BM Respirometry

a state of the art technology

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BM respirometery is a technology where the traditional and most advanced respirometry techniques are gathered in one exclusive design developed by SURCIS Company.

BM Respirometry makes use of a single reaction vessel, that in certain modes, can replicate the actions that occur at a treatment plant within the conditions set for the test.

The BM-respirometers, using powerful software, provide a way to set measurements and calculations for decisive parameters used to manage, design, and research the biological processes of wastewater treatment.

BM Respirometer system

BM respirometers

Common software

BM-EVO

BM-T+

BM-Advance / Advance Pro

BM-EVO2

BM-Advance2

Comparative table between BM respirometers

Comparative items	BM-T +	BM EVO EVO2	BM Advance Advance2	BM Advance Pro	Comments
Automatic measurements: OUR, SOUR, Rs, Rsp, CO, bCOD, rbCOD, U, q	✓	✓	✓	✓	From the automatic measurements ,corresponding applications to wastewater treatment can be made.
Thermostatic system installed in the analyzer console		✓	✓	✓	Cooling (Peltier) + Heating system included in the same console.
External thermostatic unit	✓				External unit (separated unit) formed by Cooling (Peltier) + Heating system.
Easy transportable system: Analyzer & Thermostatic Unit	✓				Console + case → 20 kg Thermostatic unit + case → 5 kg (aprox.)
Padded aluminum cases for easy transportation	✓				1 case for the console + 1 case for the external thermostatic unit.
pH measurement and control throughout the test			✓	✓	Especially important where there is a special sensitivity to pH changes.
ORP measurement during the test				✓	ORP measurements only in BM-Advance Pro model
Possibility to set the conditions at the start of the test and modify them during the test	✓	✓	✓	✓	Important to carry out studies to analyze the influence of condition changes (pH, DO., T,..) on process activity.
Latest generation BM-software	✓	✓	✓	✓	Powerful software developed by SURCIS
BM software update from Internet link	✓	✓	✓		When connected to the internet URL, the BM software is automatically updated.
Option for biomass-carrier reactor	✓	✓	✓	✓	The biomass carrier reactor for BM-T+ is rather different than the one for the BM-EVO and BM-Advance

EVO2 and Advance2 include 2 reactors

Key points of the components and control systems included in the BM respirometers

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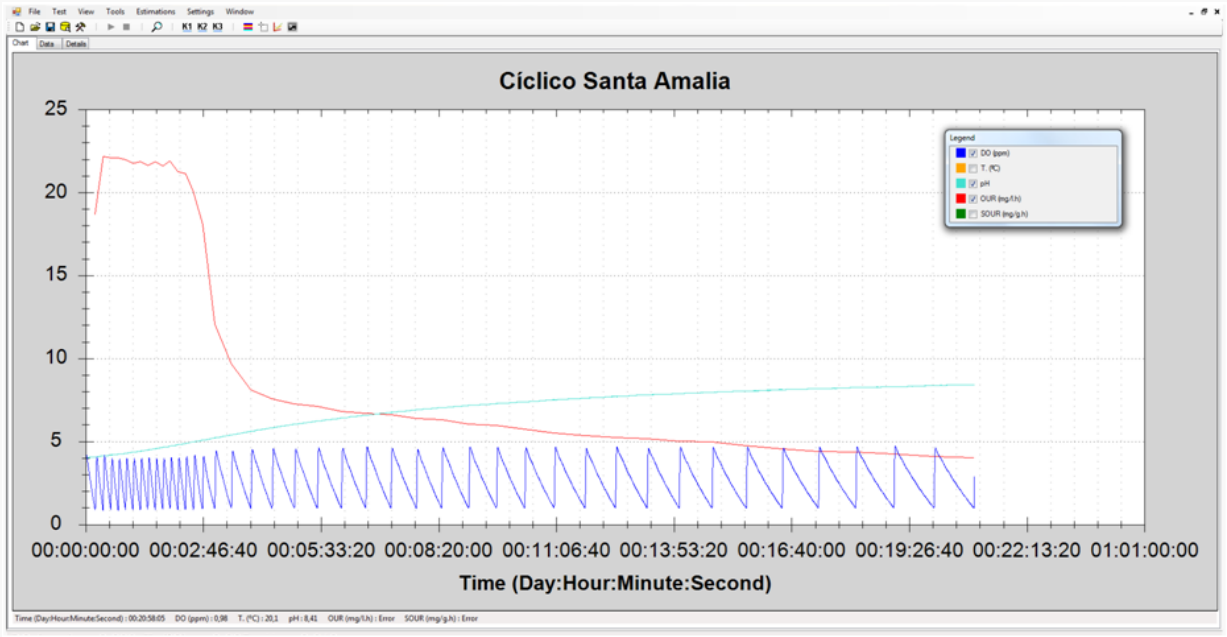
List of some key points concerning the components and systems included in the BM respirometers that make the difference

- Direct oxygen measurements from a maintenance-free oxygen sensor
- No oxygenation restriction during test performance
- pH control system in the BM-Advance system
- pH control and ORP measurements in the BM-Advance Pro system
- Automatic solid-state device for heating & cooling
- Option for a special reactor assembly to simulate a Moving Bed Biofilm Reactor (MBBR)
- Double reactor in models BM-EVO2 and BM-Advance2

No oxygenation restriction during test performance

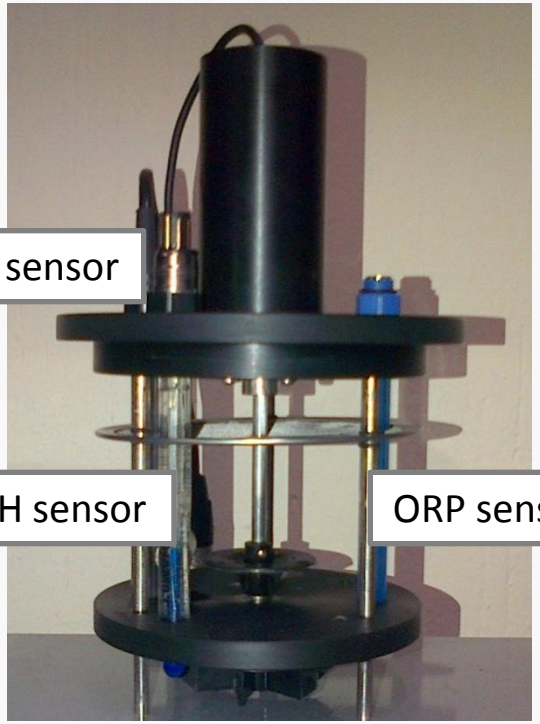
The air supplied to the reaction vessel comes from a small compressor which can be controlled in the settings board by fixing the percentage of the total air-flow.

Reactor assembly



Respirometry Cyclic OUR test of more than 20 h

High reliability Sensors



DO sensor (in all BM respirometers)
40 ppb to saturation
0 – 60 ºC
Electrochemical oxygen sensor
Patented OPTIFOLW membrane
100% maintenance-free sensor: membrane and electrolyte don't need to be replaced.
Response time is fast and independent of flow.
Very stable under harsh ambient conditions.

pH sensor (in BM-Advance and BM-Advance Pro)
pH 0 to 14
0 – 135 ºC
Almost drift-free measurement.
Reference electrolyte factory prepressurized for a clog-free diaphragm potentials.
Everef-F Reference cartridge for silver-free electrolytes.
Poison resistant "PHI" pH glass.

ORP sensor (in BM-Advance Pro)
Set to -1000 mV to + 1000 mV
0 – 130 ºC
ORP element: Pt wire
Maintenance-free sensor.
High-performance ceramic diaphragms to reduce the effect of flow potentials.

pH control in the BM-Advance model

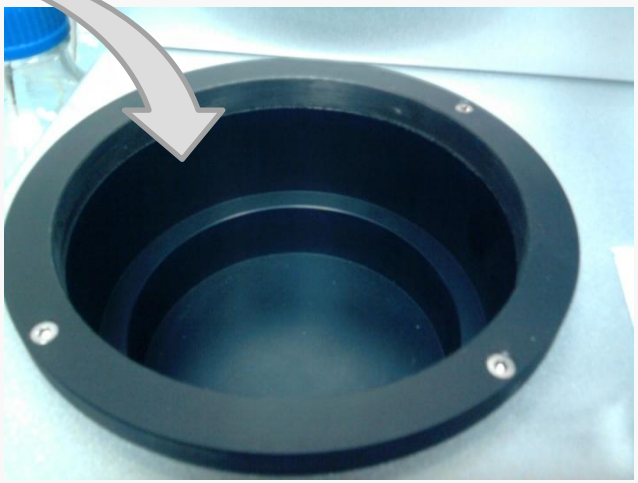
pH control system

Automatic pH buffers dosage in the reactor

Automatic heating-cooling system

Solid-state system based on peltier technology for temperature control (heating & cooling). This heating and cooling system is built into the same analyzer console without the need of using any water bath.

