ohmeda Ventilator. Alternatively all alarms are announced on the Ohmeda Ventilator itself but can be silenced by pressing the **Silence/Reset** hardkey on either the Ohmeda Ventilator **or** the Agilent CMS.

Note—If communication between the 7900 Ohmeda Ventilator and the Agilent CMS breaks down, one of the following 2 INOP messages will be displayed on the Agilent CMS:

VENT COMMUNIC LOST

VENT COMMUNIC FAIL

For further information on these INOP messages, please refer to “Ohmeda Ventilator Alarm and INOP Messages” on page 25-12 in the “Ohmeda Ventilator Interface Section - 7800/7810” of this manual.

Respiratory Loops

In this section, you will find information about Respiratory Loops and how they are displayed and stored on the Agilent CMS.

For specific information, check either the list of contents at the front of this user's guide, or the alphabetic index at the back.

Note—The Respiratory Loops application is available with all Agilent CMS models.

Introduction to Respiratory Loops

The Respiratory Loops application enables the Agilent CMS together with the 7900 Ohmeda Ventilator Interface or the M1032A Vuelink B plug-in module, to display the relationship between two ventilator waves in a graphical format.

Interpreting Respiratory Loops supports early detection of patient airway problems (e.g. atelactasis, bronchospasm, increased abdominal pressure) and Ventilator problems (e.g. leaks and kinked tubes).

The output signals provided by a ventilator determine how many loop types can be displayed on the screen. The Respiratory Loops that can be generated and displayed on the Agilent CMS (depending on the Ventilator) are as follows:

- Pressure-Volume Loop,
- Volume-Flow Loop,
- Pressure-Flow Loop.

Features

The Respiratory Loops application provides you with the following features:

- The display of up to three loop types; Pressure-Volume Loop, Volume-Flow Loop and Pressure-Flow Loop.
- The storage of up to six loops for each loop type.
- A unique color coding of the loops for ease of use.
- A built in cursor to trace the loop as it is plotted on the graph. This allows you to place the marker at any point on the loop and view related numerical values.

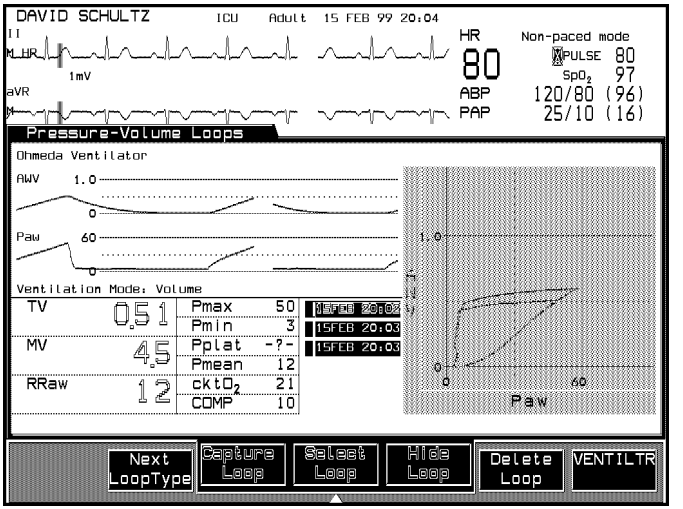
Respiratory Loops Parameters and Settings

The parameters and settings are displayed in the Loops task window, as shown in the diagram below. The Loops task window can display 1 real-time loop and up to 6 stored loops along with the ventilator waves and numerics. You can access the Loops task window by selecting:

- **Procedures** on the Agilent CMS control panel and
- **Loops** in the Procedures selection window.

Note—The **Loops** softkey can only be selected if at least one loop is stored in the Loops task window or, two airway waves have been supplied by a ventilator since the Agilent CMS was last switched off and on.
If this does not apply, the Loops softkey is displayed as hollow and cannot be selected. If the hollow softkey is selected, the following status message is displayed on the Agilent CMS:
`Waves not available to show loops`

Loops Task Window



The Loops task window displays the following information:

- The task window title, which alternates from Pressure-Volume Loops to Volume-Flow Loops to Pressure-Flow Loops, depending upon the loop type currently being generated.
- The device name of the Ventilator.
- Two ventilator waves, which can be selected in the Ventilator task window.
- The ventilation mode, displayed only if the external device supplies this information.
- Up to nine numerics if the 7900 Ohmeda Ventilator is connected and up to six numerics if the Vuelink-B Module is connected. The numerics are displayed in white and the labels in blue. Invalid numerics are displayed with a question mark.
- A graphical display of a real-time loop generated from the two ventilator waves. One wave is plotted on the vertical axis of the graph and the other on the horizontal axis.
- A graphical display of and up to six stored loops, each of which is displayed in a different color.
- A built-in graph cursor.
- A color coded, chronological, tabular list of stored loops, together with the date and time they were captured.

Loop Types

Loop Type	Wave on Horizontal Axis	Wave on Vertical Axis
Pressure-Volume Loop	Pressure	Volume
Volume-Flow Loop	Volume	Flow
Pressure-Flow Loop	Pressure	Flow

Color Coding of Loops

Loop Type	Loop Color
A real-time loop	Yellow
A captured (but not stored) loop	Yellow
A stored loop	Red, Green, Blue, Magenta, Cyan or White

Operating Controls

In the Loops task window you can:

1. Select a loop type.
2. Capture and release a loop.
3. Select a loop.
4. Show and hide a loop.
5. Delete a loop.
6. Enter the Ventilator task window.
7. Move the graph cursor on a stored loop.

Selecting a Loop Type

This softkey is only available if the 7900 Ohmeda Ventilator Interface is connected to the Agilent CMS.

Selecting the **Next Loop Type** softkey enables you to step through the three different loop types (Pressure-Volume Loop, Volume-Flow Loop and Pressure-Flow Loop). When this softkey is selected, the following status message is displayed in the Loops task window:

```
Please wait, preparing operation
```

The Loops task window is then closed and reopened with information for the next loop type.

Capturing and Releasing Loops

The **Capture Loop** and **Release Loop** softkeys switch from one to the other when selected. When the **Capture Loop** softkey is selected, a real-time loop is captured and the following status message is displayed in the Loops task window:

```
Capture in progress
```

Once the loop has been plotted in its entirety on the graph, a status message will appear in the Loops task window asking the user to confirm the storage of the loop. Press **Confirm** on the Agilent CMS control panel to store the loop.

You can replace a stored loop with a loop that has just been captured by selecting **Select Loop** or the ↑ and ↓ arrow keys on the Agilent CMS control panel. A status message is displayed in the Loops task window asking the user to confirm the replacement of the stored loop. Press **Confirm** on the Agilent CMS control panel to replace the loop.

If you decide that the loop is not required, you can release it again by selecting **Release Loop**.

Selecting a Loop

Selecting the **Select Loop** softkey enables you to step through the tabular list of up to six stored loops. Alternatively, the arrow keys on the Agilent CMS control panel can also be used.

If you leave and re-enter the Loops task window, the loop that was last selected when you left, will be re-selected when you re-enter. If less than two loops are stored, the **Select Loop** softkey will appear as hollow.

Showing and Hiding a Loop

The **Show Loop** and **Hide Loop** softkeys switch from one to the other when selected. When the **Show Loop** softkey is selected, a stored loop is displayed on the graph. When the **Hide Loop** softkey is selected, the shown loop is hidden (but still stored) and no longer displayed on the graph. If no loops are stored, the **Show Loop** / **Hide Loop** softkey will appear as hollow.

Deleting a Loop

Selecting the **Delete Loop** softkey enables you to delete a stored loop. The Agilent CMS will ask you to confirm this action before it is deleted completely from the loop storage. Once a loop has been deleted, it cannot be retrieved.

Entering the Ventilator Task Window

Selecting the **Ventiltr** softkey enters the Ventilator task window.

Moving the Graph Cursor on a stored Loop

When the arrow keys are pressed on the Agilent CMS control panel, the built-in graph cursor is activated and traces the selected, stored loop currently shown on the graph. Numerical data for each point selected by the cursor is displayed in the top right hand corner of the graph.

26
Anesthetic Gas Module Section

This chapter contains information about the Anesthetic Gas Module. It is divided into two sections:

- Section I,
  The Anesthetic Gas Module – Option A01 (page 26-3),
  contains information about the Inlet Filter and the Nafion Gas Sample Tube solution for the M1026A Anesthetic Gas Module.

- Section II,
  The Anesthetic Gas Module – Options A02 & A05 (page 26-55),
  contains information about the Watertrap and Standard Gas Sample Tube solution for the M1026A Anesthetic Gas Module.

Section I:
The Anesthetic Gas Module – Option A01

This section provides information on the Anesthetic Gas Module – Option A01. It contains information about the Inlet Filter and the Nafion Gas Sample Tube solution for the M1026A Anesthetic Gas Module.
It contains the following subsections:

Introduction to the Anesthetic Gas Module (Nafion Version)

What does it measure?

The M1026A Anesthetic Gas Module (AGM) measures the anesthetic and respiratory gases of a patient under anesthesia. The module provides the end tidal (et) and inspired (in) values of the following gases:

- Carbon Dioxide (CO_2). The values measured are $IMCO_2$ (inspired minimum - the smallest value sensed during respiration), and $ETCO_2$ (end tidal - the maximum expired value sensed during respiration).
- Nitrous Oxide (N_2O).
- Oxygen (O_2) - as an optional feature.
- Airway Respiration Rate (AWRR) - in respirations per minute (rpm).

Anesthetic Agents

- Halothane
- Isoflurane
- Enflurane
- Sevoflurane
- Desflurane.

Note—The values for only *one* anesthetic agent can be displayed at any one time.

In addition, the module can calculate and display the differences between inspired and expired gas values listed below:

- in-et N_2O
- in-et O_2
- in-et Anesthetic Agent.

How the Gas Measurement Works

The Anesthetic Gas Module uses a technique called *Non-Dispersive Infra-red Gas Concentration Measurement* (NDIR) to measure the concentration of certain gases.

This works as follows:

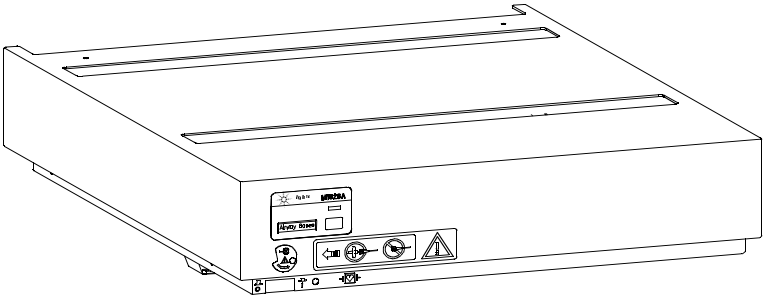
- The gases which can be measured by the Anesthetic Gas Module absorb infrared (IR) light.
- Each gas has its own absorption characteristic. The gas is transported into a sample cell, and an optical IR filter selects a specific band of IR light to pass through the gas. For multiple gas measurement, such as in the Anesthetic Gas Module, there are multiple IR filters.
- The higher the concentration of gas in a given volume the more IR light is absorbed. This means that higher concentrations of IR absorbing gas cause a lower transmission of IR light.
- The amount of IR light transmitted after it has been passed through an IR absorbing gas is measured.
- From the amount of IR light measured, the concentration of gas present can be calculated. This calculation provides the gas measurement value.

How fluids are removed from the gas sample

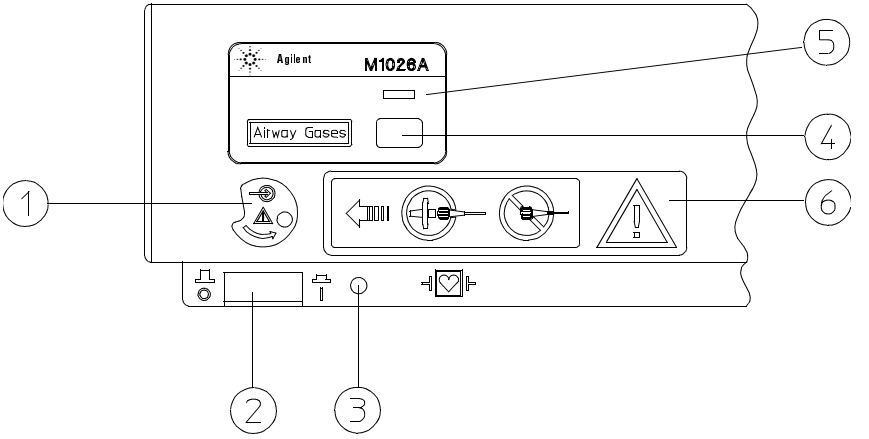
An inlet bacterial filter and a Nafion or Hybrid gas sample tube are connected to the front panel of the Anesthetic Gas Module. The gas sample tube removes vapor from the gas sample and the inlet bacterial filter collects any excess fluid remaining in the gas sample before it passes into the Anesthetic Gas Module.

Front Panel of the Anesthetic Gas Module

Anesthetic Gas Module Front View



Anesthetic Gas Module Front Panel

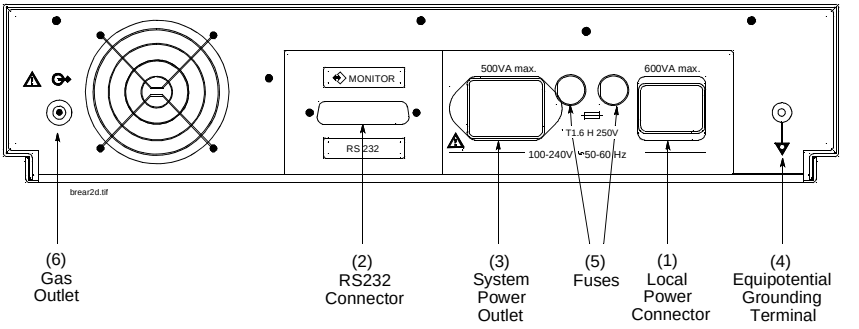


The front of the module has:

1. Module gas inlet cover.
2. Power on/off switch.
3. Power light which is illuminated when the module is switched on.
4. Parameter setup key.
5. Setup light which is illuminated when:
   a. You are in Setup Mode.
   b. For 5 - 10 seconds when the module is first switched on
   c. There is no communication for 60 seconds, or communication has been aborted between the Anesthetic Gas Module and the monitor.
   d. The light blinks if a malfunction occurs but communication is still possible for further diagnosis in a special Service Mode. In this situation, contact your biomedical engineer or the Agilent Service Engineer.
6. Label: Always use a bacterial filter to protect the module from contamination. Without a filter, bacteria and fluid can pass directly into the Anesthetic Gas Module causing contamination of the module, occlusion and incorrect readings. It is recommended that the bacterial filter be changed after every patient to minimize the risk of occlusion. Do not attempt to sterilize or clean it.

Rear Panel of the Anesthetic Gas Module

The controls and connectors on the rear panel of the module are described below.



The rear of the module has:

1. Local power connector.
2. RS232 Connector (Interface).
3. System Power outlet.
4. Equipotential Grounding Terminal.
5. Line protection fuses.
6. Anesthetic gas exhaust.

Anesthetic Gas Module Setup

What you need

You will need the following equipment to setup the Anesthetic Gas Module for use:

Equipment Required

Equipment	Part No	Comments
Anesthetic Gas Module	M1026A	Installed to work with your Agilent ACMS or Agilent Anesthesia V24 or V26 monitor.
Inlet Bacterial Filter	13904A	See Caution Note below.
Gas Sample Tube	13901A or 13905A	2 types available: see Caution Note below.
Airway Adapter(s)	13902A or M1612A	Right angle or straight. Built-in port extending from adapter wall to reduce risk of water or fluids from passing into the gas sample tube. Connects to the gas sample tube.

For a complete list of Anesthetic Gas Module accessories, please refer to *Accessories* later in this section. For information on the replacement of accessories, please refer to *Care and Cleaning* later in this section.

Caution

- Always use a bacterial filter to protect the module from contamination. Without a filter, bacteria and fluid can pass directly into the Anesthetic Gas Module causing contamination of the module, occlusion and incorrect readings. The bacterial filter must be changed after every patient to minimize the risk of occlusion. Do not attempt to sterilize or clean it.
- Use only the Agilent gas sample tubes listed below. The use of alternative gas sample tubes will risk the performance and reliability of your

Anesthetic Gas Module. There are 2 types of Agilent gas sample tubes available:

- Nafion Tube 13901A (2.4m).
- Hybrid Tube 13905A (3m).

Due to material properties of the Hybrid tube, the dynamic response for the measurement of halothane may be compromised; response time is typically extended by 300 msec.

Do not use the gas sample tube if it is kinked, as it may cause an occlusion or leakage.

- Use an Agilent Airway Adapter to prevent condensed water from passing into the gas sample tube and causing a blockage. Additionally, the airway adapter has a built in port extending from the adapter wall. This further reduces the risk of a blockage occurring.
- Do not apply excessive pressure to the AGM e.g. from a syringe, as this may cause damage to the pneumatic and optical systems.

Setup

Notes—

- To avoid condensed water collecting in the gas sample tube or bacterial filter, it is recommended that you position your Anesthetic Gas Module at or above the patient level.
- Do not set up the Anesthetic Gas Module in a position where liquid could spill onto it

1. Switch on the Anesthetic Gas Module by pressing the power-on switch. This allows time for the module to warm up while connections to the patient are being made.
   - The power-on switch is on the left hand side of the front panel.
   - The green light next to the switch is illuminated when the module is switched on.

The green INOP messages described in the table below are displayed in the top left hand corner of the monitor display before the Anesthetic Gas Module is ready for patient monitoring. How long the messages are displayed, and the module activity are also explained in the table.

Switching On the Anesthetic Gas Module

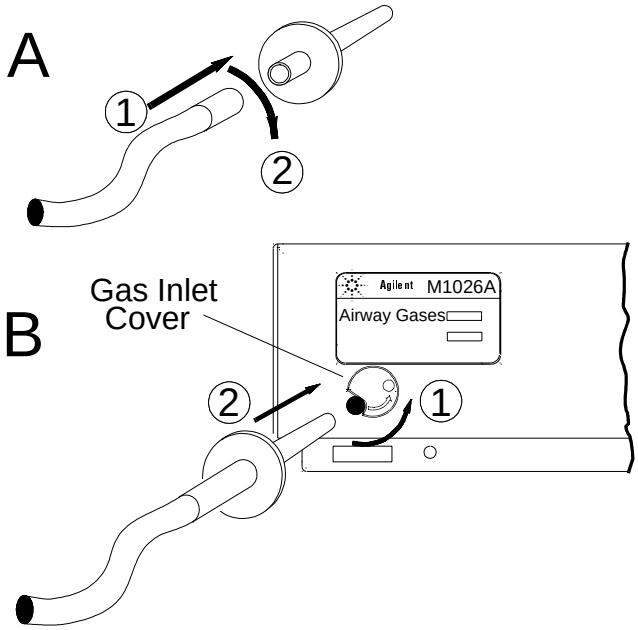
Step	INOP Message	Duration of INOP Message	Anesthetic Gas Module Activity
1.	no message displayed	5 seconds	a. Module has just been switched on. b. Parameter set-up light is illuminated. c. Not in patient monitoring mode. d. No waveforms or numerics are displayed.
2.	no message displayed	up to 2 minutes	a. Module is in self-test mode. b. Parameter set-up light is not illuminated. c. Not in patient monitoring mode. d. No waveforms or numerics are displayed.
3.	GAS AN. WARMUP	up to 8 minutes	a. Module is in warm-up mode. b. Airway gases from the patient are being measured, but with reduced accuracy. c. Waveforms and numerics are displayed. d. User can call up the Task Window. e. Small ? displayed in front of the parameter name. This means that the numerical data is questionable.

2. Fit a bacterial filter to the gas sample tube; twist the filter so that it fits tightly in place.

   If you are using the hybrid gas sample tube (part number 13905A) ensure that:

   A The end with the **braided** surface is attached to the **patients airway adapter**.

   B The end with the **smooth** surface is connected to the **bacterial filter** then to the **Anesthetic Gas Module**.



Attaching the Gas Sample Tube to the Module

3. Connect the gas sample tube with attached bacterial filter to the Anesthetic Gas Module.

    a. Use the bacterial filter (with attached gas sample tube) to push the module gas inlet cover upwards and open.

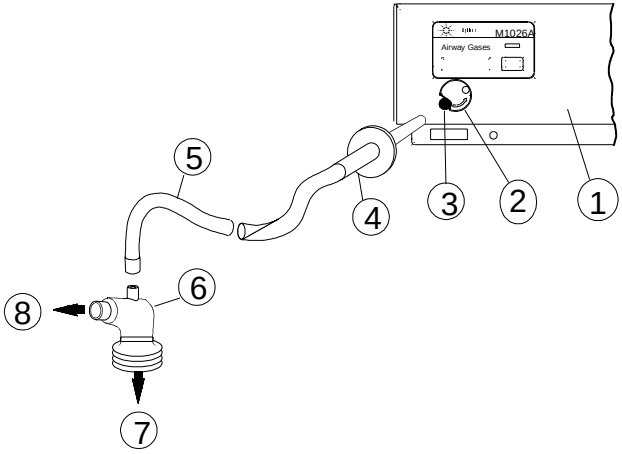
    b. Slide the bacterial filter (with attached gas sample tube) into the slot. Twist it for a quarter turn in a clockwise direction to ensure that is tightly in place.

    c. To disconnect the gas sample tube from the gas inlet on the Anesthetic Gas Module, twist the bacterial filter a quarter turn in an counter-clockwise direction and then pull it out.

    Note—The intake pump in the Anesthetic Gas Module starts to run as soon as the gas inlet cover is opened.

4. Connect the other end of the gas sample tube to the patient via the airway adapter.

   Note—The airway adapter must be positioned so that the part connecting to the gas sample tube is pointing upwards (see figure below). This prevents condensed water from passing into the gas sample tube and causing an occlusion.



Setting Up the Anesthetic Gas Module

1. Anesthetic Gas Module M1026A
2. Gas Inlet Cover
3. Gas Inlet
4. Bacterial Filter 13904A
5. Gas Sample Tube 13901A or 13905A
6. Airway Adapter 13902A or M1612A
7. Connects to patient
8. Connects to anesthesia machine.

Detecting and Preventing Leaks

Warning

Any leak in the tubing and connections from the patient to the M1026A Anesthetic Gas Module may result in dilution of the gas mixture with ambient air. If this leak exceeds a certain magnitude, the value of CO_2 and anesthetic agents displayed on the monitor may be significantly lower than the actual concentration in the patient's breathing circuit. Erroneously low values may lead to inappropriate intervention and patient safety may be at risk. To detect and prevent leaks in the tubing follow the instructions below:

1. **Carefully inspect the tubing and connections from the patient to the M1026A Anesthetic Gas Module (including the watertrap, if applicable) for damage or leakage.**
2. **Avoid any unnecessary mechanical stress to the tubing of the M1657A watertrap (if applicable).**
3. **If an unexpected low gas concentration value appears on the gas monitor, repeat the visual inspection of the entire tubing (see 1. above). If no leakage can be found, please confirm the low value by replacing the watertrap with a new one.**

Anesthetic Gas Exhaust

If N_2O and/or other inhalation anesthetics are used during anesthesia, pollution of the operating room should be prevented. Once the gas sample has passed through the Anesthetic Gas Module, it should either be *returned to* or *removed from* the anesthesia circuit.

What you need to return the gas sample

You will need the following equipment to *return* the gas sample to the anesthesia circuit:

Equipment Required

Equipment	Part No	Comments
Gas Exhaust Return Line	M1655A[a]	Tubing includes 2 parts: • Tube A = 50cm long. • Tube B = 3m long.
Gas Exhaust Return Filter	M1656A[a]	Single patient use only. See Caution note below.

a. Not available in the U.S.

Caution

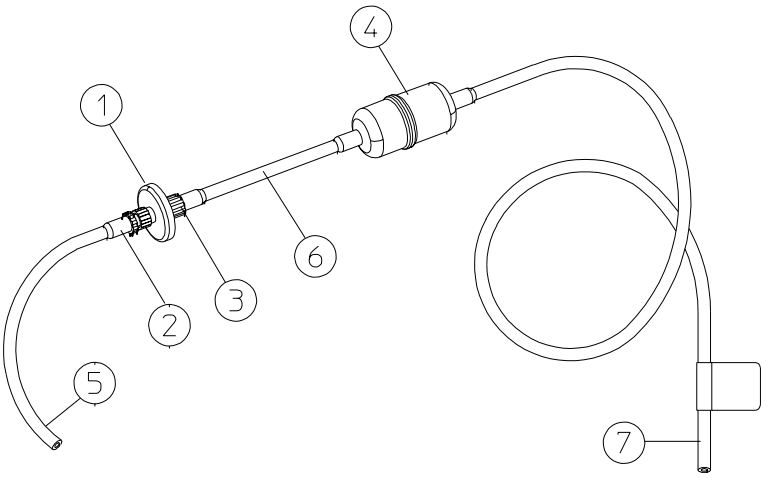
Always use an M1656A Gas Exhaust Return Filter before returning the gas sample to the patient circuit.

For information on the replacement of accessories, please refer to *Care and Cleaning* later in this section.

Setup

(see diagram below)

1. Fit the *female* connector (2) of **Tube A**, to the *male* side of the M1656A Gas Exhaust Return Filter.
2. Fit the *male* connector (3) of **Tube B**, to the *female* side of the M1656A Gas Exhaust Return Filter.
3. Fit the open end (7) of **Tube B** to the Anesthetic Gas Module outlet.
4. Fit the open end (5) of **Tube A** to the ventilation circuit.



Gas Exhaust Return Line

1. M1656A Gas Exhaust Return Filter
2. Female connector of Tube A
3. Male connector of Tube B
4. Dampener
5. Tube A (shorter tube) - connects to ventilator circuit.
6. Tube B (longer tube)
7. Open end of Tube B (longer tube) - connects to AGM.

What you need to remove the gas sample

To *remove* the gas sample from the anesthesia circuit, a scavenging system needs to be connected to the Anesthetic Gas Module. If you intend to use a scavenging system with the Anesthetic Gas Module, the following parts must also be connected to prevent the module from malfunctioning:

- an Gas Exhaust Scavenging Kit (M1015-40001),
- a Ventilator Reservoir where the suction pressure does not exceed 0.3-0.4mm Hg *or*
- a Scavenging Interface.

Anesthetic Gas Module Standby Mode

The user can manually suspend gas monitoring by activating the Anesthetic Gas Module Standby Mode. This in turn, is synchronized with the CMS and V24/26 Standby Mode, for example:

Scenario/Condition	Result
1. If the monitor enters standby mode:	the AGM standby mode is automatically **activated**.
2. If the monitor leaves standby mode:	the AGM standby mode is automatically **deactivated**.
3. If the AGM standby mode is already activated when the monitor enters standby mode:	The AGM standby mode remains activated when the monitor leaves standby mode.
4. If the monitor standby mode is not activated when the AGM enters standby mode:	the monitor will remain in monitoring mode. Monitor standby mode is not activated.

The Anesthetic Gas Module Standby Mode is activated/deactivated in the Airway Gases/Ventilation overview task window. To enter the task window press **Module Setup** followed by **Airway Gases**

- To *enter* Standby, press **Airway Standby**.
- To *leave* Standby Mode, press **Airway Resume**.

During standby, the Anesthetic Gas Module intake pump is automatically switched off and all Anesthetic Gas Module parameters disappear from the display and are marked as **OFF** in the Parameters On/Off task window. The following INOP message is displayed on the monitor:

GAS AN. STANDBY

If an airway gas parameter is switched **ON** manually during this time, the Anesthetic Gas Module standby mode is automatically deactivated and the selected parameters become active.

Automatic Switch to Standby Mode

The Anesthetic Gas Module parameters **automatically** disappear from the display if the Anesthetic Gas Module intake pump switches off. This occurs in order to maintain the life of the pump and to avoid long term failure.

The Anesthetic Gas Module intake pump is **automatically** switched off and Standby Mode is activated if:

- No breath is detected for 4 hours and
- ETCO2 is less than 4 mmHg for more than 4 hours.

To resume monitoring, do one of the following:

1. **deactivate** the Anesthetic Gas Module Standby Mode by pressing **Airway Resume** in the Airway Gases/Ventilation task window.

   OR

2. **disconnect** the bacterial filter and **reconnect** it again.

