BPC INSTRUMENTS

Standard/Smart Agitation System

Designed for GL 45 bottles

Designed and assembled in Sweden

Operation and Maintenance Manual

Sweden, 2022

Smart Agitation System

Standard Agitation System

Release History

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All photos in this manual are used for illustrative purposes.

Table of Contents

1 Preface

BPC Instruments AB

BPC Instruments AB (hereafter sometimes referred to as BPC) is a privately held company and a market leader in the area of advanced control technologies for the biotechnology related applications. The company was founded in 2006, bringing to market more than fifteen years of industry leading research in the area of instrumentation, control and automation of anaerobic digestion processes.

At the end of 2009, BPC launched the Automatic Methane Potential Test System I (AMPTS I), a revolutionary product in the area of on-site laboratory equipment for methane potential analysis. In April 2011 an update version of the AMPTS was made commercially available. The newer version of the instrument, AMPTS II, is a well-engineered analytical device developed for on-line measurements of ultra-low bio-methane flows produced from the anaerobic digestion of biological degradable substrates. The number of users of the AMPTS II grew quickly and today there are users in more than 60 countries, located in the Americas, EMEA and Asia Pacific regions. Taking into consideration the high number of systems already sold around the world and the high number of publications based on data generated by our product, it is clear that AMPTS has become the technology of choice for universities, private laboratories and biogas operators interested in efficiently determining the true methane potential of different substrates.

In 2016, the AMPTS II Light was launched. It has the same software as the AMPTS II, but a different number and size of the test vessels. In 2021 AMPTS in a new configuration and new versions of Gas Endeavour, Bioreactor Simulator and Smart Agitation Mixing Systems were launched. Gas volume measurement cells were upgraded, new software and hardware were developed, for better user experience changes in user interface were introduced.

The Standard Agitation System offers its users long-life operation and easy maintenance. The design allows user to replace parts within seconds. An innovative motor fixing system was developed in order to offer customers quick and easy system assembly on most GL 45 bottles. It is compatible with all of our systems (AMPTS, Gas Endeavour, Bioreactor Simulator), delivering compatibility and outstanding mixing efficiency for most GL 45 bottles.

Smart Agitation System was designed to work solely without AMPTS, Gas Endeavour or Bioreactor Simulator. The user can control Smart Agitation System with the control panel stationed on the system.

2 Quality rules and recommendations

- The product warranty provided corresponds to the warranty stipulated on the confirmed product order form and shipping documentation.
- Only the parts delivered with the product can be used with the system in order to guarantee the quality and performance of the product.
- BPC reserves the right to correct any possible text and image errors as well as changes to technical data in this manual.

2.1 Warranty

- Both Standard and Smart Agitation Systems are covered with one-year warranty. The warranty starts when the equipment is shipped from the production facility.
- If the repair or adjustment is required within the warranty period, and it is not the result of mishandling the equipment, BPC will either correct the non-conforming condition or replace any non-conforming goods or materials.
- BPC will also repair or adjust any product that is beyond the warranty period for a nominal fee.
- If the problem with the equipment occurs, you should not try to open or fix the equipment yourself before contacting BPCs customer support.

2.2 Before getting started

- If using any full system from BPC: Read this manual together with the manual for the instrument that is used with the motors before installing and using the equipment (see AMPTS, Bioreactor Simulator (BRS) or Gas Endeavour (GE) user manuals).
- Keep this instruction manual for future reference and make sure it is easily available for people who regularly use the Agitation System.

3 Safety notes and considerations

- The power adapter for the Agitation System **must never be** used in the of the AMPTS, Bioreactor Simulator or Gas Endeavour, or in any other device as it might cause instrument failure or danger to a user.
- Always be cautious when handling electrical devices close to water.
- When the motor is running, its rotating parts could potentially cause damage. Make sure to remove any loose clothing objects like scarves and tie back your hair if it is long.

4 Difference between Standard Agitation System and Smart Agitation System

The **Standard Agitation System** was designed to be used with one of our main systems (AMPTS, Gas Endeavour and Bioreactor Simulator), meaning that the operator of the main equipment can control the motors directly through the software of the main system units.

