Patient Monitoring

Select button to jump to section.

'Sensor-On-Patient' Detection

Once the sensor is correctly applied to the patient (see previous sections), the SDM usually detects that the sensor was put on the patient and initiates monitoring for the enabled parameters. If the sensor is applied on a site approved for SpO_2/PR monitoring (p. 21), 'Sensor-On-Patient' is typically detected within a few seconds, otherwise within less than 2 minutes.

When obtaining an adequate patient signal is difficult, it may be possible that the SDM is unable to automatically detect 'Sensor-On-Patient'. If in this case PCO_2 is enabled, you may use the 'Start Monitoring' function in the 'Quick Access Menu' (p. 44) to activate the 'Enforced Sensor-On-Patient Mode' bypassing normal 'Sensor-On-Patient' detection. To reset the SDM to 'Normal Sensor-On-Patient Mode' simply insert the sensor into the Docking Station.

Note: If the 'Enforced Sensor-On-Patient Mode' is active, the SDM's 'Sensor-Off-Patient' detection is disabled, i.e. in this case no 'Sensor off patient (↵)' alarm will be triggered. There will be a 'Check Application' Alarm instead, triggered within two minutes, if the sensor is dislodged or intentionally removed from the patient. If SpO_2/PR are enabled, SDM's algorithms typically will flag the PCO_2 and PO_2 readings to be unstable (displayed in grey) and the SpO_2 and PR readings to be invalid (respective values replaced by '---') within 15 seconds and within 30 seconds the low priority alarm 'SpO_2 signal quality' will sound.

Once 'Sensor-On-Patient' is detected, the SDM initiates monitoring and the enabled parameters stabilize. SpO_2 and PR usually stabilize within a few seconds, whereas PCO_2 typically increases and PO_2 typically decreases to reach a stabilized value within 2 to 10 minutes (see below).

TC-Stabilization after Sensor Application or 'TC-Artifacts'

A good, hermetically sealed contact between the TC Sensor and the skin provided, TC-readings typically stabilize within 2 to 10 minutes after sensor application, i.e. the time required to warm up the measurement site and to achieve equilibrium between the gas concentrations in the skin tissue and the gas concentrations on the sensor surface.

Good to know!

If INITIAL HEATING is ON (only available in Adult Mode), the sensor temperature is increased for about 13 minutes after sensor application, facilitating faster perfusion and results (+2 °C with a maximum of 44.5 °C).

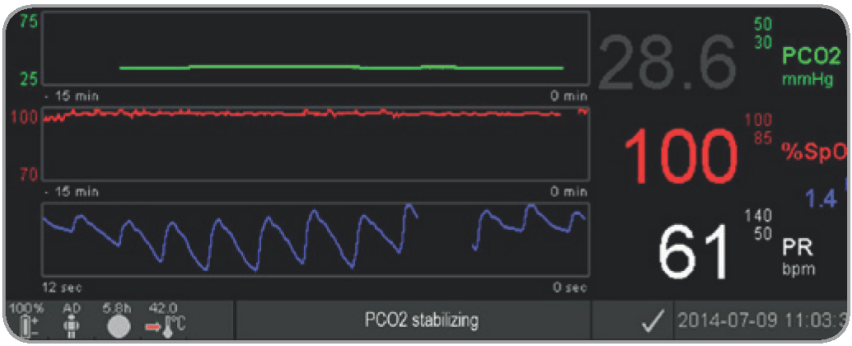
Note: The use of INITIAL HEATING is subject to institution's permission.

Once stabilized, TC-readings can be disturbed by so-called 'TC-Artifacts'. Ambient air penetrating between the sensor surface and the skin – the most frequent reason for 'TC-Artifacts' – typically will cause PCO_2 to fall and PO_2 to rise very fast.

If the penetration of ambient air is of short duration only, TC-readings will typically restabilize within a few minutes.

After sensor application or occurrence of a 'TC-Artifact', the SDM displays the message 'PCO_2/PO_2 stabilizing' if both TC-parameters are stabilizing or 'PCO_2 stabilizing' or 'PO_2 stabilizing', respectively, if only one TC parameter is stabilizing. To indicate

that TC readings during stabilization do not reflect the patient's real PCO_2 and/or PO_2 levels, the SDM displays PCO_2 and/or PO_2 readings in grey and inhibits alarms related to PCO_2 and/or PO_2 limit violations during stabilization. Furthermore, if stabilization for one or both TC parameters cannot be achieved within 10 minutes, the SDM will trigger the low priority alarm 'Check sensor application' to indicate that correct sensor application should be verified.



