



# Heartbeat Technology

## Guidebook for Liquid Analysis



## Do you know the optimal maintenance intervals for your measuring points?

Finding the optimal maintenance interval of a measuring point is not easy. If you service it too often, the effort is high – for the working time, for the materials used and for the measurement downtime during maintenance. If you maintain too seldom, the risk of an unplanned breakdown of the measuring point increases and you no longer know what is happening in the process.

**But how do you reach the perfect balance between maintenance effort and the highest possible plant availability?**

Our engineers have addressed this question and developed a solution for it. We call this solution Heartbeat Technology. Measuring devices with Heartbeat Technology perform

a permanent self-monitoring. This works like a doctor: If something changes in the health of the device, you are informed – well before the condition becomes critical and the measuring point fails unexpectedly. And, of course, you will also receive a ‘prescription’ in the form of clear instructions for action, so that you can quickly implement a remedy.

Our transmitters and samplers of the Liquiline series also have an integrated maintenance timer that you can set for the instrument itself and all connected sensors. By comparing the maintenance timer with the state of health you can determine the optimal maintenance interval for each measuring point. We will show you how to accomplish this on the following pages.



## How much time do you spend with verification of measuring points?

Maintenance managers often say that they find the verification of their measuring points quite time-consuming. First of all, they have to find and record the serial numbers and the date of the last calibration of all components. Then they check and document the current device and sensor health and enter them into the ERP system. Manual verification can take quite a long time for a single measuring point – and even more so for many measuring points. Is this also the case for you?

With Heartbeat Technology our engineers have found a unique way to simplify measuring point verification. An entire measuring point and all its components can be **verified within seconds – and during operation!** At the push of a button you can generate a detailed report with all important data and clear ‘passed’ or ‘failed’ results for the Liquiline device and the connected sensors. Download the report and maintain it directly in your ERP system. And, you do not even need to be on site for the verification, you can also perform it remotely via web server.

## How can I use Heartbeat Technology with my analytical measuring points?

In the field of Liquid Analysis, you can order Heartbeat Technology for transmitters and samplers of the Liquiline series. Heartbeat Technology is then used with these devices along with all connected Memosens sensors.

An analytical measuring device equipped with Heartbeat Technology, provides you with three modules:

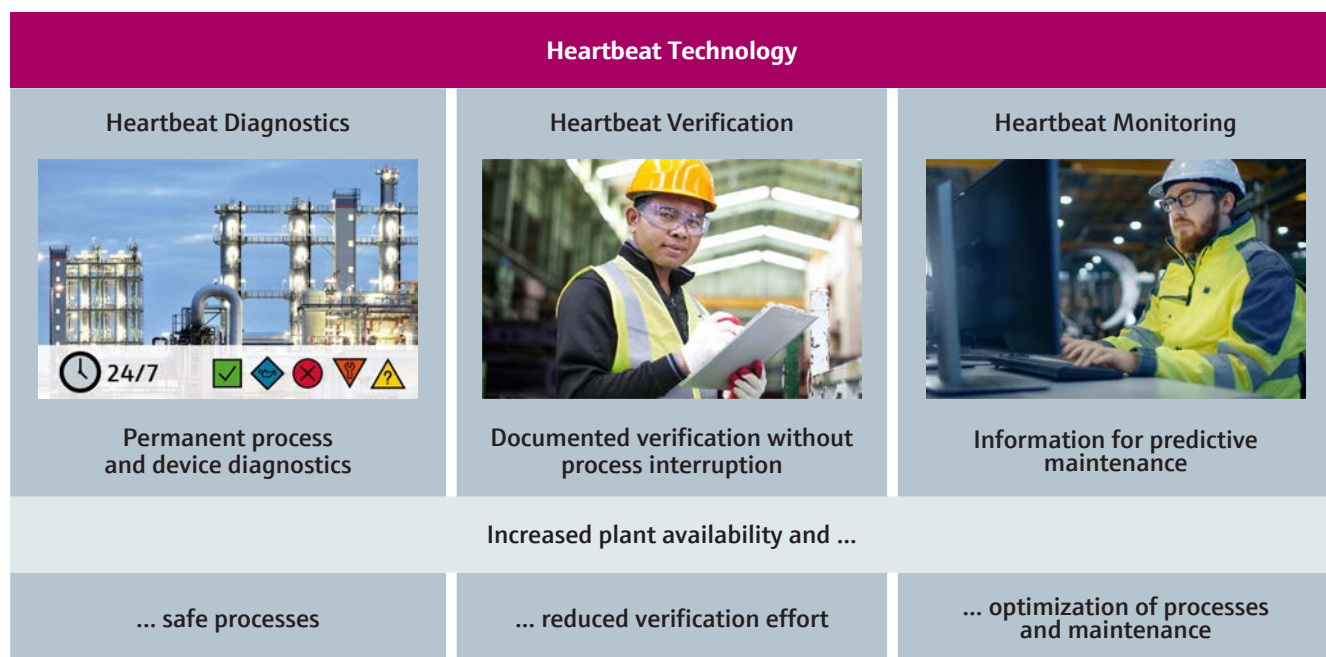
- extensive self-monitoring with clear remedy instructions (Heartbeat Diagnostics)
- easy device verification during operation (Heartbeat Verification)
- KPIs that you can call up remotely for optimizing process and maintenance (Heartbeat Monitoring)

The Heartbeat Diagnostics and Heartbeat Verification modules show you the device health at a specific time. The Heartbeat Monitoring module, on the other hand, allows you to observe the measuring devices together with the associated KPIs over time. Based on monitoring information you can derive trends. For example, **you can**

**see whether you are maintaining measuring points too rarely or too often.** And, if you change your maintenance strategy, you can determine whether the measures were successful or not. Heartbeat Monitoring allows you to find the right balance between maintenance effort and your desired plant availability.