The **Smart Agitation System** was designed to be used for any other mixing applications. It can be used without any other instrument, the main control panel can be found on the Motor Control Unit (See section 6.2), and motors can be controlled directly by the user, without any additional equipment.

Both Smart and Standard Agitation System features:

- User friendly setup – simple mounting on a GL 45 bottle without using a stand
- Availability of gas-tight conditions
- Modular design for easy cleaning and maintenance
- Strong and reliable agitation with minimal risk of irregular rotation
- Reversal of motor direction (clockwise [CW]/counter-clockwise [CCW])
- Remote speed control on a range up to 200 RPM

5 Delivery checks

At the delivery, unpack and check that the contents match the list of components in the sections 5.1 or 5.2 below.

If the packaging or the equipment is broken at delivery, please:

1. Document and take photos of the parts and packaging.
2. Inform the transport company at the time of delivery.
3. Make sure that the transport company documents the incident.
4. Inform local distributors or BPC of the incident.

5.1 Standard Agitation System

When the agitation systems are delivered as part of an instrument from BPC Instruments AB (i.e., as a part of the AMPTS II, BioReactor Simulator or Gas Endeavour) the quantities may vary, and the box may also contain items that do not belong to the agitation system.

5.1.1 Brushless DC Motor Kit 6

- 6 x Brushless DC motor
- 6 x Bottle Nut GL 45
- 1 x Motor Controller Power Adapter
- 1 x Motor Controller
- 1 x Motor Controller signal cable
- 5 x Brushless DC Motor Cable (250 mm)
- 1 x Brushless DC Motor Cable (1500 mm)
- 6 x Axis Coupling for Brushless DC Motor

5.1.2 Brushless DC Motor Kit 15

- 15 x Brushless DC motor
- 15 x Bottle Nut GL 45
- 1 x Motor Controller Power Adapter
- 1 x Motor Controller
- 1 x Motor Controller signal cable
- 15 x Brushless DC Motor Cable (200 mm)
- 1 x Brushless DC Motor Cable (1500 mm)
- 1 x Brushless DC Motor Power Splitter
- 15 x Axis Coupling for Brushless DC Motor

The picture of main components in the “Brushless DC motor kit 15” is shown below.

*Photo for illustrative purposes. The actual content might vary depending on the package.

5.2 Smart Agitation System

5.2.1 Agitation package GL 45 Kit Start

- 1 x Brushless DC motor
- 1 x Bottle Nut GL 45
- 1 x Motor Controller Power Adapter
- 1 x Motor Controller
- 1 x Brushless DC Motor Cable (1500 mm)
- 1 x Axis Coupling for Brushless DC Motor
- 1 x Stirrer GL 45 x mL, where X = 100, 250, 500, 1000, 2000 or 5000 ml

5.2.2 Agitation package GL 45 Kit 3

- 3 x Brushless DC motor
- 3 x Bottle Nut GL 45
- 1 x Motor Controller Power Adapter
- 1 x Motor Controller
- 2 x Brushless DC Motor Cable (250 mm)
- 1 x Brushless DC Motor Cable (1500 mm)
- 3 x Axis Coupling for Brushless DC Motor
- 3 x Stirrers GL 45 X mL, where X = 100, 250, 500, 1000, 2000 or 5000 ml

5.2.3 Agitation package GL 45 Kit 6

- 6 x Brushless DC motor
- 6 x Bottle Nut GL 45
- 1 x Motor Controller Power Adapter
- 1 x Motor Controller
- 5 x Brushless DC Motor Cable (250 mm)
- 1 x Brushless DC Motor Cable (1500 mm)
- 6 x Axis Coupling for Brushless DC Motor
- 6 x Stirrers GL 45 x mL, where X = 100, 250, 500, 1000, 2000 or 5000 ml

