# BM Respirometry Toxicity & COD fractions and Biodegradability



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 respirometers from SURCIS**



**BM-software** 



#### **Comparative table of the different BM respirometer models**

Comparative items	BM	BM	BM	BM	BM	BM	Comments
	T+	EVO	EVO2	Advance	Advance2	Advance Pro	
Automatic measurements:			2 x		2 x		From the automatic
OUR (mg/l.h)		1			1	1	measurements we can go to the
SOUR (mg/g.h)	~	~	~	✓	✓	✓	corresponding applications.
OUR & SOUR cíclico							
Rs mg/l.h)							
CO (mg/l)							
bCOD (mg/l) & rbCOD (mg/l)							
U (mg DQO/l.h)							
q (mg DQO/mgSS.d)							
Thermostatic system installed			2 x		2 x		Cooling (Peltier) + Heating
in the analyzer		✓	✓	✓	✓	✓	system included in the own console.
External thermo unit							External unit (separated unit)
							formed by Cooling (Peltier) +
	v						Heating system.
Easy transportable system:							Analyzer + case $\rightarrow$ 20 kg
	✓						MD-40 + case $\rightarrow$ 5 kg
Padded aluminium cases for							1 case for the console + 1 case
easy transportation	$\checkmark$						for the external thermostatic
							unit.
pH measurement and control					2 x		Especially important in all tests
throughout the test	1			1	1	1	related to nitrification and in
	•			•	•	•	those where there is a special
							sensitivity to the pH changes.
ORP measurement							Redox
Possibility to modify the test			2 x			•	Important to carry out studies to
settings during performance	✓						analyze the influence of the pH,
							OD, Temperature in the process.
BM software update from			2 x				When connected to the internet
Internet	✓	$\checkmark$	$\checkmark$	$\checkmark$	$\checkmark$	$\checkmark$	URL, the BM software is
	-	-	-	-	-		automatically updated.
Capability for biomass-carrier			2 x				The biomass carrier reactor ifor
reactor option	1	1	1	1	1		BM-T+ is rather different (and
	v	v	v	v	v	✓	more expensive) than the one
							for EVO y Advance

## Key points in the BM software



#### 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: <u>http://www.dinko.es/fitxers/BM-Advance/index.htm</u>

## Surcis BM-Respirometer

Name: BM-Respirometer

Version: 1.0.0.144

Publisher: Surcis

BM-Resp.

Icon for direct acces

The following prerequisites are required:

- Windows Installer 4.5
- Microsoft .NET Framework 4 (x86 and x64)

If these components are already installed, you can <u>launch</u> the application now. Otherwise, click the button below to install the prerequisites and run the application.

Install

#### **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       View       Tools       Estimations       Settings       Window         Image:	
v Test	Board control settings during test Temperature control 20.00 7,00 Hysteresis: 0.00 Top OFF ON OFF ON
Vf:       1000.00       ⊕       ml       Solids:       1.00       ⊕       g/L       CO:       126.05 ⊕         Vm:       1.00       ⊕       ml       Y:       0.67       ⊕       DO Low :       2.0 ⊕         fd:       Auto       1001       Image: Readings < 0       DO High:       6.0 ⊕         Encre Cb:       0.00       ⊕	Peristaltic pump Aeration 2 OFF ON OFF ON
Cancel	Accept
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.

Board	d control				
	Temperature control	),00 🌲	PH control 8,00 🖨 Hysteresis:	0,10 🜩	
	OFF		OFF ON Priming	в	
	Peristaltic pump	2	Aeration	55 🜩	
1, 2, 3 flows		—Q	1	-0	0 – 100%
5	OFF Stirrer : OFF	ON	OFF	ON ON	