The diagnostic information and KPIs provided by Heartbeat Technology are available on the Liquiline device display and in verification reports that you can generate. Diagnostic information and KPIs can be transmitted for monitoring purposes over a digital fieldbus communication protocol to your DCS.

When you order an analytical device with Heartbeat Technology you get the complete package with all three modules. However, to be able to use the full functionality of the Heartbeat Monitoring module, you need a digital fieldbus communication protocol.



- Unambiguous, standardized **diagnostic messages** with clear **instructions** enable cost-effective, status-oriented maintenance.
- **Permanent self-monitoring** of devices guarantee safe plant operation with extended test cycles.

- Measuring points can be verified and documented at any time without process interruption.
- A simple, guided test procedure guarantees **clear, documented verification results** at any time.
- An automatically generated **verification report** supports the certification requirements of regulations, laws and standards.

- The availability of **device and process data** enables the identification of trends used for **predictive maintenance**.
- The combination of device and process parameters provides the analysis needed for **targeted process optimization**.

## Heartbeat Technology status – quickly visualize the measuring point status

The Heartbeat Diagnostics module continually calculates the so called Heartbeat Technology status for the Liquiline device and each connected sensor. The status is visualized through a smiley icon (☺☹☹) on the Liquiline device display. The icon is derived from the sensor health and the maintenance timer. Both indicators are normalized to a value between 0% (poor) and 100% (excellent). For example, when a brand new sensor or a newly calibrated sensor is connected to a Liquiline transmitter or sampler,

its sensor health and its maintenance timer start at 100%. Depending on the sensor wear and on the time since last maintenance and calibration, these values decrease.

If one of these (or both) values drop below certain limits, the Heartbeat Technology status changes. This is symbolized by a change in the smiley icon as shown in the following table.

The Heartbeat Technology status at a glance			
Icon	Sensor or device health	Maintenance timer	Decision making
☺	>20% - 100%	>20% - 100%	No action necessary
☹	>5% - 20%	>5% - 20%	Maintenance is not urgent yet, but should be scheduled in due time
☹	>0% - 5%	>0% - 5%	Maintenance is recommended

The three icons help you **quickly visualize the measuring point status and make informed decisions**. For example, if the Heartbeat Technology status changes and you look more closely, the maintenance timer may have expired but the sensor is still in a good range. In this case, you can consider extending the maintenance interval and thus save time and resources.

Conversely, is the sensor’s health low but the maintenance timer still in a good range? In this case, we recommend shortening the maintenance interval in order to achieve the best possible measurement reliability.

Heartbeat Technology status allows you to adjust the maintenance interval of each measuring point more precisely to the respective application. This enables you to **develop an optimal maintenance plan for your plant**.

Using Heartbeat Technology, you always know the status of your measuring points. Knowing the status, you can minimize the probability of a sudden breakdown or failure and, at the same time, avoid unnecessary maintenance actions and field operations. Avoiding unnecessary maintenance **saves operational expenditure (OPEX) while keeping the availability** of the measuring points at a high level.

### How to activate the maintenance timer

The maintenance timer allows you to set the maintenance interval that you have defined for a sensor or device in your SOPs (Standard Operating Procedures).

To activate it, click on Menu / Setup / Inputs / <Sensor> / Extended setup / Calibration settings / Calibration monitoring / During operation

To set your desired maintenance interval, click on Menu / Setup / Inputs / <Sensor> / Extended setup / Calibration settings / Calibration validity / Alarm limit

Please note:  
The alarm limit is entered in hours. For example, 720h correspond to 30 days.



### **i** What is the difference between the Heartbeat Technology status and the NAMUR NE107 status signal?

Heartbeat Technology status shows the sensor or Liquiline device condition. The NAMUR NE107 classifications (F, C, S, M) show the reliability of the measured value (status signal). Both Heartbeat Technology and NAMUR status are interrelated but do not necessarily directly correlate.

	Heartbeat Technology status	NAMUR NE107
Used symbols	☺ / ☹ / ☹	F / C / S / M
Interpretation	Shows if a maintenance action is not / soon / now necessary	Shows the reliability of the measured value (status signal)
How it is determined	Evaluation of sensor and device health conditions and maintenance timer	Surveillance of limit value violations
Relevant for	Maintenance manager to plan actions	Operator to manage the process

#### **Example 1:**

When the number of remaining cleaning cycles (CIP) reaches 20% of the maximum number of cycles, the icon changes from ☺ to ☹. However, the measured value is still reliable, i.e. the NAMUR status signal doesn't change. When the maximum number of cleaning cycles is exceeded, the icon changes from ☹ to ☹. The measured value still can be reliable, however, the NAMUR status signal changes to 'M' (maintenance required).

#### **Example 2:**

In case of a sensor breakage both status change instantly: the Heartbeat Technology status to ☹ and the NAMUR status signal to 'F' (failure).