5.2.4 Agitation package GL 45 Kit 15

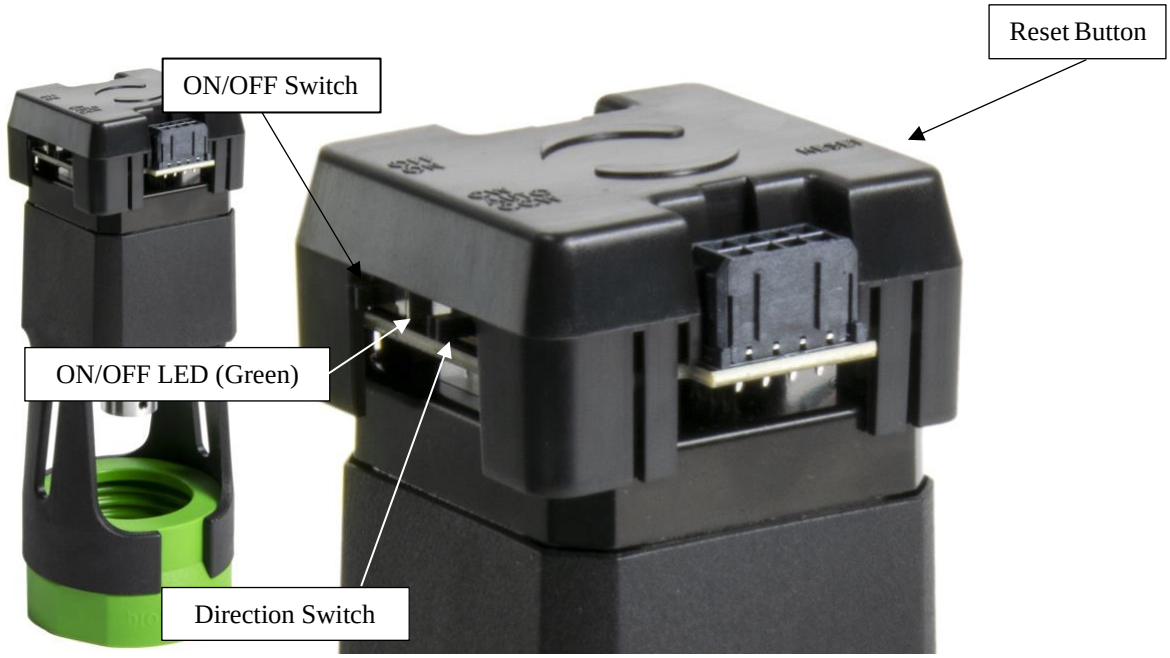
- 15 x Brushless DC motor
- 15 x Bottle Nut GL 45
- 1 x Motor Controller Power Adapter
- 1 x Motor Controller
- 15 x Brushless DC Motor Cable (200 mm)
- 1 x Brushless DC Motor Cable (1500 mm)
- 1 x Brushless DC Motor Power Splitter
- 15 x Axis Coupling for Brushless DC Motor
- 15 x Stirrers GL 45 x mL, where X = 100, 250, 500, 1000, 2000 or 5000 ml

6 Equipment description

6.1 Introduction to the Brushless DC Motor

The agitation system is a unique design from BPC Instruments AB (former Bioprocess Control AB). The main features of the Brushless DC Motors and their components are presented below:

Each Brushless DC Motor has its own driver board, which controls and supplies power to the actual motor. The switches are explained below.



Brushless DC Motor ON/OFF Switch

The ON/OFF switch is located on the side of the motor and marked on the very top of the Brushless DC Motor, just above where the actual switch is located. When a mixer is active and power is supplied, the LED next to the ON/OFF switch will shine green.

It is recommended to set the switch on each Brushless DC Motor to the OFF position before connecting or disconnecting the Motor Controller or any of the motor cables.

Direction Switch

The DIRECTION switch is located on the side of the motor and marked on the very top of the Brushless DC Motor, just above where the actual switch is located. It is used to set the motor to rotate in a clockwise or a counter-clockwise direction. Setting the switch to AUTO gives the Motor Controller control over the reversal of the direction. In the table (See section 6.2 "Mixing direction and intensity") all variations in the control of Brushless DC Motor and Motor Control Unit are explained in detail.