Reactor is carried to the heating-cooling site

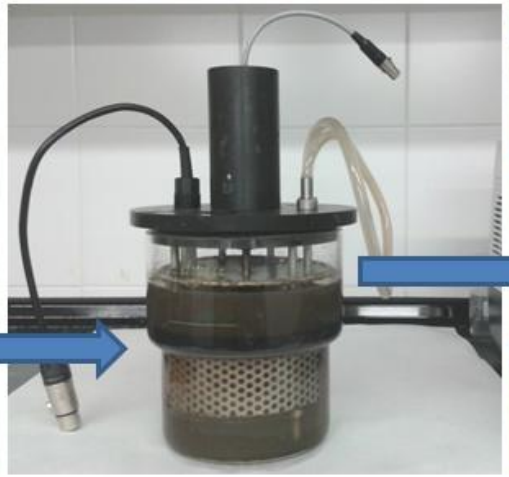


Heating-cooling assembly

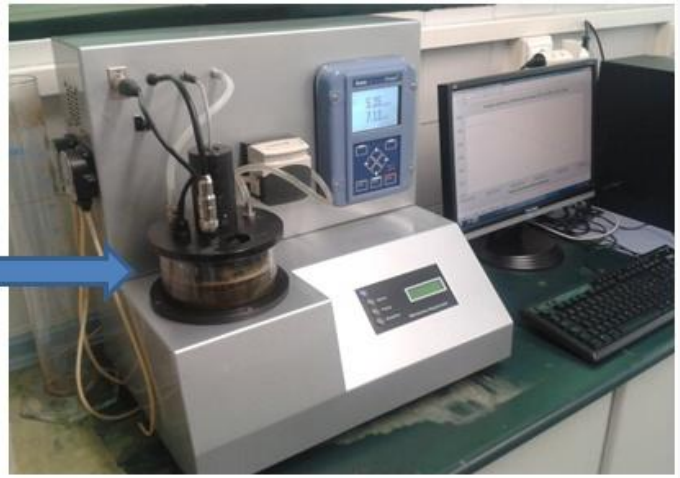
Optional reactor for MBBR

BM respirometers are the only respirometers on the market that can offer the possibility of making use of one special bio-reactor assembly (designed by Surcis) for respirometric tests simulating moving bed bio-film reactors (MBBR type) or granular biomass.

Biomass-carriers loading
in the reactor-cage



Biomass-carriers + mixed-liquor
loaded in the reactor vessel



Reactor installed in the system
and ready for the test performance

Key points in the BM software

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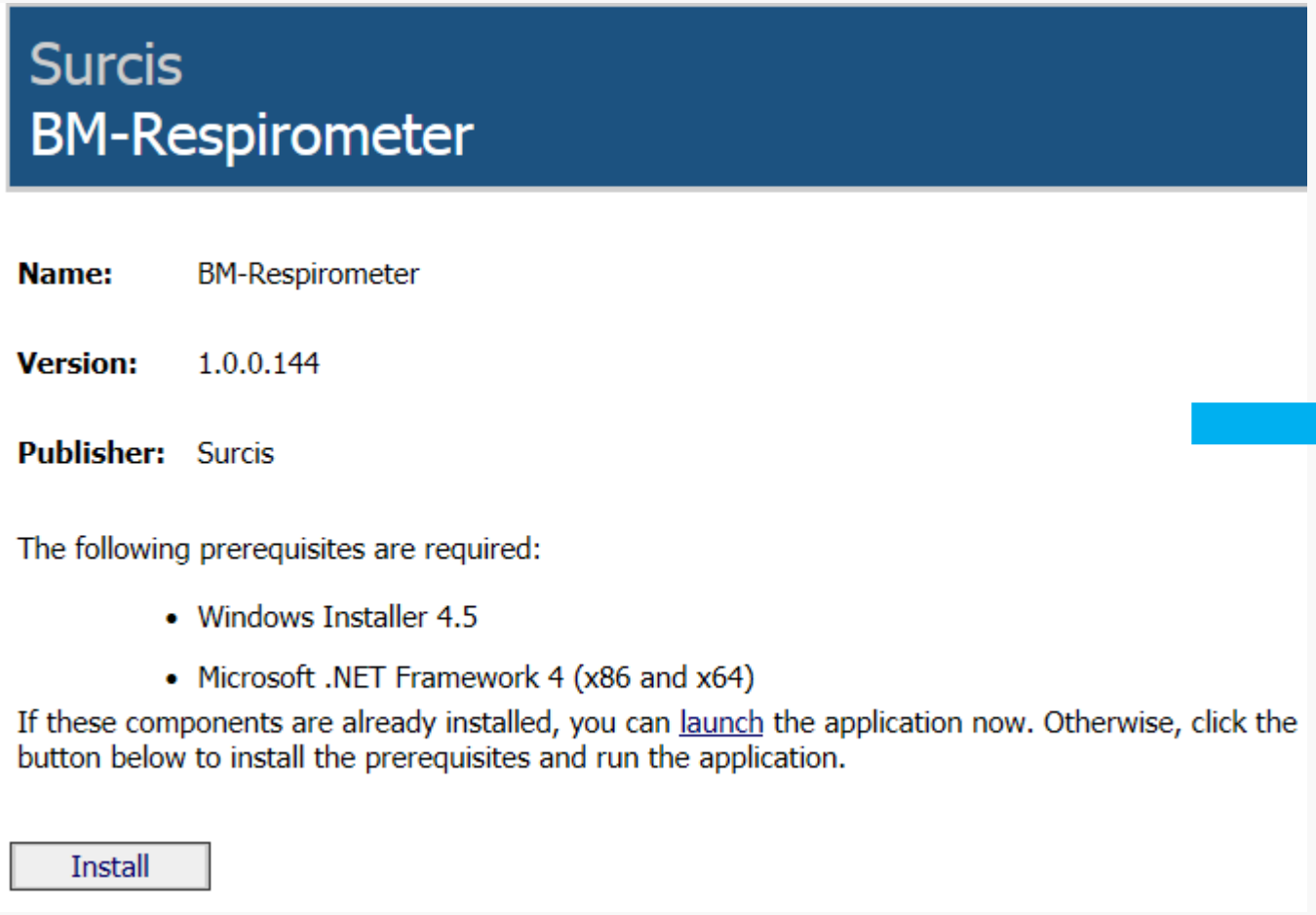
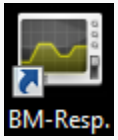
List of some key points in the BM software

- Automatic software updates versions from the internet
- Common software for all BM respirometers
- Device and condition control from the software loaded in the PC of the system
- Ability for test conditions setting and their modification during the test
- Three different operation modes with automatic measurements
- Different forms of data presentation at any point during the test
- Capacity for different respirograms and simultaneous overlying of respirograms

Automatic software update versions from internet

The BM software is automatically updated whenever you connect the PC of the system to the Internet. The software is accessed by a link: http://www.dinko.es/fitxers/BM-Advance/index.htm

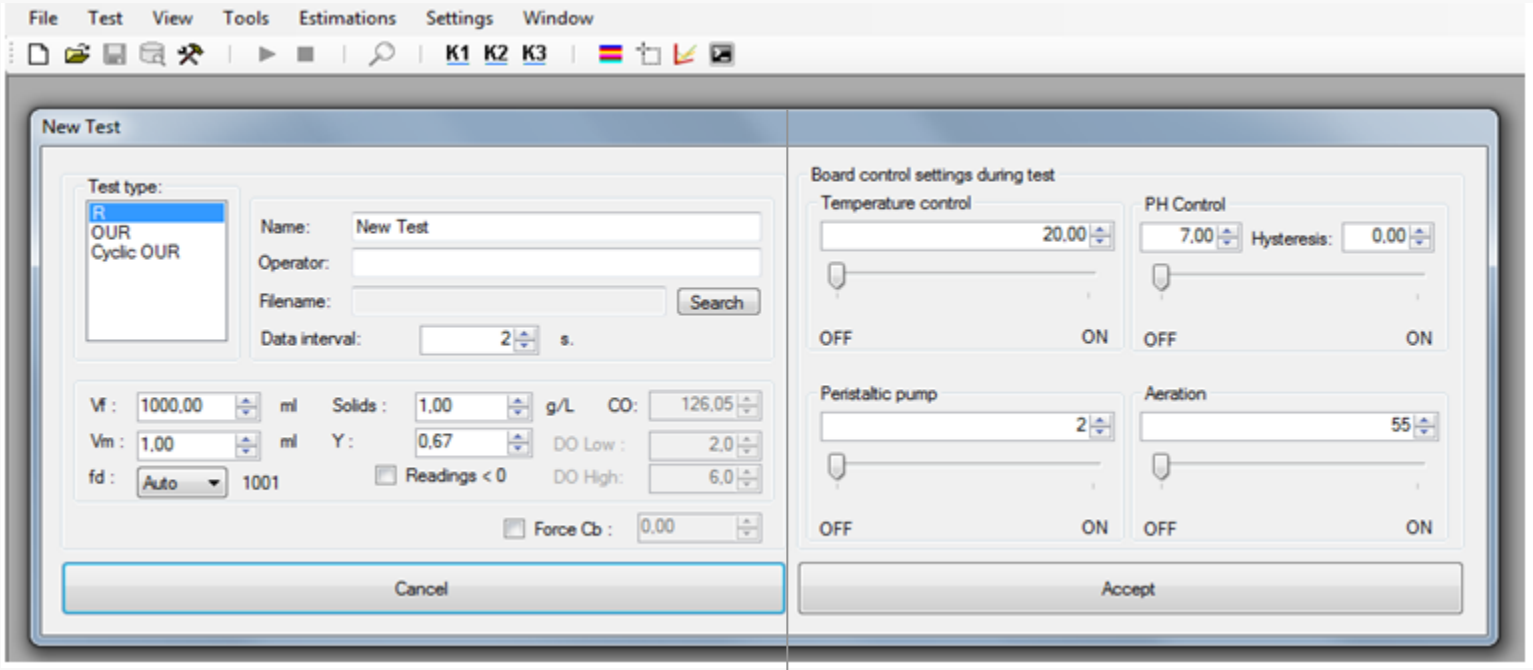




Icon for direct acces

Common software for all BM respirometers

All BM respirometers make use of a single common software. Depending on the model, test type, and specific conditions, the different program settings will be carried out.