Using the Anesthetic Gas Module during a Cardiopulmonary Bypass

During a cardiopulmonary bypass, the anesthesiologist may cease periodic mechanical ventilation. In these cases, it is important to note that an active Anesthetic Gas Module will continue to suck gases from the patient-ventilator circuit during that time. This will cause the airway pressure to drop if no active measures are taken to keep the patient-ventilator circuit stable. To stop the Anesthetic Gas Module from sucking gases, do one of the following:

- **activate** the Anesthetic Gas Module Standby Mode *and/or*
- **disconnect** the sample line either:
  a. from the Anesthetic Gas Module *or*
  b. from the patient-ventilator circuit

To continue measuring the airway gases do one of the following:

- **deactivate** the Anesthetic Gas Module Standby Mode *and/or*
- **reconnect** the sample line either:
  a. to the Anesthetic Gas Module *or*
  b. to the patient-ventilator circuit

Screen Display

Main Screen

In the standard display, you can display the following data:

1. Up to **3 waveforms**: CO_2, Anesthetic Agent, and O_2 (optional)
2. Up to **3 large format numerics** associated with the waveforms
3. **All remaining numeric**s (except i-e difference).

Note— It is only possible to display the waveform and numerics of *one* anesthetic agent at any one time.

Automatic Parameter Switch Off

The Anesthetic Gas Module parameters **automatically** disappear from the display if the intake pump on the Anesthetic Gas Module switches off. This occurs in order to maintain the life of the pump and to avoid long term failure.

The intake pump on the Anesthetic Gas Module is **automatically** switched off if:

- No breath is detected for 4 hours or longer and/or
- $ETCO_2$ is less than 4 mmHg for more than 4 hours.

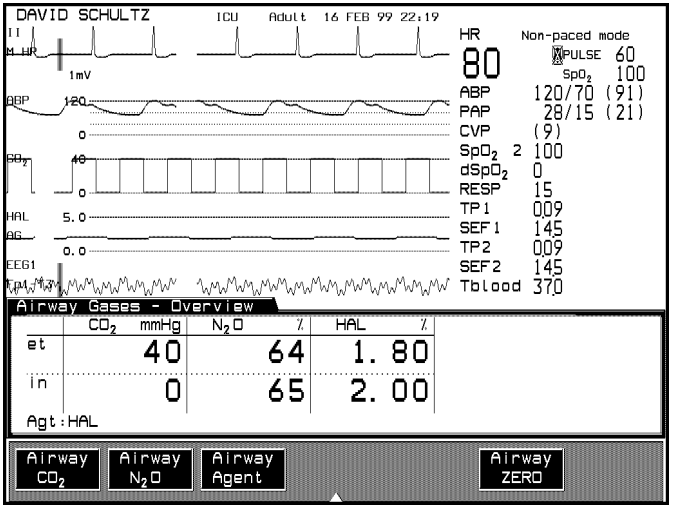
To reactivate monitoring, **disconnect** the bacterial filter and **reconnect** it.

The Overview Task Window

This Task Window displays numerics of all gases being measured by the Anesthetic Gas Module in tabular format.

Accessing

You can access the Overview Task Window by pressing the setup key on the Anesthetic Gas Module.



Airway Gases Overview Task Window - Example

The Airway Gas Task Windows

Each gas being measured has its own Task Window which displays the following:

- Waveform.
- in and et numerics.
- in-et difference value (except CO_2, which displays AWRR)
- Alarm limits.

The N_2O waveform can **only** be viewed in the Airway N_2O Task Window.

Notes—

- If you suspect that the values displayed on the screen may be inaccurate, check the inlet filter and gas sample tube for damage and/or an occlusion.
- If the waves appear to be flatter than normal, check the inlet filter and tubing for leakages and occlusions and replace if necessary. If the condition continues, contact your biomedical engineer or Agilent Service Engineer.

Automatic Agent Identification

The Anesthetic Gas Module automatically detects the predominant anesthetic gas from a set of anesthetic agents and instructs the gas analysis functions to measure the concentration of that agent.

The module in its standard configuration is able to automatically detect one agent out of the following:

- Halothane
- Isoflurane
- Sevoflurane or Desflurane

Option C01
Alternatively, Option C01 allows the Anesthetic Gas Module to detect one agent out of the following:

- Halothane
- Isoflurane
- Enflurane

Selecting an Anesthetic Agent

An anesthetic agent can be identified automatically or selected manually for measurement. To select automatic agent identification (the default), do the following:

1. Access the Airway Agent Task Window
2. Press **Select Agent**
3. Select the **AUTO** softkey in the select agent list. The agent identification feature automatically identifies which agent out of 3 has the highest concentration and selects it for measurement.
4. Press **Main Screen** .

To Manually select an anesthetic agent, do the following:

1. Access the Airway Agent Task Window
2. Press **Select Agent**

3. Select the agent you wish to measure, for example:
   ISO for isoflurane or
   None if no specific anesthetic agent is being measured. In this case the label AGT appears instead of an agent label.
4. Press **Main Screen** .

Note—As long as the label AGT appears on the monitor, the numerics displayed may not reflect the actual concentration values of the agent administered to the patient.

Exchanging Agents

If the anesthetic agent administered to the patient changes, a few minutes pass whereby a mixture of both gases is detected by the Anesthetic Gas Module until the exchange is complete. The exact amount of time needed until the exchange is complete depends on:

- the type of anesthesia (low flow or high flow)
- the agents administered and how long these agents have been administered. (Pharmacokinetics)

When one agent is exchanged with another, the following information is displayed on the monitor:

INOP Message:	**AGT MIXTURE**
Wave:	Displayed
Numerics:	Displayed together with a "?"
Labels:	If Automatic Agent ID is selected, the old agent label is automatically replaced with the new agent label. If Automatic Agent ID is *not selected*, the old agent label remains displayed and the INOP message AGT MIXTURE is followed by a second INOP message; CHECK AGENT. To display the correct agent label, select the agent manually.

The INOP message AGT MIXTURE and the "?" next to the numerics disappear, when one of the agents decreases below the relevant threshold for mixtures and the other agent predominates. The exchange is then complete.

Note—The presence of other substances in the patient such as ethanol or acetone can influence the agent identification and lead to incorrect values and incorrect identification.

Oxygen (O_2) Measurement (Optional)

O_2 measurement is an optional feature (Option #C03), enabling the measurement of inspired and end-tidal O_2.

To see if you have O_2 measurement:

1. Access the **Airway Gases** overview Task Window.
2. Look for the **Airway O2** Task Window selection key
3. If there is no O_2 selection key then your Anesthetic Gas Module does not have the O_2 measurement feature.

If you require this feature, please consult your biomedical engineer.

The O_2 analyzer uses a fast O_2 measurement technique, which takes advantage of O_2 paramagnetism. Two sealed spheres of a dumb-bell assembly are suspended in a symmetrical non-uniform magnetic field. Due to the dumb-bell's diamagnetic properties, it orients itself away from the most intense part of the field.

When the gas surrounding the dumb-bell contains a paramagnetic gas such as O_2, the dumb-bells are pushed even further out of the magnetic field by the relatively stronger paramagnetic O_2. The magnitude of the torque acting on the dumb-bell is proportional to the paramagnetism of the surrounding gases, and therefore the concentration of oxygen.

Calibration

Zero Calibration

The Anesthetic Gas Module automatically performs a zero calibration to ensure the gas measurements maintain the highest accuracy. The zero calibration is performed automatically on the Anesthetic Gas Module and, if required, manually by the user. It takes about 15 seconds to complete and may not be suspended at any time.

Automatic zero calibration

The zero calibration is performed automatically after the module has been switched on at the following intervals:

- 8, 15, 30, 45 and 90 minutes
- and then every 8 hours after each subsequent zero calibration.
- when a drift of the measurement is detected, the calibration is performed regardless of the time since the last zero calibration.

Manual Zero Calibration

A zero calibration can be performed manually by selecting the **Airway Zero** softkey in the Airway Gases/Ventilation task window or the Anesthetic Gas Module overview task window.

A zero calibration cannot be activated manually if:

1. The Anesthetic Gas Module is in Standby Mode.
2. The INOP message “EQUIP.MALF” is displayed.
3. No sample line is attached.
4. The Anesthetic Gas Module Selftest is running.
5. The Anesthetic Gas Module is warming up.
6. The Anesthetic Gas Module pump is off.
7. A zero calibration is running.

In these situations, the **Airway Zero** softkey is inactive. When pressed, the following information will be displayed on the monitor:

Status Message	Condition
"Airway Zero already ongoing"	If a zero calibration is already running.
"Gas Analyzer performing selftest, please wait"	If a selftest is running.
"Connect sample tube before starting zero"	If sample line is not attached.
"Press Airway Resume to resume gas monitoring"	If Anesthetic Gas Module is in Standby Mode.
"Airway Zero not allowed in this state"	In all other cases where a zero is not possible.

Zero Calibration Phases

1st Zero

INOP Message:	GAS AN. ZERO RUNNG
Wave:	Flat Wave
Numerics:	Displayed and accompanied with a "?"

If the first zero calibration fails, a second zero calibration is performed automatically.

2nd Zero

INOP Message:	GAS AN. ZERO RUNNG
Wave:	Flat Wave
Numerics:	Invalid and replaced by a -?-

If the second zero calibration fails, one of the following INOP messages is displayed on the monitor:

INOP Message	Status Message	Preferred Action
GAS AN. ZERO FAILED	*AGM: Check exhaust and press Airway Zero*	Check the exhaust and press **Airway Zero** to repeat the calibration.
GAS AN. ZERO FAILED	*AGM: Check altitude setting in Service Mode*	Contact your biomedical engineer or the Agilent Service Engineer.
GAS AN. ZERO FAILED	No Status Message	Press **Airway Zero** to repeat the calibration. If zero fails a second time, contact your biomedical engineer or the Agilent Service Engineer.
AGT-ID ZERO FAILED (AUTO)	*AGT-ID ZERO FAILED - Select Agent Manually*	Select the Agent manually. Press **Airway Zero** to repeat the calibration.
AGT-ID ZERO FAILED (MANUAL)	*AGT-ID ZERO FAILED*	Press **Airway Zero** to repeat the calibration. If the zero fails a second time, contact your biomedical engineer or the Agilent Service Engineer.
AGT-ID ZERO FAILED	No Status Message	Press **Airway Zero** to repeat the calibration. If the zero fails a second time, contact your biomedical engineer or the Agilent Service Engineer.
O_2 ZERO FAILED	No Status Message	Press **Airway Zero** to repeat the calibration. If the zero fails a second time, contact your biomedical engineer or the Agilent Service Engineer.

In these situations, monitoring will continue (possibly with reduced accuracy), waveforms are normal and a “?” is displayed for affected parameters.

Alarms and Zero Calibration

When a zero calibration is in progress, the patient's physiological alarm detection is frozen. When the calibration is finished, the AGM restarts breath detection. If an alarm condition is present after the zero calibration, the alarm will be activated within the specified alarm delay time.

Warning

If an Apnea occurs during a zero calibration, the time delay between the start of Apnea and the activation of the Apnea alarm could be up to 16 seconds plus the configured Apnea delay time.

Span Calibration

A check should be made once a year to see if it is necessary to perform a span calibration. Please consult your biomedical engineer.

Caution

This span calibration is a servicing task, and should only be carried out by suitably qualified personnel.

Alarms

The Anesthetic Gas Module alarm messages are rated in order of severity:

*** Red
** Yellow
INOP message

Alarm tone = a single chime repeated every second.
INOP tone = a single beep repeated every 2 seconds.

Note—Alarm limits are dependent on patient's condition.

Physiological Alarms

Alarm Message	Condition	Visual Indication	Audible Indication
CO_2			
***APNEA	Apnea - no breath detected in the selected delay time	AWRR numeric (0) blinks. Red alarm lamp.	Alarm tone
**AWRR 6< 8	AWRR is below low alarm limit.	AWRR numeric blinks. Yellow alarm lamp.	Alarm tone
**AWRR 35>30	AWRR high alarm limit has been exceeded.	AWRR numeric blinks. Yellow alarm lamp.	Alarm tone
**$ETCO_2$ 25< 30	$ETCO_2$ below low alarm limit (30 mm Hg).	$ETCO_2$ numeric blinks. Yellow alarm lamp.	Alarm tone
**$ETCO_2$ 55>50	The $ETCO_2$ high alarm limit (50 mm Hg) has been exceeded.	$ETCO_2$ numeric blinks. Yellow alarm lamp	Alarm Tone
**$IMCO_2$ 5>4	$IMCO_2$ high alarm limit (4 mm Hg) has been exceeded.	$IMCO_2$ numeric blinks. Yellow alarm lamp.	Alarm tone

Physiological Alarms

Alarm Message	Condition	Visual Indication	Audible Indication
O_2			
***inO_2 LOW OXYGEN	inO_2 below 18 vol.%	Red alarm lamp, inO_2 numeric blinks.	Alarm tone
**inO_2 18<20	inO_2 below low alarm limit (20 vol.%).	inO_2 numeric blinks. Yellow alarm lamp.	Alarm tone
**inO_2 90>80	inO_2 high alarm limit (80 vol.%) has been exceeded.	inO_2 numeric blinks. Yellow alarm lamp.	Alarm tone
**etO_2 55< 60	etO_2 below low alarm limit (60 vol.%).	etO_2 numeric blinks. Yellow alarm lamp.	Alarm tone
**etO_2 75>70	etO_2 high alarm limit (70 vol.%) has been exceeded.	etO_2 numeric blinks. Yellow alarm lamp.	Alarm tone
N_2O			
**inN_2O 90>82	inN_2O high alarm limit has been exceeded.	inN_2O numeric blinks. Yellow alarm lamp.	Alarm tone
Agent (AGT is HAL, ISO, ENF, SEV or DES)			
**inAGT 0.3<1.0	inAGT below low alarm limit(1.0 vol.%).	inAGT numeric blinks. Yellow alarm lamp.	Alarm tone
**inAGT 4.0>3.4	inAGT high alarm limit (3.4 vol.%) has been exceeded.	inAGT numeric blinks. Yellow alarm lamp.	Alarm tone
**etAGT 0.3<1.0	etAGT below low alarm limit(1.0 vol.%).	etAGT numeric blinks. Yellow alarm lamp.	Alarm tone
**etAGT 3.0>2.2	etAGT high alarm limit (2.2 vol.%) has been exceeded.	etAGT numeric blinks. Yellow alarm lamp.	Alarm tone

Technical Alarms

INOP messages appear when the monitor cannot measure or process signals properly. This could be due to patient-related or equipment-related problems but you must always check the patient's condition first. Some INOP messages are accompanied by an audible alarm which can be silenced with the **Silence/Reset** hardkey. The following table lists these messages in order of their priority.

INOP Messages

INOP Message	Monitor Response (Visual & Audible Indication)	Cause(s)	Possible Corrective Action
General INOPS			
GAS AN. STANDBY	No waves, no numerics, no tone	1) Manually activate by pressing **Airway Standby** 2) If no breath is detected for 4 hours and $ETCO_2$ is less than 4 mmHg for more tha one hour.	Press **Airway Resume** or disconnect and reconnect the bacterial filter/gas sample tube.
GAS AN. NOT AVAIL.	No wave, numerics replaced by -?-. INOP tone.	Anesthetic gas module is disconnected or switched off.	1. Check unit is switched on. 2. Check connection between AGM & monitor
GAS AN. EQUIP MALF	No wave, numerics replaced by -?-. INOP tone.	Module malfunction, e.g. device connected to wrong interface adaptor, zero failed twice.	1. Check RS232 Interface is set up correctly in the monitor's Service Mode. 2. Turn AGM on and off. If error persists, contact your Agilent Service Engineer.
GAS AN. SELFTEST	No wave, numerics replaced by -?-. No INOP tone.	Module is performing self-test (only displayed when the module is first switched on).	Wait until selftest is complete (approx. 2 minutes).
GAS AN. TUBE DISC	Flat wave, numerics replaced by -?-. INOP tone.	Gas sampling tube disconnected.	Check the gas sample tube connection.
GAS AN. OCCLUSION	Flat wave, numerics replaced by -?-. INOP tone.	Sample flow rate low due to kinked or occluded tubing, a blocked filter to the patient, or a failure of the intake pump.	Refer to the Occlusion Handling section later in this chapter.
GAS UNABLE TO MEAS	No wave, numerics replaced by -?-. INOP tone.	Gas analyzer delivers temporarily inconsistent data.	No user action required. The situation will correct itself after a few seconds.

INOP Message	Monitor Response (Visual & Audible Indication)	Cause(s)	Possible Corrective Action
GAS AN. ZERO RUNNG	First zero: no wave displayed, numerical data questionable (? displayed near label). On retry: no wave displayed, numerics replaced by -?- . No INOP tone for first zero, INOP tone with retry.	Autozero in progress. If first autozero fails then system will retry; if the retry fails then GAS AN. EQUIP MALF alarm is activated.	Wait until the zero is complete.
GAS AN. WARM UP	Waves displayed, but are not as accurate as after warm-up. Numerical data questionable (? displayed near label). No INOP tone.	Module is warming up and will measure with reduced accuracy until it reaches its operating temperature.	Wait a few minutes.
AWRR OVERRANGE	Wave displayed, numeric replaced by -?- . No INOP tone.	AWRR numeric > 60	No user action required.
GAS AN. ZERO FAILED	Waves displayed, numerics questionable - displayed with ?, no tone.	Analyzer reports that the last zero has failed.	1. Activate a zero manually. 2. Check exhaust tubing for a partial occlusion (refer to Occlusion Handling later in this chapter). 3. If the zero continues to fail, contact your Agilent Service Engineer.
GAS AN. ACCURACY?	Waves displayed, numerics questionable - displayed with ?, no tone.	Gas analyzer delivers data that is questionable.	No user action required. The situation will correct itself after a few seconds.

INOP Message	Monitor Response (Visual & Audible Indication)	Cause(s)	Possible Corrective Action
CO_2 specific INOPS			
GAS AN. NO BREATH	Wave displayed, $ETCO_2$, etO_2, etN_2O, and etAGT (AGT is replaced by the abbreviation for the selected gas) numerics replaced by -?-. The corresponding gas readings are displayed continuously for the inspired numerics. No INOP tone.	No breath can be detected.	1. Check the patient. 2. Check the inlet tubing.
CO_2 UNABLE TO MEAS.	Flat wave, numeric replaced by -?-. INOP tone.	Module unable to measure CO_2.	Wait a few seconds, the situation will correct itself.
CO_2 MEAS DISTURBED	CO_2 waves displayed, invalid in/$etCO_2$ numeric replaced by -?-, INOP tone.	in/$etCO_2$ measurement disturbed.	Wait a few seconds, the situation will correct itself.
CO_2 REDUCE SIZE	Wave and numeric displayed. No INOP tone.	Wave is larger than selected scale.	Change the wave size in the Airway CO_2 task window.
O_2 specific INOPS			
O_2 EQUIP MALF	No wave, no numeric. INOP tone.	O_2 option malfunction	Consult your Agilent Service Engineer.
O_2 ZERO FAILED	O_2 waves displayed, invalid etO_2 /inO_2 numerics replaced by -?-, INOP tone.	Last O_2 zero has failed.	1. Activate a zero manually. 2. Check exhaust tubing for a partial occlusion (refer to Occlusion Handling later in this chapter). 3. Make sure that the AGM anesthetic gas exhaust is set up correctly (refer to Anesthetic GAs Exhaust section later in this chapter). 4. If the zero continues to fail, contact your Agilent Service Engineer.
O_2 UNABLE TO MEAS.	Flat wave, numeric replaced by -?-. INOP tone.	Module unable to measure O_2.	Wait a few seconds, the situation will correct itself. If not, check that the AGM anesthetic gas exhaust is set up correctly (refer to Anesthetic Gas Exhaust section later in this chapter).

INOP Message	Monitor Response (Visual & Audible Indication)	Cause(s)	Possible Corrective Action
O_2 MEAS DISTURBED	Wave displayed, invalid in/etO_2 numeric replaced by -?-. INOP tone.	in/etO_2 measurement disturbed.	Wait a few seconds, the situation will correct itself.
O_2 REDUCE SIZE	Wave displayed, numeric replaced by -?-. No INOP tone.	Wave is larger than selected scale.	Change the wave size in the Airway O_2 task window.
N_2O specific INOPS			
N_2O UNABLE TO MEAS.	Flat wave displayed, numeric replaced by -?-. INOP tone.	Module unable to measure N_2O.	Wait a few seconds, the situation will correct itself.
N_2O MEAS DISTURBED	N_2O waves displayed, invalid etN_2O/inN_2O numeric replaced by -?- INOP tone.	in/etN_2O measurement disturbed.	Wait a few seconds, the situation will correct itself.

INOP Message	Monitor Response (Visual & Audible Indication)	Cause(s)	Possible Corrective Action
AGENT specific INOPS			
AGENT IDENT. MALF (Auto Mode: *Status Message* - AGENT IDENT. MALF - Select Agent manually)	No wave, no numeric (AUTO mode). Wave displayed but the numerical data questionable (? displayed near label) (Manual mode). INOP tone (AUTO mode), No INOP tone (Manual mode).	Only if agent identification is present. Agent identification option malfunction (INOP tone switches off when user manually selects the agent to be measured).	Select agent manually. If INOP appears repeatedly, consult your Agilent Service Engineer.
AGT ID ZERO FAILED (Auto Mode: *Status Message* - AGENT ID ZERO FAILED - Select Agent manually)	AGT waves displayed, no AGT numerics (AUTO mode). AGT waves and numerics displayed (Manual mode). INOP tone (AUTO mode), No INOP tone (Manual Mode)	The agent identification measurement reports a failed zero (INOP tone switches off when user selects the Agent manually).	Select agent manually. If INOP appears repeatedly, activate a zero manually and check exhaust tubing for a partial occlusion.
CHECK AGENT[1]	Wave displayed. Agent numerics replaced by -?-. INOP tone.	*Only if agent identification is present*. Agent selected manually differs from agent detected by the automatic agent identification function. **Or** no agent selected, but agent detected by the monitor.	Check correct agent is selected.
AGT UNABLE TO MEAS.	Flat Agent wave displayed, Agent numerics replaced by -?-. INOP tone.	Module unable to measure anesthetic agent.	Wait a few seconds, the situation will correct itself.
CHK AGT SELECTION	AGT Waves displayed, invalid etAGT/inAGT numerics replaced by -?-, INOP tone.	Agent output above range.	Check that agent administered to the patient is also selected on the monitor.
AGT MEAS RESTARTING	AGT wave displayed, invalid AGT numerics, no INOP tone.	Transition from agent overrrange	
AGT MEAS DISTURBED	AGT waves displayed, questionable numerics replaced by -?-. INOP tone.	in/etAGT measurement disturbed.	Wait a few seconds, the situation will correct itself.
GAS CONTAMINANT[1]	Wave displayed, numerical data questionable (? displayed near label). No INOP tone.	*Only if agent identification is present*. Module detects an unidentified gas contaminant.	Check breathing circuit for presence of interfering gases e.g. methane, ethanol, acetone or fluorocarbons in bronchodilators.

INOP Message	Monitor Response (Visual & Audible Indication)	Cause(s)	Possible Corrective Action
AGENT MIXTURE[1]	Wave displayed, numerical data is questionable (? displayed near label). No INOP tone.	*Only if agent identification is present*. Anesthetic mixture detected by module.	Check that only 1 agent is administered to the patient. INOP is displayed during changeover of one agent to another, message will eventually clear itself in this case.
AGT REDUCE SIZE	Wave and numerics displayed. No INOP tone.	Wave is larger than selected scale.	Change the wave size in the Airway agent task window.

[1]This INOP will not be triggered if a *manually* selected gas is not supported by the Agent ID feature.

Accessories and Ordering

13901A	Gas Sample Tube, 2.4m Nafion®
13902A	Airway Adapter, 15mm, (right angle)
M1612A	Airway Adapter (straight)
13904A	Bacterial Filters
13905A	Gas Sample Tube (hybrid)
1660B	Calibration Gas Assembly.
1659A	Calibration Tube Assembly
1015-40001	Gas Exhaust Scavenging Tubing.
M1656A	Gas Exhaust Return Filter.
M1655A	Gas Exhaust Return Line.

Performance Specifications

For safety and environmental specifications, please refer to the *Monitor Installation and Patient Safety* Chapter 11.

Note—A hazard analysis according to IEC 601-1-4 has been performed in the hardware and software development process.

Anesthetic Gas Module

All Performance and accuracy specifications are valid based on the following conditions:

- Gas sample tube used 2.4m Nafion® tubing (10% to 90% step response).
- Accuracy specifications refer to the following conditions:
  - BTPS for mmHg and kPa (CO_2 only).This corresponds to 37ºC body temperature, 95% relative humidity and 47mmHg pH_2O. The formula for calculation is as follows:

pCO_2 (mmHg) = CO_2vol% * (P_{abs} - 47) / 100

with:
pCO_2 = partial pressure
vol% = gas concentration
P_{abs} = absolute pressure

– STDP for vol% (for all other gases), and

– relative humidity of 40% - 60%.

Sample Flow Rate:
120 ml/min.

Sample Delay Time:
All measurements and alarms are subject to a delay of 3 seconds.

Total System Response Time:
The total system response time is the sum of the delay time (see above) and the rise time (see below).

CO_2 Measurement

Range:	0 to 76 mmHg
Accuracy:	1.5 mmHg (0 - 40 mmHg) 2.5 mmHg (40 - 60 mmHg) 4.0 mmHg (60 - 76 mmHg)
Resolution:	1 mmHg
Rise-time:	360 msec typical.

AWRR derived from CO_2 Waveform

Range:	0 to 60 rpm
Accuracy:	$\pm$ 2 rpm
Resolution:	1 rpm
Detection criteria:	6 mmHg variation in CO_2.

N_2O Measurement

Range:	0 to 85 vol%
Accuracy:	1.5 vol% + 5% relative
Resolution:	1 vol%
Rise-time:	450 msec typical.

O_2 Measurement

Range:	0 to 100 vol%
Accuracy:	2.5 vol% or 5% relative, which ever is greater
Resolution:	1 vol%
Rise-time:	450 msec typical.

Anesthetic Agent Measurement

Agent	Range (vol%)	Accuracy	Resolution	Rise-Time (msec)
Halothane	0 - 7.5	0.2 vol% + 4.0% relative	0.05	< 650
Enflurane	0 - 7.5	0.1 vol% + 4.0% relative	0.05	< 600
Isoflurane	0 - 7.5	0.1 vol% + 4.0% relative	0.05	< 500
Sevoflurane	0 - 9.0	0.1 vol% + 4.0% relative	0.05	< 500
Desflurane	0 - 20.0	0.1 vol% + 6.0% relative	0.05 (0-10) 0.1 (10.1 - 20)	< 500

Automatic Agent Identification

Agent ID Response Time 15 s

Gas Exhaust Return Line Measurements

Positive Inspired Pressure(PIP): up to 70cm H_2O

Respiration Rate: 0-60/minute

Alarms

Gas	High Range	Low Range
AWRR	1 - 60 rpm	0 - 59 rpm
$ETCO_2$	12 - 80 mmHg	10 - 78 mmHg
$IMCO_2$	0.0 - 20 mmHg	none
inN_2O	0.0 - 82 vol%	none
etO_2	1.0 - 100 vol%	0.0 - 99 vol%
inO_2	19 - 100 vol%	18 - 99 vol%
et SEV	0.1 - 9.0 vol%	0.0 - 8.9 vol%
in SEV	0.1 - 9.0 vol%	0.0 - 8.9 vol%
et DES	0.2 - 20.0 vol%	0.0 - 19.8 vol%
in DES	0.2 - 20.0 vol%	0.0 - 19.8 vol%
Halothane, Enflurane, Isoflurane		
et	0.1 - 7.5 vol%	0.0 - 7.4 vol%
in	0.1 - 7.5 vol%	0.0 - 7.4 vol%

Alarm Delay:
15 seconds if no automatic zero calibration occurs within that time.

Apnea Alarm:

Delay Range:	10 - 40 seconds
Criterion:	No detected breath within the adjusted delay time.
Alarm:	within 2 seconds after this criterion is met, if no automatic zero occurs.

INOP Alarms:
Refer to the Patient and Equipment related INOP tables in this chapter.

Care and Cleaning

Anesthetic Gas Module

Refer to the *General Cleaning of the System* section in the *Maintenance* chapter of this manual for details on cleaning the Anesthetic Gas Module.

Note—Do not allow disinfectants or their fumes to get into the inside of the Anesthetic Gas Module through the tubing, as this could cause damage to the module.