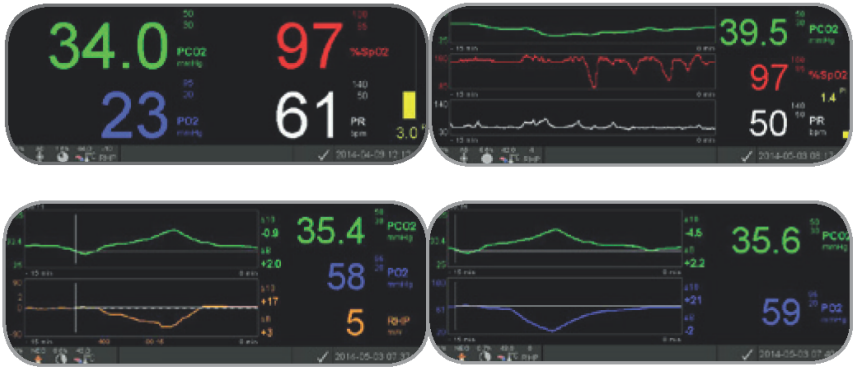
Good to know!

In order to reduce the number of 'TC-Artifacts', a good, hermetically sealed contact between the sensor and the skin is essential. Ensure to use **one small** drop of contact liquid when applying the sensor. Furthermore, ensure to verify good contact between the sensor and the skin after sensor application and to properly secure the sensor cable as well as to routinely inspect correct sensor application during monitoring.

Note: Excessive motion may cause 'TC-Artifacts'. In such cases, try to keep the patient still or change the sensor to a site involving less motion.

Preconfigured Measurement Screens

The SDM's numeric values and online trends provide continuous monitoring of the enabled parameters. Depending on the sensor type, the selected patient type and the enabled parameters, different sets of preconfigured measurement screens are available (numerical, numerical with online trends, numerical with online trend and Δx-/baseline values (p. 33), if SpO_2/PR are enabled all with either a wiper bar Pleth Wave or blip bar reflecting relative pulse amplitude). Use the Display Button (p. 44) to toggle between the available measurement displays.



Quality Indicators for Measurement Parameters

The SDM continuously evaluates the quality of the measured parameters and the Δx-values and baseline values derived thereof by assessing the severity of conditions presented to the SDM. The results of this evaluation are used to display status messages and/or quality indicators for the different parameters. While a parameter is marked as:

Valid: Alarm surveillance for the respective parameter (if applicable) is active and the SDM displays the parameter in the selected color.

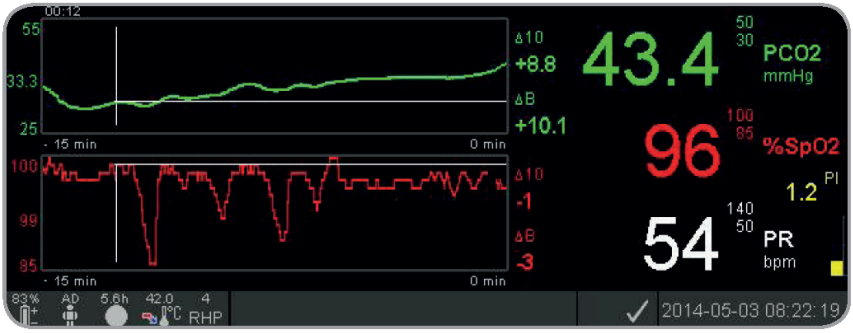
Questionable ('?'): Alarm surveillance for the respective parameter (if applicable) is active and the SDM displays the parameter in the selected color and a '?' adjacent to the parameter;

Unstable (grey): Alarm surveillance for the respective parameter is not active and the SDM displays the parameter in grey. PCO_2, for example, is displayed in grey when stabilizing after sensor application or occurrence of a 'PCO_2 artifact' (p. 31).

Invalid ('---'): Alarm surveillance for the respective parameter is not active and the SDM replaces the parameter with '---'.

Δx-Values and Baseline Values

Certain preconfigured measurement screens provide online trends with Δx-values, baseline values and baselines for PCO_2, PO_2, SpO_2 and/or RHP.



A parameter's Δx-value is displayed to the right of its online trend and corresponds to the difference between its current reading and its reading x minutes ago. x is called 'Delta-Time' and is adjustable between 1 and 120 minutes within a password-protected area of V-STATS™. The default value for 'Delta-Time' is 10 minutes.

Example: A 'Δ10-value for PCO_2' of '+ 8.8 mmHg' indicates that the current PCO_2 reading is 8.8 mmHg higher than the PCO_2 reading ten minutes ago.

