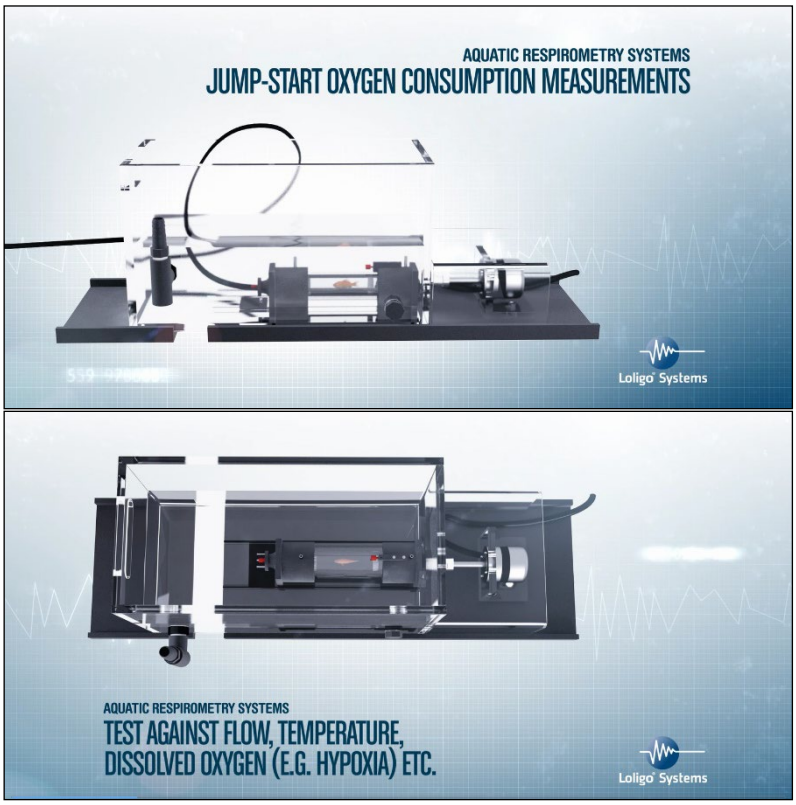
Loligo® Systems

Swim Tunnels



User Manual

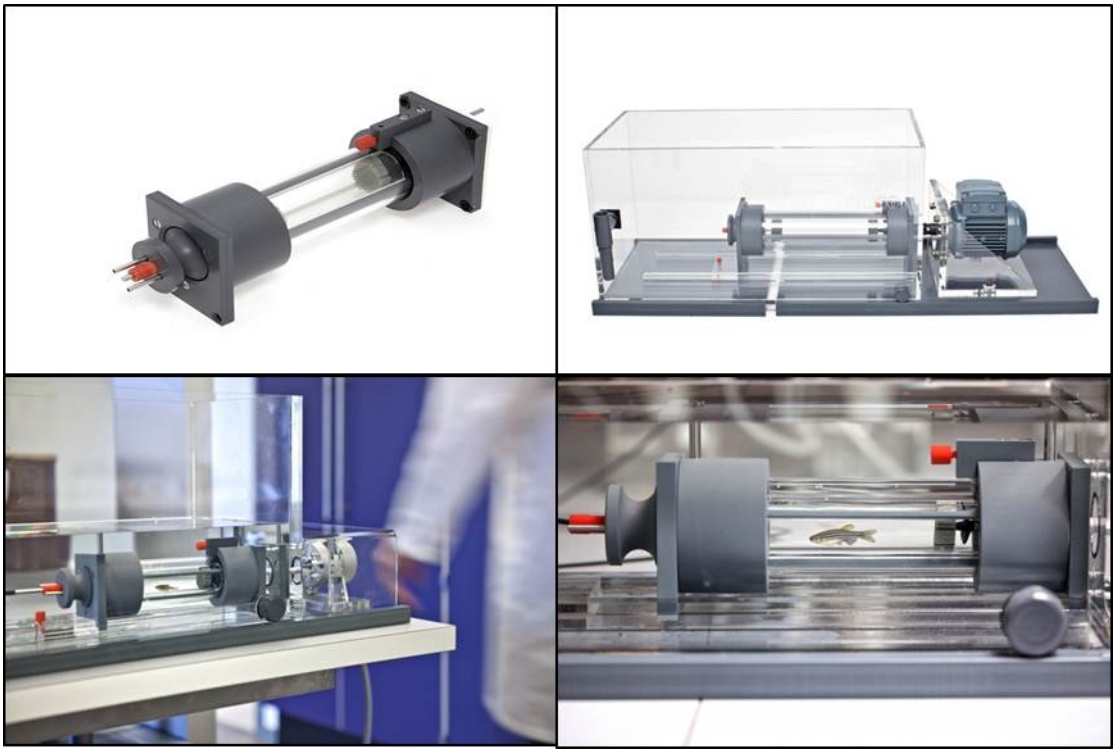
Contents

1. General background

1.1. Mini swim tunnels

The Loligo® Systems miniature swim tunnel respirometers are made in a modified Blazka-type design making them ideally suited for swim trials and active metabolic rate measurements in larvae, juveniles, or tiny adult fish like Zebra fish.

Applications span exercise physiology, oxygen consumption measurements, biomechanics, kinematics, flow visualization, public display of swimming and swim behavior analysis.