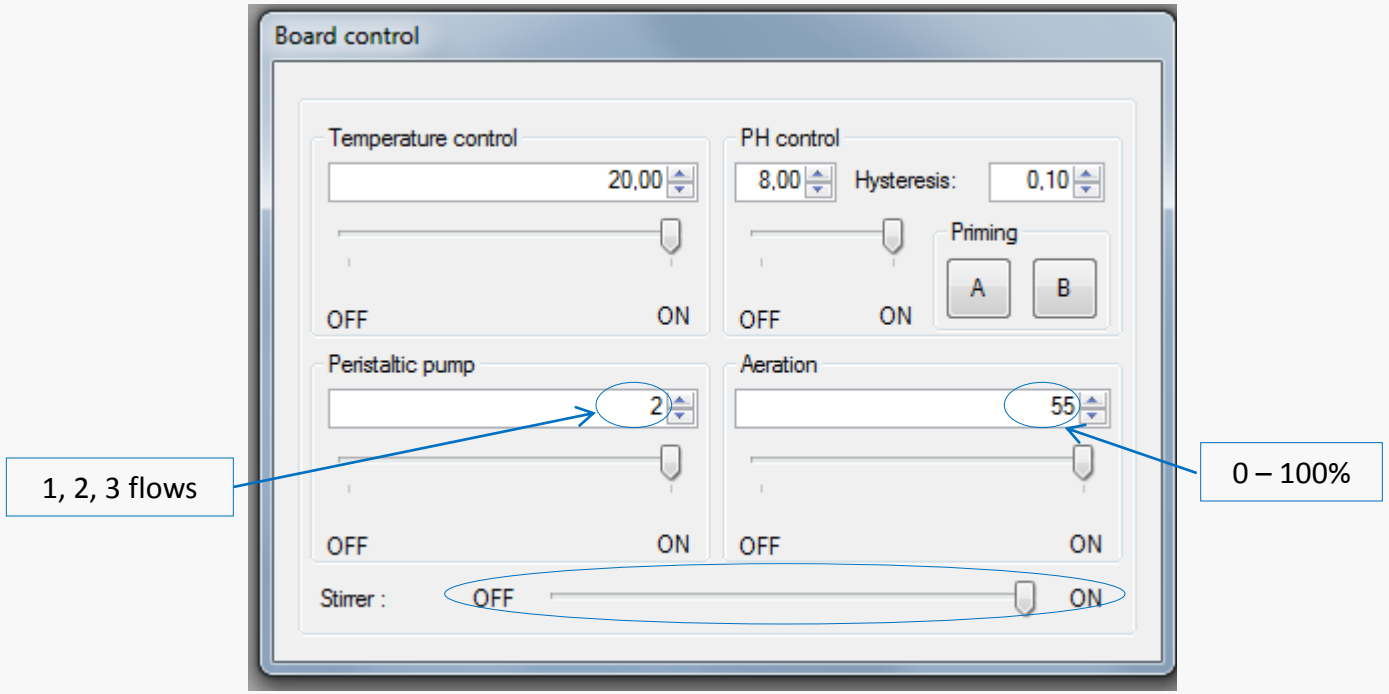


Test type selection and programming

Device and test condition settings

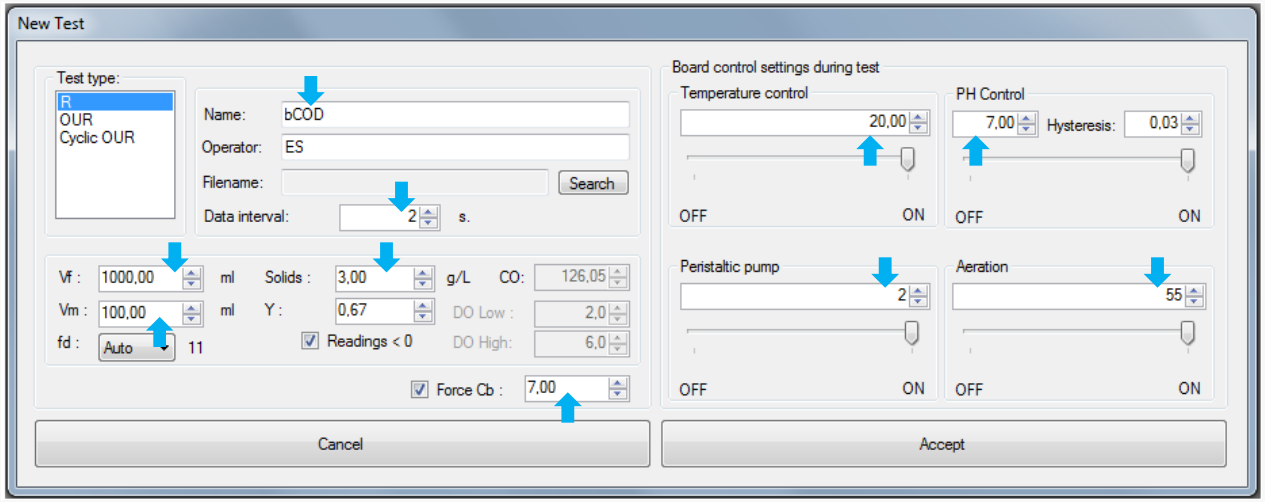
Device control from software

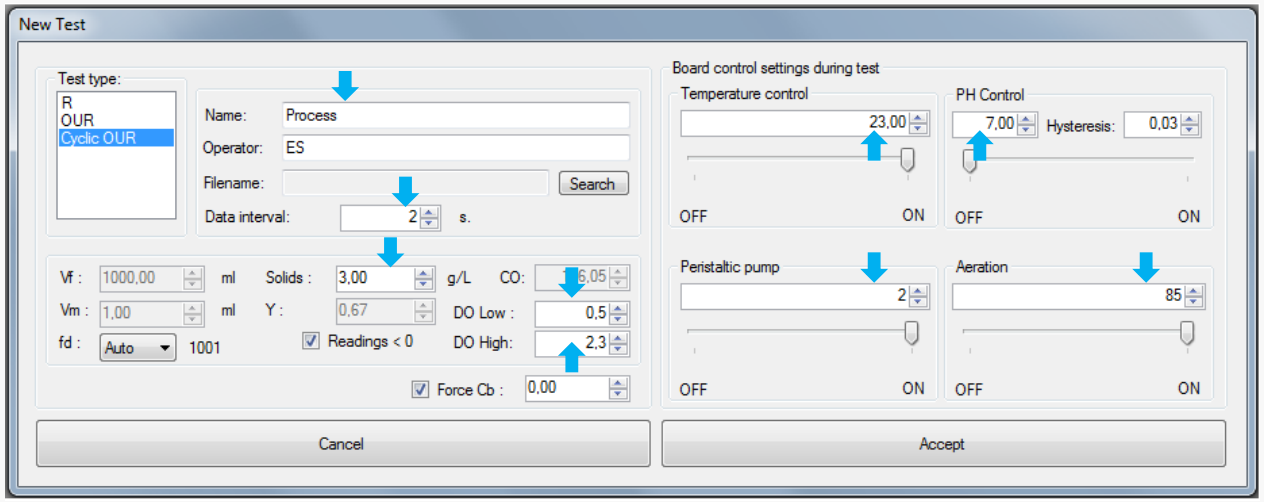
BM software provides a Board Control for device and condition settings on any respirometric test. These settings can be set before and changed during the test.



Ability for test condition setting and their modification during the test

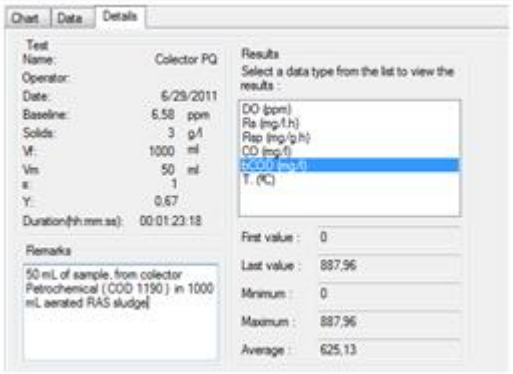
The ability to modify the test conditions and samples, permits a wide array of possibilities to perform studies. The influence of specific test conditions on the activated sludge process performance can be determined.





able to be modified

Different modes of results presentation at any time

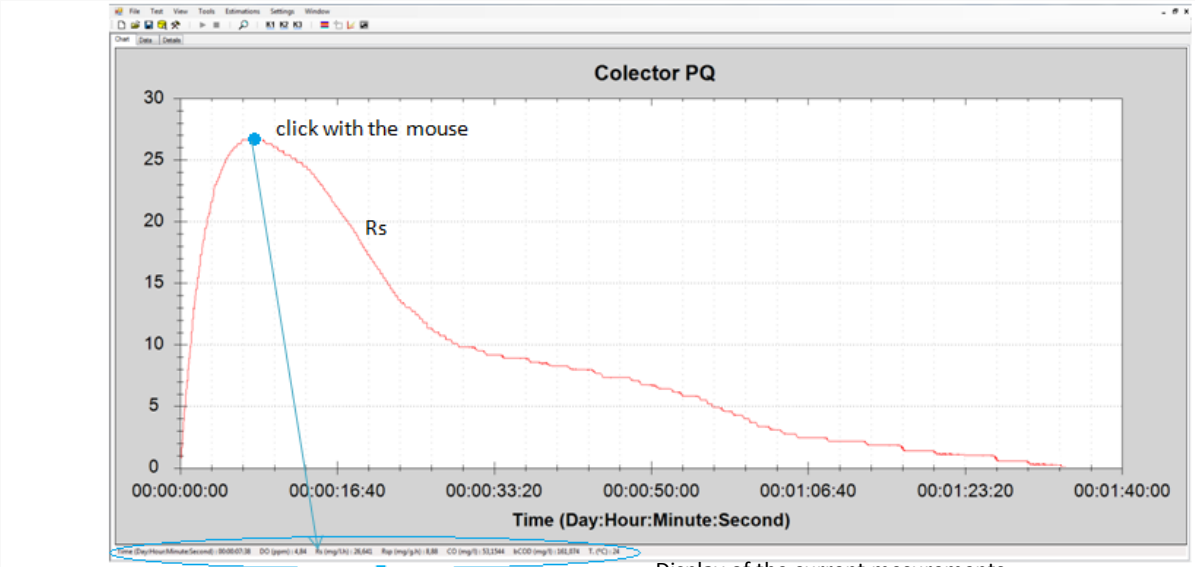


Last, minimum, maximum and average data

Chart | Data | Details

Time (Day:Hour:Minute:Second)	DO (ppm)	Rs (mg/l.h)	Rsp (mg/g.h)	CO (mg/l)	bCOD (mg/l)	T. (ºC)
00:00:34:42	6	8,88	2,96	213,9759	648,412	24
00:00:34:44	6	8,88	2,96	214,0795	648,726	24
00:00:34:46	6	8,88	2,96	214,1831	649,04	24
00:00:34:48	6	8,88	2,96	214,2867	649,354	24
00:00:34:50	6	8,88	2,96	214,3903	649,668	24
00:00:34:52	6	8,88	2,96	214,4939	649,982	24
00:00:34:54	6	8,88	2,96	214,5975	650,295	24