Accessories

The tables below describe the replacement and cleaning procedures for the Anesthetic Gas Module Accessories.

Replacement Procedures

Accessories	Usage Recommendation	Replacement Procedure
Inlet Bacterial Filter:		Single patient use only.
Nafion® Gas Sample Tube:	Recommended for all cases. In particular, for humid or long cases.	Reusable, may be cleaned twice.
Hybrid Gas Sample Tube:	Recommended if tube needs to be disposed of at the end of a case.	Single patient use only.
Airway Adapters: (Right Angle or Straight)		Single patient use only.
Gas Exhaust Return Filter:		Single patient use only.
Gas Exhaust Return Line:		Tubing is reusable; need only be replaced if it is damaged or if the connectors are loose.

Cleaning Procedures

Accessories	Cleaning Procedure
Inlet Bacterial Filter:	Do not attempt to sterilize or clean it.
Nafion® Gas Sample Tube:	For the cleaning procedure of the Nafion® gas sample tube, you will need the following: • Distilled water • Citric Acid mix (concentration of 35g/100ml) • Container - large enough to submerge the tube Syringe (50ml). **Procedure:** 1. Flush the tube with 50ml of distilled water to clean out debris that may have collected in the tube. 2. Flush the tube with 50ml of the citric acid mix. 3. Soak the tube in the citric acid mix for 20 minutes. Ensure that the tube is completely submerged during this time. 4. Flush the tube again with 50ml of the citric acid mix. 5. Flush the tube with 200ml (minimum) of distilled water to remove any remaining citric acid mix from the tube. 6. Blow air through the tube using an air-filled syringe to remove any remaining water from the tube. Do **not** use high pressure air. 7. Leave the tube to dry for a minimum of 1 hour before re-use.
Hybrid Gas Sample Tube:	Do not attempt to sterilize or clean it.
Airway Adapters: (Right Angle or Straight)	Do not attempt to sterilize or clean them.

Accessories	Cleaning Procedure
Gas Exhaust Return Filter:	Do not attempt to sterilize or clean it.
Gas Exhaust Return Line:	**Cleaning:** Dampen a cloth with a solution of warm water and soap and wipe the tubing clean. Do not immerse or soak the tubing. **Disinfecting:** Dampen a cloth with a cold chemical disinfectant (Aldehyde based derivative, Alcohol or alcohol based derivative) and wipe the tubing clean. Do not immerse or soak the tubing. After cleaning, remove disinfectant with a damp cloth and dry with a clean cloth.

Occlusion Handling

Inlet Occlusion:

This type of occlusion occurs when the inlet accesories (filter, sample line, airway adapter) become blocked or kinked.

If an occlusion is present at the inlet, the following information is displayed on the screen:

INOP Message:	GAS AN. OCCLUSION
Status Message:	*AGM: Check gas inlet accessories*
Waves:	Displayed
Numerics:	Invalid and replaced by a -?-

The preferred action for removing this type of occlusion is as follows:

Check the inlet accessories for an occlusion:

a. Replace the inlet bacterial filter

b. Check the sample tube for an occlusion and/or kinking and replace if necessary.
c. Check the airway adapter for the build up of water.
Empty the fluid and reposition the adapter if necessry.
Ensure that the airway adapter port is facing upwards.

Exhaust Occlusion

This type of occlusion occurs when the exhaust accessories (closed loop kit or scavenging tubing) become blocked or kinked.

This condition can only be detected during a zeero calibration. If a partial occlusion is present at the outlet, the calibration is aborted prematurely and the following information is displayed on the screen:

INOP Message:	GAS AN. ZERO FAIL
Status Message:	*AGM: Check exhaust and press Airway Zero*
Waves:	Displayed
Numerics:	Displayed and accompanied with a "?"

The preferred action for removing this type of occlusion is as follows:

Step 1. Check the exhaust accesories for an occlusion:

a. Replace the exhaust bacterial filter if necessary
b. Check the exhaust tube for an occlusion or kinking and replace if necessary.

Step 2. Press **Airway Zero** in the Airway Gases/Ventilation task window to perform a zero calibration.

General Occlusion

This type of occlusion occurs when either the inlet or the exhaust accessories become blocked or kinked.

If an occlusion is present at the inlet or the outlet, the following information is displayed on the screen:

INOP Message:	GAS AN. OCCLUSION
Status Message:	*AGM: Check exhaust and inlet accessories*
Waves:	Displayed
Numerics:	Invalid and replaced by a -?-

The preferred action for removing this type of occlusion is as follows:

Check the outlet accessories first for the presence of an occlusion and replace if necessary. If this is insufficient, check the inlet accessories for the presence of an occlusion and replace if necessary.

Internal Occlusion

This type of occlusion occurs when the Anesthetic Gas Module becomes contaminated internally.

If an occlusion is present internally, one of the following INOP messages is displayed on the screen:

INOP Message:	GAS AN. OCCLUSION
Status Message:	*AGM: Check gas inlet accessories*
INOP Message:	GAS AN. ZERO FAIL
Status Message:	*AGM: Check exhaust and inlet accessories*
INOP Message:	GAS AN. OCCLUSION
Status Message:	*AGM: Check exhaust and inlet accessories*

The preferred action for removing this type of occlusion is as follows:

Step 1. Follow the ususal procedure for removing an occlusion from the inlet or exhaust accessories.

Step 2. If this is not successful, press **Airway Zero** in the Airway Gases/Ventilation task window to perform a zero calibration. If the zero fails or an occlusion INOP message continues to be displayed on the screen, the presence of an internal occlusion is likely. In this situation, contact your biomedical engineer or the Agilent Service Engineer.

Section II:
The Anesthetic Gas Module – Option A02 & A05

This section describes the Anesthetic Gas Module – Options A02 & A05. It contains information about the Watertrap and Standard Gas Sample Tube solution for the M1026A Anesthetic Gas Module.This section includes the following subsections:

Introduction to the Anesthetic Gas Module (Watertrap Version)

What does it measure?

The M1026A Anesthetic Gas Module (AGM) measures the anesthetic and respiratory gases of a patient under anesthesia. The module provides the end tidal (et) and inspired (in) values of the following gases:

Carbon Dioxide (CO_2). The values measured are $IMCO_2$ (inspired minimum - the smallest value sensed during respiration), and $ETCO_2$ (end tidal - the maximum expired value sensed during respiration).

- Nitrous Oxide (N_2O).
- Oxygen (O_2) - as an optional feature.
- Airway Respiration Rate (AWRR) - in respirations per minute (rpm).

Anesthetic Agents

- Halothane
- Isoflurane
- Enflurane
- Sevoflurane
- Desflurane.

Note—The values for only *one* anesthetic agent can be displayed at any one time.

In addition, the module can calculate and display the differences between inspired and expired gas values listed below:

- in-et N_2O
- in-et O_2
- in-et Anesthetic Agent.

Automatic Agent Identification

The Watertrap Version of the AGM is available in two different options:

- Option A02 - w/ 3-Agent Identification
- Option A05 - w/ 5-Agent Identification

For details please refer to “Automatic Agent Identification” on page 26-77.

How the Gas Measure-ment Works

The Anesthetic Gas Module uses a technique called *Non-Dispersive Infra-red Gas Concentration Measurement* (NDIR) to measure the concentration of certain gases.

This works as follows:

- The gases which can be measured by the Anesthetic Gas Module absorb infrared (IR) light.
- Each gas has its own absorption characteristic. The gas is transported into a sample cell, and an optical IR filter selects a specific band of IR light to pass through the gas. For multiple gas measurement, such as in the Anesthetic Gas Module, there are multiple IR filters.
- The higher the concentration of gas in a given volume the more IR light is absorbed. This means that higher concentrations of IR absorbing gas cause a lower transmission of IR light.
- The amount of IR light transmitted after it has been passed through an IR absorbing gas is measured.
- From the amount of IR light measured, the concentration of gas present can be calculated. This calculation provides the gas measurement value.

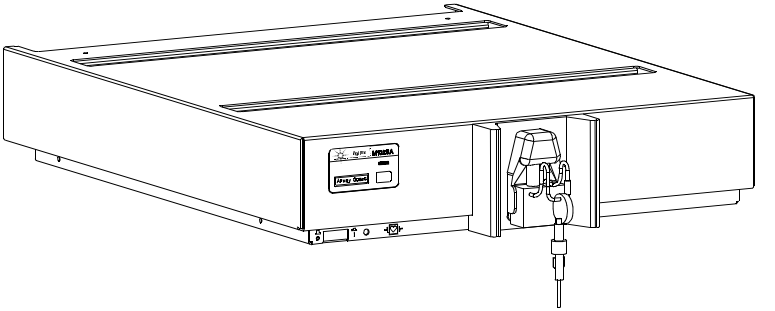
How fluids are removed from the gas sample

A watertrap (including a water separation filter) mounted on the front panel of the Anesthetic Gas Module prevents water and other fluids from passing into the Anesthetic Gas Module and causing contamination and/or internal occlusions. This system consists of a water reservoir, in which fluids are collected and a water separation filter that protects internal components.

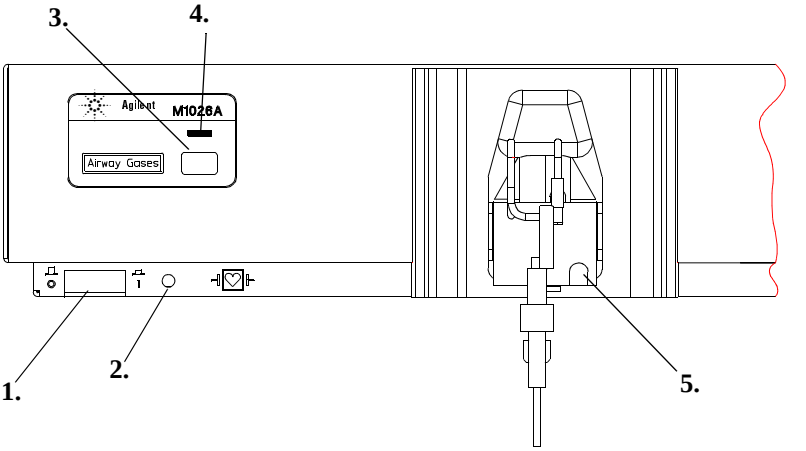
Front Panel of the Anesthetic Gas Module

The controls and connectors on the front panel of the module are described below.

Anesthetic Gas Module Front View



Anesthetic Gas Module Front Panel

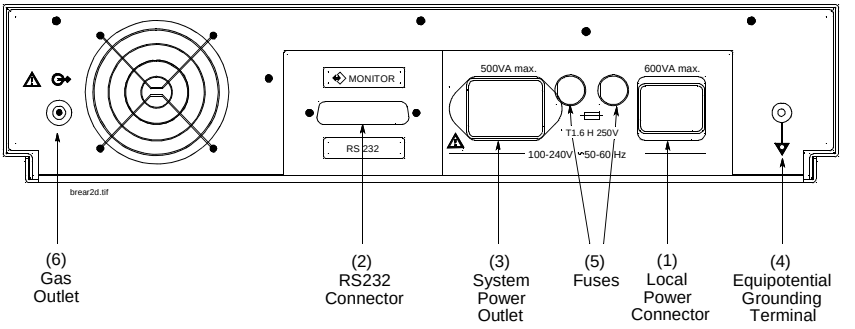


The front of the module has:

1. Power on/off switch.
2. Power light which is illuminated when the module is switched on.
3. Parameter setup key.
4. Setup light which is illuminated when:
   a. You are in Setup Mode.
   b. For 5 - 10 seconds when the module is first switched on
   c. There is no communication for 60 seconds, or communication has been aborted between the Anesthetic Gas Module and the monitor.
   d. The light blinks if a malfunction occurs but communication is still possible for further diagnosis in a special Service Mode. In this situation, contact your biomedical engineer or the Agilent Service Engineer.
5. Watertrap housing to which the watertrap connects.

Rear Panel of the Anesthetic Gas Module

The controls and connectors on the rear panel of the module are described below.



The rear of the module has:

1. Local power connector.
2. RS232 Connector (Interface).
3. System Power outlet.
4. Equipotential Grounding Terminal.
5. Line protection fuses.
6. Anesthetic gas exhaust.

Anesthetic Gas Module Setup

What you need

You will need the following items to setup the Anesthetic Gas Module for use:

Item	Part No	Comments
Anesthetic Gas Module	M1026A	Installed to work with your CMS or V24/26.
Gas Sample Tube (2.6m)	M1658A	Connects to the water separation filter.
Watertrap	M1657A	Contains a water reservoir and water separation filter. Attaches to the watertrap housing on the front panel.
Airway Adapter(s)	13902A or M1612A	Right angle or Straight. Built-in port extending from adapter wall to reduce risk of water or fluids from passing into the gas sample tube. Connects to the gas sample tube.

For a complete list of Anesthetic Gas Module accessories, please refer to *Accessories* later in this section. For information on the replacement of accessories, please refer to *Care and Cleaning* later in this section.

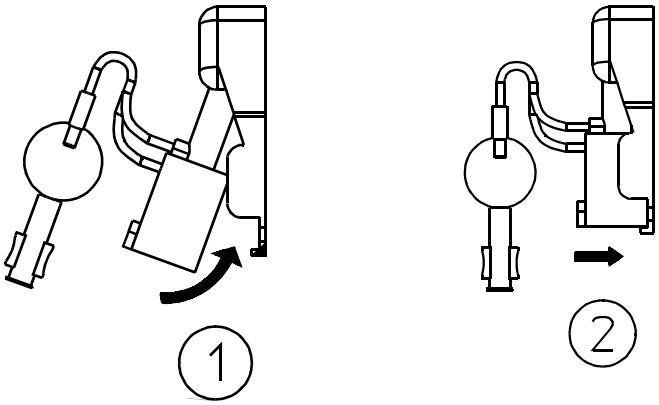
Caution

- Use only the Agilent accessories listed above. The use of alternative accessories risks the performance of your Anesthetic Gas Module.
- Do not use the gas sample tube if it is kinked, as it will cause an occlusion or leakage.
- Use an Agilent Airway Adapter to prevent condensed water from passing into the gas sample tube and causing a blockage. Additionally, the airway adapter has a built in port extending from the adapter wall. This further reduces the risk of a blockage occurring.

- Do not apply excessive pressure to the AGM e.g. from a syringe, as this may cause damage to the pneumatic and optical systems.

Setup

1. Insert a watertrap into the watertrap housing by gently pushing it up and in.



Caution

To minimize the risk of internal contamination, never leave the Anesthetic Gas Module running without a watertrap attached (except during the exchange of a watertrap).

Notes—

- To avoid condensed water collecting in the gas sample tube, it is recommended that you position your Anesthetic Gas Module at or above the patient level.
- Do not set up the Anesthetic Gas Module in a position where liquid could spill onto it

2. Switch on the Anesthetic Gas Module by pressing the power-on switch. This allows time for the module to warm up while connections to the patient are being made.
   - The power-on switch is on the left hand side of the front panel.
   - The power light next to the switch is illuminated when the module is switched on.

   The green INOP messages described in the following table are displayed in the top left hand corner of the display before the Anesthetic Gas Module is ready for patient monitoring.

Switching On the Anesthetic Gas Module

Step	INOP Message	Duration of INOP Message	Anesthetic Gas Module Activity
1.	no message displayed	5 seconds	a. Module has just been switched on. b. Parameter set-up light is illuminated. c. Not in patient monitoring mode. d. No waveforms or numerics are displayed.
2.	no message displayed	up to 2 mins.	a. Module is in selftest mode. b. Parameter set-up light is not illuminated. c. Not in patient monitoring mode. d. No waveforms or numerics are displayed.
3.	GAS AN. WARMUP	up to 8 mins.	a. Module is in warm-up mode. b. Airway gases from the patient are being measured, but with reduced accuracy. c. Waveforms and numerics are displayed. d. User can call up the Task Window. e. Small ? displayed in front of the parameter name. This means that the numerical data is questionable.

3. Connect the gas sample tube to the water separation filter.

Warning

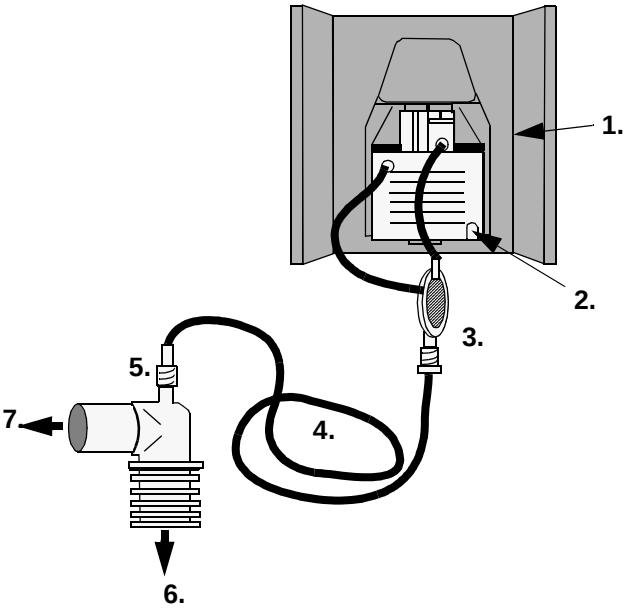
Ensure that the connections are tight when fitting the tube. Any leak in the system can result in erroneous readings due to ambient air mixing with patient gases.

4. Connect the other end of the gas sample tube to the patient via the airway adapter.

Caution

The airway adapter must be positioned so that the part connecting to the gas sample tube is pointing upwards (see figure below). This prevents condensed water from passing into the gas sample tube and causing an occlusion.

Setting Up the Anesthetic Gas Module.



1. Watertrap Housing
2. M1657A Watertrap
3. Water Separation Filter
4. M1658A Gas Sample Tube
5. 13902A/M16112A Airway Adapter
6. Connects to patient
7. Connects to anesthesia machine.

Detecting and Preventing Leaks

Warning

Any leak in the tubing and connections from the patient to the M1026A Anesthetic Gas Module may result in dilution of the gas mixture with ambient air. If this leak exceeds a certain magnitude, the value of CO_2 and anesthetic agents displayed on the monitor may be significantly lower than the actual concentration in the patient's breathing circuit. Erroneously low values may lead to inappropriate intervention and patient safety may be at risk. To detect and prevent leaks in the tubing follow the instructions below:

1. **Carefully inspect the tubing and connections from the patient to the M1026A Anesthetic Gas Module (including the watertrap for damage or leakage.**
2. **Avoid any unnecessary mechanical stress to the tubing of the M1657A watertrap.**
3. **If an unexpected low gas concentration value appears on the gas monitor, repeat the visual inspection of the entire tubing (see 1. above). If no leakage can be found, please confirm the low value by replacing the watertrap with a new one.**

Anesthetic Gas Exhaust

If N_2O and/or other inhalation anesthetics are used during anesthesia, pollution of the operating room should be prevented. Once the gas sample has passed through the Anesthetic Gas Module, it should either be *returned to* or *removed from* the anesthesia circuit.

What you need to return the gas sample

You will need the following equipment to *return* the gas sample to the anesthesia circuit:

Equipment Required

Equipment	Part No	Comments
Gas Exhaust Return Line	M1655A[a]	Tubing includes 2 parts: • Tube A = 50cm long. • Tube B = 3m long.
Gas Exhaust Return Filter	M1656A[a]	Single patient use only. See Caution note below.

a. Not available in the U.S.

Caution

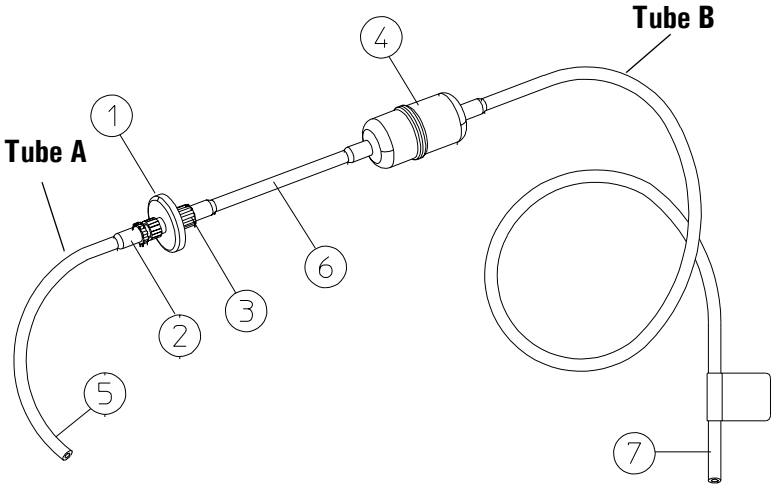
Always use an M1656A Gas Exhaust Return Filter before returning the gas sample to the patient circuit.

For information on the replacement of accessories, please refer to *Care and Cleaning* later in this section.

Setup

(see diagram below)

1. Fit the *female* connector (2) of **Tube A** (5), to the *male* side of the M1656A Gas Exhaust Return Filter.
2. Fit the *male* connector (3) of **Tube B** (6), to the *female* side of the M1656A Gas Exhaust Return Filter.
3. Fit the open end (7) of **Tube B** to the Anesthetic Gas Module outlet.
4. Fit the open end (5) of **Tube A** to the ventilation circuit.



Gas Exhaust Return Line

1. M1656A Gas Exhaust Return Filter
2. Female connector of Tube A
3. Male connector of Tube B
4. Dampener
5. Tube A (shorter tube) - connects to ventilator circuit.
6. Tube B (longer tube)
7. open end of Tube B (longer tube) - connects to AGM.

What you need to remove the gas sample

To *remove* the gas sample from the anesthesia circuit, a scavenging system needs to be connected to the Anesthetic Gas Module. If you intend to use a scavenging system with the Anesthetic Gas Module, the following parts must also be connected to prevent the module from malfunctioning:

- an Agilent Gas Exhaust Scavenging Tube (M1015-40001),
- a Ventilator Reservoir where the suction pressure does not exceed 0.3-0.4mm Hg *or*
- a Scavenging Interface.

Anesthetic Gas Module Standby Mode

The user can manually suspend gas monitoring by activating the Anesthetic Gas Module Standby Mode. This in turn, is synchronized with the CMS and V24/26 Standby Mode, for example:

Scenario/Condition	Result
1. If the monitor enters standby mode:	the AGM standby mode is automatically **activated**.
2. If the monitor leaves standby mode:	the AGM standby mode is automatically **deactivated**.
3. If the AGM standby mode is already activated when the monitor enters standby mode:	The AGM standby mode remains activated when the monitor leaves standby mode.
4. If the monitor standby mode is not activated when the AGM enters standby mode:	the monitor will remain in monitoring mode. Monitor standby mode is not activated.

The Anesthetic Gas Module Standby Mode is activated/deactivated in the Airway Gases/Ventilation overview task window. To enter the task window press **Module Setup** followed by **Airway Gases**

- To *enter* Standby, press **Airway Standby**.
- To *leave* Standby Mode, press **Airway Resume**.

During standby, the Anesthetic Gas Module intake pump is automatically switched off and all Anesthetic Gas Module parameters disappear from the display and are marked as **OFF** in the Parameters On/Off task window. The following INOP message is displayed on the monitor:

GAS AN. STANDBY

If an airway gas parameter is switched **ON** manually during this time, the Anesthetic Gas Module standby mode is automatically deactivated and the selected parameters become active.

Automatic Switch to Standby Mode

The Anesthetic Gas Module parameters **automatically** disappear from the display if the Anesthetic Gas Module intake pump switches off. This occurs in order to maintain the life of the pump and to avoid long term failure.

The Anesthetic Gas Module intake pump is **automatically** switched off and Standby Mode is activated if:

- No breath is detected for 4 hours and
- ETCO2 is less than 4 mmHg for more than 4 hours.

To resume monitoring, do one of the following:

1. **deactivate** the Anesthetic Gas Module Standby Mode by pressing **Airway Resume** in the Airway Gases/Ventilation task window.

   OR

2. **disconnect** the bacterial filter and **reconnect** it again.

Using the Anesthetic Gas Module during a Cardiopulmonary Bypass

During a cardiopulmonary bypass, the anesthesiologist may cease periodic mechanical ventilation. In these cases, it is important to note that an active Anesthetic Gas Module will continue to suck gases from the patient-ventilator circuit during that time. This will cause the airway pressure to drop if no active measures are taken to keep the patient-ventilator circuit stable. To stop the Anesthetic Gas Module from sucking gases, do one of the following:

- **activate** the AGM Standby Mode and/or
- **disconnect** the sample line either:
  a. from the Anesthetic Gas Module *or*
  b. from the patient-ventilator circuit

To continue measuring the airway gases do one of the following:

- **deactivate** the AGM Standby Mode and/or
- **reconnect** the sample line either:
  a. to the Anesthetic Gas Module *or*
  b. to the patient-ventilator circuit

Screen Display

Main Screen

In the standard display, you can display the following data:

1. Up to **3 waveforms**: CO_2, Anesthetic Agent, and O_2 (optional)
2. Up to **3 large format numerics** associated with the waveforms
3. **All remaining numeric**s (except i-e difference).

Note— It is only possible to display the waveform and numerics of *one* anesthetic agent at any one time.

Automatic Parameter Switch Off

The Anesthetic Gas Module parameters **automatically** disappear from the display if the intake pump on the Anesthetic Gas Module switches off. This occurs in order to maintain the life of the pump and to avoid long term failure.

The intake pump on the Anesthetic Gas Module is **automatically** switched off if:

- No breath is detected for 4 hours or longer and/or
- $ETCO_2$ is less than 4 mmHg for more than 4 hours.

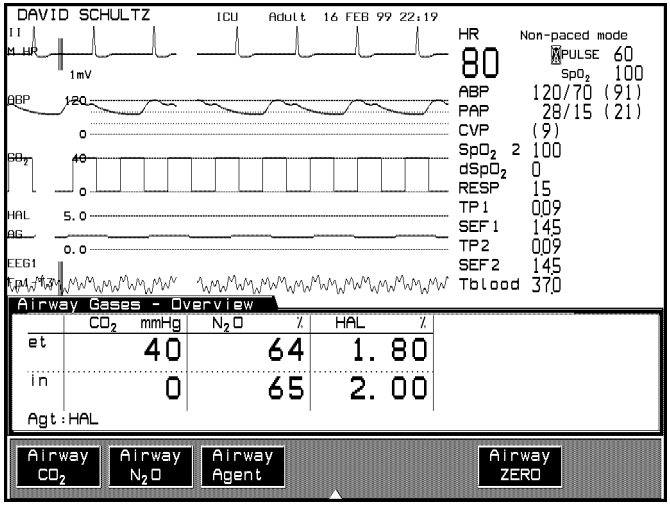
To reactivate monitoring, go to the parameter on/off window and switch all gas parameters on, or switch the Anesthetic Gas Module off and then on again

The Overview Task Window

This Task Window displays numerics of all gases being measured by the Anesthetic Gas Module in tabular format.

Accessing

You can access the Overview Task Window by pressing the setup key on the Anesthetic Gas Module.



Airway Gases Overview Task Window - Example

The Airway Gas Task Windows

Each gas being measured has its own Task Window which displays the following:

- Waveform.
- in and et numerics.
- in-et difference value (except CO_2, which displays AWRR)
- Alarm limits.

The N_2O waveform can **only** be viewed in the Airway N_2O Task Window.

Notes—

- If you suspect that the values displayed on the screen may be inaccurate, check the watertrap and gas sample tube for damage and/or an occlusion.
- If the waves appear to be flatter than normal, check the watertrap and tubing for leakages and occlusions and replace if necessary. If the condition continues, contact your biomedical engineer or Agilent Service Engineer.

Automatic Agent Identification

The Anesthetic Gas Module automatically detects the predominant anesthetic gas from a set of anesthetic agents and instructs the gas analysis functions to measure the concentration of that agent.

Option A02 - 3-Agent-Identification

The module in its standard configuration is able to automatically detect one agent out of the following:

- Halothane
- Isoflurane
- Sevoflurane or Desflurane

Option C01

Alternatively, Option C01 allows the Anesthetic Gas Module to detect one agent out of the following:

- Halothane
- Isoflurane
- Enflurane

Option A05 - 5-Agent-Identification

With 5-Agent-Identification, the module is able to automatically detect one agent out of the following:

- Halothane
- Enflurane
- Isoflurane
- Sevoflurane
- Desflurane

Selecting an Anesthetic Agent

An anesthetic agent can be identified automatically or selected manually for measurement. To select automatic agent identification (the default), do the following:

1. Access the Airway Agent Task Window
2. Press **Select Agent**
3. Select the **AUTO** softkey in the select agent list. The agent identification feature automatically identifies which agent out of 3 (or 5 if you have option A05) has the highest concentration and selects it for measurement, provided its concentration is above the relevant threshold. If no agent is detected, the label AGT is displayed.
4. Press **Main Screen** .