Good to know!

The change of a parameter's reading within a certain time ('Delta-Time') may indicate a gradual worsening of the patient's status. A 'Δ10-value for PCO_2' of '+ 7 mmHg' or more in a patient receiving opioid analgesics and sedatives, for example, indicates opioid induced hypoventilation and, therefore, may help to earlier recognize a developing respiratory depression, especially in patients receiving supplemental oxygen.

During patient monitoring, a baseline can be set by using the respective function in the 'Quick Access Menu'. The point of time, at which the baseline was set, and the baseline itself are subsequently displayed graphically (vertical and horizontal white lines). A timer in the top left of the screen indicates the elapsed time (hh:mm) since the baseline was set. A parameter's baseline is numerically indicated on the left and its ΔB-value, i.e. the difference between its current reading and its reading at the point the baseline was set, on the right of its online trend.

Example: 'Baseline values for PCO_2' of '33.3 + 10.1 mmHg (00:12)' indicate that the current PCO_2 reading is 10.1 mmHg higher than the baseline of 33.3 mmHg which was set 12 minutes ago.

Good to know!

To assess the possible impact of a change in patient treatment (e.g. changing ventilator settings, administration of drugs such as sedatives or opioids, changing supply of supplemental oxygen etc.) on the patient's ventilation and/or oxygenation, it is recommended to set a baseline just before changing the treatment.

Operator Events

By using the 'Quick Access Menu' it is possible to store up to eight different types of Operator Events in the internal memory of the SDM for subsequent display in V-STATS™ after downloading trend data. Within V-STATS™, operator events are visualized as colored triangles and, among other, can be used to split a measurement into multiple 'Analysis Periods' (e.g. to analyze the different phases of a split night).

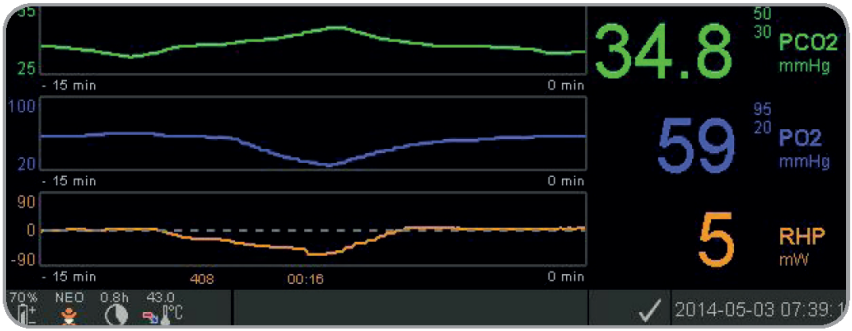
Note: Operator Events are not visualized on the SDM.

RHP Online Trends/Setting RHP Reference

Once a SenTec TC Sensor is stabilized on the skin in an environment with constant ambient temperature, the heating power required to maintain the sensor temperature depends to a small fraction on the local skin blood flow beneath the sensor site and, hence, heating power fluctuations may indicate changes in local skin blood flow.

By using the menu-parameter 'Heating Power Mode' the operator can select between the display of the 'Absolute Heating Power' (AHP), the 'Relative Heating Power' (RHP), or disable the display of the heating power. AHP and RHP values are both displayed in Milliwatts (mW).

In 'RHP-Mode', deviations of the current heating power from a stored RHP-reference value are displayed as plus or minus RHP values once the sensor is stabilized on the skin ('plus' if the current heating power is higher than the RHP-reference value, 'minus' if lower, and '0' if identical). On most measurement screens, RHP readings are – as the AHP readings – displayed in the 'Heating Power Icon' (p. 50). On certain measurement screens, however, the RHP-value is displayed underneath the PCO_2 or PO_2 value and the RHP online trend is depicted underneath the PCO_2 or PO_2 online trend.



The RHP-reference value ('408' in this example) and the time that has elapsed since it has been determined/set ('00:16' in this example) are displayed underneath the RHP online trend. The dashed horizontal center-line in the RHP online trend corresponds to a RHP of 0 mW and reflects the RHP-reference value. RHP values below/above the center-line correspond to episodes during which the sensor required less/more power to maintain the sensor temperature than the AHP-reference value. At constant ambient temperature, consequently, RHP values below/above the center-line may indicate episodes with a decreased/increased local skin blood flow beneath the sensor site.