Reset Button

If an error is encountered somewhere on the Brushless DC Motor driver board, a red LED will light up on the side of the Brushless DC Motor, opposite to where the switches are located. A marking on the top of the Brushless DC Motor shows where to find it (see picture in section 6.1 above).

The problems could be, e.g. high temperature, a disconnected motor cable or power loss. If this happens, the mixer can be reset with a quick press on the RESET button. The RESET button is marked on the very top of the Brushless DC Motor, just above the actual button. It can be reached by using a pen or other pointy object. If the mixer was reset successfully, the red LED will turn off.

6.2 Introduction to the Motor Control Unit

6.2.1 Motor Controller Standard Agitation

The Motor Controller Unit provides power to the motors via the motor cables, and **it is very important that the Motor Controller Unit is always turned off and is unplugged from the power source when any cables are connected or disconnected from the motors.** Turning the switch to the OFF is not enough.

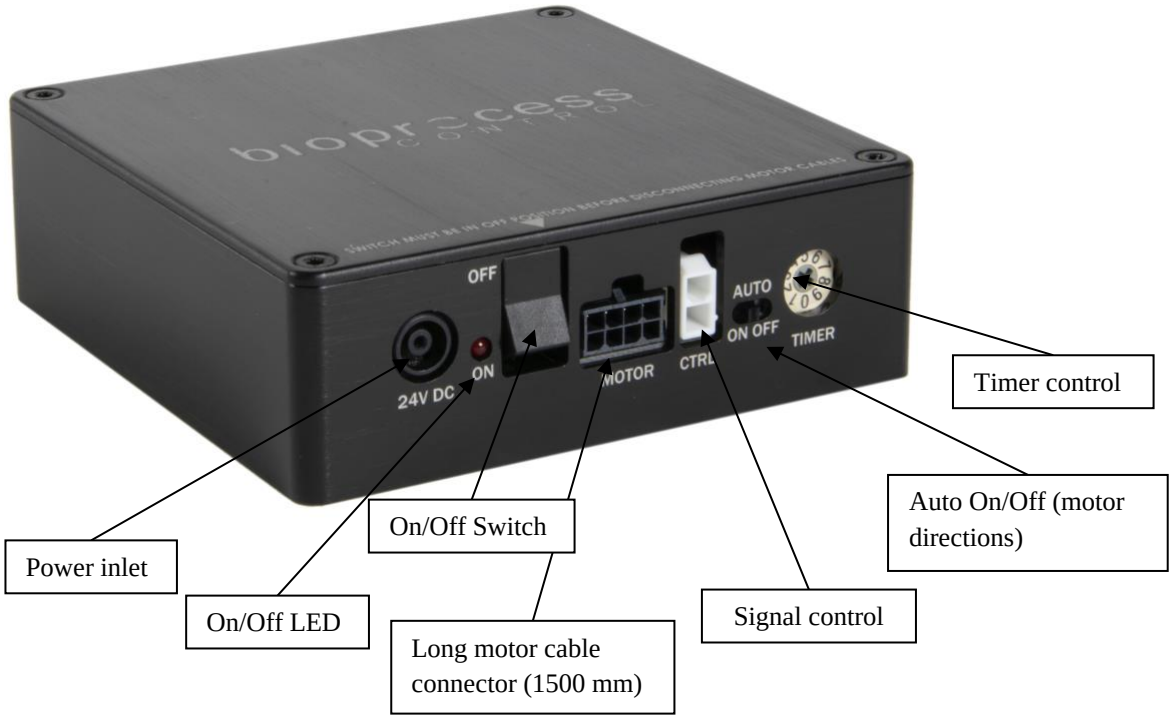
The Motor Controller Unit is the hub of the agitation system. It interprets the speed signal sent from the Gas Volume Measuring Device and controls the direction of the motors. All the Brushless DC Motors receive the same information from the Motor Controller Unit.