To Manually select an anesthetic agent, do the following:

1. Access the Airway Agent Task Window
2. Press **Select Agent**
3. Select the agent you wish to measure, for example:
   ISO for isoflurane or
   None if no specific anesthetic agent is being measured. In this case the label AGT appears instead of an agent label.
4. Press **Main Screen** .

Note—As long as the label AGT appears on the monitor, the numerics displayed may not reflect the actual concentration values of the agent administered to the patient.

Agent Thresholds

In order for an anesthetic agent to be detected by automatic agent identification, its concentration must exceed the relevant threshold.

Exchanging Agents

If the anesthetic agent administered to the patient changes, a few minutes pass whereby a mixture of both gases is detected by the Anesthetic Gas Module until the exchange is complete. The exact amount of time needed until the exchange is complete depends on:

- the type of anesthesia (low flow or high flow)
- the agents administered and how long these agents have been administered. (Pharmacokinetics)

When one agent is exchanged with another, the following information is displayed on the monitor:

INOP Message:	**AGT MIXTURE**
Wave:	Displayed
Numerics:	Displayed together with a "?"
Labels:	If Automatic Agent ID is selected, the old agent label is automatically replaced with the new agent label. If Automatic Agent ID is *not selected*, the old agent label remains displayed and the INOP message AGT MIXTURE is followed by a second INOP message; CHECK AGENT. To display the correct agent label, select the agent manually.

The INOP message AGT MIXTURE and the "?" next to the numerics disappear, when one of the agents decreases below the relevant threshold for mixtures and the other agent predominates. The exchange is then complete.

Note—The presence of other substances in the patient such as methanol or acetone can influence the agent identification and lead to incorrect values and incorrect identification.

Emergence from Anesthesia

If Automatic Agent Identification is selected during emergence from anesthesia and the agent concentration falls below its threshold (see above), the agent will no longer be identified. In this case the AGT label will be displayed on your monitor. To display the correct agent and value, select the agent manually.

Note—As long as the label AGT appears on the monitor, the numerics displayed may not reflect the actual concentration values of the agent administered to the patient.

Oxygen (O_2) Measurement (Optional)

O_2 measurement is an optional feature (Option #C03), enabling the measurement of inspired and end-tidal O_2.

To see if you have O_2 measurement:

1. Access the **Airway Gases** overview Task Window.
2. Look for the **Airway O2** Task Window selection key
3. If there is no O_2 selection key then your Anesthetic Gas Module does not have the O_2 measurement feature.

If you require this feature, please consult your biomedical engineer.

The O_2 analyzer uses a fast O_2 measurement technique, which takes advantage of O_2 paramagnetism. Two sealed spheres of a dumb-bell assembly are suspended in a symmetrical non-uniform magnetic field. Due to the dumb-bell's diamagnetic properties, it orients itself away from the most intense part of the field.

When the gas surrounding the dumb-bell contains a paramagnetic gas such as O_2, the dumb-bells are pushed even further out of the magnetic field by the relatively stronger paramagnetic O_2. The magnitude of the torque acting on the dumb-bell is proportional to the paramagnetism of the surrounding gases, and therefore the concentration of oxygen.

Calibration

Zero Calibration

The Anesthetic Gas Module automatically performs a zero calibration to ensure the gas measurements maintain the highest accuracy. The zero calibration is performed automatically on the Anesthetic Gas Module and, if required, manually by the user. It takes about 15 seconds to complete and may not be suspended at any time.

Automatic zero calibration

The zero calibration is performed automatically after the module has been switched on at the following intervals:

- 8, 15, 30, 45 and 90 minutes
- and then every 8 hours after each subsequent zero calibration.
- when a drift of the measurement is detected, the calibration is performed regardless of the time since the last zero calibration.

Manual Zero Calibration

A zero calibration can be performed manually by selecting the **Airway Zero** softkey in the Airway Gases/Ventilation task window or the Anesthetic Gas Module overview task window.

A zero calibration cannot be activated manually if:

1. The Anesthetic Gas Module is in Standby Mode.
2. The INOP message “EQUIP.MALF” is displayed.
3. The Anesthetic Gas Module Selftest is running.
4. The Anesthetic Gas Module is warming up.
5. The Anesthetic Gas Module pump is off.
6. A zero calibration is running.

In these situations, the **Airway Zero** softkey is inactive. When pressed, the following information will be displayed on the monitor:

Status Message	Condition
"Airway Zero already ongoing"	If a zero calibration is already running.
"Gas Analyzer performing selftest, please wait"	If a selftest is running.
"Connect sample tube before starting zero"	If sample line is not attached.
"Press Airway Resume to resume gas monitoring"	If Anesthetic Gas Module is in Standby Mode.
"Airway Zero not allowed in this state"	In all other cases where a zero is not possible.

Zero Calibration Phases

1st Zero

INOP Message:	GAS AN. ZERO RUNNG
Wave:	Flat Wave
Numerics:	Displayed and accompanied with a "?"

If the first zero calibration fails, a second zero calibration is performed automatically.

2nd Zero

INOP Message:	GAS AN. ZERO RUNNG
Wave:	Flat Wave
Numerics:	Invalid and replaced by a -?-

If the second zero calibration fails, one of the following INOP messages is displayed on the monitor:

INOP Message	Status Message	Preferred Action
GAS AN. ZERO FAILED	*AGM: Check exhaust and press Airway Zero*	Check the exhaust and press **Airway Zero** to repeat the calibration.
GAS AN. ZERO FAILED	*AGM: Check altitude setting in Service Mode*	Contact your biomedical engineer or the Agilent Service Engineer.
GAS AN. ZERO FAILED	No Status Message	Press **Airway Zero** to repeat the calibration. If zero fails a second time, contact your biomedical engineer or the Agilent Service Engineer.
AGT-ID ZERO FAILED (AUTO)	*AGT-ID ZERO FAILED - Select Agent Manually*	Select the Agent manually. Press **Airway Zero** to repeat the calibration.
AGT-ID ZERO FAILED (MANUAL)	*AGT-ID ZERO FAILED*	Press **Airway Zero** to repeat the calibration. If the zero fails a second time, contact your biomedical engineer or the Agilent Service Engineer.
AGT-ID ZERO FAILED	No Status Message	Press **Airway Zero** to repeat the calibration. If the zero fails a second time, contact your biomedical engineer or the Agilent Service Engineer.
O_2 ZERO FAILED	No Status Message	Press **Airway Zero** to repeat the calibration. If the zero fails a second time, contact your biomedical engineer or the Agilent Service Engineer.

In these situations, monitoring will continue (possibly with reduced accuracy), waveforms are normal and a “?” is displayed for affected parameters.

Alarms and Zero Calibration

When a zero calibration is in progress, the patient's physiological alarm detection is frozen. When the calibration is finished, the AGM restarts breath detection. If an alarm condition is present after the zero calibration, the alarm will be activated within the specified alarm delay time.

Warning

If an Apnea occurs during a zero calibration, the time delay between the start of Apnea and the activation of the Apnea alarm could be up to 16 seconds plus the configured Apnea delay time.

Span Calibration

A check should be made once a year to see if it is necessary to perform a span calibration. Please consult your biomedical engineer.

Caution

This span calibration is a servicing task, and should only be carried out by suitably qualified personnel.

Alarms

The Anesthetic Gas Module alarm messages are rated in order of severity:

*** Red
** Yellow
INOP message

Alarm tone = a single chime repeated every second. INOP tone = a single beep repeated every 2 seconds.

Note—Alarm limits are dependent on patient's condition.

Physiological Alarms

Alarm Message	Condition	Visual Indication	Audible Indication
CO_2			
***APNEA	Apnea - no breath detected in the selected delay time	AWRR numeric (0) blinks. Red alarm lamp.	Alarm tone
**AWRR 6< 8	AWRR is below low alarm limit.	AWRR numeric blinks. Yellow alarm lamp.	Alarm tone
**AWRR 35>30	AWRR high alarm limit has been exceeded.	AWRR numeric blinks. Yellow alarm lamp.	Alarm tone
**$ETCO_2$ 25< 30	$ETCO_2$ below low alarm limit (30 mm Hg).	$ETCO_2$ numeric blinks. Yellow alarm lamp.	Alarm tone
**$ETCO_2$ 55>50	The $ETCO_2$ high alarm limit (50 mm Hg) has been exceeded.	$ETCO_2$ numeric blinks. Yellow alarm lamp	Alarm Tone
**$IMCO_2$ 5>4	$IMCO_2$ high alarm limit (4 mm Hg) has been exceeded.	$IMCO_2$ numeric blinks. Yellow alarm lamp.	Alarm tone
***inO_2 LOW OXYGEN	inO_2 below 18 vol.%	Red alarm lamp, inO_2 numeric blinks.	Alarm tone

Physiological Alarms

Alarm Message	Condition	Visual Indication	Audible Indication
**inO_2 18<20	inO_2 below low alarm limit (20 vol.%).	inO_2 numeric blinks. Yellow alarm lamp.	Alarm tone
**inO_2 90>80	inO_2 high alarm limit (80 vol.%) has been exceeded.	inO_2 numeric blinks. Yellow alarm lamp.	Alarm tone
**etO_2 55< 60	etO_2 below low alarm limit (60 vol.%).	etO_2 numeric blinks. Yellow alarm lamp.	Alarm tone
**etO_2 75>70	etO_2 high alarm limit (70 vol.%) has been exceeded.	etO_2 numeric blinks. Yellow alarm lamp.	Alarm tone
N_2O			
**inN_2O 90>82	inN_2O high alarm limit has been exceeded.	inN_2O numeric blinks. Yellow alarm lamp.	Alarm tone
Agent (AGT is HAL, ISO, ENF, SEV or DES)			
**inAGT 0.3<1.0	inAGT below low alarm limit(1.0 vol.%).	inAGT numeric blinks. Yellow alarm lamp.	Alarm tone
**inAGT 4.0>3.4	inAGT high alarm limit (3.4 vol.%) has been exceeded.	inAGT numeric blinks. Yellow alarm lamp.	Alarm tone
**etAGT 0.3<1.0	etAGT below low alarm limit(1.0 vol.%).	etAGT numeric blinks. Yellow alarm lamp.	Alarm tone
**etAGT 3.0>2.2	etAGT high alarm limit (2.2 vol.%) has been exceeded.	etAGT numeric blinks. Yellow alarm lamp.	Alarm tone

Technical Alarms

INOP messages appear when the monitor cannot measure or process signals properly. This could be due to patient-related or equipment-related problems but you must always check the patient's condition first. Some INOP messages are accompanied by an audible alarm which can be silenced with the **Silence/Reset** hardkey. The following table lists these messages in order of their priority.

INOP Messages

INOP Message	Monitor Response (Visual & Audible Indication)	Cause(s)	Possible Corrective Action
General INOPS			
GAS AN. STANDBY	No waves, no numerics, no tone	1) Manually activate by pressing **Airway Standby** 2) If no breath is detected for 4 hours and $ETCO_2$ is less than 4 mmHg for more tha one hour.	Press **Airway Resume** or disconnect and reconnect the bacterial filter/gas sample tube.
GAS AN. NOT AVAIL.	No wave, numerics replaced by -?-. INOP tone.	Anesthetic gas module is disconnected or switched off.	1. Check unit is switched on. 2. Check connection between AGM & monitor
GAS AN. EQUIP MALF	No wave, numerics replaced by -?-. INOP tone.	Module malfunction, e.g. device connected to wrong interface adaptor, zero failed twice.	1. Check RS232 Interface is set up correctly in the monitor's Service Mode. 2. Turn AGM on and off. If error persists, contact your Agilent Service Engineer.
GAS AN. SELFTEST	No wave, numerics replaced by -?-. No INOP tone.	Module is performing self-test (only displayed when the module is first switched on).	Wait until selftest is complete (approx. 2 minutes).
GAS AN. TUBE DISC	Flat wave, numerics replaced by -?-. INOP tone.	Gas sampling tube disconnected.	Check the gas sample tube connection.
GAS AN. OCCLUSION	Flat wave, numerics replaced by -?-. INOP tone.	Sample flow rate low due to kinked or occluded tubing, a blocked filter to the patient, or a failure of the intake pump.	Refer to the Occlusion Handling section later in this chapter.
GAS UNABLE TO MEAS	No wave, numerics replaced by -?-. INOP tone.	Gas analyzer delivers temporarily inconsistent data.	No user action required. The situation will correct itself after a few seconds.

INOP Message	Monitor Response (Visual & Audible Indication)	Cause(s)	Possible Corrective Action
GAS AN. ZERO RUNNG	First zero: no wave displayed, numerical data questionable (? displayed near label). On retry: no wave displayed, numerics replaced by -?- . No INOP tone for first zero, INOP tone with retry.	Autozero in progress. If first autozero fails then system will retry; if the retry fails then GAS AN. EQUIP MALF alarm is activated.	Wait until the zero is complete.
GAS AN. WARM UP	Waves displayed, but are not as accurate as after warm-up. Numerical data questionable (? displayed near label). No INOP tone.	Module is warming up and will measure with reduced accuracy until it reaches its operating temperature.	Wait a few minutes.
AWRR OVERRANGE	Wave displayed, numeric replaced by -?- . No INOP tone.	AWRR numeric > 60	No user action required.
GAS AN. ZERO FAILED	Waves displayed, numerics questionable - displayed with ?, no tone.	Analyzer reports that the last zero has failed.	1. Activate a zero manually. 2. Check exhaust tubing for a partial occlusion (refer to Occlusion Handling later in this chapter). 3. If the zero continues to fail, contact your Agilent Service Engineer.
GAS AN. ACCURACY?	Waves displayed, numerics questionable - displayed with ?, no tone.	Gas analyzer delivers data that is questionable.	No user action required. The situation will correct itself after a few seconds.

INOP Message	Monitor Response (Visual & Audible Indication)	Cause(s)	Possible Corrective Action
CO_2 specific INOPS			
GAS AN. NO BREATH	Wave displayed, $ETCO_2$, etO_2, etN_2O, and etAGT (AGT is replaced by the abbreviation for the selected gas) numerics replaced by -?-. The corresponding gas readings are displayed continuously for the inspired numerics. No INOP tone.	No breath can be detected.	1. Check the patient. 2. Check the inlet tubing.
CO_2 UNABLE TO MEAS.	Flat wave, numeric replaced by -?-. INOP tone.	Module unable to measure CO_2.	Wait a few seconds, the situation will correct itself.
CO_2 MEAS DISTURBED	CO_2 waves displayed, invalid in/$etCO_2$ numeric replaced by -?-, INOP tone.	in/$etCO_2$ measurement disturbed.	Wait a few seconds, the situation will correct itself.
CO_2 REDUCE SIZE	Wave and numeric displayed. No INOP tone.	Wave is larger than selected scale.	Change the wave size in the Airway CO_2 task window.
O_2 specific INOPS			
O_2 EQUIP MALF	No wave, no numeric. INOP tone.	O_2 option malfunction	Consult your Agilent Service Engineer.
O_2 ZERO FAILED	O_2 waves displayed, invalid etO_2 /inO_2 numerics replaced by -?-, INOP tone.	Last O_2 zero has failed.	1. Activate a zero manually. 2. Check exhaust tubing for a partial occlusion (refer to Occlusion Handling later in this chapter). 3. Make sure that the AGM anesthetic gas exhaust is set up correctly (refer to Anesthetic GAs Exhaust section later in this chapter). 4. If the zero continues to fail, contact your Agilent Service Engineer.
O_2 UNABLE TO MEAS.	Flat wave, numeric replaced by -?-. INOP tone.	Module unable to measure O_2.	Wait a few seconds, the situation will correct itself. If not, check that the AGM anesthetic gas exhaust is set up correctly (refer to Anesthetic Gas Exhaust section later in this chapter).

INOP Message	Monitor Response (Visual & Audible Indication)	Cause(s)	Possible Corrective Action
O_2 MEAS DISTURBED	Wave displayed, invalid in/etO_2 numeric replaced by -?-. INOP tone.	in/etO_2 measurement disturbed.	Wait a few seconds, the situation will correct itself.
O_2 REDUCE SIZE	Wave displayed, numeric replaced by -?-. No INOP tone.	Wave is larger than selected scale.	Change the wave size in the Airway O_2 task window.
N_2O specific INOPS			
N_2O UNABLE TO MEAS.	Flat wave displayed, numeric replaced by -?-. INOP tone.	Module unable to measure N_2O.	Wait a few seconds, the situation will correct itself.
N_2O MEAS DISTURBED	N_2O waves displayed, invalid etN_2O/inN_2O numeric replaced by -?- INOP tone.	in/etN_2O measurement disturbed.	Wait a few seconds, the situation will correct itself.

INOP Message	Monitor Response (Visual & Audible Indication)	Cause(s)	Possible Corrective Action
AGENT specific INOPS			
AGENT IDENT. MALF (Auto Mode: *Status Message* - AGENT IDENT. MALF - Select Agent manually)	No wave, no numeric (AUTO mode). Wave displayed but the numerical data questionable (? displayed near label) (Manual mode). INOP tone (AUTO mode), No INOP tone (Manual mode).	Only if agent identification is present. Agent identification option malfunction (INOP tone switches off when user manually selects the agent to be measured).	Select agent manually. If INOP appears repeatedly, consult your Agilent Service Engineer.
AGT ID ZERO FAILED (Auto Mode: *Status Message* - AGENT ID ZERO FAILED - Select Agent manually)	AGT waves displayed, no AGT numerics (AUTO mode). AGT waves and numerics displayed (Manual mode). INOP tone (AUTO mode), No INOP tone (Manual Mode)	The agent identification measurement reports a failed zero (INOP tone switches off when user selects the Agent manually).	Select agent manually. If INOP appears repeatedly, activate a zero manually and check exhaust tubing for a partial occlusion.
CHECK AGENT[1]	Wave displayed. Agent numerics replaced by -?-. INOP tone.	*Only if agent identification is present*. Agent selected manually differs from agent detected by the automatic agent identification function. **Or** no agent selected, but agent detected by the monitor.	Check correct agent is selected.
AGT UNABLE TO MEAS.	Flat Agent wave displayed, Agent numerics replaced by -?-. INOP tone.	Module unable to measure anesthetic agent.	Wait a few seconds, the situation will correct itself.
CHK AGT SELECTION	AGT Waves displayed, invalid etAGT/inAGT numerics replaced by -?-, INOP tone.	Agent output above range.	Check that agent administered to the patient is also selected on the monitor.
AGT MEAS RESTARTING	AGT wave displayed, invalid AGT numerics, no INOP tone.	Transition from agent overrrange	
AGT MEAS DISTURBED	AGT waves displayed, questionable numerics replaced by -?-. INOP tone.	in/etAGT measurement disturbed.	Wait a few seconds, the situation will correct itself.
GAS CONTAMINANT[1]	Wave displayed, numerical data questionable (? displayed near label). No INOP tone.	*Only if agent identification is present*. Module detects an unidentified gas contaminant.	Check breathing circuit for presence of interfering gases e.g. methane, ethanol, acetone or fluorocarbons in bronchodilators.

INOP Message	Monitor Response (Visual & Audible Indication)	Cause(s)	Possible Corrective Action
AGENT MIXTURE[1]	Wave displayed, numerical data is questionable (? displayed near label). No INOP tone.	*Only if agent identification is present*. Anesthetic mixture detected by module.	Check that only 1 agent is administered to the patient. INOP is displayed during changeover of one agent to another, message will eventually clear itself in this case.
AGT REDUCE SIZE	Wave and numerics displayed. No INOP tone.	Wave is larger than selected scale.	Change the wave size in the Airway agent task window.

[1]This INOP will not be triggered if a *manually* selected gas is not supported by the Agent ID feature.

Accessories and Ordering

M1658A	Gas Sample Tube, 2.6m
M1657A	Watertrap
13902A	Airway Adapter, 15mm, (right angle)
1660A	Calibration Gas Assembly.
1659A	Calibration Tube Assembly
M1612A	Airway Adapter (straight)
1015-40001	Gas Exhaust Scavenging Tubing
M1655A	Gas Exhaust Return Line
M1656A	Gas Exhaust Return Filter.

Performance Specifications

For safety and environmental specifications, please refer to the Installation and Patient Safety chapter.

Note—A hazard analysis according to IEC 601-1-4 has been performed in the hardware and software development process.

Anesthetic Gas Module Performance Specifications

All Performance and accuracy specifications are valid based on the following conditions:

- Gas sample tube used
  2.6m tubing (10% to 90% step response) (M1658A).
- Accuracy specifications refer to the following conditions:
  - BTPS for mmHg and kPa (CO_2 only).This corresponds to 37ºC body temperature, 95% relative humidity and 47mmHg pH_2O. The formula for calculation is as follows:

    pCO_2 (mmHg) = CO_2vol% * (P_{abs} - 47) / 100

    with:
    pCO_2 = partial pressure
    vol% = gas concentration
    P_{abs} = absolute pressure
  - STDP for vol% (for all other gases), and
  - relative humidity of 40% - 60%.

Sample Flow Rate:
120 ml/min.

Sample Delay Time:
All measurements and alarms are subject to a delay of 3 seconds.

Total System Response Time:
The total system response time is the sum of the delay time (see above) and the rise time (see below).

CO_2 Measurement

Range:	0 to 76 mmHg
Accuracy:	1.5 mmHg (0 - 40 mmHg) 2.5 mmHg (40 - 60 mmHg) 4.0 mmHg (60 - 76 mmHg)
Resolution:	1 mmHg
Rise-time:	410 msec typical.

AWRR derived from CO_2 Waveform

Range:	0 to 60 rpm
Accuracy:	$\pm$ 2 rpm
Resolution:	1 rpm
Detection criteria:	6 mmHg variation in CO_2.

N_2O Measurement

Range:	0 to 85 vol%
Accuracy:	1.5 vol% + 5% relative
Resolution:	1 vol%
Rise-time:	510 msec typical.

O_2 Measurement

Range:	0 to 100 vol%
Accuracy:	2.5 vol% or 5% relative which ever is greater
Resolution:	1 vol%

Rise-time: 450 msec typical.

Anesthetic Agent Measurement

Agent	Range (vol%)	Accuracy	Resolution	Rise-Time - Typical (msec)
Halothane	0 - 7.5	0.2 vol% + 4.0% relative	0.05	< 740
Enflurane	0 - 7.5	0.1 vol% + 4.0% relative	0.05	< 620
Isoflurane	0 - 7.5	0.1 vol% + 4.0% relative	0.05	< 610
Sevoflurane	0 - 9.0	0.1 vol% + 4.0% relative	0.05	< 570
Desflurane	0 - 20.0	0.1 vol% + 6.0% relative	0.05 (0-10) 0.1 (10.1 - 20)	< 540

Automatic Agent Identification

Agent ID Response Time 15 s

Agent Thresholds (Option #A05)

Agent	Threshold
HAL, ISO, ENF	0.20 vol%
SEV	0.24 vol%
DES	0.30 vol%

Note—During warmup time the thresholds are three times the values listed above.

Gas Exhaust Return Line Measurements

Positive Inspired Pressure(PIP): up to 70cm H_2O

Respiration Rate: 0-60/minute

Alarms

Gas	High Range	Low Range
AWRR	1 - 60 rpm	0 - 59 rpm
$ETCO_2$	12 - 80 mmHg	10 - 78 mmHg
$IMCO_2$	.0 - 20 mmHg	none
inN_2O	0.0 - 82 vol%	none
etO_2	1.0 - 100 vol%	0.0 - 99 vol%
inO_2	19 - 100 vol%	18 - 99 vol%
et SEV	0.1 - 9.0 vol%	0.0 - 8.9 vol%
in SEV	0.1 - 9.0 vol%	0.0 - 8.9 vol%
et DES	0.2 - 20.0 vol%	0.0 - 19.8 vol%
in DES	0.2 - 20.0 vol%	0.0 - 19.8 vol%
Halothane, Enflurane, Isoflurane		
et	0.1 - 7.5 vol%	0.0 - 7.4 vol%
in	0.1 - 7.5 vol%	0.0 - 7.4 vol%

Alarm Delay:
15 seconds if no automatic zero calibration occurs within that time.

Apnea Alarm:

Delay Range: 10 - 40 seconds

Criterion: No detected breath within the adjusted delay time.

Alarm: within 2 seconds after this criterion is met, if no automatic zero occurs.

INOP Alarms:
Refer to the Patient and Equipment related INOP tables in this chapter.

Care and Cleaning

Anesthetic Gas Module

Refer to the *General Cleaning of the System* section in the *Maintenance* chapter of this manual for details on cleaning the Anesthetic Gas Module.

Note—Do not allow disinfectants or their fumes to get into the inside of the Anesthetic Gas Module through the tubing, as this could cause damage to the module.

Accessories

The tables below describe the replacement and cleaning procedures for the Anesthetic Gas Module Accessories.

Replacement Procedures

Accessories	Part No.	Replacement Procedure
Gas Sample Tube:	M1658A	Single patient use only.
Watertrap:	M1657A	Multi patient use. A watertrap may be used with one or more patients. It must be exchanged (at the latest) when the reservoir is full (indicated by a fill marker). To remove the watertrap, hold it gently at the bottom and pull out and down.
Airway Adapter:	13902A or M1612A	Single patient use only.
Gas Exhaust Return Filter:	M1656A	Single patient use only.
Gas Exhaust Return Line:	M1655A	Tubing is reusable; need only be replaced if it is damaged or the connectors are loose.

Cleaning Procedures

Accessories	Part No.	Cleaning Procedures
Gas Sample Tube:	M1658A	Do not attempt to sterilize or clean it.
Watertrap:	M1657A	Do not attempt to sterilize or clean it.
Airway Adapter:	13902A or M1612A	Do not attempt to sterilize or clean it.
Gas Exhaust Return Filter:	M1656A	Do not attempt to sterilize or clean it.
Gas Exhaust Return Line:	M1655A	*Cleaning:* Dampen a cloth with a solution of warm water and soap and wipe the tubing clean. Do not immerse or soak the tubing. *Disinfecting:* Dampen a cloth with a cold chemical disinfectant (Aldehyde based derivative, Alcohol or alcohol based derivative) and wipe the tubing clean. Do not immerse or soak the tubing. After cleaning, remove disinfectant with a damp cloth and dry with a clean cloth.

Occlusion Handling

Inlet Occlusion:

This type of occlusion occurs when the inlet accesories (filter, sample line, airway adapter) become blocked or kinked.

If an occlusion is present at the inlet, the following information is displayed on the screen:

INOP Message:	GAS AN. OCCLUSION
Status Message:	*AGM: Check gas inlet accessories*
Waves:	Displayed
Numerics:	Invalid and replaced by a -?-

The preferred action for removing this type of occlusion is as follows:

Check the inlet accessories for an occlusion:

a. Replace the watertrap
b. Check the sample tube for an occlusion and/or kinking and replace if necessary.
c. Check the airway adapter for the build up of water.
   Empty the fluid and reposition the adapter if necessry.
   Ensure that the airway adapter port is facing upwards.

Exhaust Occlusion

This type of occlusion occurs when the exhaust accessories (closed loop kit or scavenging tubing) become blocked or kinked.

This condition can only be detected during a zeero calibration. If a partial occlusion is present at the outlet, the calibration is aborted prematurely and the following information is displayed on the screen:

INOP Message:	GAS AN. ZERO FAIL
Status Message:	*AGM: Check exhaust and press Airway Zero*
Waves:	Displayed
Numerics:	Displayed and accompanied with a “?”

The preferred action for removing this type of occlusion is as follows:

Step 1. Check the exhaust accesories for an occlusion:

a. Replace the exhaust bacterial filter if necessary

b. Check the exhaust tube for an occlusion or kinking and replace if necessary.

Step 2. Press **Airway Zero** in the Airway Gases/Ventilation task window to perform a zero calibration.

General Occlusion

This type of occlusion occurs when either the inlet or the exhaust accessories become blocked or kinked.

If an occlusion is present at the inlet or the outlet, the following information is displayed on the screen:

INOP Message:	GAS AN. OCCLUSION
Status Message:	*AGM: Check exhaust and inlet accessories*
Waves:	Displayed
Numerics:	Invalid and replaced by a -?-

The preferred action for removing this type of occlusion is as follows:

> Check the outlet accessories first for the presence of an occlusion and replace if necessary. If this is insufficient, check the inlet accessories for the presence of an occlusion and replace if necessary.