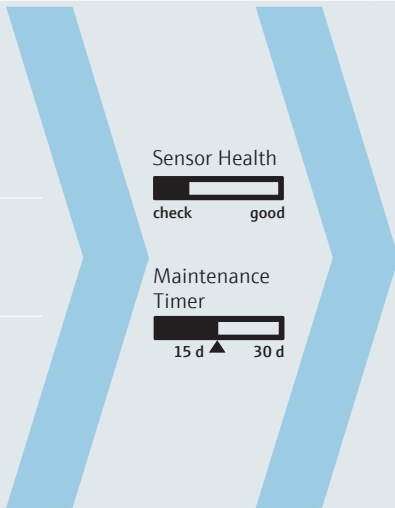
# Which factors influence the device health and the sensor health?

## Sensor health:

Each sensor type has a unique calculation for sensor health. The evaluated factors for the sensor health calculation are current sensor condition, calibration results and sensor history.

- **Current sensor condition:** We have integrated in our Memosens sensors several self-monitoring functions that provide data enabling us evaluation of the sensor condition. For pH glass sensors this is, for example, continuous measurement of glass impedance.
- **Calibration results:** Evaluation if certain calibration values are in the recommended ranges. For pH sensors these calibration values are, for example, slope and zero point.
- **Sensor history:** Historical sensor data such as operating hours and exposition to extreme conditions are evaluated. For pH sensors these data are, for example, operation time above certain temperature levels, number of sterilization and cleaning cycles.

The sensor health determines, together with the maintenance timer, the Heartbeat Technology status. As an example, the following table shows the factors that are used to determine the Heartbeat Technology status of a pH measuring point:

Self-monitoring functions	Factors that are used to determine the Heartbeat Technology status of a pH sensor		
During operation	<ul style="list-style-type: none"><li>■ Plain text diagnostic messages</li><li>■ Liquiline hardware self-monitoring</li><li>■ Connection check of sensor to transmitter</li><li>■ Sensor power supply surveillance</li><li>■ Sensor Check System (SCS)</li><li>■ Glass impedance measurement</li><li>■ Reference impedance measurement</li></ul>		Heartbeat Technology status 😊 / 😐 / ☹️
After calibration	<ul style="list-style-type: none"><li>■ Slope evaluation</li><li>■ Difference between two sensor slope adjustments</li><li>■ Zero point evaluation</li><li>■ Difference between two sensor zero point adjustments</li></ul>		
Time based during operation (historic events recorded in the head of the Memosens sensor)	<ul style="list-style-type: none"><li>■ Overall operating hours counter</li><li>■ Operating hours counters for specific measured values (pH&gt;12 / pH&lt;2)</li><li>■ Operating hours counters for specific temperatures (80°C / 120°C)</li><li>■ SIP counter and CIP counter</li><li>■ Calibration timer</li></ul>		

## Device health:

The health calculation for a Liquiline transmitter or sampler device depends on the device type. For example, the health condition of a Liquistation automatic water sampler is influenced by several counters (pump lifetime,

valve operating cycles, etc.) as well as by the surveillance of the internal electronics. If the counters reach a user-definable limit value or the self-monitoring detects any issue, the sampler's health changes accordingly.

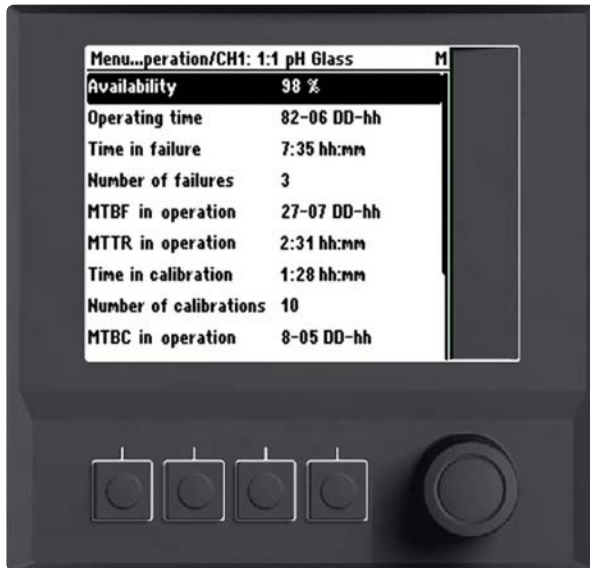
## Factors per sensor that influence the sensor health