Current data values in a table

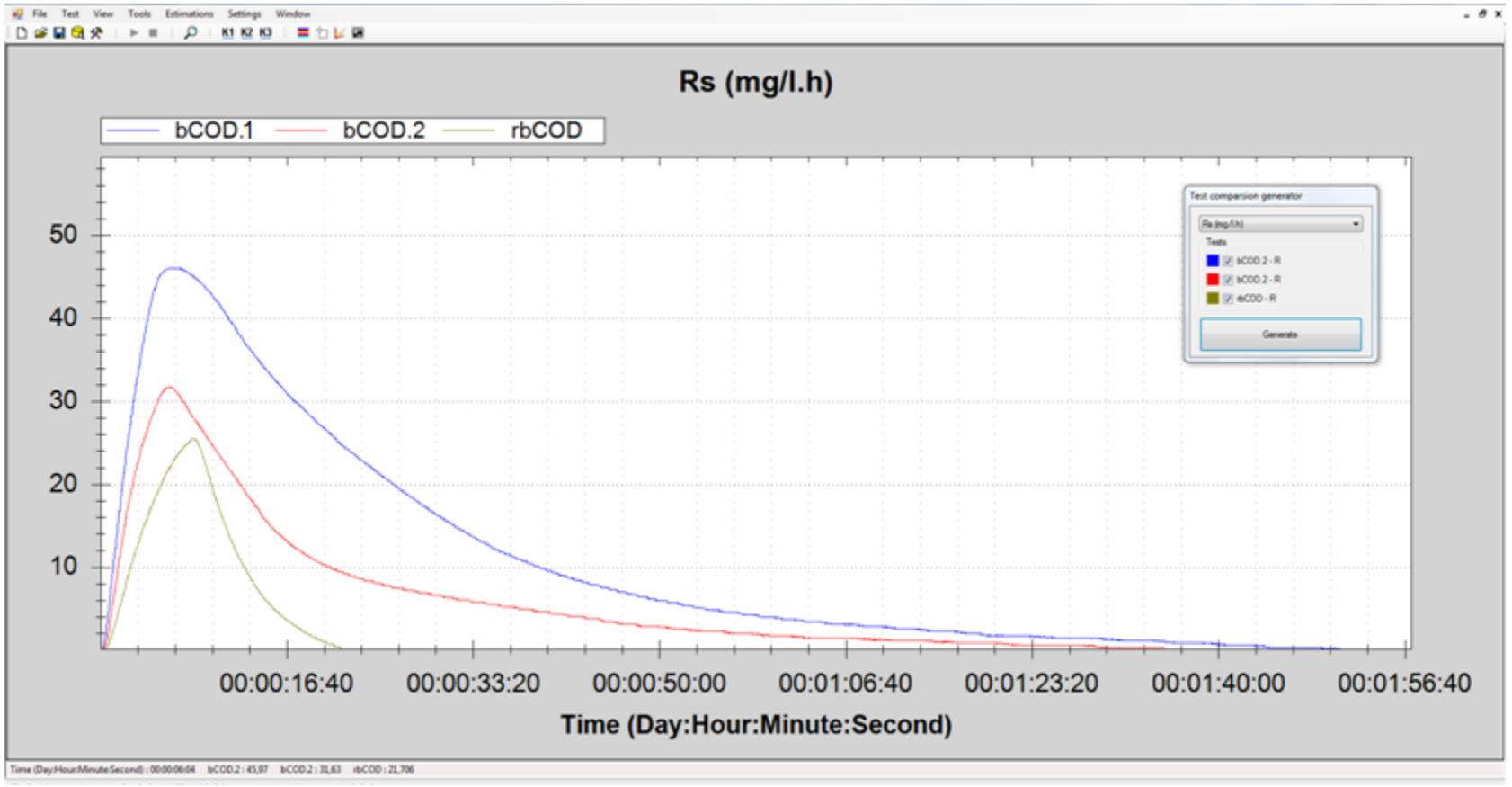


Display of the current mesurements

All results in one click on the respirogram, at the end, and during the test

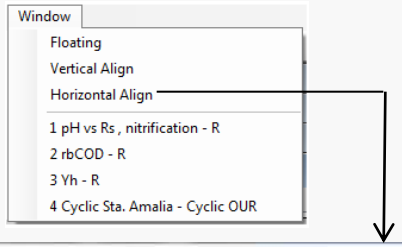
Ability to overlay different respirograms

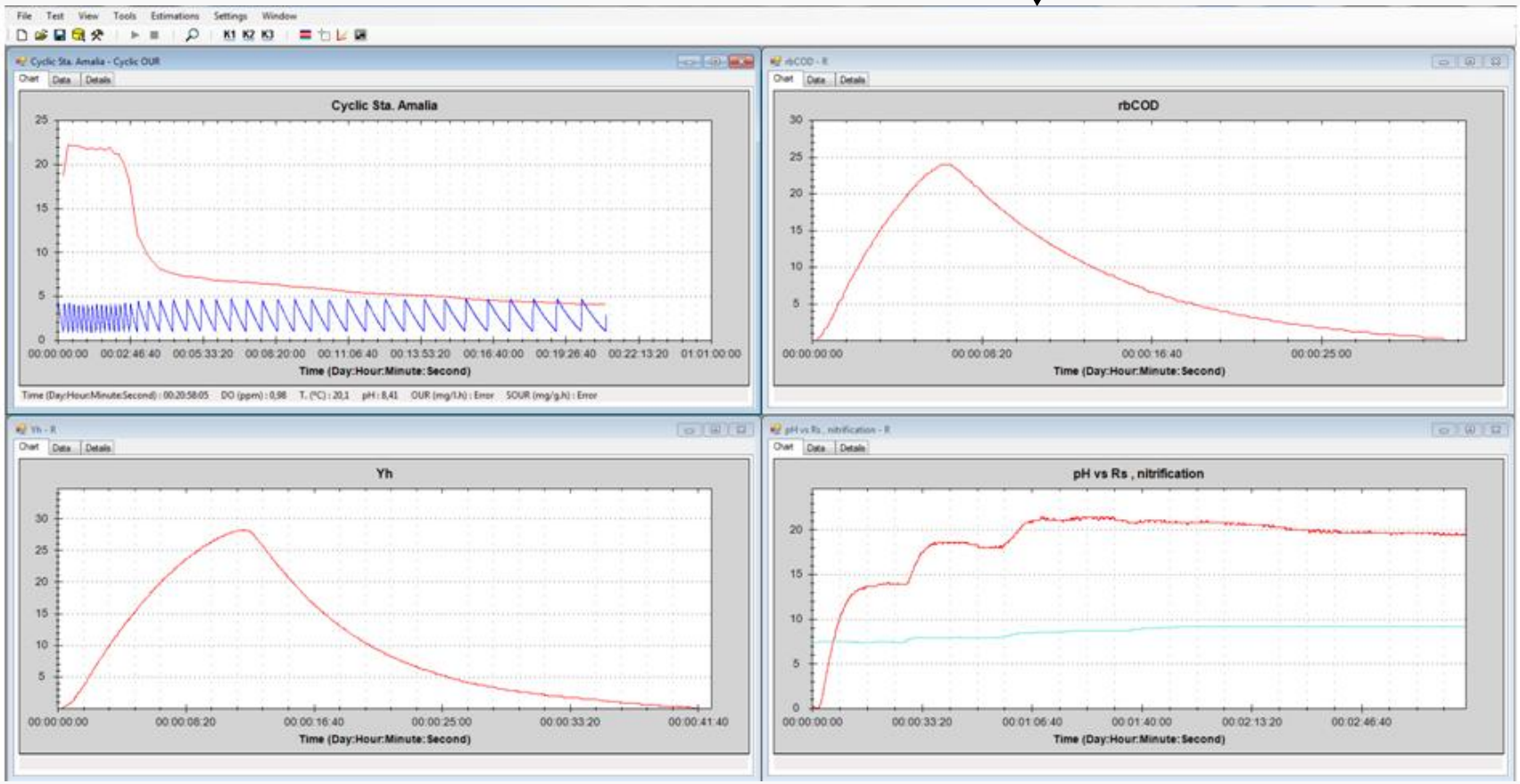
This ability allows for different respirograms to be overlayed with any stored ones.



Ability to display several respirograms at the same time

BM software has the ability to display all or selected stored tests in different modes. This allows for the comparison between test modes and conditions.