6.2.2 Motor Controller Smart Agitation

The Motor Controller Unit provides power to the motors via the motor cables, and **it is very important that the Motor Controller Unit is always turned off and is unplugged from the power source when any cables are connected or disconnected from the Brushless DC Motors.** Turning the switch to the OFF position is not enough.

The Motor Controller Unit is the hub of the agitation system. It provides the speed and direction control for the Brushless DC Motors. All the Brushless DC Motors receive the same information from the Motor Controller Unit.

The picture below shows the control panel on the back side of the Motor Controller Unit (**the appearance is the same in both the Standard Agitation and in the Smart Agitation systems).**



The **ON/OFF switch** (shown in the picture above) controls the power of the Motor Controller. When the switch is ON, the red LED will be lit in order to indicate that the system is active. It is required to set the switch to OFF before connecting / disconnecting the Motor Controller to / from the power mains.

When the **AUTO switch** on Motor Controller Unit is set to OFF, the Brushless DC Motors will be operated in continuous rotation mode, i.e. the Brushless DC Motors will always rotate in the same direction. Setting the switch to ON will activate the AUTO reversing mode, which

will make the Motor Controller Unit change the Brushless DC Motors directions at regular intervals.

For the auto reversing mode to work as intended, the DIRECTION switch on each motor needs to be in the AUTO (middle) position. If the switch is set to either the CW or CCW position, the mixer will start and stop but never change direction. See section Mixing Direction and Intensity (further in this section) for further explanation of the different combinations of settings on the Motor Controller Unit and the Brushless DC Motors.

Timer control on the Motor Controller Unit (Standard Agitation)

The rotary Timer switch can be used to set the time that should elapse before the direction is changed. 10 positions are available ranging between 5 s to 1 h (valid for motor unit Switch in AUTO position).

Timer switch position	Time
0	5 s
1	15 s
2	30 s
3	45 s
4	60 s (1 min)
5	120 s (2 min)
6	300 s (5 min)
7	600 s (10 min)
8	1800 s (30 min)
9	3600 s (60 min)

Timer control on the Motor Controller Unit (Smart Agitation)

When the **AUTO switch** on Motor Controller Unit is set to **OFF mode**, the rotary timer switch is used to control the speed of the motors (where 0 - slowest speed, 9 - highest speed).

Speed switch position	RPM
0	20
1	40
2	60
3	80
4	100
5	120
6	140
7	160
8	180
9	200

Motor Controller Signal Cable (only used in Standard Agitation)

The Motor Controller Unit receives speed information for the Brushless DC Motors through an analogue signal cable (pictured below).

Brushless DC Motor Cable

The signal and required power from the Motor Controller Unit are distributed to each Brushless DC Motor through the motor cables (see picture below). They should be connected serially and are fastened to the Brushless DC Motors with the help of latches. The 1.5 m cable is used to connect the output of the Motor Controller Unit with the first Brushless DC Motor. Motor cables come in different lengths (check section 5 for more accurate information).

Mixing Direction and Intensity

The motors can be operated at different speeds ranging from 10-200 RPM. The speed is adjusted linearly between 10 and 200 RPM, referred to as per cent (5 – 100%) (In Standard Agitation). At a DC-signal of 0 (zero) V, the motor is motionless, and at 12 V it is rotating at top speed (200 RPM). An acceleration /deceleration ramp is built into the system to provide a smooth transition between different speeds.

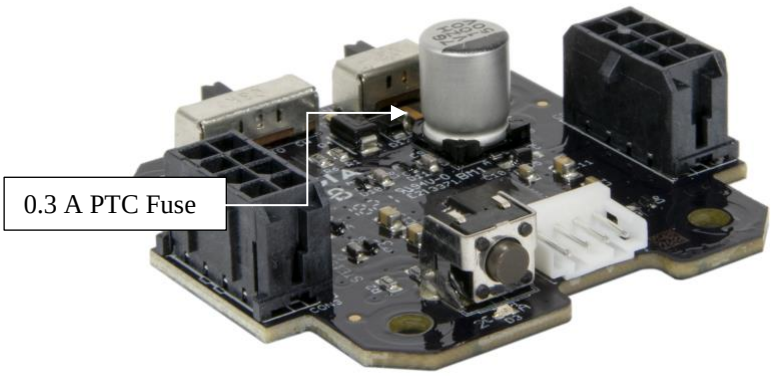
In the tables, presented in the next page, the main differences in controlling both Smart and Standard Agitation Systems are shown.