Sensor type	Sensor specific factors		General factors
pH sensors	<ul style="list-style-type: none"><li>▪ Slope, zero point</li><li>▪ Working point (pH ISFET)</li><li>▪ Glass impedance</li></ul>	<ul style="list-style-type: none"><li>▪ Operating time when exceeding specific process limits</li><li>▪ Number of SIPs</li></ul>	<ul style="list-style-type: none"><li>▪ Total operating time</li><li>▪ Sensor diagnostics such as NAMUR NE107 categories (Failure / Check / Out of Specification / Maintenance)</li><li>▪ Sensor measurement status GOOD or BAD</li></ul>
ORP sensors	<ul style="list-style-type: none"><li>▪ ORP mV monitoring</li><li>▪ 1-point mV offset</li></ul>		
Combined pH/ORP sensors	See pH and ORP		
Optical oxygen sensor Memosens COS81D	<ul style="list-style-type: none"><li>▪ Sensor and cap operating time when exceeding specific temperature limits</li><li>▪ Total operation counter cap</li><li>▪ Calibration quality index</li><li>▪ CIP, autoclaving, cap autoclaving</li></ul>	<ul style="list-style-type: none"><li>▪ Number of cap calibrations</li><li>▪ Number of SIPs</li><li>▪ Number of cap SIPs</li></ul>	
Amperometric oxygen sensor Oxymax COS22D	<ul style="list-style-type: none"><li>▪ Operating time when exceeding specific temp. limits</li><li>▪ Slope, zero point</li><li>▪ Electrolyte counter</li></ul>		
Optical oxygen sensor Oxymax COS61D	<ul style="list-style-type: none"><li>▪ Operating time at specific oxygen values</li></ul>	<ul style="list-style-type: none"><li>▪ Operating time when exceeding specific temp. limits</li><li>▪ Slope</li></ul>	
Amperometric oxygen sensor Oxymax COS51D	<ul style="list-style-type: none"><li>▪ Zero point</li><li>▪ Electrolyte counter</li></ul>		
Disinfection sensors	<ul style="list-style-type: none"><li>▪ Slope, zero point</li><li>▪ Number of cap calibrations</li><li>▪ Operating hour limits of the cap</li><li>▪ Electrolyte counter</li></ul>		
Cond. conductivity sensors incl. Memosens CLS82D	<ul style="list-style-type: none"><li>▪ Number of CIPs</li><li>▪ Number of SIPs</li></ul>	<ul style="list-style-type: none"><li>▪ Operating time when exceeding specific process limits</li><li>▪ Cell constant</li></ul>	
Toroidal (inductive) conductivity sensors	<ul style="list-style-type: none"><li>▪ Number of SIPs</li></ul>		
Photometers	<ul style="list-style-type: none"><li>▪ Lamp operating time</li><li>▪ Reference filter operating time</li><li>▪ Lamp intensity</li></ul>	<ul style="list-style-type: none"><li>▪ Filter operating time</li></ul>	
Nitrate/SAC sensor	<ul style="list-style-type: none"><li>▪ Flash counter filter</li><li>▪ Flash counter lamp</li></ul>		
Turbidity sensors	<ul style="list-style-type: none"><li>▪ Aging of LED (monitored inside the sensor and influences the sensor diagnostics)</li></ul>		
ISE sensor	<ul style="list-style-type: none"><li>▪ Operating time when exceeding specific temperatures</li></ul>		

## Heartbeat Technology KPI dashboard

Heartbeat Technology calculates Key Performance Indicators (KPIs), which enable you to **evaluate the success of maintenance optimizations**. For this purpose you can compare the KPIs before and after an optimization action. Examples of these KPIs are the availability of the measuring

point, operating times, Mean Time Between Failures (MTBF) in operation, Mean Time To Repair (MTTR) in operation and many more. Detailed information can be found in the chapter ‘Glossary’.



### Heartbeat Technology KPIs screen

To see the key performance indicators you get with Heartbeat Technology, please click on Menu / Diagnostics / System information / Heartbeat operation / <Device> or <Sensor>.

Please note:

KPI values shown here in the Liquiline menu are constantly updated. A Heartbeat Technology verification report shows the KPI values at the time of verification.

## Can Heartbeat Technology be adapted to an individual application?

Heartbeat Technology offers, for each sensor type, default settings which already fit to the majority of applications. Of course, you can adjust these settings to your individual application. To do so, change the settings in the Liquiline transmitter under “Diagnostics settings”. Changes in these settings have a direct influence on the evaluation of the sensor health. For example, when the settings for

slope limits, zero point limits, operating hours limits, glass impedance limits, etc. are changed, the Heartbeat Technology status changes faster or slower from ☺ to ☹ or from ☹ to ☺.

With these adjustments, you can optimize the maintenance cycles of your measuring points.



### How to access the diagnostics settings?

To change the settings please click on Menu / Setup / Inputs / <Sensor> / Extended setup / Diagnostics settings.

The example screen on the left shows the diagnostic settings for glass pH sensors.

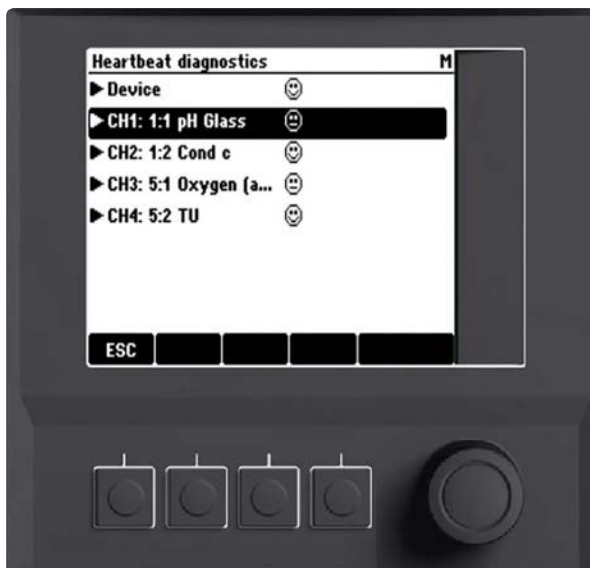


## Heartbeat Diagnostics screens



### Device overview screen

Shows the Heartbeat Technology status of all connected sensors with a smiley icon (☺☹☹).



### Heartbeat Diagnostics screen

In the Heartbeat diagnostics view, the user selects the device or a sensor for more detailed information.

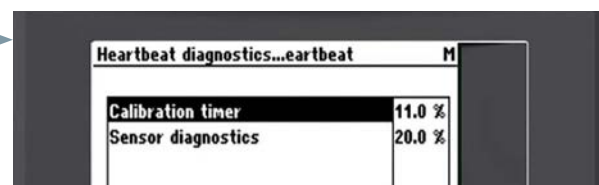


### Detailed Heartbeat Diagnostics screen

The detailed Heartbeat Diagnostics screen shows the sensor health (ranging from good to check), and the maintenance timer showing the remaining time to the next maintenance and the maintenance interval.