BM
operation modes

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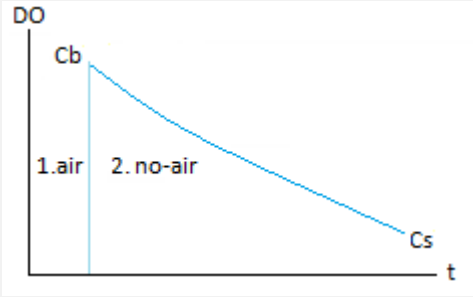
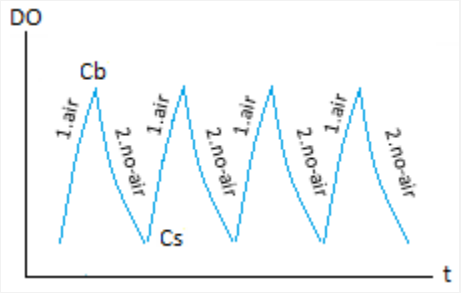
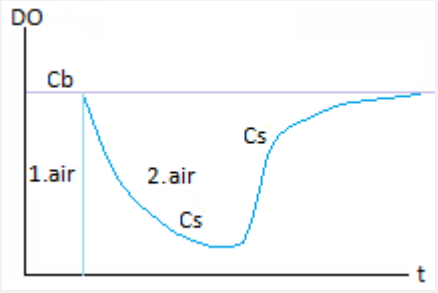
Three different operation modes

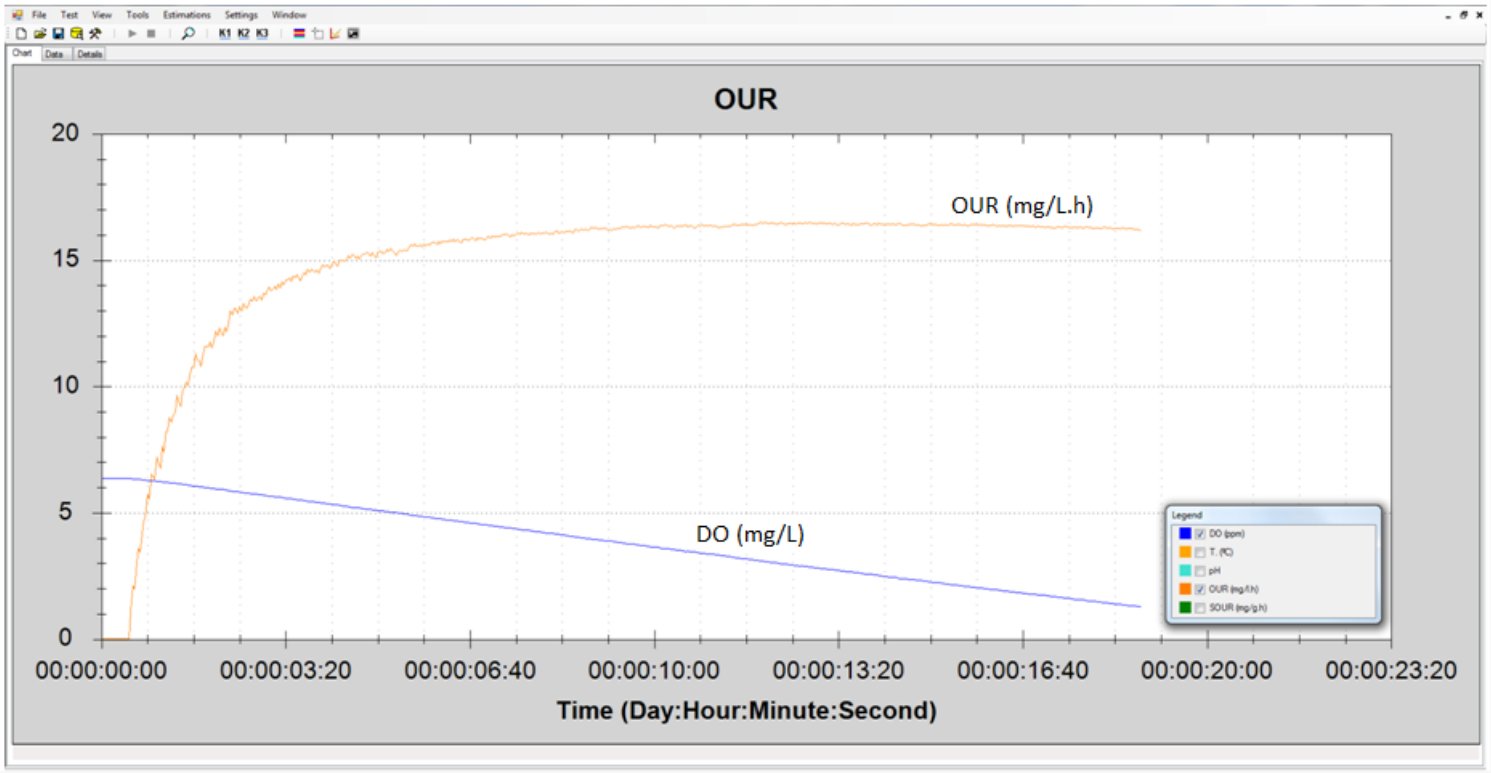
While most of the respirometers on the market offer only one operation mode, the BM respirometers have three different operation modes: OUR mode, Cyclic OUR mode, and R mode. Each mode develops different respirograms for automatic parameters including D.O., Temperature, and pH (in BM-Advance) from where specific applications can be made.

In a single batch reactor, the measuring system can work as LSS and LFS batch respirometry. The system is optimized by a one-sense membrane device, that together with a dividing plate, is able to isolate the measuring chamber and avoid bubbles against the DO sensor.

OUR	Cyclic OUR	R
This mode is making use of the LSS respirometry type. The OUR mode consists of a single test to measure the OUR and/or SOUR parameters (by manually setting the MLVSS concentration). It also has the option the get a partial SOUR for any period within the respirogram.	The cyclic OUR mode consists of a progressive sequence of OUR measurements, generated from the DO trajectory when it fluctuates between the DO. Low and DO. High set-points that were set at the start of the test.	The R mode corresponds to a modified LFS respirometry type test. The measuring system can be considered as a completely mixed batch reactor. In this mode, we get the important advantage to work with a small volume of samples in order to minimize the test time for an important package of several simultaneous parameters measurement.
		

Simultaneous parameters and respirograms in OUR mode

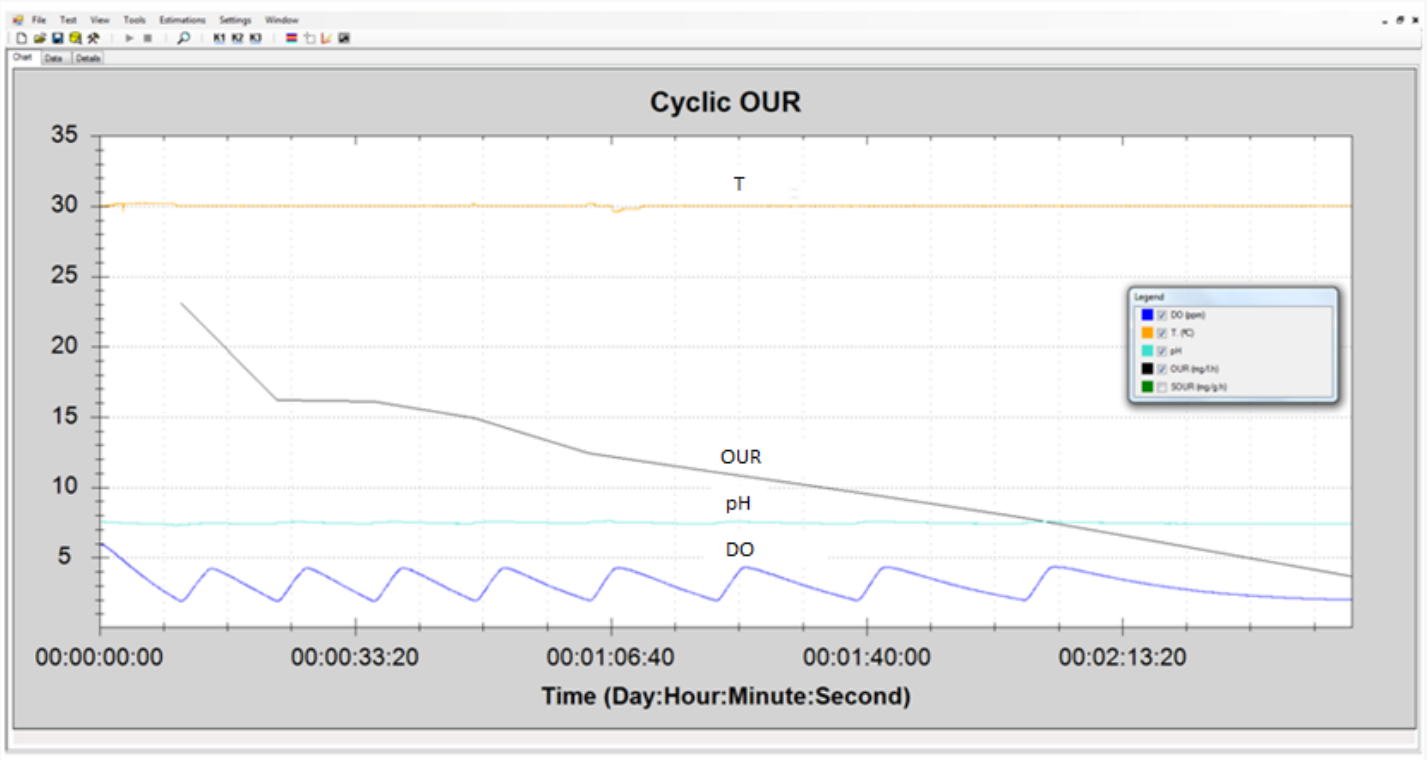
OUR	Oxygen Uptake Rate in mixed-liquor (mg O_2/L.h)
SOUR	Specific OUR related to MLVSS (mg O_2/gVSS.h)
Partial SOUR	SOUR for any determined period within the respirogram (mg O_2/gVSS.h)
DO	Dissolved Oxygen (mg/L)
T	Temperature (ºC)
pH	(in BM-Advance and BM-Advance Pro models)
ORP	(in BM-Advance Pro model)