Features:

- Modified Blazka-type design with ports for oxygen consumption measurements
- No heating of water during operation - the swim respirometer comes submerged in a buffer tank
- Glass materials for convenient observation and no O_2 uptake/release
- Tool-free assembly for easy cleaning and handling of animals
- Speed control with analog output
- Strong DC brushless motor for high speeds and long-term operation
- Optional replacement glass tubes for changing the length of the test section

NB Flow measurement equipment is not included, we recommend using the DPTV system or dye technique.

1.2. Large swim tunnels

The Loligo® Systems swim tunnel respirometers have been developed for measuring the physiology, energetics, behavior, biomechanics, and kinematics of swimming fish, through years of research and laboratory use.

Applications also include studies of fluids, visualization of flow around objects, hydraulics, and public display of aquatic wildlife.

The unique and compact design allows adequate space for movements and at the same time a minimum footprint and a low volume required for reliable oxygen consumption measurements.

The planar walls and lid made of clear Plexiglas makes for excellent observations from above and from the side. All other components are made of non-corrosive materials (PVC and stainless steel).

The swim tunnels are unpressurized, and a lid-in-a-lid design permits excellent access to the test section during operation. The external motor and surrounding water bath allow for accurate and rapid water temperature control.

Features:

- Anti-corrosive materials for minimum maintenance
- Tool free assembly for easy cleaning and transportation
- Double lid for easy instrumentation and handling of animals
- Adjustable vanes for modifying flow profile in test section
- Speed control with analog in- and output
- Re-usable wooden crate for transportation
- Ports for oxygen and temperature probes

For help on using swim tunnel respirometers, refer to instructional videos that can be found on our website:

www.loligosystems.com

2. Mini swim tunnels (170 mL and 1.5 L)

2.1. List of parts

- ✓ Mini swim tunnel
- ✓ Ambient tank (temperature bath) with plastic fittings
- ✓ Submersible flush pump
- ✓ Brushless DC motor
- ✓ Motor + speed control instrument w/analog output
- ✓ box and power cord
- ✓ Maintenance kit
- ✓ Fittings and tubes
- ✓ User manual

2.2. Installation and set-up

The mini swim tunnel comes fully assembled.

Please **do not** try to disassemble or run the swim tunnel while dry – it should be immersed in water.

Place the ambient tank with the swim tunnel and motor on a firm and level surface.

Remove any protective film from the tank walls.

Connect the motor cable to the control box, and secure by using the connector clamp.

Finally connect the control box to a grounded 100-240V outlet using the power cord.

Make sure to fill the ambient tank and swim tunnel with water before running it.

To avoid trapping air bubbles inside, disassemble the swim tunnel and piece it together again piece by piece, making sure to remove all air bubbles from each piece before putting it into place.

Assembly procedure

1. Start with the propeller end cap mounted to the ambient tank wall as shipped (ambient tank not shown on pictures).

2. Then push the outer glass tube into the end cap.

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3. Insert the inner glass tube into the outer one. The honeycomb section should end up right next to the propeller.

4. Then push the other end cap over the end of the outer tube. The two screws in the mounting bracket at the floor of the ambient tank should fit the lower holes in the end cap.

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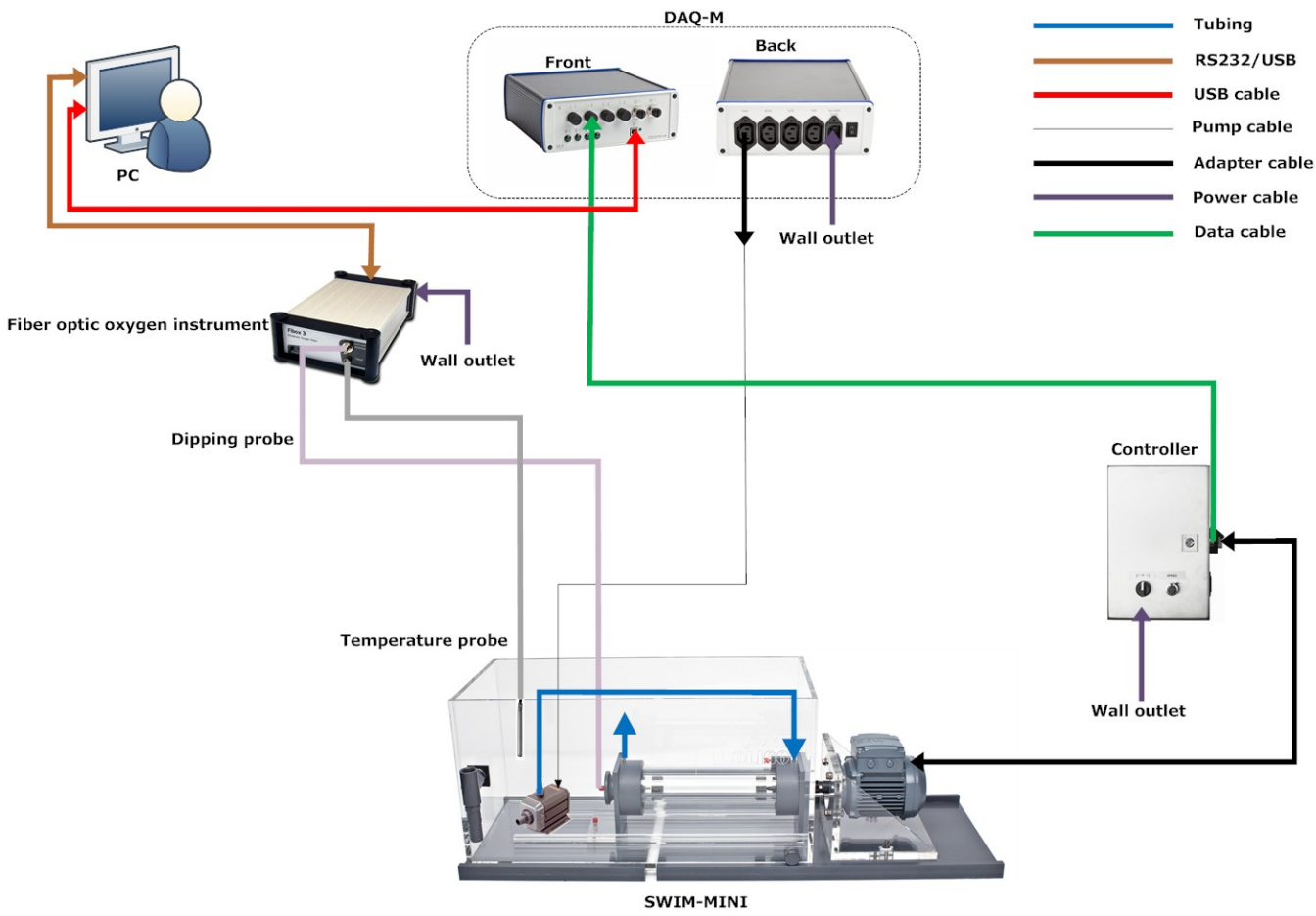
5. Finally push the stopper into place.