## 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.

est type:	Board control settings duri	ing test			ab
	Temperature control		PH Control		m
DUR Name: bCOD		20,00 🚔	7.00 Hysteresis:	0,03 🚔	
Operator: ES			-		
Filename: Search		Ĩ		Ť	
Data interval: 2 📩 s.	OFF	ON	OFF	ON	
ff: 1000,00 🔶 ml Solids: 3,00 🗼 g/L CO: 126,05 👾	Peristaltic pump		Aeration		
m: 100,00 ml Y: 0.67 💭 DO Low: 2,0		2 🌻		55 🚔	
d : Auto 11	1		1		
✓ Force Cb : 7.00	OFF	ON	OFF	ON	
Cancel		Ac	cept		
			·		
rst					
st time:	Board control settings durin	ng test			
est type:	Board control settings durin Temperature control	ng test	PH Control		
est type:	Board control settings durin Temperature control	ng test	PH Control	0.03 ÷	
est type: UR Velic OUR Operator: ES	Board control settings durin Temperature control	ng test	PH Control	0.03	
est type: UR VUR Volic OUR Operator: ES Filename: Search	Board control settings durin Temperature control	ng test	PH Control	0,03	
est type: UR Velic OUR Operator: ES Filename: Data interval: 2 v s.	Board control settings durin Temperature control	ng test	PH Control 7.00 Hysteresis: 0	0.03 -	
test UR VUR Volic OUR Process Operator: ES Filename: Data interval: 2↓ s. f: 1000.00 ← ml Solids: 3.00 ← α/L CO· ● 0.05 ←	Board control settings duri Temperature control	ng test	PH Control 7.00 Hysteresis: 0FF Aeration	0,03 -	
test UR Velic OUR Velic OUR Derator: ES Filename: Data interval: 2 x s. F: 1000,00 x ml Solids: 3,00 x g/L CO: 8,05 x mi 100 kl ml Y: 0.67   DO Leve: 0.5 kl	Board control settings duri Temperature control	ng test	PH Control 7.00 + Hysteresis: 0FF Aeration	0,03 - , ON 85 -	
est type: UR VUR Velic OUR Derator: ES Filename: Search Data interval: 2 x s. F: 1000.00 x ml Solids: 3.00 x g/L CO: \$.05 x m: 1.00 x ml Y: 0.67 x DO Low: 0.5 x H: 1.00 x ml Y: 0.67 x DO Low: 0.5 x	Board control settings duri Temperature control	ng test	PH Control 7.00 + Hysteresis:	0.03 ÷ ON	
test type: UR Velic OUR Derator: ES Filename: Data interval: 2 ÷ s. F: 1000,00 ÷ ml Solids: 3,00 ≠ g/L CO: \$0.05 ÷ m: 1,00 ÷ ml Y: 0,67 ÷ DO Low: 0.5 ÷ I: Auto ▼ 1001 ♥ Readings < 0 DO High: 2,3 ÷	Board control settings durin Temperature control	ng test 23,00 ÷ 0N 2 ÷	PH Control 7.00 + Hysteresis:	0.03 ÷ ON	
est est st type: UR Velic OUR Derator: ES Filename: Data interval: 1000.00 ☆ ml Solids: 1000.00 ☆ ml Y: 1000.00 ☆ ml Y: 1000 ☆ ml	Board control settings durin Temperature control	ng test 23.00 ★ ON 2 ★ ON	PH Control 7.00 Hysteresis: OFF Aeration OFF	0.03 - - - - - - - - - - - - - - - - - - -	

#### Different modes of results presentation at any time

Diat Data Detais	
Test Name: Colector I Operator:	Results Select a data type from the list to view the results
Baseline:         6.58         pp           Solds:         3         gA           Vf.         1000         ml	DO (ppm) Re (mp/t) Re (mp/t) CD (mp/t)
Vm 50 ml e 1 Y: 0.67 Durationality annual: 000122118	T. (C)
Remarka	First value : 0
50 mL of sample, from colector	Last value : 837,96
Petrochemical (COD 1190) in 100 mL aerated RAS studge	Mrimum : 0
	Maximum : 887,96
	Average : 625,13

Chart Data Details						
Time (Day:Hour:Minute:Second)	DO (ppm)	Rs (mg/1.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

Last, minimum, maximum

#### and average data

#### Current data values in a table



Time (Day:Hour:Minute:Second) : 00:00:07:38 DO (ppm) : 4,84 Rs (mg/l.h) : 26,641 Rsp (mg/g.h) : 8,88 CO (mg/l) : 53,1544 bCOD (mg/l) : 161,074 T. (°C) : 24