OUR & DO Respirogram

Simultaneous parameters and respirograms in Cyclic OUR mode

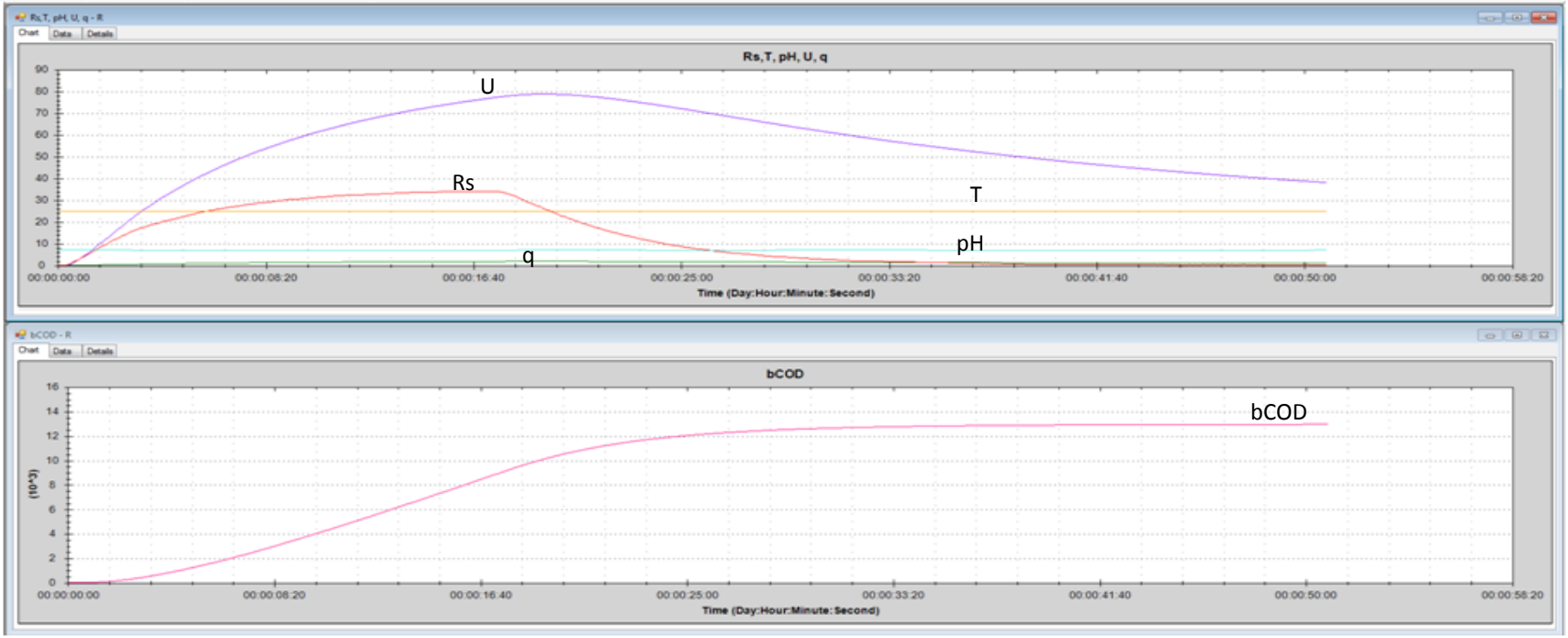
OUR	Oxygen Uptake Rate in mixed-liquor (mg O_2/L.h)
SOUR	Specific OUR related to MLVSS (mg O_2/gVSS.h)
DO	Dissolved Oxygen (mg/L)
T	Temperature (ºC)
pH	(in BM-Advance and B; Advance Pro models)
ORP	(in BM-Advance Pro model)



Cyclic respirogram for several parameters

Simultaneous parameters and respirograms in R mode

DO	Dissolved Oxygen (mg/L)
Rs	Exogenous respiration rate (mg O_2/L.h)
Rsp	Exogenous specific respiration rate (mg O_2/gVSS.h)
CO	Consumed Oxygen (mg O_2/L)
bCOD or **rbCOD**	Total or readily biodegradable COD (mg O_2/L)
U	bCOD or rbCOD removal rate (mg COD/L.h)
q	Specific bCOD or rbCOD removal rate (mg COD/mgVSS.d)
T	Temperature (ºC)
pH	(in BM-Advance and BM-Advance Pro models model)
ORP	(in BM-Advance Pro model)



Some state of the art applications for the BM Respirometers

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27

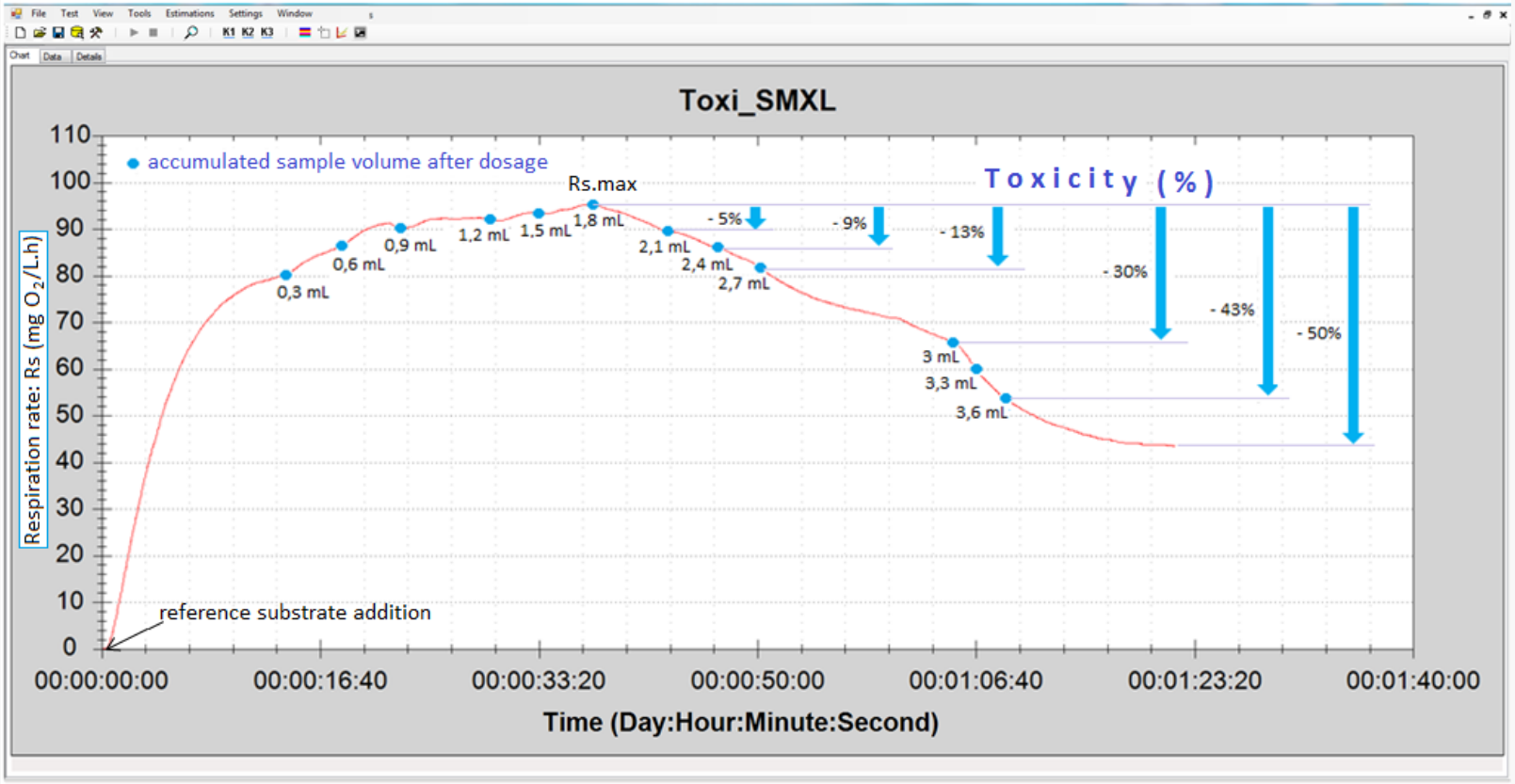
The BM software is a powerful tool which by its three different operation modes and flexibility, permits unlimited applications for management, research, protection, and design for biological wastewater treatment processes.

In this chapter, we include some possible state of the art applications that can be carried out with this BM software within a frame of easy and fast performance.