Standard Agitation V2.3		
MCU Auto mode	**Motor**	**Action**
On	**CW**	Turns CCW, stops every set amount of seconds and keeps turning CCW
	CCW	Turns CW, stops every set amount of seconds and keeps turning CW
	Auto	Switches spinning direction
Off	**CW**	Turns CCW all the time
	CCW	Turns CW all the time
	Auto	Turns CW only (it can turn CCW only if the MCU Auto was set from ON to OFF while the motor was spinning CCW, but after restarting the system (power OFF/ON) motor start turning CW again)

Smart Agitation V2.4			
MCU Auto mode	**Motor**	**Action**	When the MCU auto is set to ON the Timer Switch works to change the rotation direction, the external speed control (voltage up to 12 V) can be used to adjust the mixing speed
On	**CW**	Turns CCW, stops every set amount of seconds and keeps turning CCW	
	CCW	Turns CW, stops every set amount of seconds and keeps turning CW	
	Auto	Switches spinning direction	
Off	**CW**	Turns CCW all the time	When the MCU auto is set to OFF the external speed control doesnt work, then one can control the speed with the timer (where 1 - slowest speed, 9 - highest speed)
	CCW	Turns CW all the time	
	Auto	Turns CW only (it can turn CCW only if the MCU Auto was set from ON to OFF while the motor was spinning CCW, but after restarting the system (power OFF/ON) motor start turning CW again)	

Fuse

There is a PTC resettable fuse inside the Motor Controller Unit. It's rated 3 A. This fuse is resettable, meaning it will start working again if the system is turned off for a while and the error is resolved (the fuse is triggered by high temperature which can be caused by short-circuiting or applying more voltage than rated). This is the main fuse and shared by the entire system and all 15 motors. Each Brushless DC Motor driver board is also equipped with their own resettable PTC fuse rated at 0.3 A. This will trigger if there is a problem with any of the individual driver boards. The fuse of the Brushless DC Motor driver board is presented below:



Motor Controller Power Adapter

The Motor Controller is powered by a 24 V / DC 2.71 A power adapter. The power is then distributed from the Motor Controller, through the 8-pin cables, to each Brushless DC Motor.

WARNING: The power supply always has to be disconnected from the Motor Controller before removing or connecting any of the cables from the motors.

7 Equipment assembly

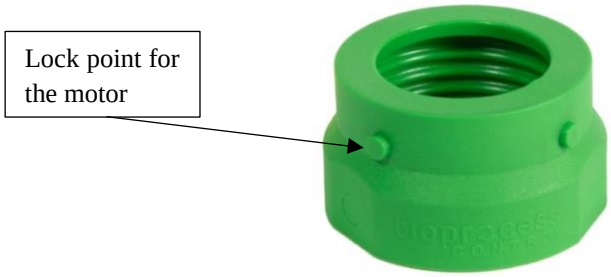
Figures below will explain how the Agitation System has to be assembled and operated. Please follow these steps carefully and assemble the equipment according to this manual. Sections 7.1 and 7.2 are the same for Standard Agitation as well as for Smart Agitation Systems.