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



## **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.
DO	DO	DO







#### Simultaneous parameters and respirograms in OUR mode

OUR	Oxygen Uptake Rate in mixed-liquor (mg O <sub>2</sub> /L.h)
SOUR	Specific OUR related to MLVSS (mg O <sub>2</sub> /gVSS.h)
Partial SOUR	SOUR for any determined period within the respirogram (mg O <sub>2</sub> /gVSS.h)
DO	Dissolved Oxygen (mg/L)
Т	Temperature (ºC)
рН	(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 <sub>2</sub> /L.h)		
SOUR	Specific OUR related to MLVSS (mg O <sub>2</sub> /gVSS.h)		
DO	Dissolved Oxygen (mg/L)		
Т	Temperature (ºC)		
рН	(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 <sub>2</sub> /L.h)
Rsp	Exogenous specific respiration rate (mg O <sub>2</sub> /gVSS.h)
СО	Consumed Oxygen (mg O <sub>2</sub> /L)
bCOD or rbCOD	Total or readily biodegradable COD (mg O <sub>2</sub> /L)
U	bCOD or rbCOD removal rate (mg COD/L.h)
q	Specific bCOD or rbCOD removal rate (mg COD/mgVSS.d)
т	Temperature (ºC)
рН	(in BM-Advance and BM-Advance Pro models model)
ORP	(in BM-Advance Pro model)



# Toxicity



#### Toxicity by progressive aliquot accumulation in the sludge

To the endogenous sludge we add a reference substrate on saturation level base (1 g sodium acetate / g of MLSS) Once reached the maximum respiration rate, 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 several 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. Toxicity can be assessed by comparing the maximum Rs (Rs.max) on the overlaid respirograms.



# COD fractions and Biodegradability



## **Biodegradable COD (bCOD)**

We can determine the total biodegradable COD (bCOD) by means one R test with influent wastewater to the biological reactor and endogenous sludge.

BM-respirometer software will automatically calculate the on-going bCOD value by making use of the Y and the accumulated consumed oxygen (CO) and, during the test performance, we can see at any moment the bCOD that is being utilized.

Simultaneously to the CO and bCOD, the software calculates de specific COD utilization rate (q), which indicates how fast the biodegradable COD is being removed.



### Readily biodegradable COD (S<sub>s</sub>)

In the same way as the biodegradable COD, we can obtain the redily biodegradable COD (rbCOD =  $S_s$ ), but making use of a soluble wastewater sample.

Also, simultaneously to the CO and rbCOD, the software also calculates de specific soluble COD utilization rate (q), which indicates how fast the soluble readily biodegradable COD is being removed.



#### **bCOD** and **rbCOD** in one single R test

Wherever possible to distinguish the readily biodegradable part in the Rs respirogram for bCOD, in the settings board we can make use of the option "Force Cb" to raise the base-line to the turning point.

In this way, we can cut the Rs respirogram, convert the turning point level as a new base-line, and automatically create a new respirogram corresponding to the readily biodegradable COD.

Thus determine the biodegradable and readily biodegradable COD from one single test



bCOD respirogram

rbCOD (S<sub>s</sub>) respirogram

Source: Influent fractionation using a respirometric method for the characterization of primary sedimentation Ellen Vanassche, 2014 - Faculty of Bioscience Engineering – UNIVERSY OF GENT (Belgium)

#### Slowly (X<sub>s</sub>) and non-biodegradable COD (nbCOD) 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)

 $X_s = bCOD - S_s$ nbCOD = COD - bCOD



#### **Biodegradability for a specific activated sludge**

This biodegradability as seen from the activated sludge respirometry view, under equivalent conditions to the actual ASP, should be considered not only from the biodegradable character of the wastewater sample to be analyzed but also from the sludge activity health and sample adaptation to the biomass. For that reason, this type of biodegradability should be specific for the activated sludge responsible of the organic matter oxidation of the influent wastewater.

bCOD / COD	Character
> 0.8	Very biodegradable
$0.7\sim0.8$	Biodegradable
$0.3 \sim 0.7$	Very little biodegradable
< 0.3	Unbiodegradable

Biodegradability (%) = 100 \* bCOD/COD

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