Please note: the maintenance timer is only displayed if the calibration timer is activated in the Liquiline's sensor menu.

When the Heartbeat Technology status is ☹ or ☹, a corresponding button is displayed. By pressing the button you get detailed information about the cause.



## How to spend less time verifying measurement points

A verification is a documented check of a measuring point's functionality. However, verification is a manual task that is very time consuming even for experienced users. With Heartbeat Technology, verification is an easy and guided procedure. You can do it **without process interruption in less than one minute**, locally at the measuring point or remotely via webserver.

The result is a clear 'passed' or 'failed' for the complete measuring point: the transmitter or sampler and all connected sensors. With just one click you can generate a comprehensive verification report in PDF format and transfer it to a computer via SD card or download it directly via the webserver. This process allows you to **integrate the reports quickly and error-free into your ERP system**.

### How many verification reports can be stored?

After performing a verification you can create a PDF of the report that is stored in the Liquiline device with a unique file name containing the verification date and time. Each verification is overwritten as soon as you perform the next verification, therefore we recommend you to always export new reports to an SD card or download them via the webserver.

Heartbeat Verification minimizes efforts, saves time and simplifies measuring point documentation. The higher the internal or legal requirements for documentation are, the more you benefit from Heartbeat Technology.

To increase transparency and traceability, the report also documents additional sensor and transmitter information such as serial numbers or installed electronic modules. In the case of a defect you can instantly identify any part that may require replacement, simplifying service.

Verification reports contain key performance indicators (KPIs) that allow you to evaluate the success of maintenance optimizations, by comparing verification reports before and after an optimization action. Examples for these KPIs are the availability of the measuring point, operating times, Mean Time Between Failures (MTBF) in operation, Mean Time To Repair (MTTR) in operation and many more. For detailed information refer to the 'Glossary' chapter.



**Heartbeat Verification Report** Endress+Hauser   
People for Process Automation

Verification Report Analytical Measuring Device

Plant Operator: Peter

**Device Information**

Installation location	Factory 1, Area 52
Tag name	EH_CM448_M10AA605G00
Product family	Liquiline CM448
Order code	CM448-71E00
Original order code extended	CM448-AA18A41AABAAEH
Current order code extended	CM448-AA18A41AABAAEH
Serial number	M10AA605G00
Firmware version	01.06.05-0014

**Verification Information**

Total operating time*	183-01 DD-HH
Date/time of device	04.08.2017 / 10:22:45
Verification ID	1

**Verification Results**

Overall result\*  passed

\*Overall result: Result of the complete device check performed with Heartbeat Technology.

Comment

\_\_\_\_\_  
Date      Operator's signature      Inspector's signature

– 1 –

### Heartbeat Technology verification report title page:

The title page summarizes the overall verification results for the entire measuring point. The report is also prepared for both operator and inspector signatures.

Report contents:

- Name of operator who performed the verification
- Liquiline device information
  - Installation location
  - Device tag
  - Product family
  - Order code
  - Serial number
  - Firmware version
- Verification information about the entire measuring point
  - Total operating time
  - Date/time of the device
  - Verification ID (= consecutive number)
- Overall result of the verification (either passed or failed)


Heartbeat Verification Report Endress+Hauser 	
Verification Report Analytical Measuring Device	
<b>Module Information</b>	
Backplane 2 with CPU	M1468B05B00
BASE	M12C2B05B00
BASE-E	M1353105B00
4AO	M1209505B06
2AO	M1204B05B06
4R	M10F9F05B00
2DS	M1204D05B06
<b>Device</b>	
Heartbeat status	⊕
Device health	100.0 %
Heartbeat operation:	
Availability	100.0 %
Operating time	183-01 DD-HH
Time in failure	0:00 HH:MM
Number of failures	0
Mean time between failures (MTBF)	183-01 DD-HH
Mean time to repair (MTTR)	0:00 HH:MM
<b>Detailed Verification Results</b>	
Power supply check	⊕ passed
CPU temperature check	⊕ passed
Status signal	⊕ passed
Analog output 1:1	⊕ passed
Analog output 1:2	⊕ passed
Analog output 2:1	⊕ passed
Analog output 2:2	⊕ passed
Analog output 2:3	⊕ passed
Analog output 2:4	⊕ passed
Analog output 3:1	⊕ passed
Analog output 3:2	⊕ passed
<b>Active Diagnostic Codes</b>	
– 2 –	

**Detailed information about the transmitter or sampler:**

Page two shows the verification result and device specific information for the Liquiline device.

Report contents:

- Information about the electronic modules inside the device including their serial numbers
- Several Heartbeat Technology KPIs
  - Heartbeat Technology status
  - Device health
  - Availability
  - Operating time
  - Time in failure
  - Number of failures
  - Mean Time Between Failures (MTBF) in operation
  - Mean Time To Repair (MTTR) in operation
- Detailed verification results
  - Power supply check
  - CPU temperature check
  - Status signal
  - Check of all analog outputs
- Currently active diagnostic messages according to NAMUR NE107 (F, C, M, S) with clear text information
- Additional verification results for automatic water samplers
  - Cooling system / heating system
  - Air ventilation
  - Distribution arm
  - Sample volume / sample bottle
  - Pump hose (only peristaltic pump)

Heartbeat Verification Report Endress+Hauser 	
Verification Report Analytical Measuring Device	
<b>Sensor Information Channel 1</b>	
Channel	1:1
Description	pH Glass
Serial number	M252B05E00
Order code	CPS11D-7BA21
Last calibration	04.08.2017 / 10:20:00
Total operating time	3437.50 h
Heartbeat status	⊕
Sensor health	88 %
Next maintenance	30 d
Maintenance interval	30 d
Heartbeat operation:	
Availability	100.0 %
Operating time	61-15 DD-HH
Time in failure	0:00 HH:MM
Number of failures	0
Mean time between failures (MTBF)	61-15 DD-HH
Mean time to repair (MTTR)	0:00 HH:MM
Time in calibration	1:03 HH:MM
Number of calibrations	2
Mean time between calibrations (MTBC)	30-19 DD-HH
– 3 –	

**Detailed information about the connected sensors:**

For each connected sensor there is a further page with more detailed information about the sensor.