Please see below for a diagram depicting full set-up of mini-swim tunnel with fiber optic instrument and sensor (supplied separately).



2.3. Operation

Before running the motor make sure that the swim tunnel is immersed in water.

Make sure that the potmeter knob is turned to zero. Then turn the knob for flow direction from zero and to the left or right, and slowly turn up the potmeter to start running the motor.

DO NOT change the direction of flow is the potmeter is not turned to zero, since this may harm the motor and electronics!

Noise or vibrations during operation, might be caused by misalignment of the propeller shaft and motor shaft. Make sure that the foundation is level and firm or try to change motor position to get proper alignment of the two flexible coupling parts connecting the motor and propeller shafts. Use the Allen wrench to loosen the flexible coupling parts if necessary.

2.4. Flush pump

Avoid oxygen depletion and metabolites building up due to animal respiration, by flushing the swim respirometer with ambient water intermittently. Pumping a volume equivalent to 5 times that of the respirometer during each flushing event will secure a 99% wash-out.

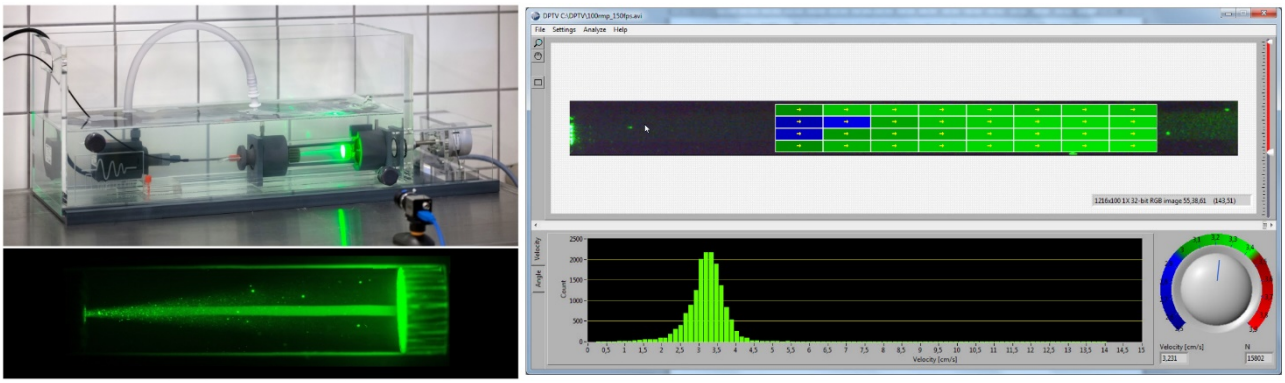
2.5. Volume calibration

For respirometric measurements, it is important to determine the exact volume of the swim tunnel respirometer. This can be done by filling the swim tunnel respirometer completely (do not fill any water in the ambient tank) with plugged outlet/inlet fittings. Make sure to get rid of all air bubbles and then pour the water into a measuring beaker.

Or alternatively, weigh the entire swim tunnel with and without water.