Internal Occlusion

This type of occlusion occurs when the Anesthetic Gas Module becomes contaminated internally.

If an occlusion is present internally, one of the following INOP messages is displayed on the screen:

INOP Message:	GAS AN. OCCLUSION
Status Message:	*AGM: Check gas inlet accessories*
INOP Message:	GAS AN. ZERO FAIL
Status Message:	*AGM: Check exhaust and inlet accessories*
INOP Message:	GAS AN. OCCLUSION
Status Message:	*AGM: Check exhaust and inlet accessories*

The preferred action for removing this type of occlusion is as follows:

Step 1. Follow the ususal procedure for removing an occlusion from the inlet or exhaust accessories.

Step 2. If this is not successful, press **Airway Zero** in the Airway Gases/Ventilation task window to perform a zero calibration. If the zero fails or an occlusion INOP message continues to be displayed on the screen, the presence of an internal occlusion is likely. In this situation, contact your biomedical engineer or the Agilent Service Engineer.

27
Blood Analysis

In this section you will find information on:

- Setting up the Blood Analysis module.
- Point-of-care blood analysis using the M1022A Blood Analysis module.
- Viewing the results of the analysis and identifying critical or questionable results.

To find specific information, check either the contents list at the front of this guide or the alphabetic index at the back. To find detailed information about the individual tests, including performance characteristics and clinical significance, refer to the Cartridge and Test Information section in the i-STAT System Manual.

Introduction to the Blood Analysis Module

The Blood Analysis module uses blood analysis technology from i-STAT Corporation[1]. The module is used together with i-STAT single-use, disposable cartridges for point-of-care determination of specific analytes in whole blood. There are several cartridges with a variety of test configurations. Tests include pH, blood gases, glucose, sodium, potassium, chloride, ionized calcium, BUN/urea, hematocrit and a number of calculated parameters.

Two to three drops of blood are needed for the analysis and results are available in around two minutes.

The cartridges are self-calibrating. Each cartridge contains a sealed pack of calibrating solution with a known concentration of each analyte. This calibrating solution is passed over the measurement sensors followed by the blood sample. A comparison of the sensor's response to the two fluids allows the computation of the concentration of each analyte in the sample.

The cartridges must be stored under refrigeration at 2 to 8°C (35 to 46°F). The operating temperature range for the module is 16 to 30°C (64 to 86°F).

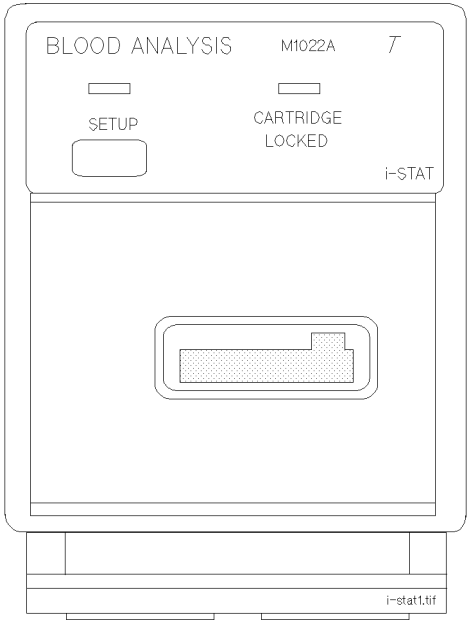
The module must be placed in a horizontally mounted rack to ensure accurate results and avoid spillage onto the air vents on the sides and bottom of the module.

1. i-STAT is a registered trademark of i-STAT Corporation

Blood Analysis Module Keys

The front of the Blood Analysis module has the following controls and indicators.

- The setup key for Blood Analysis setup; a light appears above the key when one of the Blood Analysis task windows is displayed. Pressing this key when a measurement is running will display the Blood Analysis Setup task window. When no measurement is running, you will automatically enter the Blood Analysis Results task window where the results of the last measurement are displayed.
- The cartridge slot where the cartridge is inserted for processing.
- The **Locked** light blinks when a cartridge is being processed; the cartridge **must** be left in the slot and should not be touched until the light goes off.



M1022A Blood Analysis Module

Caution

When the cartridge or electronic simulator is inserted into the module it is held in position by an internal mechanism. Trying to remove a cartridge or simulator when the **Locked** light is blinking may cause damage to this mechanism in the module or result in an error message. The module should always be left in the monitor when a cartridge is inserted. If the module is unplugged from the monitor rack, the **Locked** light cannot function, but the mechanism may still be locked if the module was unplugged during analysis. If this occurs, plug in the module again and wait until an error message is displayed and the cartridge released.

Obtaining Blood Specimens

The specimen used to fill a cartridge must be collected and handled properly to ensure that the results represent the patient's current status. Only fresh whole blood samples either without anticoagulant or with an appropriate heparin anticoagulant are recommended for use with the i-STAT cartridges.

Suitable Specimens

- Fresh whole blood collected in a capillary tube or a plastic syringe without anticoagulant (test within 3 minutes of collection)
- Fresh whole blood collected in a capillary tube with lithium or sodium heparin anticoagulant (test within 3 minutes of collection; for ionized calcium use balanced heparin)
- Fresh whole blood collected in a collection tube or syringe with lithium or sodium heparin anticoagulant (fill tubes to capacity; fill syringes for correct blood to heparin ratio; test within 10 minutes of collection)

If the cartridge is not filled immediately after drawing and mixing the blood, the blood must be remixed thoroughly. Mix tubes by gentle inversion 7 times. Mix syringes by rolling between the palms for at least 5 seconds in 2 directions.

Criteria For Specimen Rejection

- Evidence of clotting
- Specimens collected in vacuum tubes or syringes with anticoagulant other than lithium or sodium heparin
- Syringe for pH, PCO_2, and PO_2, with air bubbles in sample
- Incompletely filled heparinized vacuum tube or syringe for the measurement of ionized calcium
- Other sample types such as urine, CSF and pleural fluid

Circum-stances to Avoid

- Drawing a specimen from an arm with an I.V.
- Stasis (tourniquet left on longer than one minute before venipuncture)
- Extra muscle activity (fist pumping)
- Hemolysis (alcohol left over puncture site, or a traumatic draw)
- Icing before filling cartridge
- Time delays before filling cartridge
- Exposing the sample to air when measuring pH, PCO_2, and PO_2.

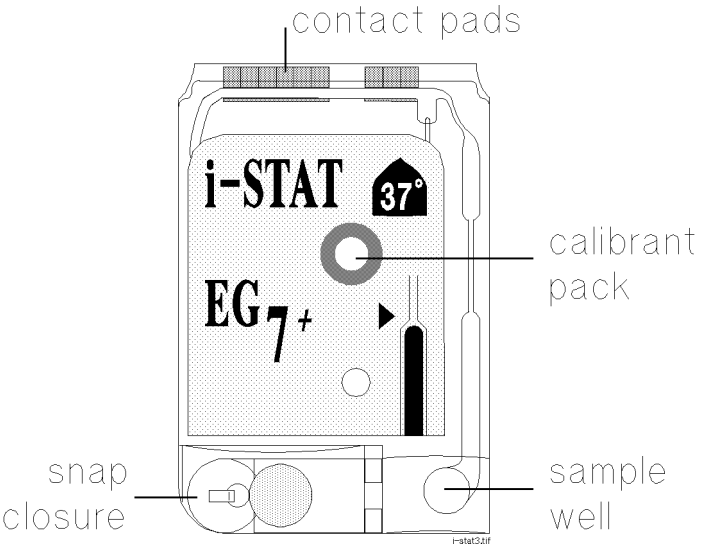
Procedure for Analysis

Preparing Cartridges for Use

Cartridges must come to room temperature and equilibrium before use. For cartridges with thermal control (marked 37°C) leave a box or an individual cartridge at room temperature for four hours; for cartridges without thermal control, leave a box for one hour or an individual cartridge for 5 minutes at room temperature. Before using a cartridge, check that the date marked on the cartridge pouch has not expired and that the cartridge has not been at room temperature for more than two weeks.

Procedure

1. Remove the cartridge from its pouch. Avoid touching the contact pads or exerting pressure over the calibrant pack in the center of the cartridge.
2. Place the cartridge on a flat surface or hold it in a horizontal position. Do not hold the cartridge between the fingers if using a syringe with needle to fill.
3. Direct the tip of the syringe, capillary tube or dispenser containing the blood into the sample well.
4. Dispense the sample until it reaches the ▶ mark on the cartridge. Leave some sample in the well.
5. Close the snap closure over the sample well until it snaps into place. (Press on the rounded edge of the closure and not over the sample well.)



Blood Analysis Cartridge

6. Push the cartridge into the slot on the front of the module, holding it at the front next to the sample well, until it clicks into place.

7. If required, enter Operator ID, Blood Sample Type, Patient temperature, the O_2 value and additional information in the Blood Analysis Setup screen.

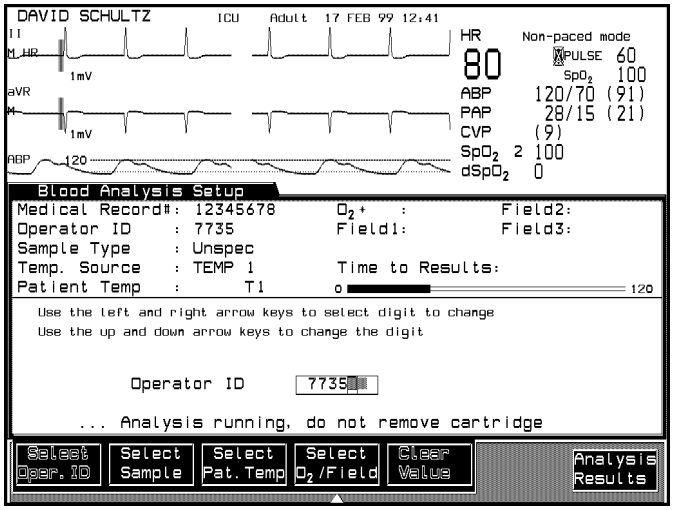
8. If you are in the Setup screen when the measurement is completed, view results by pressing the **Analysis Results** key; if not, press the **Setup** key on the module to view results.

9. Transmit the results (see see “Transmitting Results” on page 15) to make them available for recordings and in the Blood Review task window.

10. After the **Locked** light stops blinking, remove the cartridge. Discard the used cartridge in a container for biohazardous or contaminated waste.

Blood Analysis Setup

During the analysis, you can enter setup information as required in the Blood Analysis Setup screen. Depending on the monitor configuration, the setup screen will either appear immediately when you insert a cartridge or as required when you press the Setup key on the module. The Blood Analysis Setup screen is the default choice when a measurement is running. Settings can still be changed after a measurement is completed, as long as the results have not been transmitted. If the measurement has been completed, the Blood Analysis Setup task window can be accessed by the **Analysis Setup** softkey in the Blood Analysis Results task window.



In this screen you can see:

- The status of a running measurement. It shows the elapsed time, status information and error messages.

- The module software revision and the cartridge standardization version.
- The measured ambient pressure, if no measurement is being made.
- The medical record number, from the local patient database or centrally via SDN.

In this screen you can:

- Select or enter an Operator ID (this is the window shown above).
- Select or enter a Blood Sample Type.
- Select a patient temperature source or enter a value.
- Enter an O_2 value.
- Enter information into three free-entry fields.

At the beginning of a measurement, depending on the configuration for each individual setting, the monitor will either display the setting or value from the last measurement or will display no setting/value.

Note—The Medical Record Number (Patient ID) cannot be changed in this screen. To change the Medical Record Number refer to the **Admit/ Discharge/End Case** section (Chapter 7) of this Reference Guide.

Selecting an Operator ID

When the **Select Oper. ID** key is highlighted you can select one of the ID numbers on the screen (if available) or press **Manual Entry** to enter your ID number. The number can be entered either by using the arrow keys to adjust the initial number shown.

If your monitor is so configured that Operator ID entry is required, you will not be able to view and transmit results without first entering the ID. If the **Select Oper. ID** key does not appear on your monitor, the Operator ID functionality has been configured off.

To maintain the confidentiality of Operator IDs, your monitor may be configured not to show the ID number on the results screen, the Blood Review screen, recordings and reports. In this case, if you need to change the ID number after entering it, you must first clear it with the **Clear Value** softkey then enter the complete ID number again.

Selecting the Blood Sample Type

When the **Select Sample** key is highlighted you can select one of the Sample types on the screen. The **Control** selection should always be used when doing performance verification with Level Control solutions. This ensures that the result is not stored in the patient's database on the monitor but is passed on to the Central Data Station and/or other systems for quality assurance purposes.

Selecting a Patient Temperature

When blood gases are included in the analysis, the cartridge is always heated to 37°C. If the patient temperature value is known, the blood gas values can be mathematically adjusted from 37°C to this actual patient temperature. When the **Select Pat. Temp** key is highlighted you can select one of the Temperature modules as the source for the patient temperature used for this adjustment. The temperature value at the time the cartridge was inserted will be used. You can also select the Cardiac Output module as temperature source (Tblood). If the selected module is not providing a valid temperature value, there will be no value shown after **Patient Temp:** in the settings list.

Press **Manual Entry** to enter a value for patient temperature. Values must be entered in degrees Celsius (°C). The value can be entered by using the arrow keys to adjust the initial value shown. If you select **Off**, or if the selected temperature source does not provide a valid temperature, no temperature adjustment will be done and no temperature-adjusted parameter values will appear in the results window.

Entering an O_2 Value

When the **Select O2 / Field** key is highlighted, you can enter a new value or switch O_2 entry off. The value can be entered either by using the arrow keys to adjust the initial value shown, or directly using the numerics keys on the keypad. Values can be entered for FIO_2 (e.g. 0.35) or Oxygen Flow (e.g.6.9)

Entering Information into the Free-Entry Fields

When the **Select O2 / Field** key is highlighted, you can also enter additional information into the free-entry fields by pressing again on the **Select O2 / Field** key: once for field 1, twice for field 2, and three times for field 3.

Caution

The settings you have made will apply a few seconds after you *leave* the Blood Analysis Setup window. After making settings, leave the window and wait a few seconds before inserting a new cartridge or removing the module from the rack.

Blood Analysis Results Selection

It is possible to chose which results are to be displayed in the Blood Analysis Results window, provided that Results Selection is enabled in the Blood Analysis Configuration task window. If it is enabled there will be a **Select Results** soft key in the Blood Analysis Setup and Blood Analysis Results task windows.

Display the Blood Analysis Results Selection task window by pressing the **Select Results** soft key. This window displays all parameters that are obtained from the analysis with an *on/off* status for each parameter. You can select any combination of parameters, measured or calculated, all of which will then be displayed on completion of the analysis.

Only parameters that have been chosen will be displayed in the Blood Analysis Results task window or transmitted when the Confirm key is pressed or the Auto-Transmit feature is enabled and the time delay selected has elapsed. All parameters that have the status off, will be displayed as a blank result - parameter name without a value. More parameters can be selected upto the point that the results are transmitted.

Warning

Any parameters that are selected and displayed in the Blood Analysis Results task window during a particular measurement cannot subsequently be switched off.

The selected parameters will continue to be used for subsequent measurements.

After a patient has been discharged or following a system cold start, all selections are switched to off. You will be reminded of this with the message:

Check Results Selection. *ALL* results are switched off!

Blood Analysis Results

When a measurement is completed the results are immediately available in the Blood Analysis Results task window. If your monitor is configured to **require** entry of Operator ID and/or Patient ID, you can only view the Results when the IDs have been entered. Patient ID (Medical Record #) can be entered in the Admit Patient window.

The Blood Analysis Results task window displays the results of the last measurement taken, until either a new measurement is started or the last measurement is more than 24 hours old. If no valid measurement exists, the Blood Analysis Results task window is empty.

If a valid measurement existed before a hot start is made, the empty screen is again displayed and the measurement related data is recovered from the module. All task window softkeys are inactive, and the message “Recovering result ongoing” is displayed.

While a measurement is being carried out, the Blood Analysis Results task window displays the type of cartridge being used and displays a bar graphic, indication the time remaining before a result is expected. Identification of the cartridge type may take approximately 30 seconds.

While a measurement is being made, the Blood Analysis Results task window can only be accessed by entering the Blood Analysis Setup task window, and then pressing **Analysis Results** softkey

When you enter the Blood Analysis Results task window, the selected parameter results are displayed together with the corresponding units. If the units are not displayed, press the **Ranges / Units** key repeatedly until they appear. Calculated results are marked with an **’,** for example **’**HCO3. Temperature-adjusted results are marked with an **&**, for example &PCO_2.

Values which are outside of the given reference ranges are displayed in yellow (or inverse video on a monochrome display). To display the reference ranges, press the **Ranges / Units** key repeatedly until they appear.

Note—Reference ranges for pCO_2, HCO_3, tCO_2 , BEecf and pH are only used on the EC6+ and EC8+ cartridges; for other cartridges no out-of-range indication will be given for these test parameters. A listing of the reference ranges for all parameters can be found in the i-STAT System Manual.

If results are outside of the **measurement range**, the limit which has been exceeded will be shown with an **<** or **>**, for example **>180** when the upper limit of the measurement range is 180. If a calculated result depends on such an out-of-range value, it will not be calculated and shown as **-?-**. If an out-of-range result is rejected, **-?-** appears instead of the value.

Three stars *** will appear instead of a value if the signals from that particular sensor are uncharacteristic. Uncharacteristic signals can be caused by a compromised sensor or an interferent in the sample. Stars will also appear for any result that depends on another result which is itself flagged with stars.

Transmitting Results

The results must be transmitted before a recording can be made and in order for the system to include them in the Blood Analysis Review screen and pass them on to the Central Data Station or other Information systems.

If any setup data, such as Operator ID, blood sample type, Tpat, has been incorrectly entered, it is possible to enter the Blood Analysis Setup task window and change the current values. A measurement can also be rejected and marked as invalid/questionable. Until the measurement is transmitted, other data display or storage systems outside the monitor, such as Blood Review or recorder, cannot see the information. You will be warned of this with the message:

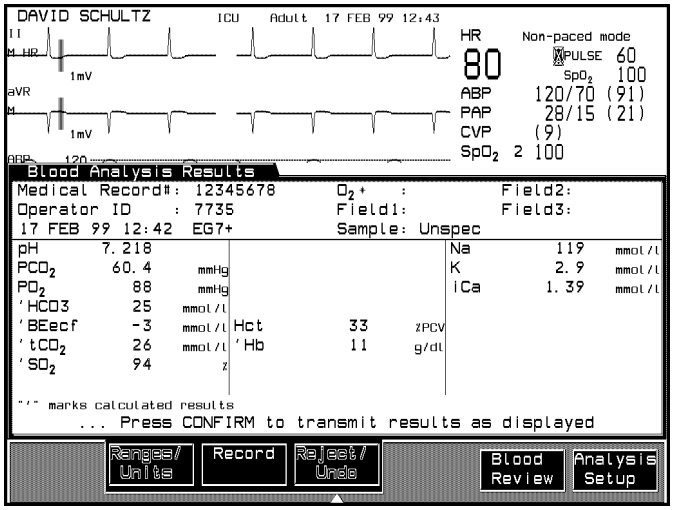
“Press CONFIRM to transmit results as displayed.”

A measurement result can be “rejected” by being marked as *invalid-questionable* with the **Reject / Undo** key. All selected parameter results will be marked with a question mark, ?. Pressing the Confirm key will transmit these results as “Rejected”. The Auto-Transmit function will also work as normal when *Reject* is selected.

It is possible to configure the monitor to automatically transmit the results after a certain time has passed. If this Auto-transmit function is configured, the time remaining until transmission occurs will be shown on the results page. The transmission will only occur at that time if you have left the Results and Setup task windows. If your monitor is configured to **require** entry of Operator ID and/or Patient ID, the count-down to transmission starts only then when the IDs have been entered. Even if Auto-Transmit is not configured, the system will automatically transmit results if any of the following situations occur before you have started transmission:

1. a new measurement is started
2. the module is unplugged
3. the Blood Analysis parameter is switched off or the monitor switched to standby
4. a power failure has occurred

If required items such as Operator ID and Patient ID were not yet entered when one of the above situations occurred, the results would only be transmitted to the CDS and not be made available in any other form (e.g. in Blood Review, for Recording, for other information systems, etc).



Procedure for Transmitting Results

1. Check the results and the associated setup information.
2. If setup corrections are necessary, press **Analysis Setup** to go to the setup task window.
3. When the corrections have been made, return to the Analysis Results window.
4. If the results are valid, press **Confirm** to transmit the results.
5. If you have any doubts about the validity of the results, press **Reject Results** to mark all results with **?**, then press **Confirm** to transmit them.

Only after the results have been transmitted are they available for recording and are included in the Blood Review and passed on to the Central Data Station and other Information Systems.

Recording Results

Once results have been transmitted, they can be recorded on a recorder module by pressing the **Record** key in the Blood Analysis task window.

Alternative Procedure

Should the Blood Analysis module become inoperable for any reason, specimens should be collected and submitted to the laboratory in accordance with the Laboratory Procedure Manual.

Blood Analysis Alarm and INOP Messages

The Blood Analysis module does not generate any physiological alarms.

Technical Alarms

INOP messages appear when the monitor cannot measure or process signals properly. In the case of the Blood Analysis module this will be due to equipment-related problems. The INOP message is accompanied by an audible alarm which can be silenced with the Silence/Reset key. More detailed information relating to the cause of the INOP can be found in the Blood Analysis task window. In most cases, a numerical error code will also be shown which can assist the service engineer in diagnosing the problem.

INOP Message	Condition	Audible Indication
BLOODANL UNPLUGGED	Blood Analysis module is un-plugged from the rack	INOP tone
BLOODANL EQU.MALF	Malfunction in the module hardware	INOP tone
BLOODANL CONFIG	A configuration problem has been detected: invalid software, invalid or expired CLEW, invalid date, invalid customization data or incompatible language	INOP tone
BLOODANL ROOM TEMP	Module environment is too warm or too cold - operating range 16 to 30°C (64 to 86°F)	INOP tone

Accessory Ordering Information

All accessories can be ordered from Abbott Laboratories.

Cartridges

	Measured Values													Calculated Values					
	Na	K	Cl	BUN / Urea	Glu	iCA	pH	pCO_2	pO_2	Hct	Crea	Lact	ACT	HCO_3	TCO_2	BE / BEecf	sO_2	Anion Gap	Hb
EG7+	•	•				•	•	•	•	•				•	•	•	•		•
EG6+	•	•					•	•	•	•				•	•	•	•		•
G3+							•	•	•					•	•	•	•		•
EC8+	•	•	•	•	•		•	•		•				•	•	•		•	•
6+	•	•	•	•	•					•									•
EC6+	•	•			•	•	•			•									•
EC4+	•	•			•					•									•
G					•														
E3+	•	•								•									•
Crea											•								
ACT													•						
CG4+							•	•	•			•		•	•	•	•		•
CG8+	•	•			•	•	•	•	•	•				•	•	•	•		•

System Control and Verification Materials

Level 1 Control (10 per pack)

Level 3 Control (10 per pack)

Calibration verification set

Care and Cleaning

The module can be cleaned using the standard cleaning solutions as described in Chapter 13. However, water or cleaning solution **must not** enter the air vents on the sides and bottom of the module, or the cartridge insertion slot on the front, as this could damage the equipment. To avoid this:

- ensure that liquid is well squeezed out of the cloth used for wiping the module clean, and
- wipe around the vents and insertion slot and not over them.

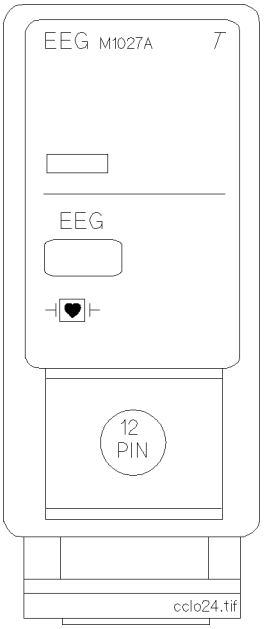
28
EEG Module Section (Agilent CMS only)

In this section you will find information on EEG Monitoring with the M1027A EEG Module.

Introduction to EEG Parameter Module

The Electroencephalograph (EEG) Module monitors the patient's cerebral function by measuring the electrical activity of the brain. EEG monitoring assists in diagnosing many neurological illnesses and diseases, such as epilepsy, tumor, cerebrovascular lesions (e.g. seizures). ischemia and problems associated with head trauma.

In the Operating Room, EEG monitoring provides a record of the adequacy of anesthesia and information about cortical blood flow.



The EEG Module

How the EEG Parameter Works

The EEG module produces two channels of EEG realtime waves which can be displayed and recorded. They are labeled EEG1 and EEG2. For each channel, the following eight numerics are calculated:

- **Spectral Edge Frequency (SEF)** - this is the frequency below which 90% of the EEG activity occurs.
- **Mean Dominant Frequency (MDF)**
- **Peak Power Frequency (PPF)**
- **Total Power (TP)**
- **Percentage of total power in each frequency band**:
  - **Alpha -** Alpha waves represent the EEG in a normal awake adult. Their frequency is defined as 8-13 Hz.
  - **Beta** - Beta waves represent the EEG during periods of conscious effort. Their frequency is defined as 13 to 30 Hz
  - **Theta** - Theta waves are usually seen in the presence of pathology. Their frequency is defined as 4 to 8 Hz
  - **Delta** - Delta waves are seen in the presence of pathology, coma and certain stages of anesthesia. Their frequency is defined as 0.5 to 4 Hz

Two of these numerics can be selected for continuous display, trending and recording. The selected numerics are displayed in large digits next to their respective wave. If one of the selected numerics is a frequency (i.e. SEF, MDF or PPF), a trend line for this frequency will be displayed in the Compressed Spectral Array (CSA). See section below for details.

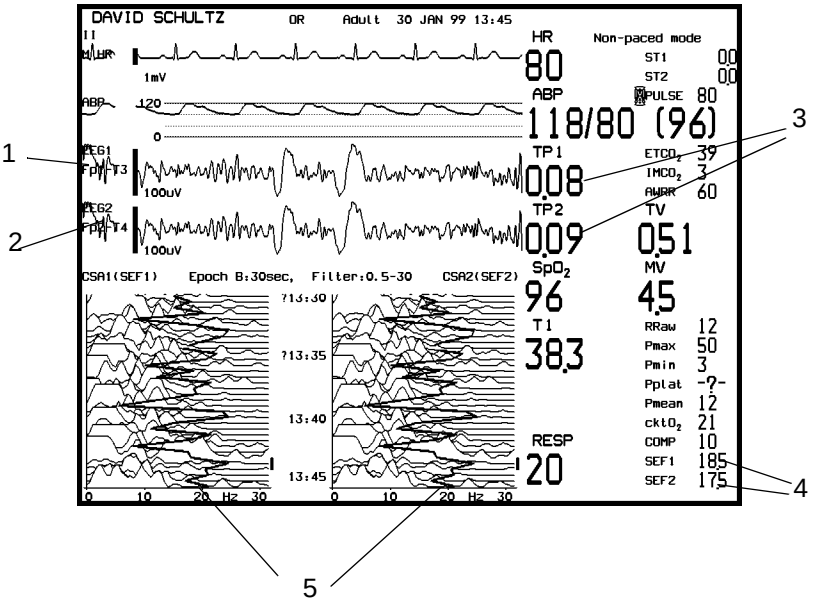
The main quality indicator for the measured EEG signal is the electrode-to-skin impedance. During normal EEG monitoring, electrode-to-skin impedance is measured continuously and disconnected electrodes are detected. The impedance value for each single, independent electrode is displayed in the Electrode Impedance Task Window and the Electrode Montage Task Window.

Compressed Spectral Array (CSA)

The raw EEG signals are processed by Fast Fourier Transformation (FFT). This means that the continuous EEG signal is sampled periodically and the value stored in a frame. Then the FFT over this frame computes the energy at each frequency. This results in a frequency spectrum for the frame.

Compressed Spectral Array (CSA) is a method of displaying this spectrum. It compresses a large amount of data into a compact, easy to read trend. The CSA stacks each sample's spectrum one right below the other at selected time intervals.

The drawing below shows a CSA display.



1. EEG1 Wave
2. EEG2 Wave
3. Selected Numerics
4. Selected Numerics
5. Trend of SEF, MDF, or PPF within CSA Display

Considerations When Monitoring EEG

Listed below are important considerations to remember when monitoring EEG.