Keeping in mind the possible influence of local skin blood flow fluctuations on transcutaneous blood gases (p. 6), it is understandable that an abrupt change of transcutaneous blood gases coupled with a significant change of RHP readings may indicate a change in local skin blood flow, while abrupt changes of transcutaneous blood gases unaccompanied by a significant change of RHP readings may indicate consistent blood flow but a change in arterial blood gases. Providing RHP online trends underneath PCO_2 online trends or PO_2 online trends, consequently, permits the clinicians to assess at a glance whether a change of PCO_2 and/or PO_2 reflects a corresponding change of the respective arterial blood gases or is caused or influenced by a significant change of the local skin blood flow beneath the sensor site.

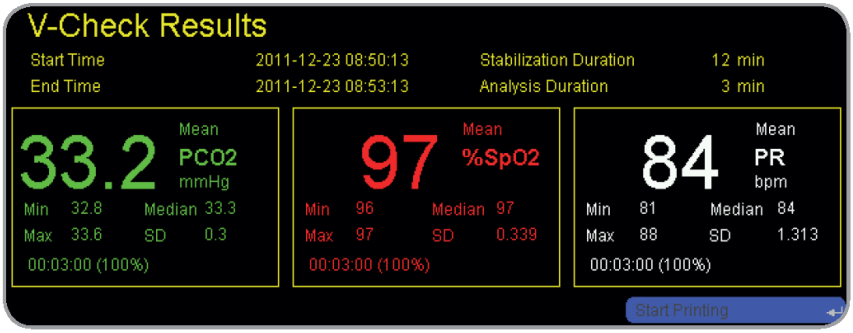
If in RHP-mode the sensor is applied to the patient when no RHP-reference value is yet available, the SDM automatically determines the RHP-reference value once the sensor is stabilized on the skin (which is typically the case 5 to 10 minutes after sensor application).

If the sensor is stabilized on the skin, the RHP-reference value can be set either a) by using the respective function in the 'Quick Access Menu' that activates after pressing the Enter Button when a measurement screen is active or b) by changing the menu-parameter 'Heating Power Mode' from 'Relative' to 'Absolute' or 'OFF' and back to 'Relative'.

To clear/reset the RHP-reference value, either remove the sensor from the patient and insert it into the Docking Station or set the menu-parameter 'Relative Heating Mode' to 'OFF'.

'V-Check™ Mode'

In standard configuration, the SDM's numeric values and online trends provide continuous monitoring of the enabled parameters. If the menu-parameter '**V**-Check™ Mode' is set to ON (only selectable if enabled by the institution), the SDM provides a Ventilation Spot **Check** with a statistical result screen displaying mean, minimum, maximum, median and standard deviation for the enabled parameters.



A V-Check™ Measurement consists of the V-Check™ Stabilization Phase (default duration 8 minutes) and the V-Check™ Measurement Phase (default duration 2 minutes). If the V-Check™ Measurement is finished two short signal tones sound and the V-Check™ Results Screen activates, displaying the above mentioned statistical results for the data assessed during the V-Check™ Measurement Phase. The V-Check™ Results Screen remains displayed until the Menu or Display Button are pressed or another V-Check™ Measurement is started.

Note: The 'V-Check™ Mode Indicator' appears on the 'Ready for use' and 'Calibration' screen (p. 23) if the V-Check™ Mode is ON. On measurement screens (p. 32), the V-Check™ Down-Counter (format hh:mm:ss) is displayed on the very right of the Status Bar (p. 50). This down-counter indicates the

duration of the V-Check™ Measurement if the V-Check™ Measurement has not yet been started, the remaining time to finish the V-Check™ Measurement during an ongoing V-Check™ Measurement, and 00:00:00 once the V-Check™ Measurement is finished. If the SDMS is not ready for use, it indicates --:--:--.

Note: Print-out of the trend curves (including the statistical results) is automatically activated upon completion the V-Check™ Measurement if the protocol 'Serial Printer' is selected and a printer is connected to the SDM.

Note: The SDM automatically stores V-Check™ Events in its internal memory at the start and at the end of each V-Check™ Measurement Phase. After trend data download to V-STATS™ the start and end of a V-Check™ Measurement Phase are visualized by two colored triangles and it is possible to generate a report which includes the same information as is provided on the SDM's V-Check™ Results Screen.

Good to know!

To use V-Check™, select the SenTec-preconfigured SDM Profile V-CHECK as standard 'SDM Profile'. This will set the sensor temperature to 43.5 °C, the 'Site Time' to 0.5 hours, SITE PROTECTION to ON, the 'Calibration Interval' to 1 hour, and the 'Time Range for Trends' to 15 minutes.