Report contents:

- Sensor channel
- Sensor type description
- Serial number
- Order code
- Last calibration date and time
- Total operating time
- Heartbeat Technology status
- Sensor health
- Time until next maintenance
- Currently set maintenance interval
- Several Heartbeat Technology KPIs
  - Availability
  - Operating time
  - Time in failure
  - Number of failures
  - Mean Time Between Failures (MTBF) in operation
  - Mean Time To Repair (MTTR) in operation
  - Time in calibration
  - Number of calibrations
  - Mean Time Between Calibrations (MTBC) in operation

## Heartbeat Verification screens



### How to access the verification menu?

To access the verification menu, please click on Menu / Diagnostics / Systemtest / Heartbeat.

Here, you can perform a verification or see the results of the latest verification.



### Verification results overview screen

After performing a verification, overall results are displayed as shown in this screen. Here, operators can insert their name and they get a clear statement if the measuring point has passed or failed the verification.

Additionally, operators can export the report to an SD card where it is stored in PDF format with verification date and time.

Please note:  
The report can also be downloaded via the webserver.





You can verify your Liquiline transmitters and your Liquistation samplers on site and during operation – including all connected sensors. Or you carry out the verification remotely via web server. The whole process takes only a few minutes.



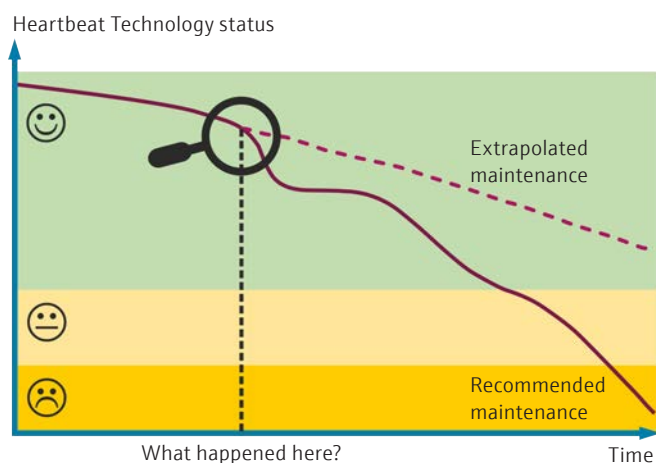
## How to open the door to predictive maintenance of your plant

If you want to optimize your maintenance strategy, i.e. when which measuring point has to be serviced and in which order, it is sometimes quite challenging to find the right starting point. Unfortunately, it is not possible to make a universally valid statement, because every measuring point has its own characteristics. And, it depends strongly on the medium and the ambient conditions how much a sensor is “stressed”. For example, a pH sensor is stressed much more by a very acidic medium than by a pH-neutral medium. Optimizing the maintenance of an entire plant can therefore seem like a closed door.

We have the **right key for this door**: Heartbeat Technology provides you with KPIs that help you learn more about your measuring points and your process. With the Heartbeat Monitoring module you can call up all KPIs and additional data remotely via your distributed control system (DCS). This information can be used for an in-depth analysis. What is the best maintenance interval for each measuring point? How often is a measuring point calibrated and how often is it serviced? What is the availability of each measuring point?

Heartbeat Technology helps you answer these questions and derive trends from them. For example, you can detect whether certain sensors in your plant are exposed to a particularly high stress level and therefore fail more often than other sensors. For these measuring points, a shorter maintenance interval could be useful to keep their measurement reliability high. Thanks to the KPIs, you can assess the success and effects of the change in your maintenance strategy. Compare the KPIs before and after. Has the plant availability increased? If so, then your measures have proven successful.

Also take a look at the KPI ‘Mean Time To Repair in operation’. This KPI shows you how quickly your measuring point could be repaired in the event of an error. The lower the KPI value is, the faster the measuring point is back in operation after a failure. A high value can have several causes: Maybe there were no spare parts in stock, or it may also have taken a long time to inform the service department. Or, the maintenance team did not have free capacity to fix the failure promptly. **Heartbeat Technology helps you find the right approach to minimize downtime.** In this case, you could expand the spare parts inventory or optimize the flow of information to the service team, or provide them with more resources to increase their capacity.



### **i** What happened here?

Heartbeat Monitoring allows you to detect when the recommended and the extrapolated maintenance of a sensor or Liquiline device differ, as shown in this graph, for example. Now the question is what happened at the point in time when the two statuses began to diverge. Was the production process changed? Did something go wrong during a maintenance operation? Or, were there external influences?

#### **Example 1 – Wastewater Treatment Plant (WWTP):**

In a WWTP, sensor stress can correlate with the weather, e.g. when heavy rainfall events occur and the wastewater is thus more heavily contaminated with pollutants. The plant operator could then adapt his maintenance strategy to the seasons: In months with more heavy rainfall, he would therefore maintain his measuring points more frequently than in other months.