2.6. Flow velocity

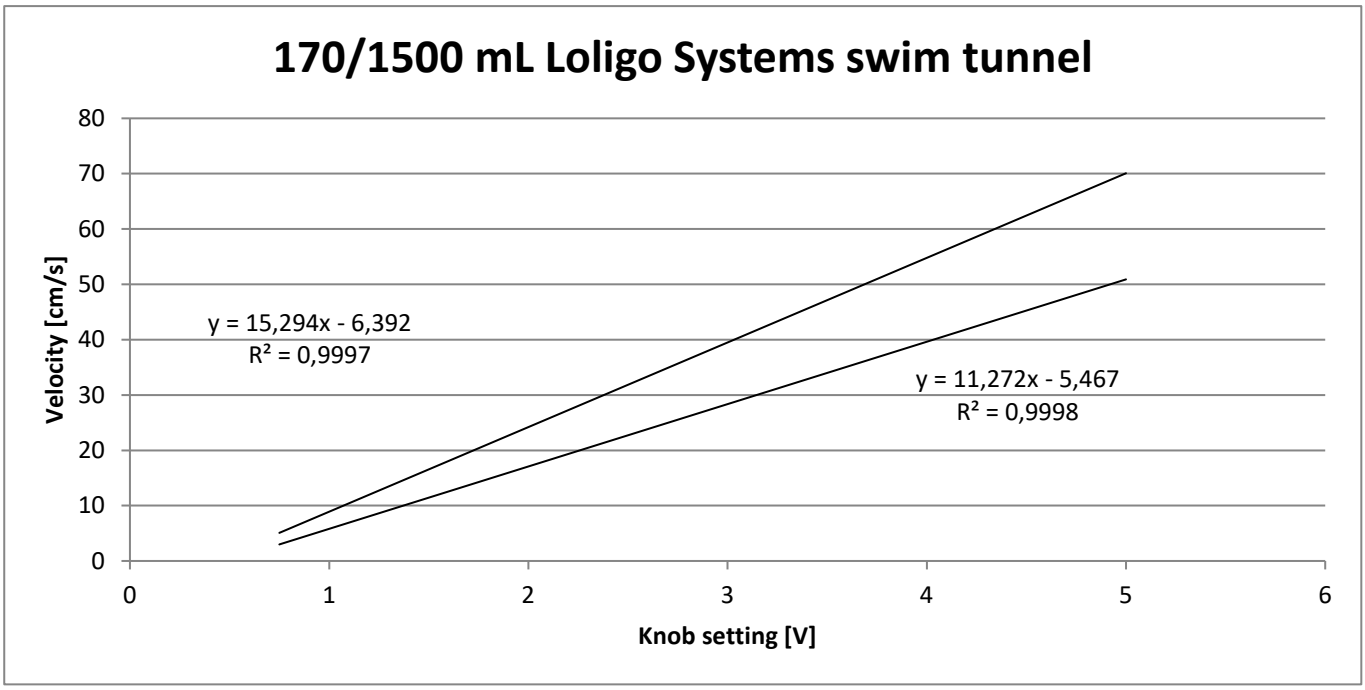
Optional flow measuring equipment is required for flow velocity calibrations. We strongly recommend using the DPTV system, AC10550, from Loligo Systems, please see below.



Alternatively, we recommend using dye technique.

Start flow calibrating the swim respirometer by filling it completely with water and add the green spheres. Set up the camera and turn on the laser. Then record the analog output from the motor frequency converter or the RPM readings on the display as water velocity increase stepwise. For each of 5-10 steps, record a 10 second long AVI file. Run the DPTV software to get the velocity from the AVI files.

In this way a linear relationship between the output (RPM or DC signal) and water velocity can be established. From this relationship, water velocity can be adjusted during experiments without the need for simultaneous flow measurements.



2.7. Maintenance

The mini swim tunnel respirometer is made of non-corroding parts. However, we recommend frequent cleaning (use a mild detergent) and flushing all parts with tap water to avoid problems with corrosion and wear of seals and bearings – especially if using warm full-strength sea water.

IMPORTANT: DO NOT USE ALCOHOL ON ANY ACRYLIC SURFACES – IT WILL CAUSE CRACKS!

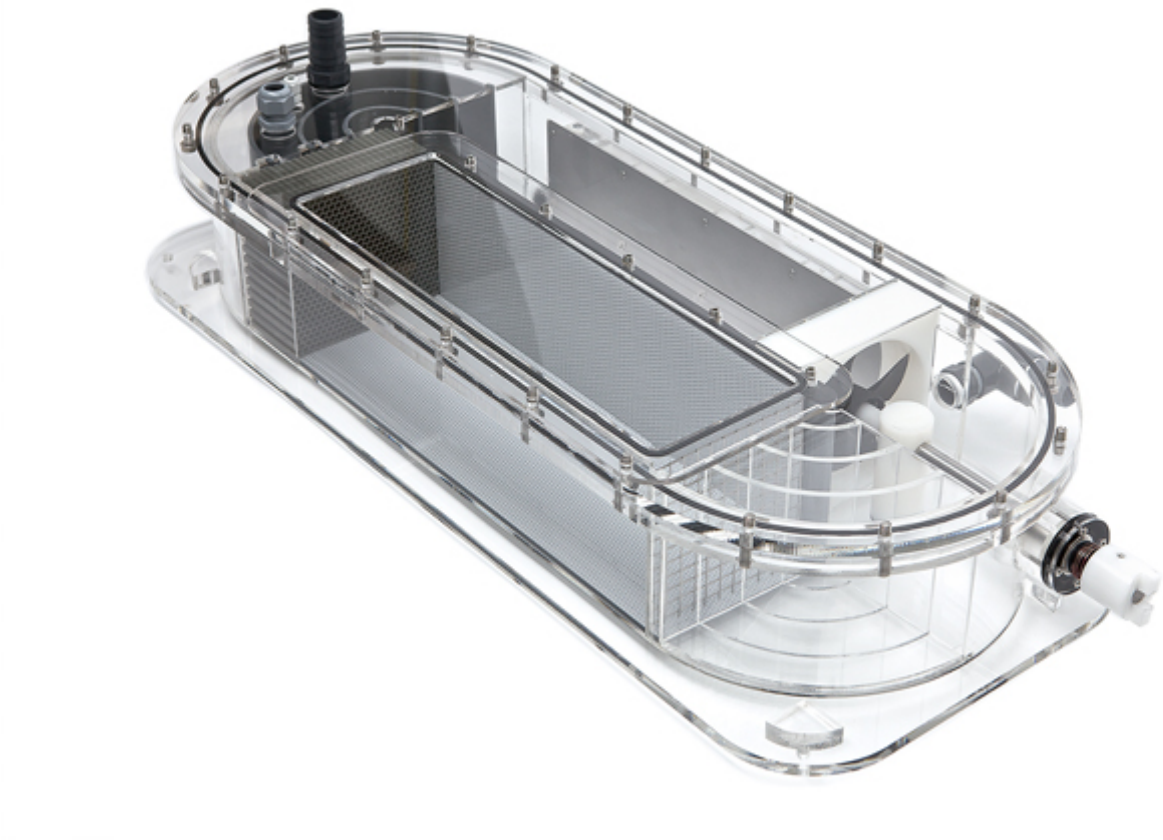
Shaft bearings and packing seals will eventually wear down with use. We therefore recommend an annual check for any backlash due to wearing of bearings and pressure seals. Also check the shaft and the propeller for any damage!