7.1 Motor-driven agitators

1) Firstly, the Stirrer has to be inserted in the GL 45 bottle. When the stirrer will be inside the bottle press the grey plastic cap inside the bottle to make it tight. The picture below shows how does the stirrer looks like:

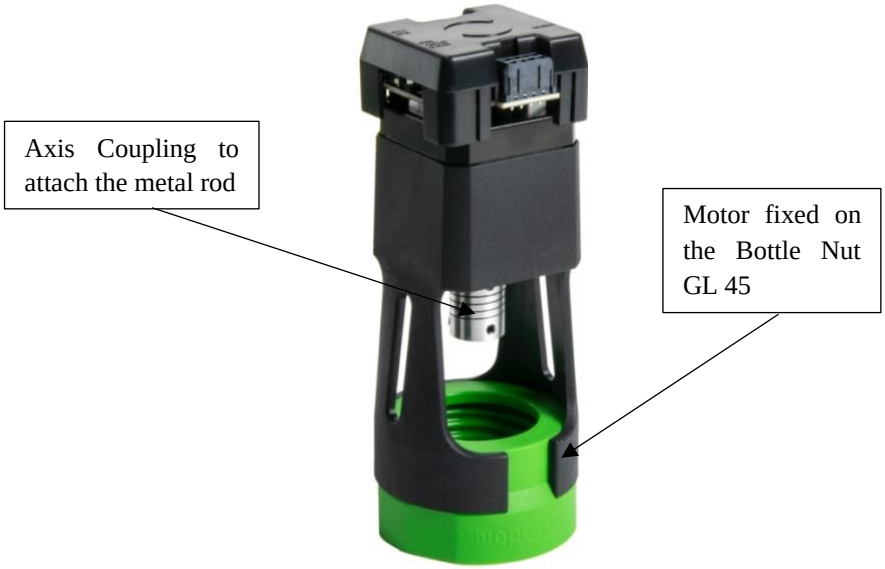
The metal rod has two bending points, they divide the bending rod into 3 parts (one short end, one long end and the middle part). The shorter end should always go inside the rubber part of the stirrer, the longer part should be directed towards the Axis coupling.

2) Attach (screw on) Bottle Nut GL 45 on the GL 45 bottle (remember, the stirrer should be inside of the bottle already). The Bottle Nut GL 45 will tighten the grey plastic lid on the bottle and prevent any gas leakage. It will be also used to fix the Brushless DC Motor on. The Bottle Nut GL 45 is presented below:



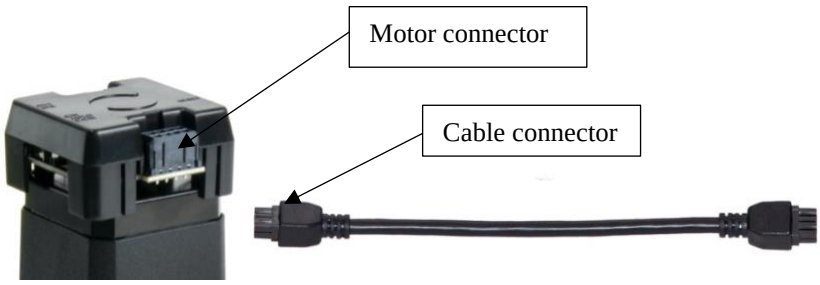
3) Once the Bottle Nut GL 45 is attached on the GL 45 bottle it is time to place on the Brushless DC Motors. Putting on the motor on the Bottle Nut GL 45 is easy, find the position where “lock points (check step 2)” can enter the plastic railway and gently rotate the motor to fix it on the Bottle Nut GL 45. You have to make sure that the metal rod (check step 1) will be inside of the Axis Coupling of the motor. When inserting metal rod make sure it is mounted in the right height so that the rubber part of the stirrer

will not get damaged. When everything is in place tighten the screws of the Axis Coupling and try to rotate the stirrer by rotating the Axis Coupling by hand, if there is a strong resistance do not start the motor, check if everything is connected properly. In the picture below the motor with the Bottle Nut GL 45 will be shown:



7.2 Connecting the motors together

1) Firstly, make sure Motor Controller Unit is disconnected from the power supply socket. Secondly make sure ON/OFF button on the Motor Controller is set to OFF (check picture in section 6.2). The motors can be connected together using "Brushless DC Motor Cable 250 mm" cables. The cable can be fitted only in one way and is equipped with latch, so before connecting it make sure the cable is facing the correct way. The cable and the connector of the motor is presented below:



2) Using short "Brushless DC Motor Cable 250 mm" cables connect all motors together. I.e. Motor 1 should be connected to Motor 2, Motor 2 to Motor 3 and so on. There must be one empty Motor connector in the first motor and in the last motor.