PCO_2 In-Vivo Correction

Subject to institution's permission, 'In-Vivo Correction' (IC) of PCO_2 values is possible at the bedside. The 'PCO_2 In-Vivo Correction' allows for adjusting the SDM's PCO_2 readings based on the result of an arterial blood gas analysis. The 'PCO_2 In-Vivo Correction' adjusts the 'Metabolic Offset' (M) used in the 'Severinghaus Equation' (p. 5) such that the difference between the PCO_2 value displayed by the SDM when taking the blood sample and the $PaCO_2$ value as determined by the blood gas analysis cancels out. The 'PCO_2 In-Vivo Correction' should only be used when a systematic difference between the SDM's PCO_2 readings and $PaCO_2$ is clearly established by several arterial blood gas measurements.

Note: 'The Quick Access Menu' provides a short-cut to the sub-menu 'PCO_2 In-Vivo Correction', which is only accessible if enabled by the institution.

Note: If PCO_2 values are in-vivo corrected, the 'PCO_2 In-Vivo Correction' indicator ('IC-indicator') is displayed adjacent to the PCO_2 label (IC=xx.x (if 'mmHg'); IC=x.xx (if 'kPa'), where xx.x/x.xx is the current offset, respectively; if additionally a fixed 'Severinghaus Correction' is used, the 'PCO_2 In-vivo Correction' offset is marked with an asterisk: e.g. 'IC=x.xx*').

WARNING: A 'PCO_2 In-Vivo Correction' should only be enabled by personnel understanding the principles and limitations of transcutaneous PCO_2 monitoring (p. 6). If a 'PCO_2 In-Vivo Correction' is made it must be checked periodically and adapted in case of changes.

Patient Data Management

The SDM automatically stores PCO_2, PO_2, SpO_2, PR, RHP and PI data as well as system status information in its internal memory for subsequent on-screen viewing or printing of graphical trends and statistical summary/histograms. The Data Recording Interval is institution-selectable between 1 and 8 seconds and provides between 35.2 and 229.9 hours of monitoring data, respectively. V-STATS™ provides fast data download to the PC with V-STATS™ (approx. 3 min. for 8 hours data at 4-seconds resolution) for subsequent display, analysis and reporting within V-STATS™.

Patient data acquired by the SDM can be output through the multipurpose I/O-port (analog output; nurse call), the serial data port (RS-232) or the LAN port, all located on the rear panel of the SDM. These ports can be connected to external devices such as multiparameter bedside monitors, PCs, poly(somno)graphs, nurse call systems, chart recorders or data loggers.

By using V-CareNeT™, for example, remote monitoring and secondary alarm surveillance of multiple SDMs connected to the same network as the PC is possible. 'Operator Events', 'Baselines', and certain SDM settings can be set/controlled remotely on the included SDMs. Furthermore, download of SDM Trend Data is simultaneously possible for multiple SDMs.

'Remaining Monitoring Time'/'Site Time Elapsed' Alarm

During monitoring, the 'Remaining Monitoring Time' Icon (p. 50) continuously indicates the 'Remaining Monitoring Time', i.e. the time until either the selected 'Site Time' or – if PCO_2 is enabled – the 'Calibration Interval' elapse (whichever will occur first).

When the 'Calibration Interval' elapses before the selected 'Site Time', the 'Remaining Monitoring Time' Icon is highlighted yellow, the message 'Sensor calibration recommended' is displayed and monitoring is possible another 4 to 6 hours with PCO_2 marked as 'questionable'. Thereafter, sensor calibration is mandatory and PCO_2 and PO_2 are marked as 'invalid' (values replaced by '---'). When the 'Site Time' elapses, the icon is highlighted in red and the low priority alarm 'Site time elapsed' is triggered. In this case, the sensor must be removed from the patient for site inspection.

Note: To terminate the 'Site time elapsed' alarm, remove the sensor from the patient and either press the Enter Button while the message 'Sensor off patient (↵)' displays or insert the sensor into the Docking Station.

CAUTION: Do not reattach the sensor to the same site if any skin irritations are noted during site inspection.

Good to know!

If the safety feature SITE PROTECTION is ON, the SDM will reduce the sensor temperature to safe values once the sensor application duration overruns the selected 'Site Time' by more than 10% or 30 minutes. PCO_2/PO_2 are marked as 'invalid' thereafter (values replaced by '---').

During monitoring, the current setting for SITE PROTECTION is indicated in the 'Sensor Temperature' icon (p. 50). A 'red-blue rightward arrow with tip down' displays if SITE PROTECTION is ON, a 'red rightward arrow' if it is OFF.