We do of course offer replacement parts, if needed!

3. Large swim tunnels (5-185 L)

3.1. List of parts

- ✓ Large Swim tunnel respirometer
- ✓ Temperature bath (surrounding buffer tank)
- ✓ Submersible flush pump
- ✓ Speed control (frequency converter) with analog output (tacho)
- ✓ Fittings, tubing, tools
- ✓ Maintenance kit (bearings, seals, wing nuts, washers)
- ✓ User manual
- ✓ Wooden crate on a flat pallet



3.2. Installation and set-up

IMPORTANT: DO NOT LIFT THE SWIM TUNNEL using the propeller shaft out of the wooden crate and/or buffer tank, since this may break acrylic parts housing shaft bearings and seals.

Place the buffer tank on top of the two grey PVC bases and on a firm and level surface supporting the weight of the entire set up including water.

Mount the motor on the longer of the two bases, using the acrylic sheets packed with the screws. Make sure that the two shaft coupling parts come together fully aligned.

Connect the motor cable to the speed control box, and secure by using the connector clamp. Finally connect the power cord a grounded wall plug outlet using the power cord.

IMPORTANT: DO NOT RUN THE MOTOR WITHOUT WATER IN THE SYSTEM!

During operation, the buffer and respirometer tank should always be filled with water to above the level of the shaft, bearings, and seals for proper lubrication! The mechanical shaft seals will be destroyed within minutes of operation even at low speeds if running while dry!

3.2.1 Lids

There is one large main respirometer lid and two smaller ones for the test section, e.g.

- *one for measuring oxygen consumptions in a closed respirometer volume*
- *one with a circular insert for a flow probe. The latter is not sealed for oxygen consumption measurements.*

Remember to secure the large main lid with ALL the wing nuts and washers, tightening the nuts in a gradual way. The large hose fitting in the main lid is where water leaves the respirometer while flushing the chamber with the submersible "flush" pump.

At high water velocities the water level might raise and spill due to increased pressure. To avoid this, simply place a piece of stiff tubing on the hose fittings to prevent water from leaving the respirometer during MO_2 measurements. The main lid also has two probe ports, e.g. one for an oxygen probe and one for a temperature probe.