Toxicity by progressive aliquot accumulation in the sludge

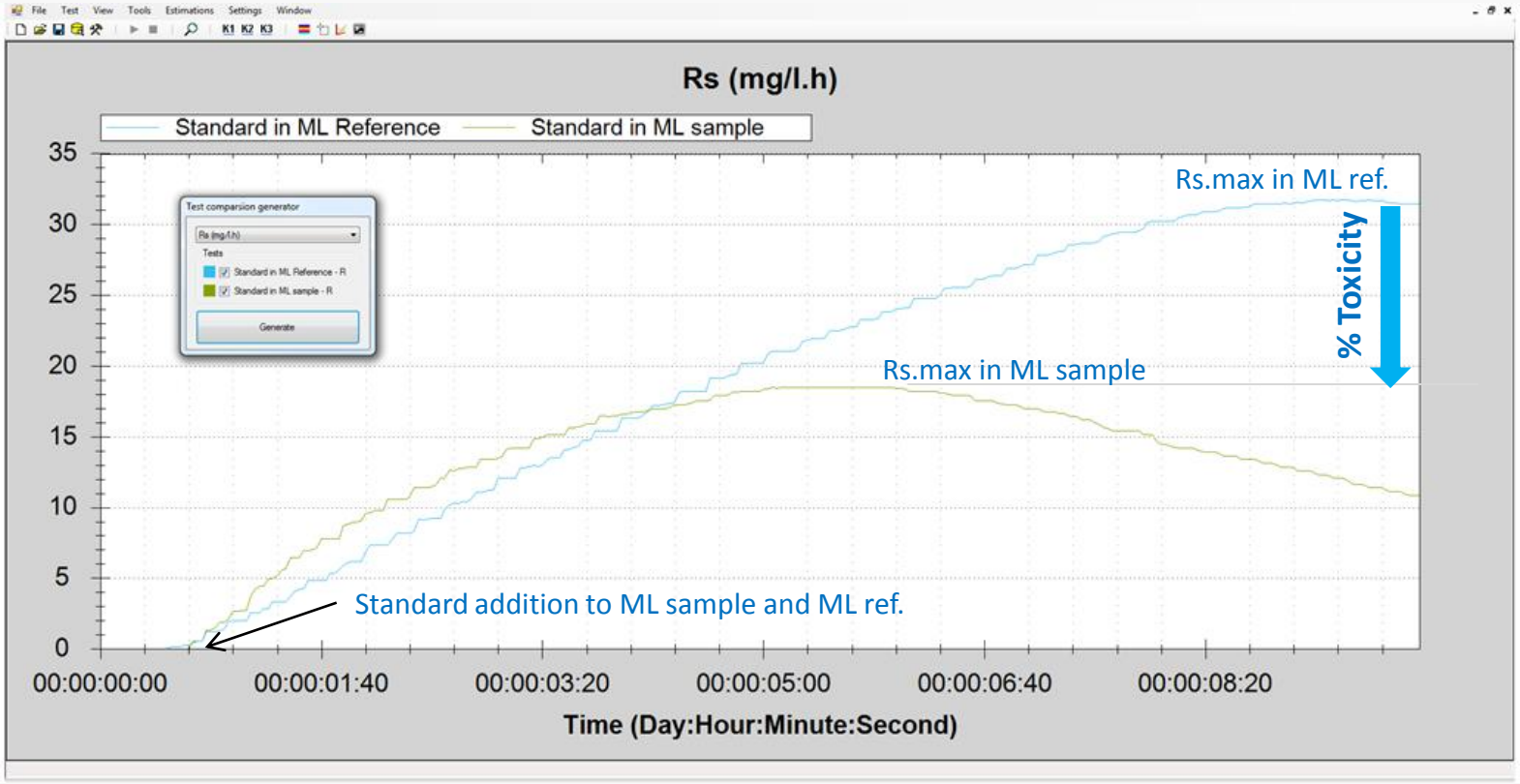
To the endogenous sludge we add a reference substrate on saturation level base. Once reached the reference plateau, we add progressive doses of aliquot in order to progressively increase the substrate concentration in the activated sludge.

In case of toxicity, as we are sequentially adding a serial of doses, the respiration rate value in the respirogram will also progressively decrease vs reference level (Rs. Max) We can stop the test as soon as we reach the target inhibition % (e.g. EC50) Then, the equivalence volumes sample/sludge ratio will give us the value of how much toxicant substrate can support our activated sludge process.



Toxicity of slow effect in the sludge

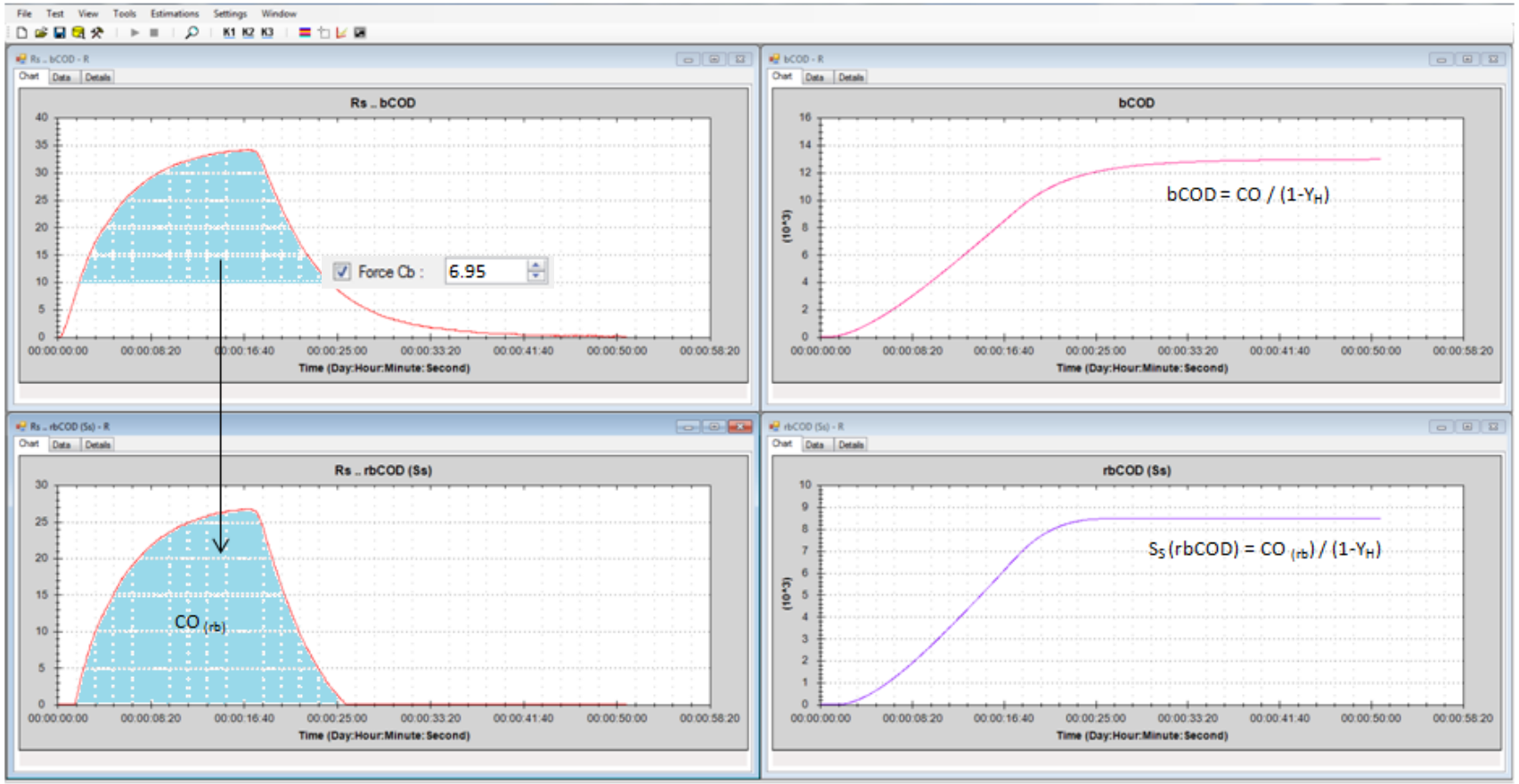
Sometimes the effect of the toxicity is not immediate and it can take more than 24 hours.
We can detect and assess any slow toxicity effect by mean two respirometric test where we add the same standard compound to the two previously prepared endogenous mixed-liquors: one with the sample (ML sample) and the other one without (ML reference) for a time > 24 hours. And then, comparing the maximum Rs (Rs.max) on the overlaid respirograms.



Biodegradable COD (bCOD) and readily biodegradable COD (S_S)

Whenever it is possible to distinguish the readily biodegradable part in the Rs respirogram for bCOD, in the settings board we can make use of the option of "Force Cb" to raise the base-line. In this way, we can cut the Rs respirogram and automatically create a new one with only the part that correspons to the readily biodegradable COD. In this way, with one single test, we determine the bCOD and the S_S (rbCOD) fraction (*)

(*) The other way to determine the S_S would be to carry out a new respirometric R test with a truly soluble wastewater sample in endogenous sludge.

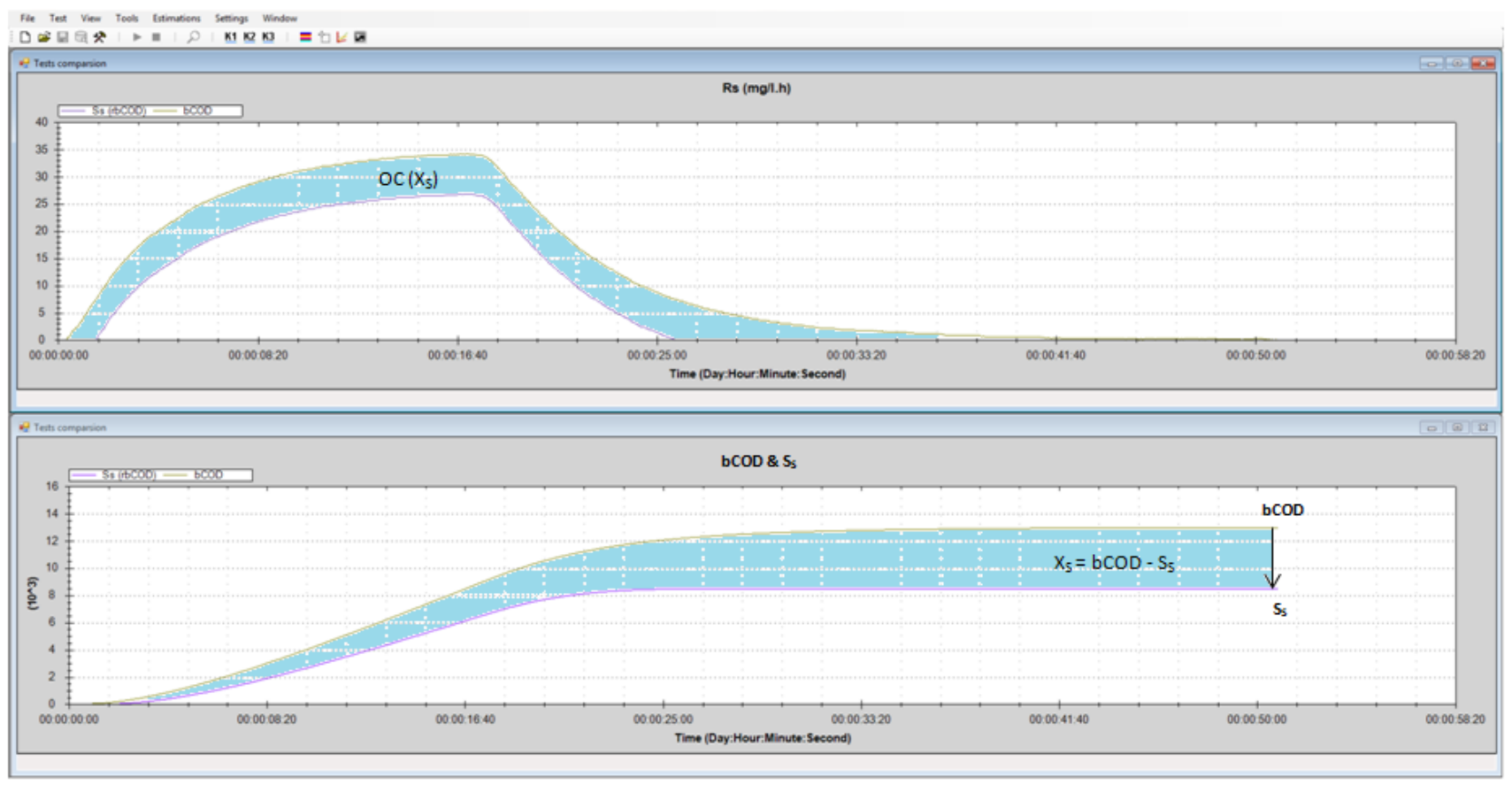


Slowly and non-biodegradable COD fractions

Once we have determined the bCOD and S_S values, we have the tools to calculate the slowly biodegradable COD (X_S) and the inert or non-biodegradable COD (nbCOD)