Note—Interference from a non-grounded instrument near the patient, and electrosurgery interference can cause problems with the waveform.

Note—Radiated field strengths above 1 V/m and ≤ 50 µV may cause noise on the EEG waves at various frequencies. Therefore, it is recommended to avoid the use of electrical radiating equipment in close proximity to the patient monitor. The noise does not influence the accuracy.

Note—Interference from ECG can be eliminated by adjusting the low filter settings.

Warning

•DO NOT TOUCH THE PATIENT, OR TABLE OR INSTRUMENTS DURING DEFIBRILLATION.

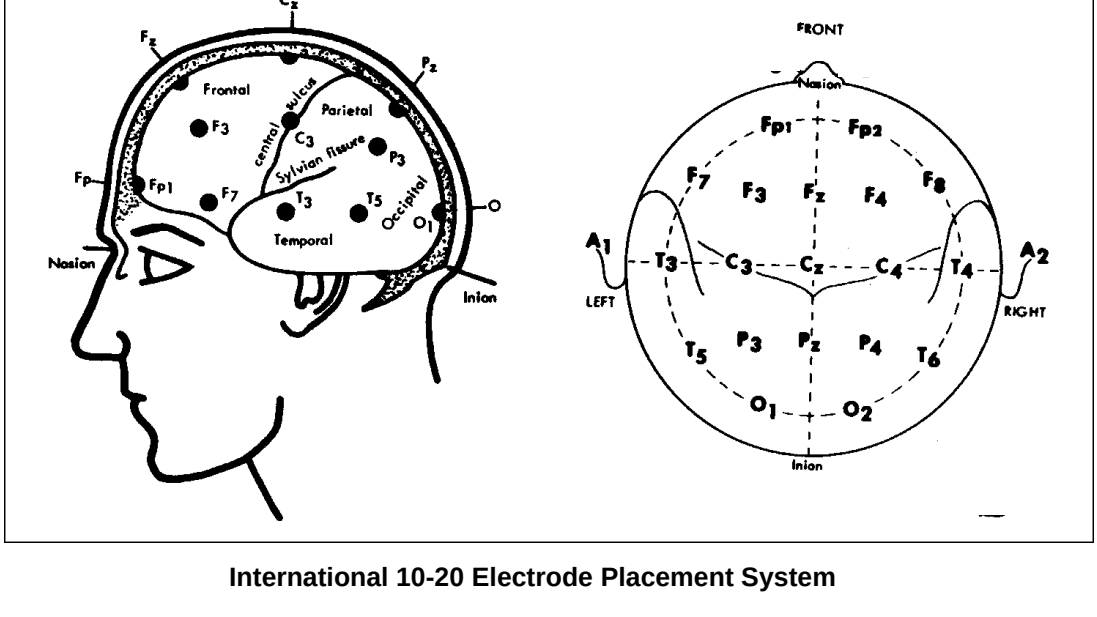
• When connecting electrodes and/or patient cables, ensure that the EEG leads and connectors do not come into contact with other conductive parts or earth.

EEG Monitoring Setup

1. Check that the EEG module is inserted in the rack.
2. Plug in the trunk cable to the EEG module.
3. Prepare the patient's skin prior to placing the electrodes.The skin is a poor conductor of electricity, therefore preparation of the patient's skin is important to facilitate good electrode to skin contact. Recommendations :
   - Shave hair from sites, if necessary.
   - Wash sites thoroughly with soap and water. (Never use ether or pure alcohol, because this increases skin resistance).
   - Use the Agilent M1936A Skin Preparation Paste before placing the electrodes to remove skin cells and oil.
4. Select the desired electrode montage. (See *Placing the Electrodes for EEG Monitoring*)
5. Attach the reference electrode first.
6. Place the electrodes on the patient's head according to the selected montage. Use electrode gel prior to placement if pre-gelled electrodes are not used.
   - Remember to select a site where the signal will not be interfered with by muscle artefacts.
7. Connect the electrode connector end to the trunk cable according to the display instruction.
8. Check the Electrode-to-Skin Impedance in the Electrode Montage Task Window.
9. For good signal quality, keep all lead wires together and away from other electric devices and metallic bodies.

Placing the Electrodes for EEG Monitoring

To simplify the electrode placement, one of five pre-configured electrode montages can be selected. The appropriate electrode locations on the patient's head as well as the electrode wiring are displayed inside the EEG Montage Task window. The locations are labeled according to the international 10-20 electrode placement system. (see figure below)



International 10-20 Electrode Placement System

Electrode Montages

The following table lists the factory default settings for the five electrode montages:

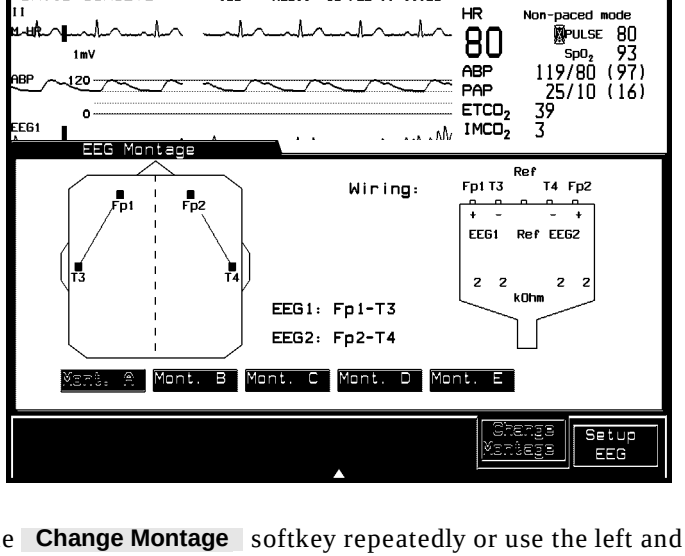
Montage	Name	EEG1+	EEG1-	Label1	EEG2+	EEG2-	Label2
1	Mont.A	Fp1	T3	Fp1-T3	Fp2	T4	Fp2-T4
2	Mont.B	O1	T3	O1-T3	O2	T4	O2-T4
3	Mont.C	F3	C3	F3-C3	F4	C4	F4-C4
4	Mont.D	C3	P3	C3-P3	C4	P4	C4-P4
5	Mont.E	Fp1	T5	Fp1-T5	Fp2	T6	Fp2-T6

The five configurations can be modified to create your own electrode montages. This is done in a special configuration mode by either your biomedical engineer or your Agilent Service Engineer.

Electrode Montage Selection

To enter the EEG Montage Task Window, press either the Setup key on the EEG module or the following key sequence:

Module Setup → **EEG** → **Change Montage**



Press the **Change Montage** softkey repeatedly or use the left and right arrow keys to select the desired electrode montage.

The assigned lead labels for each channel, the electrode locations on the patient's head, the wiring for the selected montage and the electrode-to-skin impedance are displayed inside the Task Window. The location symbols for the electrodes may vary in color, depending on the actual electrode-to-skin impedance and the setting for the impedance limit.

Notes—

- The new montage does not become active until this Task Window is closed.
- If the reference electrode is not connected or has fallen off the patient's head, the prompt message *Connect Reference Electrode first* is displayed in the Task Window.

- If Parameter Settings Transfer is on, the additional selection **Transfrd** appears in the Task Window. If a module, which carries a configuration different from the five configured montages, is plugged into the monitor, **Transfrd** will select the transferred montage.

To return to the EEG Setup Task Window press **Setup EEG**.

EEG Adjustments

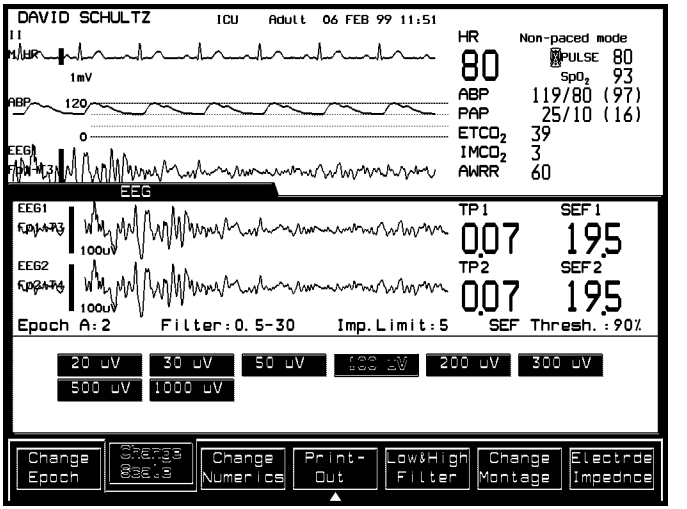
Information about the following EEG adjustments is provided on the following pages:

The key sequence to get into the Task Windows for these adjustments is shown above the screen figures in the following sections.

Changing the Scale

The **Change Scale** softkey allows you to change the size of both the real time waves and the CSAs. Press either the setup key on the plug-in module or the following key sequence:

Module Setup → **EEG** → **Change Scale** .



Procedure

1. Press the **Change Scale** softkey repeatedly or use the left and right arrow keys to select the new scale. The new scale becomes active immediately.

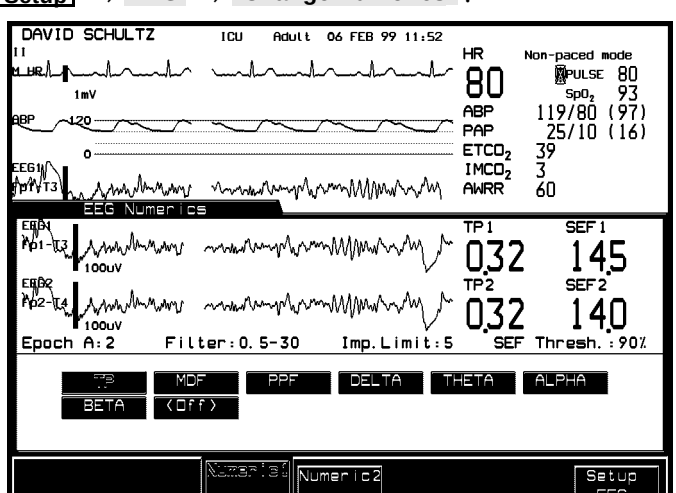
Note—If the item *Show Gridlines* is configured to **Yes**, the following selections are displayed instead of the ones pictured above:

±10 µV **±15 µV** **±25 µV** **±50 µV** **±100 µV**
±150 µV **±250 µV** **±500 µV**

Selecting the Numerics

Two of the eight numerics calculated by the EEG Module can be selected for continuous display, trending and recording. These selections can be changed in the EEG Numerics Task Window.

Module Setup → **EEG** → **Change Numerics** .



When entering this task window, the **Numeric 1** softkey is selected, and the following selections appear in the bottom half of the Task Window (if **Off** is selected for the second numeric):

TP	**SEF**	**MDF**	**PPF**	**DELTA**	**THETA**
ALPHA	**BETA**	**Off**			

The configured threshold for the spectral edge frequency numeric is shown above the corresponding **SEF** selection.

The selection already assigned to Numeric 2 (if different to **Off**) is not offered.

If the **Numeric 2** softkey is pressed, the same selections appear in the bottom half of the Task Window as for Numeric 1, except for the selection already assigned to Numeric 1.

Procedure

1. Press **Numeric 1** repeatedly to change the selection for Numeric 1. The new numeric selection becomes active immediately.
2. Press **Numeric 2** repeatedly to change the selection for Numeric 2. The new numeric selection becomes active immediately.
3. To return to the **EEG** setup Task Window press **Setup EEG** .

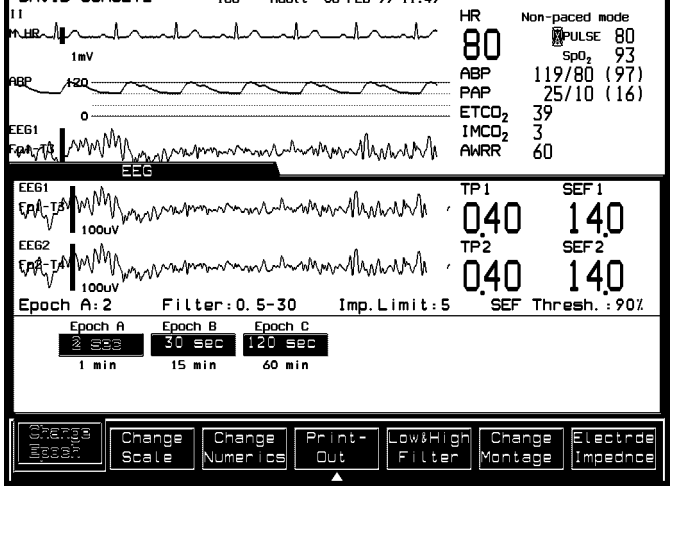
Notes—

- If you want to have a trend line displayed in the CSA display, select a frequency numeric (i.e. SEF, MDF or PPF)
- If, due to the change of the numerics settings, a different numeric is used for the trend line within the CSA, the CSAs and the status line above the CSAs are updated. The new trend line is shown over the full CSA time.
- The two selected numerics are available for viewing as Graph Trends (see Chapter 8 *Trends and Calculations*)

Changing the CSA Epoch

The duration of a CSA Epoch can be changed in the EEG Task Window. Press either the Setup key on the plug-in module or the following key sequence:

Module Setup → **EEG**



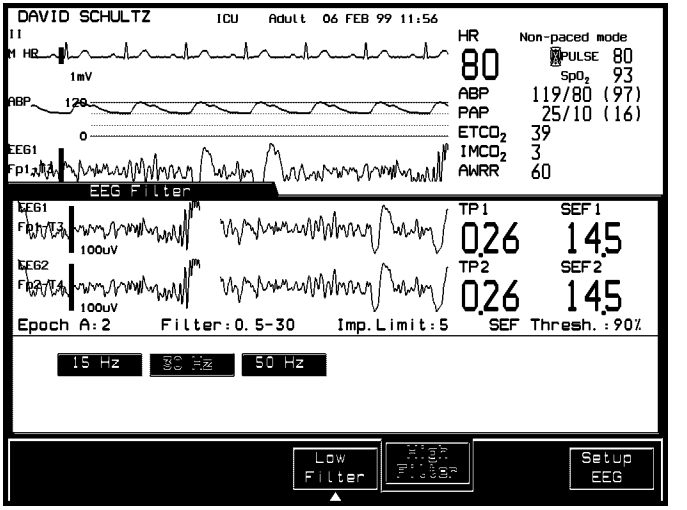
Procedure

1. Press the **Change Epoch** softkey repeatedly to select one of the three available CSA trends. The displayed CSA can be changed without any loss of data.

Low & High Filter

The filter settings for the upper and lower corner frequencies of the EEG channels can be changed in the EEG Filter Task Window.

Module Setup → **EEG** → **Low&High Filter** .



Procedure

1. Press the **High Filter** softkey repeatedly to select the desired setting for the high filter (upper corner frequency).
2. Press the **Low Filter** softkey repeatedly to select the desired setting for the low filter (lower corner frequency).
3. To return to the EEG Setup Task Window press **Setup EEG** .

The new filter settings become active as soon as the EEG Filter task window is closed. The filter settings shown in the status line reflect the current active filter settings.

Notes—

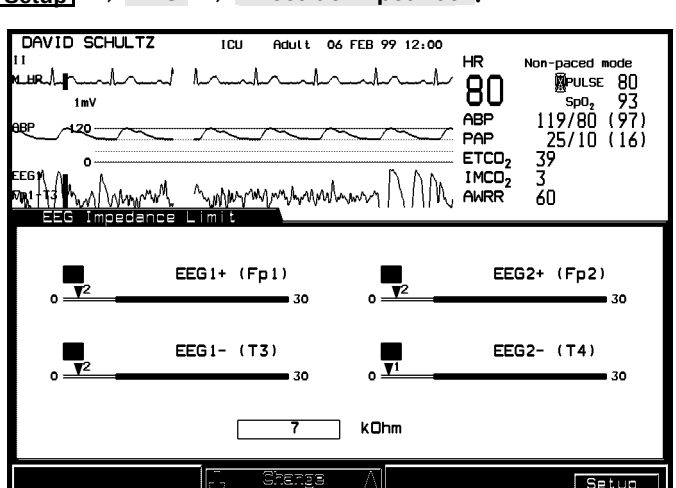
- Since the new filter settings do not become active and the effects of the changed filter settings on the EEG raw wave are not visible until the EEG Filter Task Window is closed, the filter settings shown in the status line do not follow the selections while this task window is active.

- If the filter setting is changed a thin marker appears next to the old CSA data (i.e. data before the filter change) within the CSA display.

Changing the Impedance Range Limit

The limits for the electrode-to-skin impedance range of the EEG electrodes can be changed in the Electrode Impedance Task Window.

Module Setup → **EEG** → **Electrde Impednce** .



The thinner part of the displayed bars represent the impedance range below the selected limit. The triangles and values above the bars indicate the actual measured electrode-to-skin impedances for each electrode. If the measured electrode-to skin impedance of one or more electrodes is above the limit, an INOP will be issued (see *INOP Messages*).

Procedure

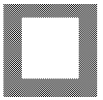
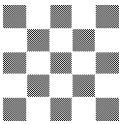
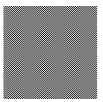
1. Press either the **Change Limit** softkeys or the arrow keys to change the impedance range limit.

Note—The impedance limit can only be changed for all electrodes at the same time within a range of 0 to 30 kOhm and in steps of 1 kOhm. The adjusted impedance limit is shown numerically in a box above the **Change Limit** softkeys and is indicated graphically by the bars.

2. To return to the EEG Setup Task Window, press **Setup EEG**

Graphic Symbols in the Electrode Impedance Task Window

In addition to the numeric values, graphic symbols above the bars in the Electrode Impedance Task Window indicate the range of the measured impedance. The following table explains the meaning of the different symbols:

Electrode/Skin Impedance	Symbol	Color	Displayed Impedance Value	Action
Electrode not connected		red	no value	connect electrode
Not enough electrodes connected, Impedance cannot be measured		white	60 kΩ (fixed)	attach more electrodes
Electrode connected, Impedance above limit		yellow	measured value (e.g 15 kΩ)	check limit, check electrode-to-skin contact
Electrode connected, Impedance at or below limit		green	measured value (e.g. 3 kΩ)	

Note—If the reference electrode is not connected or has fallen off the patient's head, the electrode impedances cannot be measured and the triangles and actual measured values disappear. The prompt message *Connect Reference Electrode first* is displayed in the Task Window, indicating that the reference electrode should be connected.

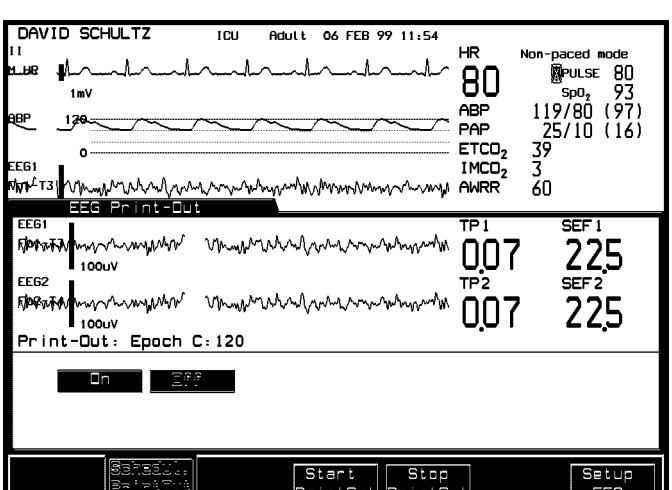
Note—For impedance measurement at least three electrodes (including reference electrode) must be connected.

Print-Out

Two types of EEG print-outs can be controlled in the EEG Print-Out Task Window:

1. Manual Print-Outs
2. Scheduled Print-Outs

Module Setup → **EEG** → **Print-Out** .



Manual Print-Outs

1. Press the **Start Print-Out** softkey to start an EEG print-out immediately. To cancel a current report, press **Stop Print-Out** .
2. To return to the EEG Setup Task Window, press **Setup EEG** .

Note—A manually triggered print-out does not influence the timing of the scheduled print-outs.

Note—Manual print-outs will always contain the user-selected CSA Epoch. The CSA Epoch in the status line of the Print-Out Task Window is only valid for scheduled print-outs.

Scheduled Print-Outs

1. Press the **Scheduled Print-Out** softkey to turn scheduled EEG print-outs on or off. The time for scheduled print-outs is configured in

Configuration Mode by either your biomedical engineer or your Agilent Service Engineer.

2. To return to the EEG Setup Task Window, press **Setup EEG**.

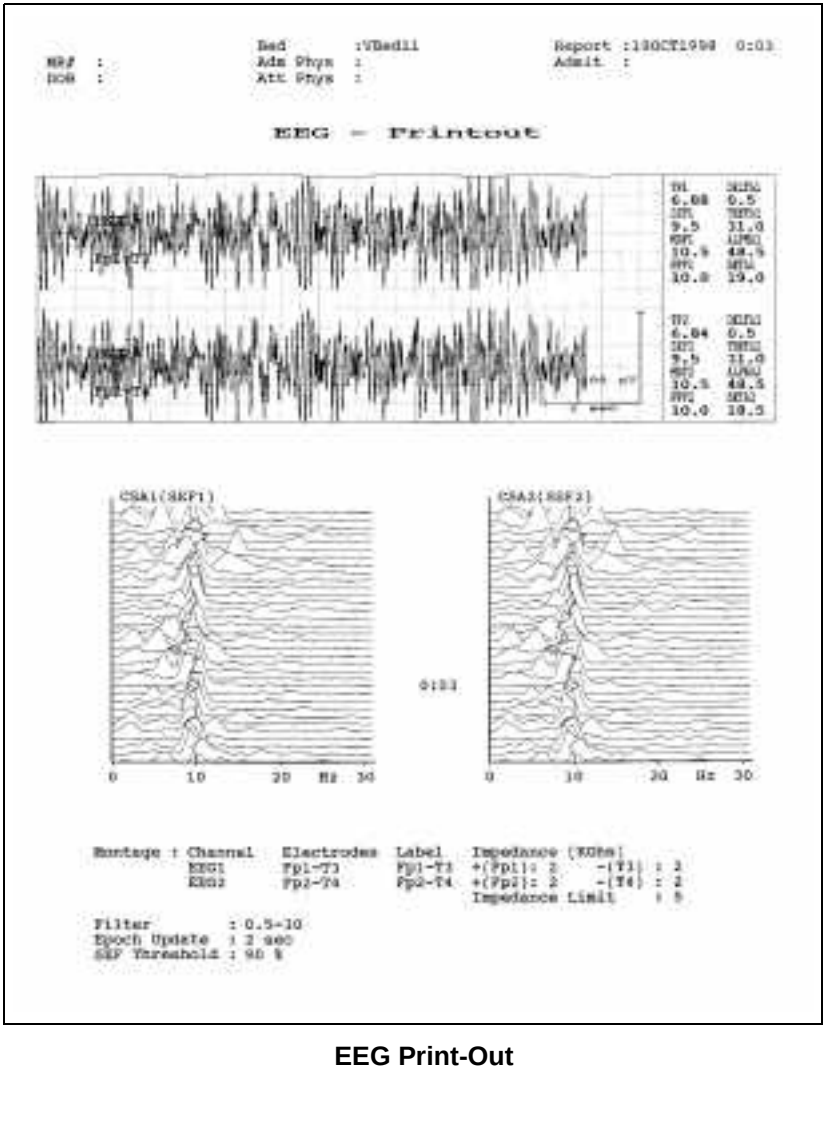
Note—For both, manually triggered print-outs and scheduled print-outs, the data at the time of the print request is printed, even if the actual printing is delayed due to another ongoing print job.

The following status line is an example of the status line displayed, if scheduled print-outs are on:

Print-out: Epoch C:120 Every:10 min Next: 07:40

If scheduled print-outs are off, the following status line is shown:

Print-out: Epoch C:120

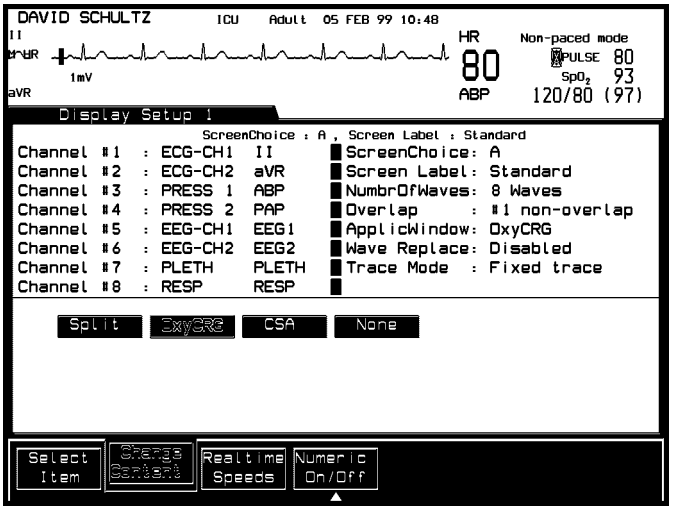


EEG Print-Out

Switching CSA Screen On/Off

The CSA Screen can be turned on or off in the Display Setup Task Window for each independent display.(See also Chapter 3 “Setting up your monitor)

Monitor Setup → **Display1 Setup** → **Select Item**



Procedure

1. Press **Select Item** until “ApplicWindow” is selected on the screen.
2. Press **Change Content** to choose CSA to be displayed.
3. Press **Monitor Setup** to return to the selection window or **Main Screen** to return to the Main Screen.

Note—The CSA screen is turned off automatically, if Split Screen or oxyCRG Screen is selected as Application Window and vice versa.

EEG INOP Messages

INOP Message	Explanation	Action
EEG UNPLUGGED	EEG plug-in module has been unplugged.	Plug in module
EEG EQUIP MALFUNC	Equipment Malfunction	Call Service Representative
EEG NO TRANSDUCER	Trunk cable has been disconnected from EEG plug-in module.	Connect Trunk Cable
EEG LEADS OFF	If multiple lead electrodes are not connected, this INOP is issued instead of the channel specific INOPs.	Connect electrodes (start with reference electrode)
EEG1 LEADS OFF **EEG1 LEAD OFF [*lead label*]**	Lead electrodes of channel EEG1 are not connected to or have fallen off the patient's head. If a single lead electrode is disconnected, the INOP is shown with the electrode location label (e.g. F3).	Connect channel 1 electrodes. Connect specified electrode (e.g. F3)
EEG2 LEADS OFF **EEG2 LEAD OFF [*lead label*]**	Same as INOP above, but for channel EEG2.	Same as above, but for channel 2
EEG1 OVERRANGE **EEG2 OVERRANGE**	Input signal is too high. This is usually caused by interfering signals such as line noise or electrosurgery.	
EEG OVERRANGE	Input signal is too high in both channels.	
EEG1 IMPEDANCE>[*limit*] **EEG1 IMPED.[*lead label*]>[*limit*]**	Electrode impedance of signal electrode in channel EEG1 is above the user selected limit. If the impedance of a single lead electrode in channel EEG1 is above the user adjusted limit, the INOP is displayed with the electrode location label (e.g. F3).	Check Impedance. When impedance too high, reconnect the electrode according to the EEG monitoring setup guidelines on page 28-6
EEG2 IMPEDANCE>[*limit*] **EEG2 IMPED [*lead label*]>[*limit*]**	Same as INOP above, but for channel EEG2.	Same as above, but for channel 2

INOP Message	Explanation	Action
EEG IMPEDANCE>[*limit*]	Electrode impedance of signal electrodes in both channels is above the user-selected limit.	see above.
EEG1 MUSCLE NOISE **EEG2 MUSCLE NOISE**	Too much power above 30 Hz in channel EEG1 or EEG2.	Check Electrode-to-Skin Impedance and reposition the electrode away from possible muscle activity, if necessary.
EEG MUSCLE NOISE	Too much power above 30 Hz in both channels at the same time.	see above.
EEG1 LINE NOISE **EEG2 LINE NOISE**	Excessive line noise in channel EEG1 or EEG2.	Keep all cables together and away from metallic bodies, other cables & radiated fields.
EEG LINE NOISE	Excessive line noise in both channels at the same time.	

Accessories and Ordering Information

Since the Agilent cables and accessories were designed specifically for your Agilent CMS or Agilent ACMS, we recommend the use of only Agilent cables and accessories for optimum monitor performance.