#### **Example 2 – Food & Beverage:**

The cleaning agents used in Cleaning-in-Place (CIP) processes are often a stress factor for the analytical sensors installed. This is even more true the higher the temperatures are during cleaning. Observe with Heartbeat Monitoring how the health of the installed sensors drops after a CIP process. If there is a trend, you will recognize it much easier and you will be able to maintain your measuring points predictively.

### Which outputs can be used for the Heartbeat Monitoring module?

To be able to use the full functionality of Heartbeat Monitoring, you need a digital fieldbus communication protocol. The following table shows how Heartbeat Technology information is accessible via different device outputs:

Outputs	Heartbeat Technology status + sensor health + maintenance timer	Other Heartbeat Technology KPIs*	Memosens data**	NAMUR NE107 categories
0/4...20 mA	yes***	no	no	F
HART	via AI block	acyclic read	acyclic read	F, C, S, M
PROFIBUS DP	via AI block	acyclic read	acyclic read	F, C, S, M
Modbus RS485 (RTU)	via AI block	acyclic read	acyclic read	F, C, S, M
Modbus TCP	via AI block	acyclic read	acyclic read	F, C, S, M
EtherNet/IP	via AI block	acyclic read	acyclic read	F, C, S, M
PROFINET	via AI block	acyclic read	acyclic read	F, C, S, M


\*Other Heartbeat Technology KPIs are:

Availability; operating time; time in failure; number of failures; MTBF in operation; MTTR in operation; MTBC in operation

\*\*Memosens data are:

Sensor serial number; manufacturing and initial operation date of sensor; min. and max. measured extreme values; several counters (operating hours under extreme conditions; number of SIP and CIP cycles; number of calibrations; ...); calibration method of last calibration; zero point; offset; slopes and many more

\*\*\* The Heartbeat Technology status, the sensor health and the maintenance timer can each be assigned to a separate analog output

 If you use EtherNet/IP, PROFIBUS, Modbus TCP or Modbus RS485 as your fieldbus, all Heartbeat Technology information is available in your DCS. If you use HART or PROFIBUS DP, the transmitted information might be slightly reduced. For detailed information, please refer to the special documentation which can be downloaded from [www.endress.com/downloads](http://www.endress.com/downloads) > **Manuals and Datasheets**. Enter the corresponding documentation code in the search field:

- HART -> SD01187C
- PROFIBUS DP -> SD01188C
- Modbus RS485 and Modbus TCP -> SD01189C
- EtherNet/IP -> SD01293C
- PROFINET -> SD02490C

## How to order Heartbeat Technology?



### What do you get when you select the Heartbeat Technology option?

In the field of Liquid Analysis, you can order the Heartbeat Technology for transmitters and samplers of the Liquiline series – it is then functional with these devices along with all connected Memosens sensors.

When you order an analytical device with Heartbeat Technology **you get the complete package** with all three modules: Heartbeat Diagnostics, Heartbeat Verification and Heartbeat Monitoring. However, to be able to use the full functionality of the Heartbeat Monitoring module, you need a digital fieldbus communication protocol.

Since the release of firmware version 1.06.04, new transmitters and samplers of the Liquiline series can be ordered with Heartbeat Technology.

If you did not order Heartbeat Technology originally, you can upgrade your devices with an activation code at a later date. No additional electronic hardware is required for this upgrade.

Installed Liquiline devices with older firmware versions can be easily upgraded by a firmware update (at least version 1.06.04) and a Heartbeat Technology activation code. Again, additional electronic hardware is not needed.

To obtain an activation code for an already installed Liquiline device, please contact your Endress+Hauser sales office, stating the serial number. An individual activation code is required for each Liquiline device.



### You can use Heartbeat Technology with your existing installed base

The processing of Heartbeat Technology information is a function of the Liquiline device. Therefore, the order option Heartbeat Technology is offered for Liquiline platform devices (transmitters, samplers and in the future also for analyzers).

When the option is active in one of these devices, **any Memosens sensor – newly ordered or already installed – can be used**. That means, Heartbeat Technology does not have to be ordered separately for Memosens sensors.

## Availability of Heartbeat Technology for analytical devices

### Availability of Heartbeat Technology for Liquiline transmitters, Liquistation samplers and Memosens sensors

Device	Heartbeat Diagnostics	Heartbeat Verification	Heartbeat Monitoring
Liquiline CM44	✓	✓	✓
Liquiline CM44R	✓	✓	✓
Liquiline CM44P	✓	✓	✓
Liquistation CSF34	✓	✓	✓
Liquistation CSF39	✓	✓	✓
Liquistation CSF48	✓	✓	✓
pH sensors	✓	✓	✓
Conductivity sensors	✓	✓	✓
ORP sensors	✓	✓	✓
Combined pH/ORP sensors	✓	✓	✓
Dissolved oxygen sensors	✓	✓	✓
Chlorine sensors	✓	✓	✓
Turbidity sensors	✓	✓	✓
SAC sensors	✓	✓	✓
Nitrate sensors	✓	✓	✓
ISE sensors	✓	✓	✓
Process photometers	✓	✓	✓

### Availability of Heartbeat Technology KPIs

Heartbeat Technology KPI	Heartbeat Diagnostics	Heartbeat Verification	Heartbeat Monitoring
Heartbeat Technology status	✓	✓	✓
Sensor health	✓	✓	✓
Maintenance timer	✓	✓	✓
Availability	✓	✓	✓
Operating time	✓	✓	✓
Time in failure	✓	✓	✓
Number of failures	✓	✓	✓
MTBF in operation	✓	✓	✓
MTTR in operation	✓	✓	✓
MTBC in operation	✓	✓	✓

## Example use cases for Heartbeat Technology



### Dairy

In the food and beverage industry CIP (cleaning-in-place) is regularly performed. A dairy, for example, can produce several products using one production line. After each production charge the filling machines, pipes, valves, etc. have to be cleaned in order to avoid product contamination. A CIP cycle causes stress to the measuring devices because of high temperatures, aggressive cleaning agents, etc.