$$\mathbf{X_S} = bCOD - S_S$$

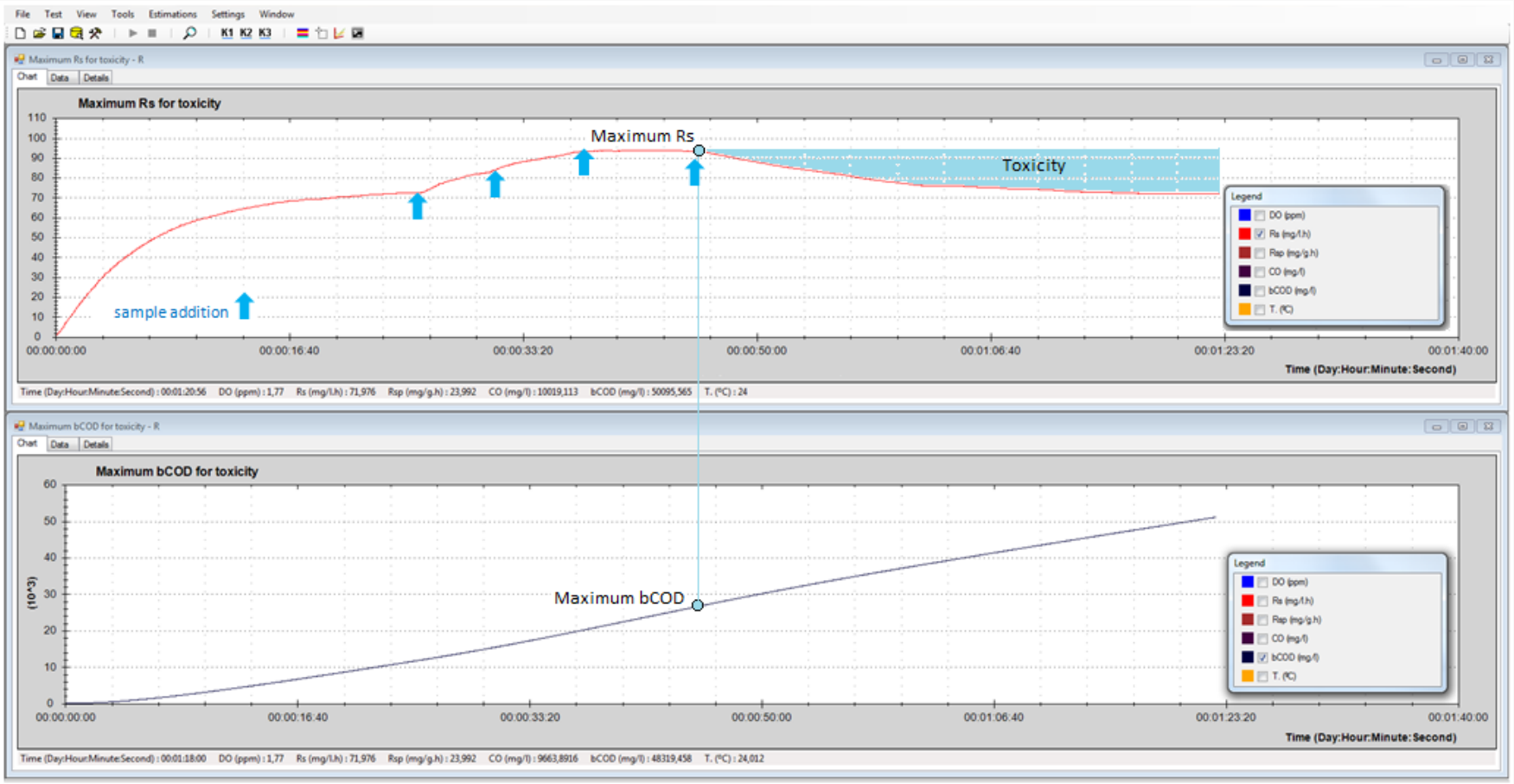
$$\mathbf{nbCOD} = COD - bCOD$$



Break-point for maximum allowed flow & bCOD in the sludge when there is toxicity in the wastewater

In a R mode respirometric test, we are adding consecutive doses of wastewater sample in a RAS sludge up to the break point where the Rs begins to drop significantly as a sign of toxicity.

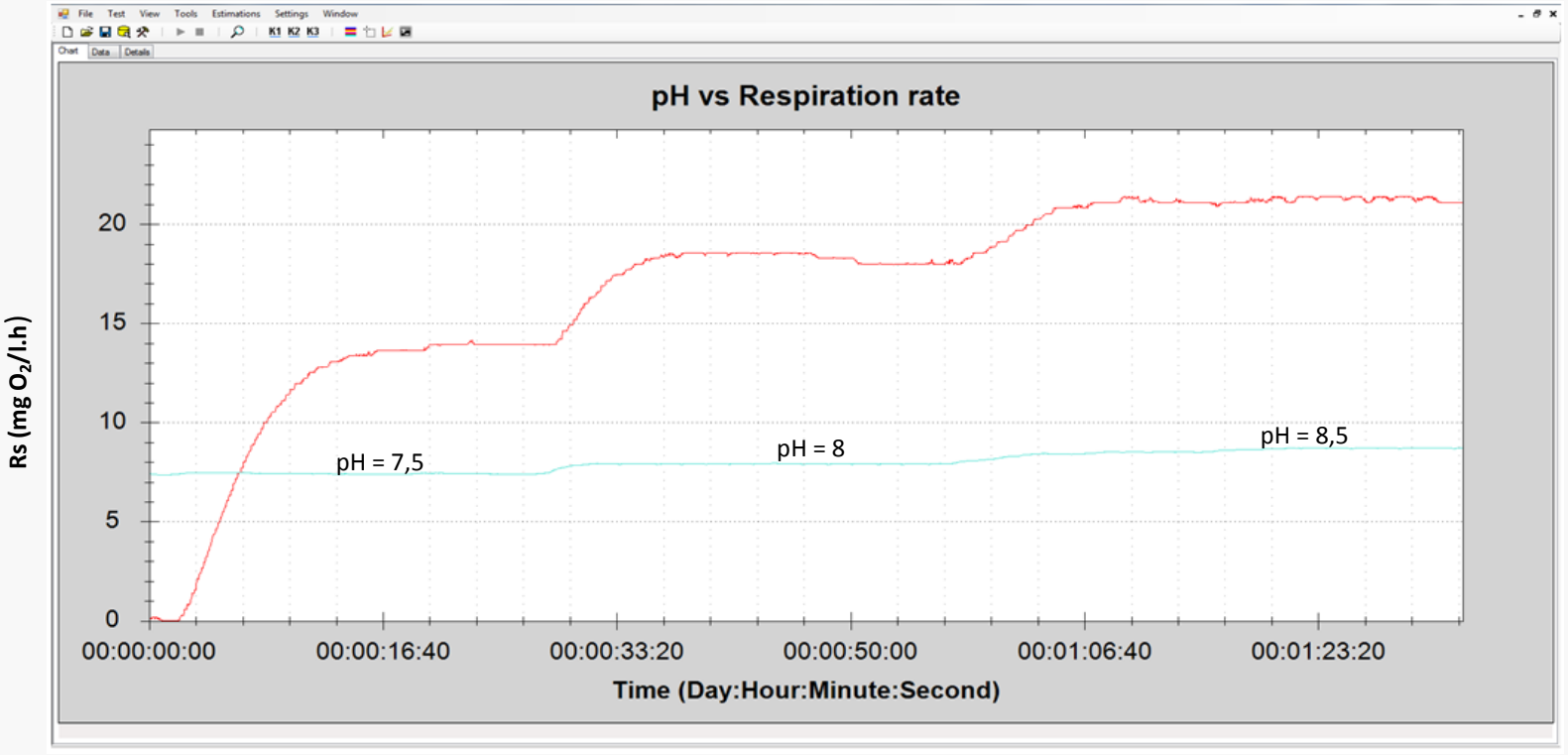
From (total wastewater volume added) / (RAS volume) = (Influent flow) / (RAS flow), and the simultaneously measured bCOD, the maximum allowed flow and bCOD can be calculated.



Influence of pH on the nitrification rate in a single R mode respirometric test

We apply ammonium chloride to endogenous sludge for a reliable respirometric R test to analyze the nitrification rate. In this test, thanks to the ability to modify the pH during the test, we will get te corresponding respiration rates (Rs) influenced by the pH. Then, from the representative respiration rate values, we calculate the corresponding nitrification rates (AUR)

(Only in the BM-Advance model)



Nitrification rate (mg N-NH_4/L.h): **AUR** = Rs / 4.57

34

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