Part Number	Description
M2268A	Trunk Cable, 2.7 m
M2269A	Trunk Cable, 1.0 m
M1931A	Reusable 80-cm-long 5-lead cables with 10mm silver/silverchloride leadwired cup electrodes (Adult)
M1932A	Reusable 80-cm-long 5-lead cables with 6mm silver/silverchloride leadwired cup electrodes (Pediatric/Neonatal)
M1934A	Reusable 80-cm-long 5-lead cables with miniclip connectors
M1935A	4 sets of 25 disposable wet gel electrodes

Order Number	Description
M1936A	Omni Prep® (EEG skin preparation paste)
M1937A	EC2™ Electrode Cream (conductive paste)

Care and Cleaning

Patient Cables and Leads

Clean cables after each use as follows:

1. Remove any adhesive used to secure the electrodes to the patient and wipe off any remaining electrode gel from the electrodes. (If adhesive tape residue has to be removed, use a plaster remover solution or the Scholl MfgCo Double seal tape remover. Acetone, alcohol, ammonia, chloroform or other strong solvents are not recommended, because they will eventually damage the vinyl cabling.)

2. Sponge trunk cables with warm water and soap, or another suitable cleaning solution, and dry. Do not immerse them in water.

3. Check each cable for corrosion, cracks and deterioration.

Autoclave the silver/silverchloride cup electrode leadsets (M1931A, M1932A & M1934A) at 136°C maximum.

Do not autoclave other cables and disposable electrodes or heat them above 75°C (167°F). If the metal surfaces become tarnished, they may be cleaned with any cleaner which does not leave a residue. Do not use any metallic abrasive such as steel wool. The cables should be stored in an environmental temperature between -20°C to 75°C (-68°F to 167°F). They should be hung up or laid flat to prevent damage to the cable.

Note—Do not attempt to clean the black coating off the silver/ silverchloride cup electrodes.

EEG Performance Specifications

For safety and environmental specifications, please refer to the *Installation and Patient Safety* chapter (Volume 1).

Leakage Current	<=10 µA @ $110V_{ac}$
Input Signal Range	1 mV_{p-p}
Differential Input Impedance	>15 MΩ @ 10 Hz
Max. DC Input Offset Voltage	±320 mV
Input Protection	Against defibrillation (5 kV) and electrosurgery
Common Mode Rejection	>105 dB @ 5kΩ imbalance and 60 Hz
Noise	<0.4 µVRMS (1 to 30 Hz)
Electromagnetic Susceptibility	<10 μV_{p-p} @ 3 V/m, 26-1000 MHz
Electrode Impedance Measurement Range	0 to 30 kΩ
Electrode Impedance Measurement Accuracy	±1 kΩ
Bandwidth	0.5 Hz to 50 Hz (–3 dB)
Low Filter Cut-Off Frequencies	0.5, 1.0, 2.0, and 5.0 Hz (12 dB/octave)
High Filter Cut-Off Frequencies	15 Hz (65 dB/octave) 30 Hz (75 dB/octave) 50 Hz (85 dB/octave)

A

Summary of Formulas Used in Calculations

Hemodynamics

INPUTs

Label	Units
HR	bpm
ABP (mean)[a]	mmHg or kPa[b]
PAP (mean)	mmHg or kPa[b]
PAWP	mmHg or kPa[b]
CVP (mean)	mmHg or kPa[b]
C.O.	l/min
Height	cm or in[b]
Weight	kg or lb or g[b]

a. If only systolic and diastolic pressures are manually entered, the mean value will be calculated using the following formula which is in general clinical use: (systolic + diastolic x 2) / 3

b. Depending on the configuration of your system

OUTPUTS

Label	Units	Equation	Normal Range
C.O.	l/min	C.O.	--
CI	l/min/m2	C.O./BSA	2.5 - 4.0
SV	ml	(C.O./HR) x 1000	--
SI	ml/m2	SV/BSA	41 - 51
SVR	dynes x sec/cm5	79.96 x (ABPm - CVP)/C.O.	770 - 1500
SVRI	(dynes x sec/cm5) x m2	SVR x BSA	1970 - 2390
PVR	dynes x sec/cm5	79.96 x (PAPm - PAWP)/C.O.	100 - 250
PVRI	(dynes x sec/cm5) x m2	PVR x BSA	225 - 315
LCW	kg x m	0.0136 x (ABPm - PAWP) x C.O.	--
LCWI	kg x m/m2	LCW/BSA	3.4 - 4.2
LVSW	g x m	0.0136 x (ABPm - PAWP) x SV	--
LVSWI	g x m/m2	LVSW/BSA	50 - 62
RCW	kg x m	0.0136 x (PAPm - CVP) x C.O.	--
RCWI	kg x m/m2	RCW/BSA	0.54 - 0.66
RVSW	g x m	0.0136 x (PAPm - CVP) x SV	--
RVSWI	g x m/m2	RVSW/BSA	7.9 - 9.7
BSA (Boyd)*	m2	3.207/104 x WT(0.7285 -0.0188 x log WT) x HT0.3	
BSA (Dubois)*	m2	.00718 x (WT/1000).425 x HT.725	

*Where WT is the body weight in grams and HT is body height in centimeters.

Oxygenation

Inputs

Label	Units
C.O.	l/min
PaO_2	mmHg
$PaCO_2$	mmHg
SpO_2	%
PvO_2	mmHg
Hb	g/dl
Height	cm or in*
Weight	kg or lb or g*
PB	mmHg

*Depending on the configuration of your system

OUTPUTS

Label	Units	Equation	Normal Range
CaO_2	ml/dl	(1.34 x Hb x SpO_2/100) + (0.0031 x PaO_2) If PaO_2 is not available: (1.34 x Hb x SpO_2 /100)	17 - 20
Ca-vO_2	ml/dl	(1.34 x Hb x SvO_2/100) + (0.0031 x PvO_2) If PvO_2 is not available: (1.34 x Hb x SvO_2 / 100)	12 - 15
$CavVO_2$	ml/dl	CaO_2 - CvO_2	4.2 - 5.0
DO_2	ml/min	CaO_2 x C.O. x 10	950 - 1150
DO_2I	(ml/min)/m^2	O_2AV/BSA	550 - 650
VO_2	ml/min	$avDO_2$ x CO x 10	--
VO_2I	(ml/min)/m^2	VO_2/BSA	115 - 165
O_2ER	decimal fraction	(CaO_2 - CvO_2)/CaO_2	.24 - .28
$AaDO_2$	mmHg or kPa	PAO_2 - PaO_2	10 - 15
Qs/Qt	%	100 x (1.34 x HGB + 0.0031 x PAO_2 - CaO_2)/ (1.34 x HGB + 0.0031 x PAO_2 - CvO_2)	3 - 5
BSA (Boyd)**	m^2	$3.207/10^4$ x $WT^{(0.7285 - 0.0188 \times \log WT)}$ x $HT^{0.3}$	
BSA (Dubois)**	m^2	.00718 x $(WT/1000)^{.425}$ x $HT^{.725}$	

**Where WT = body weight in grams and HT = body height in centimeters.

CALCULATION PARAMETER SUBSTITUTIONS

Parameter Description	First Choice	Second Choice	Third Choice
Arterial oxygen partial pressure	PaO2	&PO2 from arterial sample	PO2 from arterial sample
Arterial carbon dioxide partial pressure	PaCO2	&PCO2 from arterial sample	PCO2 from arterial sample
Arterial oxygen saturaton	SpO2 manually entered	‘SO2 from arterial sample	SpO2 continuously monitored
Venous oxygen partial pressure	PvO2	&PO2 from mixed venus sample	PO2 from mixed venous sample
Hemoglobin	Hb	‘Hb	
Ambient pressure	PB	Patm from M1022A Module	
Cardiac Output	C.O.	!CCO	
Heart Rate	HR	Pulse	extHR
Tidal Volume	TV	TVex	TVin

Ventilation

INPUTS

Label	Units
RESP	rpm
$PaCO_2$	mmHg
TV	ml/breath
PIP	cmH_2O
PEEP	cmH_2O
$PECO_2$	mmHg/KPa

OUTPUTS

Label	Units	Equation	Normal Range
MINVOL	l/min	TV x RESP/1000	--
COMP	ml/cmH_2O	TV/(PIP - PEEP)	25 - 35
Vd	ml	$(PaCO_2 - PECO_2) \times TV/PaCO_2$	145 - 155
Vd/Vt	decimal fraction	Vd/TV	0.25 - 0.40
ALVENT	ml/min	(TV - Vd) x RESP	--

Abbreviations and Unit Definitions

Abbreviations

$AaDO_2$	Alveolar-Arterial Oxygen Difference
ABP	Arterial Blood Pressure
ALVENT	Alveolar Ventilation
Ao	Aortic Pressure
ART	Arterial Pressure
$Ca\text{-}vO_2$	Arteriovenous Oxygen Difference
AWRR	Airwave Respiration Rate
BSA	Body Surface Area
CaO_2	Arterial Oxygen Content
CH_2O	Free Water Clearance
C.I.	Cardiac Index
C.O.	Cardiac Output
COMP	Compliance
CORET	Body Core Temperature
$tcpCO_2$	Transcutaneous Partial Pressure CO_2
$tcpO_2$	Transcutaneous Partial Pressure Oxygen
CPP	Cerebral Perfusion Pressure
CvO_2	Venous Oxygen Content
CVP	Central Venous Pressure

$ETCO_2$	End Tidal CO_2
FIO_2	Fractional Inspired Oxygen
HT	Height
HB	Hemoglobin
HR	Heart Rate
ICP	Intracranial Pressure
$IMCO_2$	Inspiratory Minimum CO_2
IMV	Intermittent Mandatory Ventilation
IUP	Intrauterine Pressure
LAP	Left Atrial Pressure
LCW	Left Cardiac Work
LCWI	Left Cardiac Work Index
LVSW	Left Ventricular Stroke Work
LVSWI	Left Ventricular Stroke Work Index
MINVOL	Minute Volume
DO_2	Oxygen Availability
DO_2II	Oxygen Availability Index
O_2ER	Oxygen Extraction Ratio
P1	First (or only) nonspecified pressure
P2	Second nonspecified pressure
P3	Third nonspecified pressure
P4	Fourth nonspecified pressure

PaO_2	Partial Pressure of Oxygen in Arterial Blood
$PaCO_2$	Partial Pressure Carbon Dioxide (arterial)
PAO_2	Alveolar O_2 Pressure
PAP	Pulmonary Artery Pressure
PAWP	Pulmonary Artery Wedge Pressure
PB	Barometric Pressure
$PECO_2$	Mean Expired Carbon Dioxide
PEEP	Positive End-expiratory Pressure
PIP	Peak Inspiratory Pressure
PULSE	Pulse rate (from invasive pressure)
PvO_2	Venous Partial Pressure Oxygen
PVR	Pulmonary Vascular Resistance
PVRI	Pulmonary Vascular Resistance Index
Qs/Qt	Percent shunt
RAP	Right Atrial Pressure
RCW	Right Cardiac Work
RCWI	Right Cardiac Work Index
RESP	Respiration Rate
RVSW	Right Ventricular Stroke Work
RVSWI	Right Ventricular Stroke Work Index
SpO_2	Percent Oxyhemoglobin Saturation -- Arterial
SI	Stroke Index

SO_2	Oxygenation Saturation (%)
SV	Stroke Volume
SvO_2	Percent Oxyhemoglobin Saturation -- Mixed Venous
SVR	Systemic Vascular Resistance
SVRI	Systemic Vascular Resistance Index
T	First (or only) nonspecified temperature
T1	First (or only) nonspecified temperature
T2	Second nonspecified temperature
TV	Tidal Volume
Vd	Dead Space
Vd/Vt	Dead Space/Tidal Volume Ratio
VO_2	Oxygen Consumption
VO_2I	Oxygen Consumption Index
VPB	Ventricular Premature Beats
WT	Weight

Selected Units Defined

bpm	beats per minute
mmHg	millimeters of mercury
l/min	liters per minute
cm	centimeters
kg	kilograms
g	grams
ml/m^2	milliliters per meter square
dynes x sec/cm^5	dyneseconds per 5th power centimeter
kg x m/m^2	kilogram meters per meter squared
g/dl	grams per deciliter
ml/cmH_2O	milliliters per centimeter of water
kPa	kiloPascals
rpm	respirations per minute

References

1. Berk, J., et al: *Handbook of Critical Care*. Boston, Little, Brown and Company, 1976.

2. Hewlett-Packard Company: An Implementation of Bedside Physiological Calculation. *Hewlett-Packard Monograph*, 1988; HP part number 5954-1779.

3. Shoemaker, W., et al: Early Prediction of Death and Survival in Postoperative Patients in Circulatory Shock by Nonparametric Analysis of Cardiopulmonary Variables. *Critical Care Medicine*, 2:317, 1974.

4. Vij, Deepak, et al: A Simplified Concept of Complete Physiological Monitoring of the Critically Ill Patient. *Heart and Lung*, 10:75, 1980.

5. Gordon B. Avery, M.D., Ph.D.: Neonatology - Pathophysiology and Management of the Newborn

6. L. Wille and M. Obladen: Neugeborenen - Intensivpflege (Grundlagen und Richtlinien)

7. John W. Severinghaus: Transcutaneous Blood Gas Analysis (the 1981 Donald F. Egan Lecture - *Respiratory Care*, Vol 27, No 2, Feb 1982)

B

Analog Output Section
(Agilent CMS Only)

In this section you will find information on configuring the Agilent Component Monitoring System's Analog Output:

.

Introduction to the Analog Output

The analog output function card provides 8 channels of analog output for connection to recorders and other data collection instruments. All channels can be controlled individually with respect to wave or numeric output, and gain and offset control.
Both wave output and numeric output are supported.
Both "Absolute" (scale independent) and "Scaled" (scale dependent) wave outputs can be configured.
In addition, 8 ALARM/INOP status lines are provided as digital outputs. These status lines are ideal for triggering alarm recorders or other data collection devices. Arrhythmia alarms are not however supported by the analog output.

All the selections for waves, numerics, gain and offset can be configured through the Agilent Component Monitoring System's human interface.

Warning

The analog output function is not for use with balloon pumps, defibrillators or other critical timing devices. Output delay may exceed 250ms.

Technical Terms

The Agilent Component Monitoring System's Analog Output allows the user to adjust the size (**gain**) and position (**offset**) of each analog signal. With these adjustments, the user can individually tailor each output for their recording or data collection device.

Gain

This term is equivalent to size control. Increasing the gain of an ECG signal, for example, is identical to increasing its size. Gain is an important feature because it allows the user to adjust each waveform to the desired size.

Offset

This term is equivalent to position. Adjusting the offset of a pressure signal, for example, is identical to adjusting its position. Offset is an important feature because it allows the user to adjust each waveform to the desired position.

Application Information

Scaled Waves

The scaled wave output can be configured from any existing physiological wave in the HP Viridia CMS. The size of the wave output depends on the wave's display scale on the HP Viridia CMS.
For instance:

> If the user changes the scale of a pressure wave from 60 to 120, the size of the pressure wave is halved on the HP Viridia CMS display, and on the output channel.
>
> If the user changes the scale from 60 to 30, the size is doubled.
> The user can adjust the gain and the offset for each output individually.

Absolute Waves

An absolute wave output can be derived from any physiological wave with absolute scaling (ECG, Pressure, and CO_2). The user can adjust the gain and the offset of each channel individually.
The appearance of the wave on the output channel is independent of the wave's display scale on the HP Viridia CMS, (as long as the wave is not clipped on the display), and is determined by the gain and offset settings selected by the user.

Numeric Trends

The numeric output is a trend wave of a parameter numeric, for instance Pressure 1 (systolic).
Each trend wave is composed of numeric values continuously derived by the HP Viridia CMS.
The user can adjust the gain and the offset of each trend wave individually.

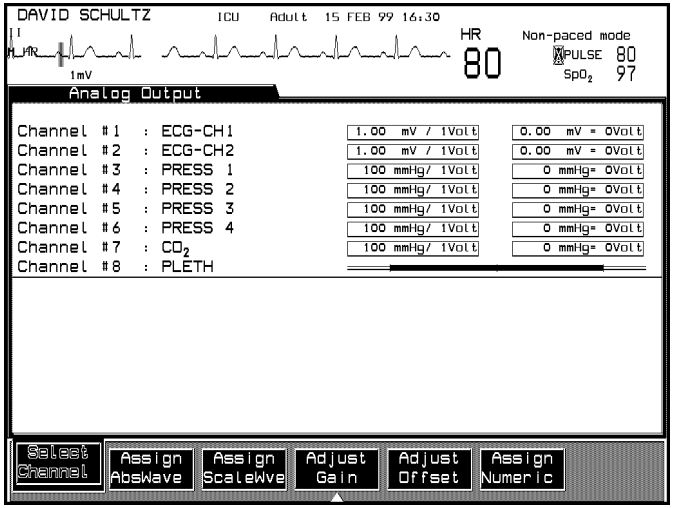
Configuring Scaled Wave Outputs

The following things must be done:

1. Select the channel
2. Assign a scaled wave
3. Adjust the gain
4. Adjust the offset

Selecting the channel

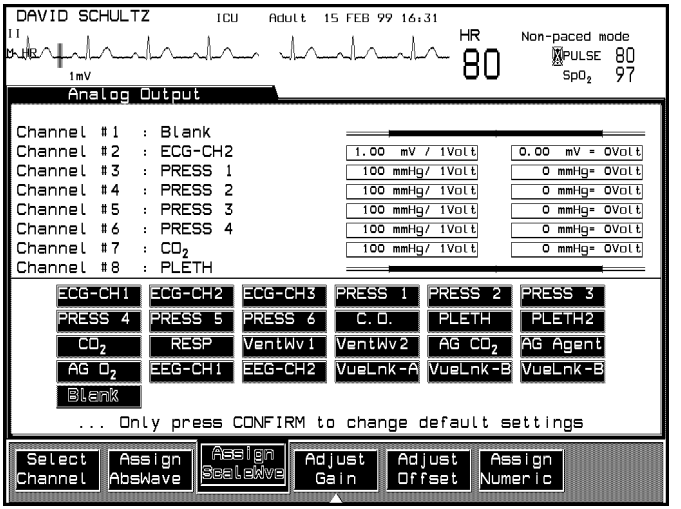
Monitor Setup → **Analog Output** → **Select Channel**



Press **Select Channel** to highlight the desired channel.

Assigning the\Scaled Wave

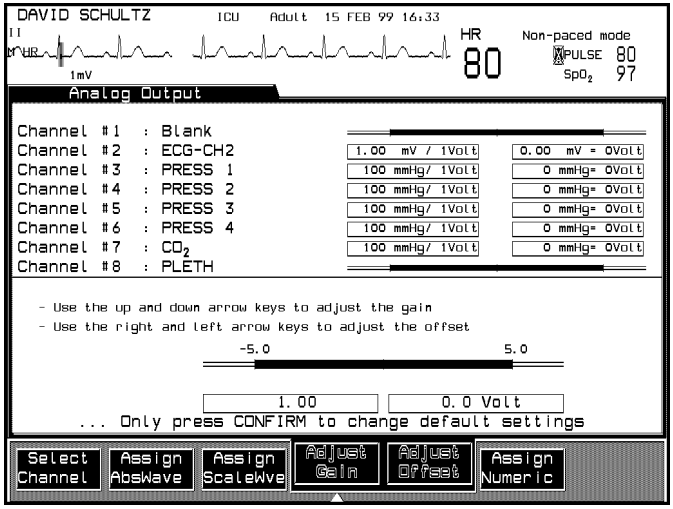
Monitor Setup → **Analog Output** → **Assign ScaleWve**



- Press **Assign ScaleWve** to highlight the desired parameter
- Press **Confirm** to store this analog output configuration as the user default. (If you do not press **Confirm**, the setting will revert to the last confirmed user default if the power is turned off for one minute or longer).

Adjusting the Gain and Offset

Monitor Setup → **Analog Output** → *either* **Adjust Gain** *or* **Adjust Offset**



The horizontal bar in the Task Window indicates the mapping of the display channel to the analog output channel.
The display channel is marked as the solid part of the bar. The analog output voltage limits are indicated by the transition from a thick (within limits) to a thin (outside limits) bar.
The factory default maps the display channel boundary limits to the analog output limits.
Adjusting gain and offset so that part of the solid bar lies outside the analog output limits will cause the affected wave to be clipped on the analog output before it is clipped on the display. This is usually an undesirable event.

Procedure for Adjusting the Scaled Wave Size

- To increase the wave size, press **Adjust Gain** or [↑]. The gain numeric increases and the horizontal bar in the task window becomes longer.
- To decrease the wave size, press [↓]. The gain numeric decreases. The horizontal bar in the Task Window becomes shorter.

Procedure for Adjusting the Scaled Wave Position

- To shift the wave upwards, press **Adjust Offset** or [→] . The offset numeric increases and the horizontal bar is shifted to the right of the center line.
- To shift the wave downwards, press [←] . The offset numeric decreases and the horizontal bar is shifted to the left of the center line.

Press **Confirm** to store all choices as the user defaults. (If you do not press **Confirm**, the setting will revert to the last confirmed user default if the power is turned off for one minute or longer.)

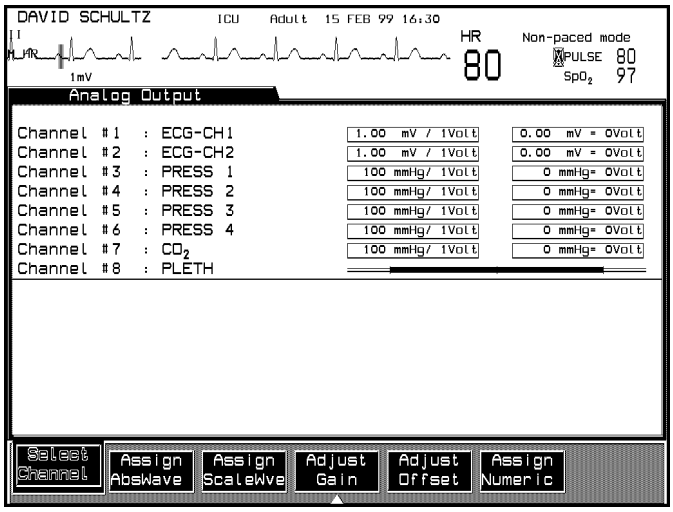
Configuring Absolute Wave Outputs

The following things must be done:

1. Select the channel
2. Assign the Absolute Wave
3. Adjust the gain
4. Adjust the offset

Selecting the Channel

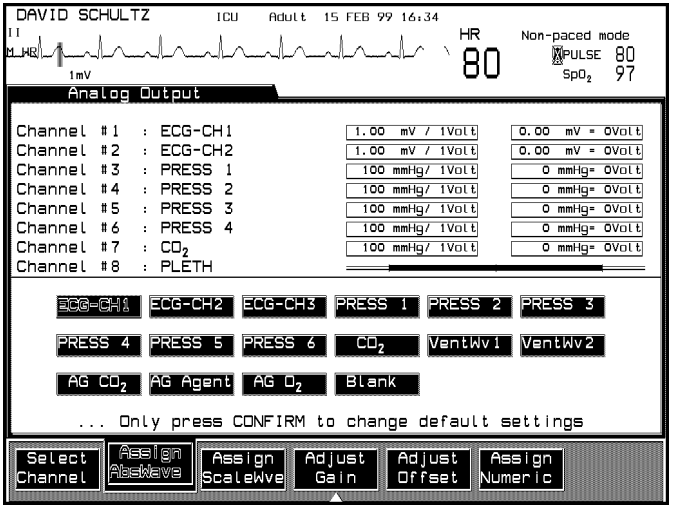
Instrument Config → **Analog Output** → **Select Channel**



Press **Select Channel** to highlight the desired channel.

Assigning the Absolute Wave

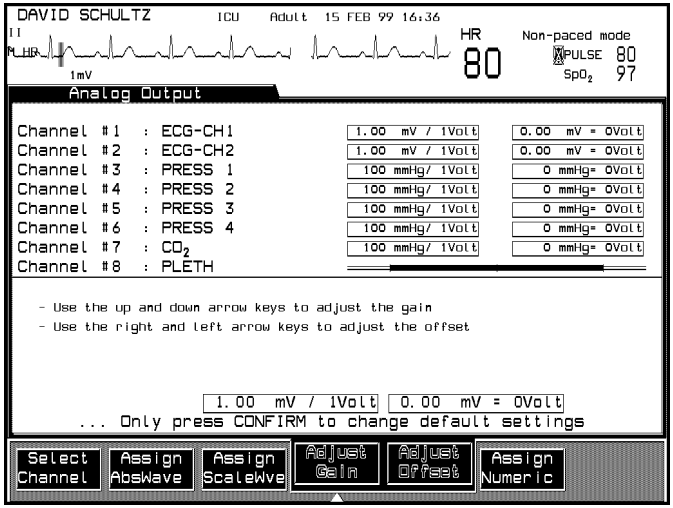
Monitor Setup → **Analog Output** → **Assign AbsWave**



- Press **Assign AbsWave** to highlight the desired wave.
- Press **Confirm** to store all choices as the user default. (If you do not press **Confirm**, the setting will revert to the last confirmed user default if the power is turned off for one minute or longer.)

Adjusting the Gain and Offset

Monitor Setup → **Analog Output** → *either* **Adjust Gain** *or* **Adjust Offset**



The gain and offset numerics in the Task Window represent the absolute size and position of the wave at the output channel.

Procedure for Adjusting the Absolute Wave Size

- To increase the wave size, press [↓]. The numeric decreases, and the wave size increases.
- To decrease the wave size, press **Adjust Gain** or [↑]. The numeric increases, and the wave size decreases.

Procedure for adjusting the Absolute Wave Position

- To shift the wave downwards, press **Adjust Offset** or [→] to increase the offset numeric.
- To shift the wave upwards, press [←] to decrease the offset numeric.

Press **Confirm** to store all choices as the user default. (If you do not press **Confirm**, the settings will revert to the last confirmed user defaults if the power is turned off for one minute or longer.)

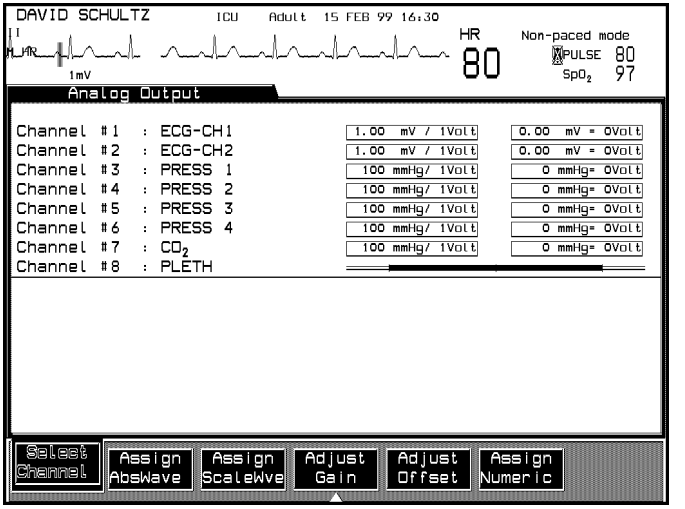
Configuring Numeric Trend Outputs

The following things must be done:

1. Select the channel
2. Assign the Numeric Trend
3. Adjust the gain
4. Adjust the offset

Selecting the Channel

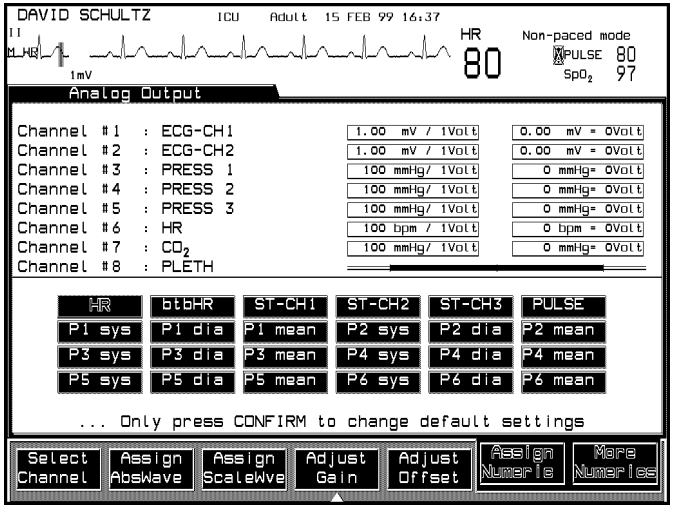
Monitor Setup → **Analog Output** → **Select Channel**



Press **Select Channel** again to highlight the desired channel.