3.2.2 Fittings

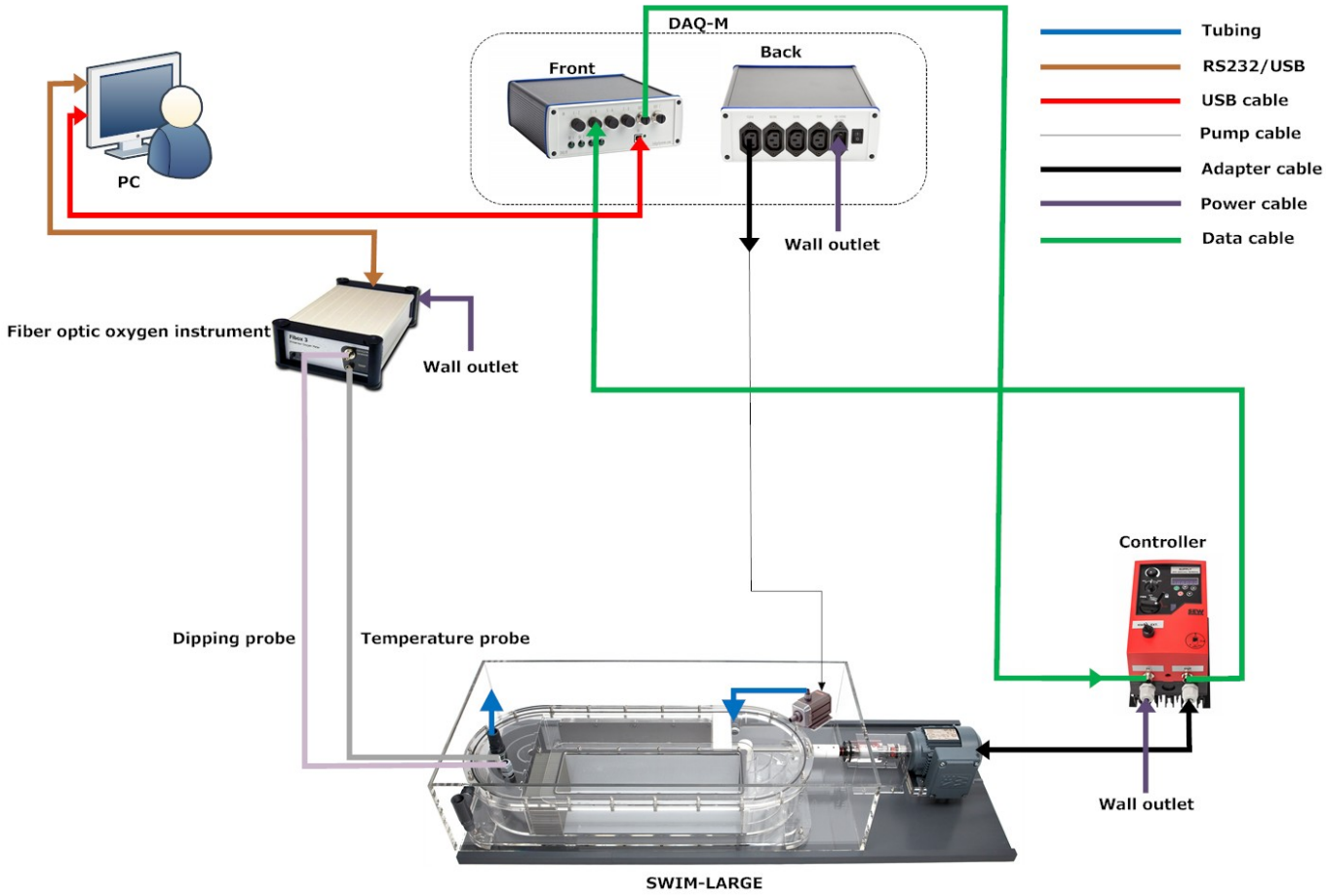
Mount the plastic T-piece and hose fitting on the overflow in the buffer tank, allowing excess water to leave the system. For long-term experiments, we recommend replenishing water by adding a continuous flow of purified system water to the ambient tank, and to connect the overflow hose to a drain.

Alternatively, place a pump sump below the buffer tank and return the water through a flow-through UV sterilizer and a biofilter with activated charcoal using a pump (see example below).