7.3 Connecting power supply and signal cable (Standard Agitation)

1) Connect “Brushless DC Motor Cable 1500 mm” to the first motor and to the Motor Controller “Motor cable connector” port (check picture in section 6.2).

2) Connect “Motor Controller Signal Cable” to the Gas Volume Measurement Device and to the Motor Controller “Signal control (top) / Ground (bottom)” (check picture in section 6.2).

3) Connect “Motor Controller Power Adapter” to the Motor Controller “Power inlet” port first and then to the power outlet socket (100 – 240 V) (check picture in section 6.2).

4) Set the switches on each Brushless DC Motor to ON (check section 6.1).

5) Turn on Motor Controller power supply by setting ON/OFF button on the Motor Controller to ON (check picture in section 6.2).

6) The motors can be controlled directly through the Gas Volume Measurement Device software using computer with Windows or MAC operating systems (check the user manual for Gas Endeavour, AMPTS or BRS).

7.4 Connecting power supply (Smart Agitation)

1) Connect “Brushless DC Motor Cable 1500 mm” to the first motor and to the Motor Controller “Motor cable connector” port (check picture in section 6.2).

2) Connect “Motor Controller Power Adapter” to the Motor Controller “Power inlet” port first and then to the power outlet socket (100 – 240 V) (check picture in section 6.2).

3) Set the switches on each Brushless DC Motor to ON (check section 6.1).

4) Turn on Motor Controller power supply by setting ON/OFF button on the Motor Controller to ON (check picture in section 6.2).

5) The motors can be controlled directly through the Motor Controller Unit (Timer control and Auto On/Off (motor directions)), (check section 6.2).

8 Technical characteristics

Motor type	Brushless 2-phase Stepper DC Motor with direct drive
Maximum current level	2 A
Maximum power output	48 W
Minimum speed	10 RPM at 5% (0.5 V)
Maximum speed	200 RPM at 100% (12V)
Motor Fuse	0.3 A PTC resettable
Motor Controller fuse	3 A PTC resettable
Power adapter for the Motor Controller	Input 100-240 V 50/60 Hz 2A Output 24 VDC / 2.71 A

9 End of Operation

9.1 Standard Agitation System

To stop the motors when the experiment has reached its end, and the data logging is stopped from the software, disconnect the motors according to the following steps:

1) Turn off the motors from the software interface (refer to the software section in the manual for those instruments).
2) Set the switches on each Brushless DC Motor to OFF
3) Set the System switch on the Motor Controller to OFF
4) Unplug the Motor Controller power adapter from the power source.
5) Unplug the power adapter from the Detection Unit.
6) Remove the signal cable from the Motor Controller and the Detection Unit.
7) Remove the long motor cable between the Motor Controller and the first motor.
8) Remove the cables between the motors.
9) Unscrew the screws on each helical coupling.
10) Remove the Brushless DC Motors.
11) Remove the Bottle Nut GL 45 and Lid GL 45 with twin Connectors.

9.2 Smart Agitation System

1) Set the ON/OFF switch on the Motor Controller to OFF
2) Set the switches on each Brushless DC Motor to OFF
3) Unplug the Motor Controller Power Adapter from the power source.
4) Remove the long motor cable between the Motor Controller and the first motor.
5) Remove the short cables between the motors.
6) Unscrew the screws on each helical coupling.
7) Remove the Brushless DC Motors from the glass bottles.
8) Remove the Bottle Nut GL 45 and Lid GL 45 with twin Connectors.

10 Equipment disposal

Please dispose of your agitation equipment according to your local waste and recycling regulations for electromechanical devices (regarding the motor). Keep in mind that it could be your responsibility to decontaminate the equipment from any biological and chemical contamination, to protect from health hazards during recycling of the equipment.

By doing this, you will help to conserve natural and environmental resources and you will ensure that your equipment is recycled in a manner that protects human health. Thank you!