Assigning the Numeric Trend

Monitor Setup → **Analog Output** → **Assign Numeric**

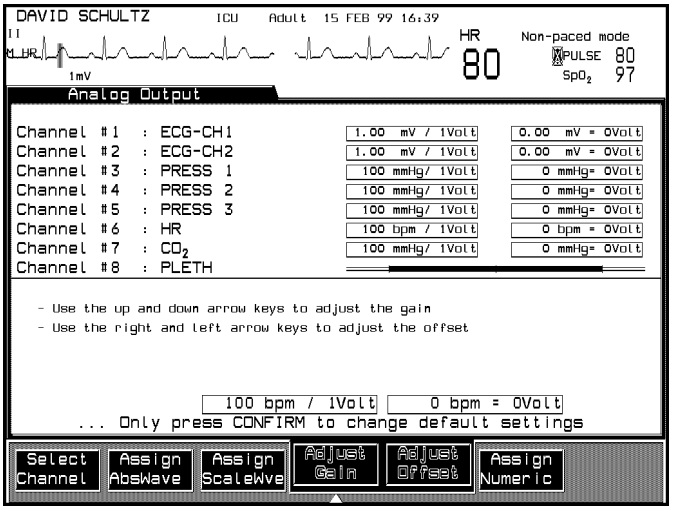


Press **Assign Numeric** to highlight the desired parameter numeric. (*To show more numerics*:Press **More Numerics**)

Press **Confirm** to store all choices as the user default. (If you do not press **Confirm**, the setting will revert to the last confirmed user default if the power is turned off for one minute or longer.)

Adjusting the Gain and Offset

Monitor Setup → **Analog Output** → *either* **Adjust Gain** *or* **Adjust Offset**



The gain and offset numerics in the Task Window represent the absolute size and position of the trend wave on the output channel.

Procedure for adjusting the Trend Size

- To increase the trend size, press [↓]. The numeric decreases, and the trend size increases.
- To decrease the trend size, press **Adjust Gain** or [↑]. The numeric increases and the trend size decreases.

Procedure for Adjusting the Trend Position

- To shift the trend downwards, press **Adjust Offset** or [→] to increase the offset numeric.
- To shift the trend upwards, press [←] to decrease the offset numeric.

Press **Confirm** to store all choice as the user default. (If you do not press **Confirm**, the setting will revert to the last confirmed user default if the power is turned off for one minute or longer.)

C

Calibrating the Pressure System

This appendix provides information on how to zero the transducer and the mercury calibration procedure.

Methods of Calibrating the Pressure System

The calibration (CAL) factor of a transducer shows the relationship between applied pressure and transducer sensitivity. Your Biomedical Engineering Department can tell you the CAL factor for any pre-tested reusable transducer.

The CAL factor is displayed in the Mercury Calibration Task Window.

There are two ways to calibrate the instrument:

1. Perform a mercury calibration.
2. Alter the CAL factor in the Mercury Calibration Task Window.

To alter the CAL factor:

- Press softkey **Mercury Calibr** or press the ▲ and ▼ arrow keys until correct CAL factor shown.
- Press **Confirm** to store the CAL factor.

Calibrate the instrument *either* whenever a new transducer is used, *or* as frequently as dictated by your Hospital Procedures Policy.

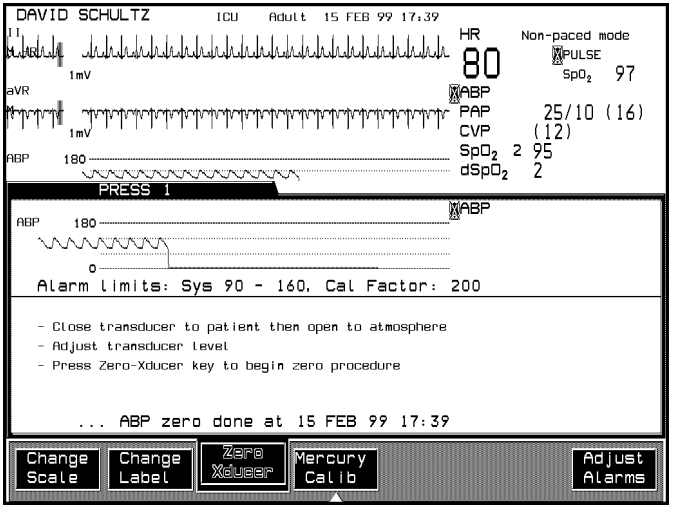
Zeroing the Transducer

Points to Remember

- Turn off patient stopcock before you start the zero procedure.
- Zero procedure should be performed before starting the monitoring and at least once a day.
- The transducer must be vented to atmospheric pressure before the zero procedure.
- The transducer should be placed level with the heart, approximately mid axillary line.
- There are two ways to zero the transducer; either press the ZERO key on the front of the module (until the message “zero in process” appears); or get into the Zero Xducer Task Window via the Module Setup Selection Window.
- The monitor is not able to zero if;
  - the wave is pulsatile
  - overpressure offset of transducer >±200 mm/Hg
  - the monitor is in test mode

A message “Unable to zero <P1>” will be displayed. (Whichever pressure label is used will be shown in the message).

Procedure for Zeroing the Transducer



Warning

If the pressure alarms are turned on, they are automatically turned off during this procedure while the message "zero in process" appears on the screen. This is true whether the procedure is performed via a Task Window, or via the ZERO key on the parameter module. On completion of the procedure, the alarms are automatically turned back on.

1. Press the softkey **Zero Xducer** and the date and time of the last zero will be displayed.
2. Adjust transducer level if necessary, turn stopcock to patient off, and vent the other stopcock to atmospheric pressure.
3. Press **Zero Xducer** again and the pressure signal and numeric should descend to the zero scale. A prompt tone and message will appear when the procedure is complete.

- If the monitor is unable to zero the transducer, an error message will appear on the screen.

4. Close the stopcock to atmospheric pressure and then open the stopcock to the patient.
5. To perform a mercury calibration, press the softkey **Mercury Calibr** and follow the procedure as described in “Mercury Calibration”.

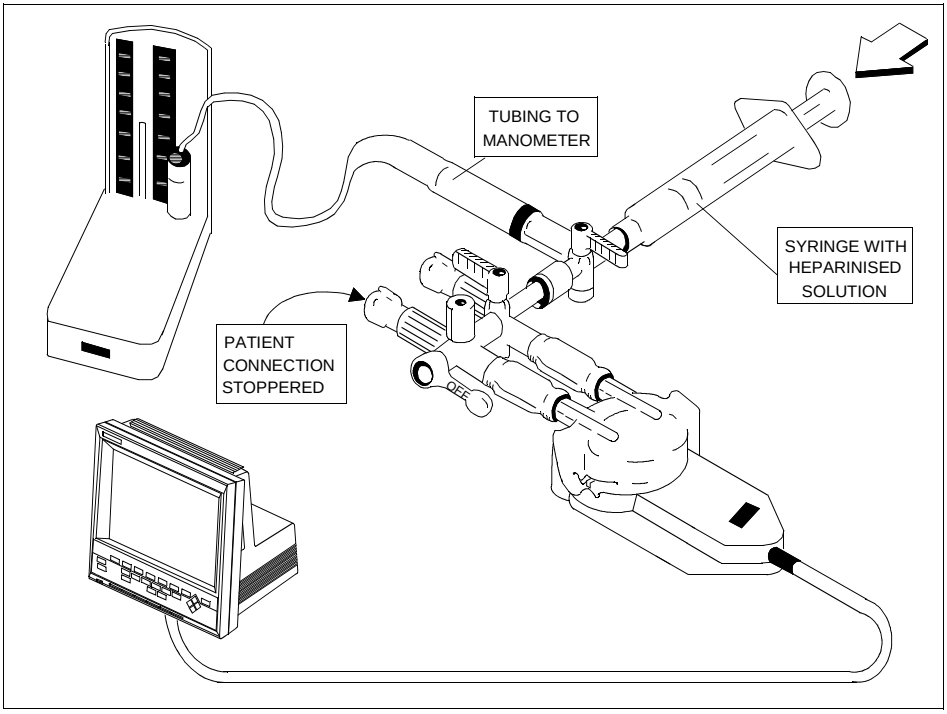
Mercury Calibration

Points to Remember

- Mercury calibration should be performed by the biomedical engineering department *either* whenever a new transducer is used, *or* as frequently as dictated by your Hospital Procedures Policy.
- The purpose of the calibration is to ensure that the system gives you accurate measurements.
- Before starting a mercury calibration, a zero procedure *must* be performed.
- If you need to perform this procedure yourself you will need the following pieces of equipment:

  Standard sphygmomanometer
  Sterile 10 cc syringe with heparinised solution
  3-way stopcock
  Tubing approximately 25 cm long

See diagram on the next page for the setup


TUBING TO
MANOMETER
SYRINGE WITH
HEPARINISED
SOLUTION
PATIENT
CONNECTION
STOPPERED
OFF

Procedure for Mercury Calibration

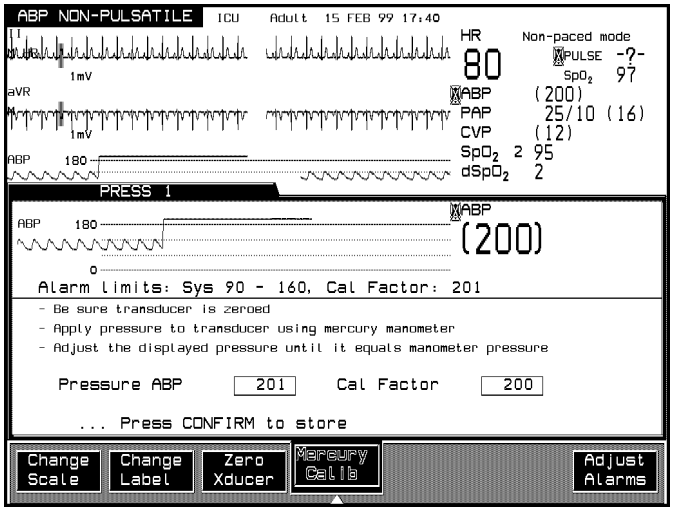
Warning

You must NEVER perform this procedure while patient is being monitored.

1. Close the stopcock that was open to atmospheric pressure for the zero calibration.
2. Attach the tubing to the manometer.
3. Ensure that connection that would lead to patient is off.
4. Connect the 3-way stopcock to the stopcock that is not connected to the patient catheter (when monitoring a patient). Attach the syringe to one port and the tubing from the manometer onto the other port.
5. Open the port to the manometer.
6. Press the syringe barrel in and raise the mercury to 200 mm/Hg or 30 kPa and then follow the procedure in the mercury calibration Task Window on the next page.

Mercury Calibration Task Window

Module Setup --> **Press1**



Warning

If the pressure alarms are turned on, they are automatically turned off during this procedure. On completion of the procedure the alarm is automatically turned back on.

1. Press the softkey **Mercury Calibr** and the date and time of the last mercury calibration will be displayed.
2. Adjust the displayed pressure until it equals the manometer pressure.
3. Press **Confirm** to store the calibration values. The new date and time of the calibration will then be displayed.
4. Remove the manometer tubing, syringe and extra stopcock.
5. It is recommended that after calibrating the instrument, the dome and tubing of the transducer used should be replaced by sterile ones.

6. Refer to Pressure Module Section for information on zeroing the transducer.

7. Turn the stopcock to the patient back on.

8. Press **Main Screen** to return to the Main Screen.

D

SpO_2 Transducer Information

This chapter provides information on SpO_2 transducers for use with the Agilent CMS, V24 and V26 monitors. It includes the following sections:

Description of Transducers

Disposable Transducers|

These should be used once only and then discarded. However, they can be relocated to a different patient-site if the first location does not give the desired results. Disposable transducers must not be reused on different patients.

Reusable Transducers

These can be reused on different patients after being cleaned and disinfected.

Transducers and Accessories

Description	*NELLCOR*® Label	Agilent Part No.	Qty.
Agilent Reusable Transducer:			
Adult finger[1]		M1190A	1
Adult finger[2]		M1191A	1
Small Adult/Pediatric finger[2]		M1192A	1
Infant Finger[2]		M1195A	1
Neonatal foot/hand[2]		M1193A	1
Adult/Pediatric clip[2]		M1194A	1
Disposable Transducers:			
Nasal	Oxisensor II™ R-15	M1905A	12
Adult digit	Oxisensor II™ D-25	M1904A	24
Pediatric finger (toe[3])	Oxisensor II™ D-20	M1903A	24
Infant toe (finger[3])	Oxisensor II™ I-20	M1902A	24
Neonatal foot (hand[3])	Oxisensor II™ N-25	M1901A	24
Accessories:			
Adaptor cable (for disposable transducers)		M1900B	1
Adaptor cable (for M1191A to M1194A)		M1940A	1

[1]Backwards compatible with all existing HP Viridia 24/26 Series software revisions; can be distinguished by it's grey cable.

[2]Not compatible with HP Viridia Model 24/24C/24CT software revisions prior to Release E; can be distinguished by it's blue cable.

[3]Alternative application site.

OXISENSOR II™ is a trademark of NELLCOR® Incorporated. Disposable transducers are not available as Agilent parts in the USA.

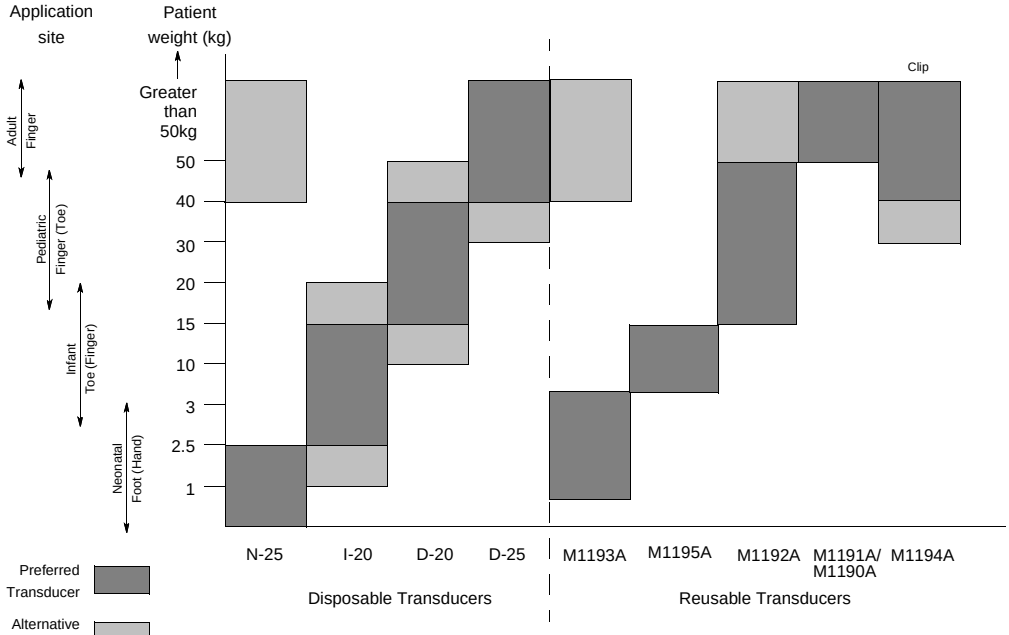
Note—The above listed accessories are not shipped with every instrument. Contact your Agilent sales representative for details.

Materials used for Agilent Reusable Transducers

M1190A	housing: silicone	cable: silicone
M1191A	housing: silicone	cable: silicone
M1192A	housing: silicone	cable: polyurethane
M1193A	housing: silicone	cable: polyurethane
M1194A	housing: polyurethane	cable: polurethane
M1195A	housing: silicone	cable polyurethane

Transducer Selection

Use the following chart as a guideline to select the most appropriate transducer for your patient. Find the patient's weight on the vertical axis, and draw a horizontal line across the chart. Each shaded area that the line passes through represents a transducer which can be used on this patient. Areas of dark shading indicate that the transducer is the most appropriate one in that weight range. Areas of light shading indicate that the transducer may be used in this weight range, even though it is not the most appropriate transducer.

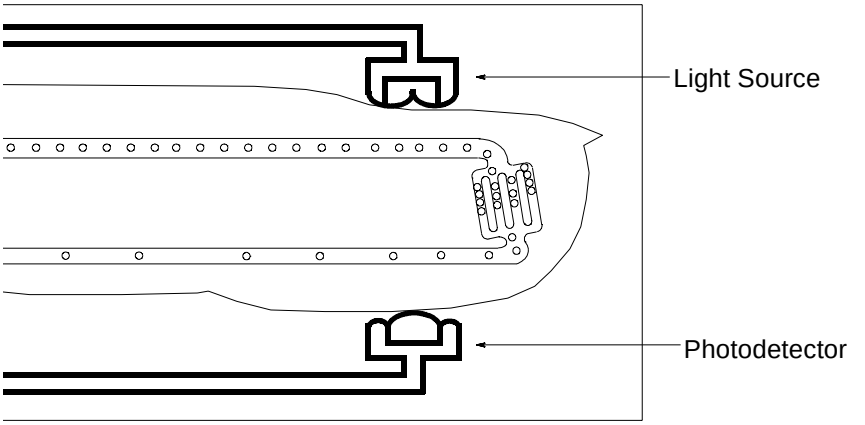


Application Information

A minimum pulsatile flow must be present at the application site of your patient to obtain measurements.

Select an appropriate transducer and apply the transducer properly to avoid incorrect measurements. Use one of the preferred application sites for your transducer. Selecting the most suitable transducer and application site will help you to ensure that:

- the light emitter and the photodetector are **directly** opposite each other and that **all** the light from the emitter passes through the patient's tissues,
- the application site is of the correct thickness for light to pass through. If the application site is too thick (for example, the upper portion of the foot) or too thin (for example, a baby's finger), an "SpO_2 NON-PULSATILE" INOP will occur. You should then select another site as appropriate.
- Applying a small amount of pressure at the application site can improve the measurement. Use the perfusion indicator or plethwave form in SQI mode to determine the optimum sensor and sensor application site.



Positioning of the Light Emitters and Photodetector

Inspect the application site every 2 to 3 hours to ensure skin integrity and correct optical alignment. If skin integrity changes, move the transducer to another site.

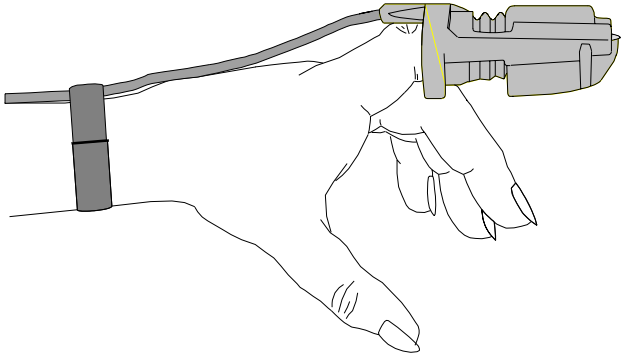
Warning

- **Failure to apply the transducer properly may cause incorrect measurement of SpO_2.**
- **Specific attention must be given to sensor site inspection for changes in skin quality, proper optical path alignment and attachment. Check the application site at regular intervals and change the site if any compromise in skin quality should occur.**
- **Using a transducer during MR imaging can cause severe burns. To minimize this risk, ensure that the cable is positioned so that no inductive loops are formed. If the transducer does not appear to be operating properly, remove it immediately from the patient.**
- **Using a transducer in the presence of bright lights may result in inaccurate measurements. In such cases, cover the site with opaque material.**
- **Failure to remove any nail polish from the selected finger may cause an incorrect measurement of SpO_2.**
- **Injected dyes such as methylene blue or intravascular dyshemoglobins, such as methemoglobin may lead to inaccurate measurements.**
- **Performance may be compromised by excessive motion. This can lead to inaccurate SpO_2, PERF and Pulse rate readings.**
- **Performance may be compromised by electrical interference. This can lead to inaccurate SpO_2, PERF and Pulse rate readings or INOP messages. Always keep power cables away from transducer cable connector.**
- **Avoid placing the SpO_2 transducer on any extremity with an arterial catheter, or intravascular venous infusion line.**
- **Do not use disposable transducers on patients who exhibit allergic reactions to the adhesive.**

- **For Neonatal Patients:**
  - **When using a disposable transducer, always ensure that the adapter cable is outside the humid atmosphere of the incubator, as this could lead to inaccurate readings.**
  - **Do not wrap or pull the tape too tightly, as this results in venous pulsation and may severely obstruct circulation, leading to inaccurate measurements.**

Application of the Agilent Reusable Adult Finger Transducer (M1190A, M1191A)

Push the transducer over the fingertip in such a way that the fingertip touches but does not protrude from the end of the transducer. The fingernail must be uppermost and the cable must lie on the back of the hand. This ensures that the light sources cover the base of the fingernail giving the best measurement results. The cable can be held in place by the accompanying wristband.



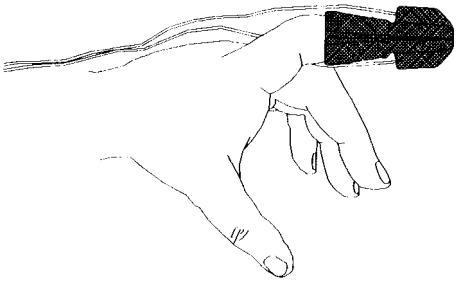
M1190A / M1191A Adult Finger Transducer

Warning

Failure to apply the transducer properly may cause incorrect measurement of SpO_2. For example, not pushing the transducer far enough over the finger can result in inaccurate SpO_2 readings. Pushing the transducer too far, so that the finger protrudes from the transducer, can pinch the finger, resulting in inaccurately low SpO_2 readings.

Application of the Agilent Reusable Pediatric Finger Transducer (M1192A)

Push the transducer over the fingertip in such a way that the fingertip touches but does not protrude from the end of the transducer.



M1192A Pediatric Finger Transducer

Warning

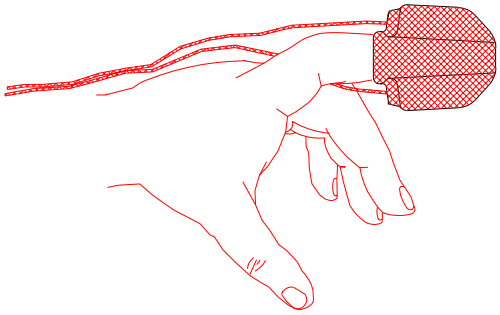
Failure to apply the transducer properly may reduce the accuracy of the SpO_2 measurement.

Application of the Agilent Reusable Infant Finger Transducer (M1195A)

To obtain the best signal from the transducer, ensure that:

- the most appropriate fingersize is selected for the transducer,
- the light source is directed from above onto the fingernail,
- the fingertip touches but does not protrude from the end of the transducer.

As patients of this age are prone to movement, it is recommended that you secure the transducer cable with tape to prevent it from coming off the finger.



M1195A Infant Finger Transducer

Warning

Failure to apply the transducer properly may cause incorrect measurement of SpO_2. For example, not pushing the transducer far enough over the finger can result in inaccurate SpO_2 readings. Pushing the transducer too far, so that the finger protrudes from the transducer, can pinch the finger, resulting in inaccurately low SpO_2 readings.

Application of the Agilent Reusable Neonatal Foot/ Hand Transducer (M1193A)

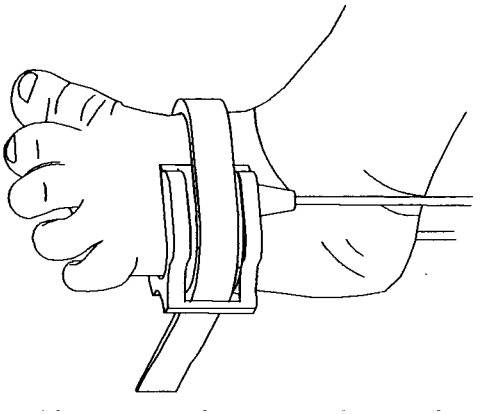
Step 1. Position the transducer on the foot or on the hand. Make sure that the optical components are opposite each other.

Step 2. Hold the transducer and stretch the strap so the transducer will be held firmly. Do not stretch the strap more than 2.5cm (1 inch).

Warning

Do not pull the strap too tightly, as this results in venous pulsation which may severely obstruct circulation and leads to inaccurate measurements

Step 3. Put the stretched strap into the slot on the top of the transducer and hold it there.



M1193A Neonatal Foot/Hand Transducer

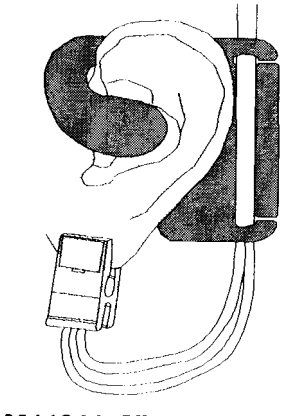
Step 4. Holding the stretched strap in the slot, thread the end through the latch.

Step 5. If the strap is too long, thread it through the second latch and secure it so that it is not in the way.

You can also attach the strap before slipping it onto the foot. This ensures that the strap is not too tight

Application of the Agilent Reusable Clip Transducer (M1194A)

Clip the probe onto the fleshy part of the ear lobe as shown in the diagram below. The plastic fixing mechanism helps to minimize artifact generated by patient motion. Do not position the probe on cartilage or where it presses against the head.



M1194A Clip Transducer

The clip transducer can be used as an alternative if the adult finger transducer does not provide satisfactory results. The preferred application site is the ear lobe, although other application sites with higher perfusion (such as the nostril) can be used. The PERF numeric can be useful in optimizing the sensor application site. Due to the physiologically lower perfusion in the ear lobe, you should be aware of the reduced accuracy of the measurement.

Warning

Failure to apply the clip transducer properly may reduce the accuracy of the SpO_2 measurement.

Application of Disposable Transducers

See the Directions for Use supplied by Nellcor® with these transducers.

Care and Cleaning

Agilent Adapter Cable (M1900B, M1940A)

Regularly clean the adapter cable by wiping it with a cleaning solution such as isopropyl alcohol. Do not use Clorox®.

Do not immerse the adapter cable in liquid, as this can lead to incorrect SpO_2 readings.

Agilent Reusable Transducers

(M1190A, M1191A, M1192A, M1193A, M1194A)

1. Remove the transducer from the patient and disconnect it from the monitor.
2. Clean the transducer in a mild detergent solution, a salt solution (1%) or one of the following solutions:

Mucasol (3%)	Buraton (pure)
Incidin (10%)	Alcohol (70%)
Cidex (pure)	Alconox (1:84)
Sporicidin (1:16)	Cetylcide (1:63)

3. Rinse the transducer in water. Wipe it with a dry cloth and then leave to dry completely.
4. Check the transducer and cable, and if you see signs of deterioration or damage, do not use for further patient monitoring.

Caution

Do not autoclave the transducers.

To get the best results from your SpO_2 reusable transducer:

- Always handle the transducer and cable with care. The soft finger sleeve houses a sensitive electronic device that can be damaged by harsh treatment. Always protect the cable from sharp-edged objects.
- Do not use bleaches containing Sodium Hypochlorite (for example Clorox®).
- Use the wristband that is supplied with your M1190A/M1191A transducer. By keeping the cable between the finger transducer and the wristband fairly loose, you will maintain good monitoring conditions. (To order additional wristbands, use Agilent part number M1627A.)

Normal wear and tear associated with patient movement and regular transducer cleaning naturally mean that your transducer will have a limited lifetime. However, provided you handle the transducer and its cable with care, you can expect useful service from it for up to two years. Harsh treatment will drastically reduce the lifetime of the transducer. Moreover, Agilents warranty agreement shall not apply to defects arising from improper use.

E

Supported Device Information

This appendix contains user information about the supported devices that can be connected to the VueLink module. This includes:

- Summary information of the supported devices available for connection via the VueLink to the Agilent CMS, V24 and V26 monitors.
- A list of waves, numerics, alarms, inops and modes for each external device.
- An indication of which numerics are available for further processing, such as standard display, trending, recording and calculations.
- An indication of which waves, numerics, alarms and inops are available via the Agilent CareNet.

Note—You will receive this appendix as a separate booklet with any VueLink Device you order. This booklet also includes instructions on how to insert it into this appendix.

F

Main Sales and Support Offices

For more information, please call your local Agilent sales office listed in your telephone directory or an Agilent regional office listed below for the location of your nearest sales office.

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Index

A

B

C

E

F

G

H

I

M

N

O

P

R

S

T

U

V

W

Z