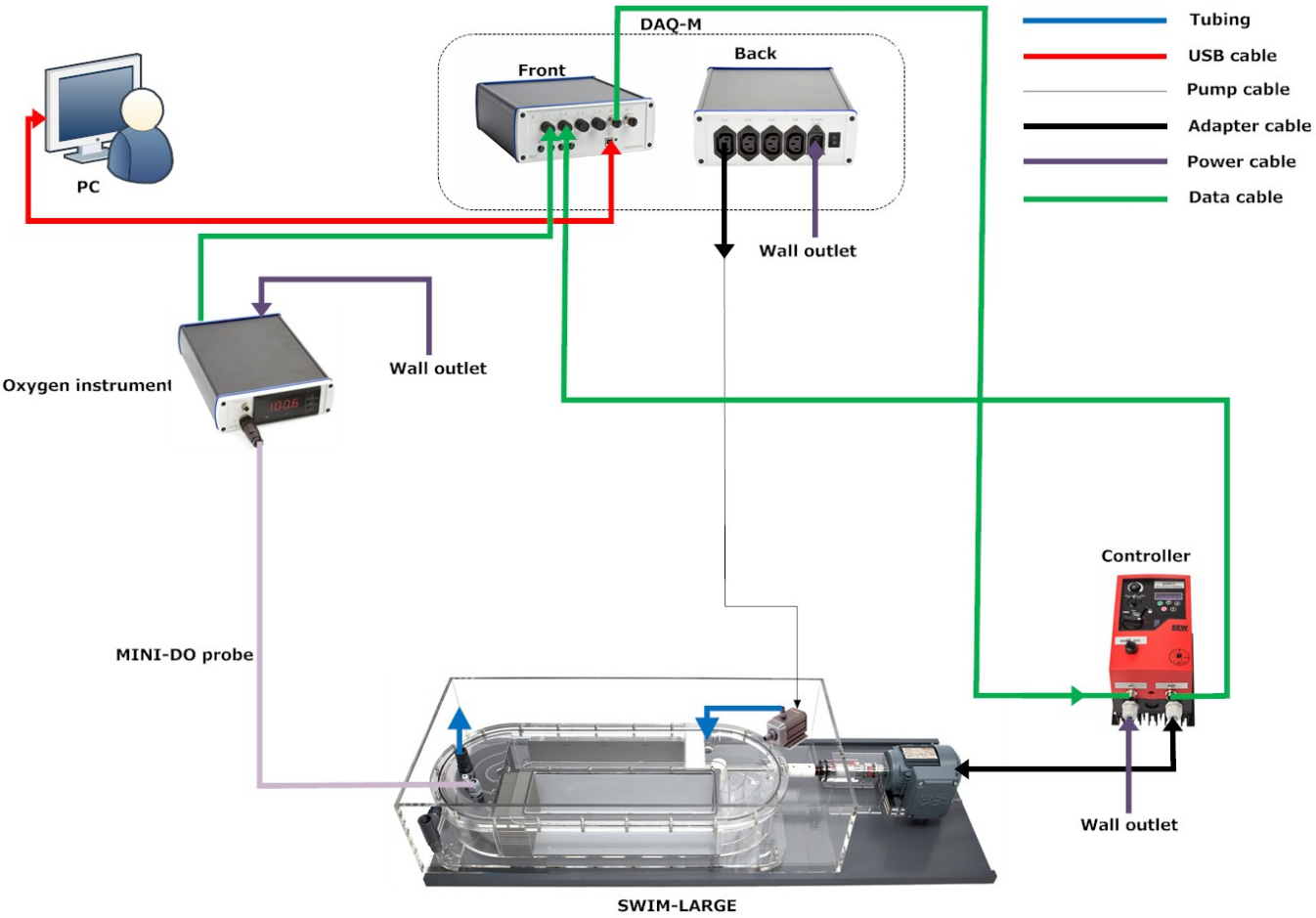
3.2.3 Flush pump

To avoid oxygen depletion and metabolites building up, due to animal respiration inside the closed swim tunnel respirometer, the volume of water should frequently be flushed/replenished. For this purpose, place the submersible flush pump in the buffer tank and connect it with a piece of tubing to the hose fitting near the propeller. The flush pump should always be powerful enough to pump water in and out through the large hose fitting in the main lid!

Please see below for a diagram depicting full set-up of large swim tunnel with fiber optic instrument and sensor (supplied separately).



Please see below for a diagram depicting full set-up of large swim tunnel with OXY-REG instrument and galvanic electrode (supplied separately).


DAQ-M
Front
Back
PC
Wall outlet
Tubing
USB cable
Pump cable
Adapter cable
Power cable
Data cable
Oxygen instrument
Wall outlet
Controller
MINI-DO probe
Wall outlet
SWIM-LARGE

3.3. Frequency converter

3.3.1 Operation

Turn the main switch clockwise to power the motor – this requires some force to avoid accidents from happening. Turn the control knob towards EXT to allow for velocity control via software (e.g., AutoResp), or towards KNOB to allow for manual control via the speed knob.

3.3.2 Analog output

Use wires 8 (+) and 9 (0) to pick up a 0-10 VDC linear analog output from the frequency converter. This output can be connected to one of our DAQ instruments to monitor and record water velocities and solid blocking corrected swim speeds in real-time via a PC.

3.3.3 Analog input

Use wires 6 (+) and 7 (0) to control motor speed using a 0-10VDC input, e.g. from a D/A PC device or similar. To over-ride the manual speed knob, switch the large lower knob to position "PC".

For further instructions on the motor frequency converter, please refer to the MOVITRAC user manual.

3.4. Calibration

3.4.1 Respirometer volume

For respirometric measurements, it is important to determine the exact volume of the swim tunnel respirometer. This is easily done by filling the swim tunnel respirometer completely (do not fill any water in the ambient tank) with all ports sealed/blocked. Make sure to get rid of all air bubbles. Finally empty all the water into a measuring beaker or alternatively, weigh the entire swim tunnel respirometer with and without water to determine the volume.