With the Heartbeat Technology status and the sensor health you are informed as soon as sensor maintenance becomes imminent. You can appraise how long the measured value is still reliable and plan the maintenance action accordingly. This way, you avoid downtime and ensure that your product is not contaminated.

### Sugar production

A typical issue in this industry is the fouling and soiling of sensors. When the sensitive area of a sensor is covered with adhering molasses, measurement error can occur. Therefore, the sensor has to be cleaned and maintained in a timely manner. Heartbeat Technology provides several KPIs enabling the user to analyze if the maintenance strategy fulfills their needs or if there is an optimization potential. An optimization could result in a shorter or in a longer maintenance interval. A shorter maintenance interval would be applied, when it turns out that a higher maintenance frequency would improve the reliability of the measured value. A longer maintenance interval could be applied if the reliability of the measured value does not deteriorate as a result of coating.

The Heartbeat Technology KPIs allow a comparison between different maintenance strategies, so that you can develop the best strategy for your plant. Did the Mean Time Between Failures (MTBF) in operation rise? Did the Mean Time To Repair (MTTR) in operation decrease? And, could the availability of the measuring point be optimized?

### Sampling in the effluent of a wastewater treatment plant (WWTP)

WWTPs use samplers to prove to authorities that their effluent water meets legal requirements. If the sampler meets certain standards, e.g. ISO 5667, wastewater treatment plant operators can be sure that the samples taken comply with regulations. Wastewater treatment plant operators can use Heartbeat Verification to determine if their device is still working properly (sample temperature, sample volume accuracy, etc.) and that the samples taken are representative.

At the touch of a button on the sampler display or via the webserver, the device and all connected sensors are checked. With the verification report the operator recognizes malfunctions at a glance and can fix them quickly. Regular verification with Heartbeat Technology thus contributes to the integrity of the sampler.





## Glossary

### Mean Time Between Failures (MTBF) in operation:

Definition	$\text{MTBF} = (\text{Operating time} - \text{Time in failure}) / \text{Number of failures}$ <p>It is calculated individually for the Liquiline device and each sensor channel in days, hours and minutes.</p>
Interpretation	The higher the MTBF the more reliable the measuring point runs. It identifies the measuring points which are prone to failures, so that the maintenance department can take corrective measures.
Example 1	If a glass sensor breaks often, resulting in a low MTBF. You could, for example, install a protection such as a cage or try another sensor type.
Example 2	If a diaphragm of a glass sensor is often blocked, the MTBF will be low. In this case, you could clean the sensor more often.



#### Please note

In general, the MTBF is a value for the reliability of a unit. It is often defined as a statistical failure rate for a complete product series. In this case it is a static value calculated under optimum conditions.

Analytical measuring points, however, are always individual: sensor properties, the handling and operation through the personnel and the individual process conditions influence the MTBF, so that its value is dynamic. Hence, in our analytical devices the MTBF is a real-time number showing how well a measuring point has been adapted to an application.

### Mean Time Between Calibrations (MTBC) in operation:

Definition	$\text{MTBC} = (\text{Operating time} - \text{Time in calibration}) / \text{Number of calibrations}$ <p>It is calculated individually for each connected sensor channel in days and hours.</p>
Interpretation	The MTBC reveals compliance of maintenance personnel with specified calibration intervals.

### Mean Time To Repair (MTTR) in operation:

Definition	$\text{MTTR} = \text{Time in failure} / \text{Number of failures}$ <p>It is calculated individually for the Liquiline device and each sensor channel in hours and minutes.</p>
Interpretation	The lower the MTTR the better the maintenance strategy. It shows how fast the maintenance personnel fixes failures and allows an evaluation if optimization measures (e.g. additional resources) are needed.

### Availability:

Definition	$\text{Availability} = ((\text{Operating time} - \text{Time in failure}) / \text{Operating time}) * 100$ <p>It is calculated individually for the transmitter and each sensor channel in percent.</p>
Interpretation	A high availability is the result of a high MTBF and a low MTTR. It allows an evaluation if optimization measures are successful.

### Reset of counters:

The counters used for the Heartbeat Technology KPIs can be reset in the Liquiline menu. Resetting is useful in the following cases:

- During setup of the process and the measuring point there might be a high number of failures, which occur for example when no sensor is connected or there is a lack of process medium. These failures would distort the Heartbeat Technology KPIs. We, therefore, strongly recommend resetting the counters once the measuring point is finally commissioned and there is a stable process.
- Heartbeat Technology KPIs help to monitor if maintenance optimizations and other corrective measures are successful. To be able to compare optimization actions with each other, the counters should be reset before an action is taken.
- Heartbeat Technology KPIs help to monitor the efficiency of a maintenance department or an external service provider. When there is any organizational change (e.g. a new service provider), the counters can be reset to evaluate the success of the change.



More information about Heartbeat Technology is available at  
[www.endress.com/Heartbeat-Technology](http://www.endress.com/Heartbeat-Technology)

[www.addresses.endress.com](http://www.addresses.endress.com)

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