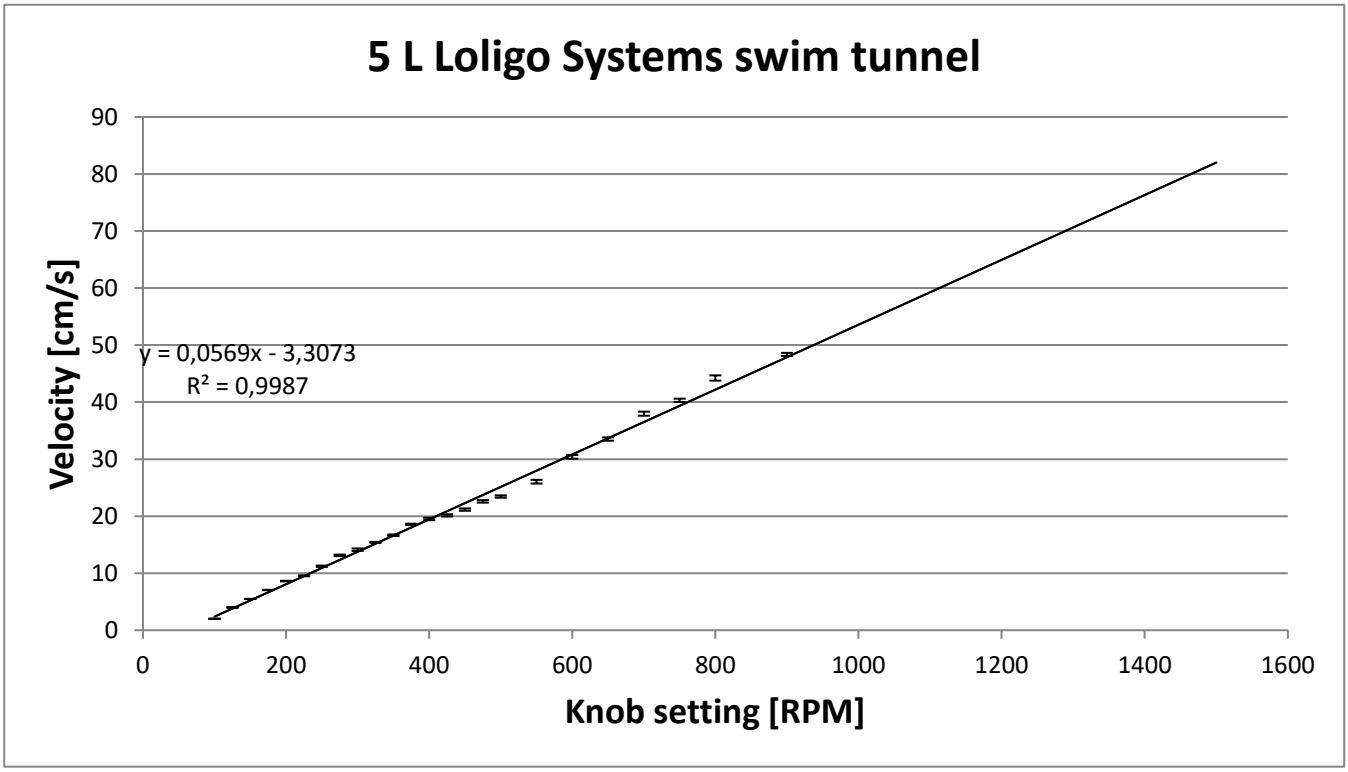
3.4.2 Flow velocity

Optional flow measuring equipment is required for flow velocity calibrations. We strongly recommend using the digital anemometer from Höntzsch (AC10000) and 30mm vane wheel flow probe (AC10002), please see below.

Alternatively, we recommend using dye technique.

Start flow calibrating the swim respirometer by filling it completely with water, (no air bubbles) and make sure that all wing nuts are firmly tightened. Then record the analog output from the motor frequency converter or the RPM readings on the display as water velocity increase stepwise. For each of 5-10 steps, record the DC output or RPM versus measured flow velocity.

In this way a linear relationship between the output (RPM or DC signal) and water velocity can be established. From this relationship, water velocity can be adjusted during experiments without the need for simultaneous flow measurements.



3.4.3 Adjusting flow

The swim tunnel design allows for modification of the flow profile inside the test section. This is usually not necessary, but might be useful to fit different experimental purposes, i.e. reducing

/eliminating wall effects on fish swimming behaviour by means of high flows near walls and low flows in the centre of the test section. Changing the sideway position of the adjustable vanes (next to the honeycomb material), will redistribute water flows in the test section.

Start by removing the main lid, and then carefully lift out the half circle shaped section holding the vanes. Take the center vane out and then the two adjustable ones. Change the sideway position of one or both vanes, by tiny adjustments of the screw holding the vane in the slot.

Reassemble and check the flow profile with a flow probe or flow visualization technique. It might be necessary to perform the operation several times to get the proper results.

3.5. Maintenance

The swim tunnel is designed for effortless maintenance and easy cleaning. Thus, all inner parts are detachable and can be taken out for cleaning or repairs.

To remove the swim respirometer from the buffer tank, unscrew the four corner wing nuts holding it in place. Then turn the submerged shaft coupling to a position allowing you to lift the respirometer up and out.

3.5.1 Cleaning

The swim tunnel respirometers are made of non-corroding parts. However, we recommend frequently rinsing the entire swim tunnel and buffer tank with tap water and wiping it dry, to avoid problems with corrosion, or biofilm on surfaces. If necessary, use a mild detergent to remove dirt.

The swim tunnel is made mainly of acrylic materials (PMMA) due to its fine optical and mechanical properties, and high resistance to UV-radiation. However, PMMA is **NOT** to be used with most dissolvent, especially not polar solvents, *i.e.* gasoline, concentrated acids or alcohol.

IMPORTANT: DO NOT USE ALCOHOL ON ANY ACRYLIC SURFACES – IT WILL CAUSE CRACKS!

3.5.2 Prop shaft bearings and seals

Even though the moving part (shaft bearings and spring-loaded mechanical seals) of the swim tunnel are made of high-quality stainless materials and glass bearings, they may require service or replacement after extended operation. To remove the shaft and service/replace parts, detach the shaft coupling parts using the small hexagonal wrench and take the swim tunnel out of the buffer tank. Unscrew both plastic housings holding the bearings and pull out the shaft from within the swim tunnel.

Contact us for more details.

4. Tips and tricks

Through years of research experience, we have learned a few tricks that might help you minimize problems associated with experimental handling stress and animal behavior.

4.1 Handling stress

Handling stress can affect the metabolism of experimental animals for several hours! For instance, fish oxygen consumption rates often increase by an order of magnitude following initial handling (netting, weighing etc.).

Thus, minimize handling and allow fish time to recover (>5 hours) from any lactic acidosis while swimming slowly at low speeds (½-1 body lengths s^{-1}).

4.2 Other stressors

Confinement inside a swim tunnel is an initial stressor for most animals, external stimuli from experimenters and lab surroundings as well. It is therefore a good idea to isolate the swim tunnel behind dark curtains and monitor the fish by using a video camera.

4.3 Swimming behavior

Individual and interspecific variation in swimming mode and behavior, challenge experimenters – *and the odd specimens we never got to swim!*

However, if an animal refuses to swim steady, even at low speeds, try to provide the fish with some visual cues to help it keep stationary in the swim tunnel, e.g. a few vertical stripes of adhesive tape on the working section wall.

If an animal rests at the downstream grid, perhaps tail against the current, turn the motor off, reverse the direction of flow, and slowly increase the flow until the fish is carried away from the grid. When the animal faces upstream, turn the motor off, reverse the direction of flow and increase the speed slowly. Repeat this procedure several times if necessary.

One of several other ways to avoid experimental animals resting against the grid is to create a dark environment at the upstream portion of the working section and mount a strong light source over the top of the grid.