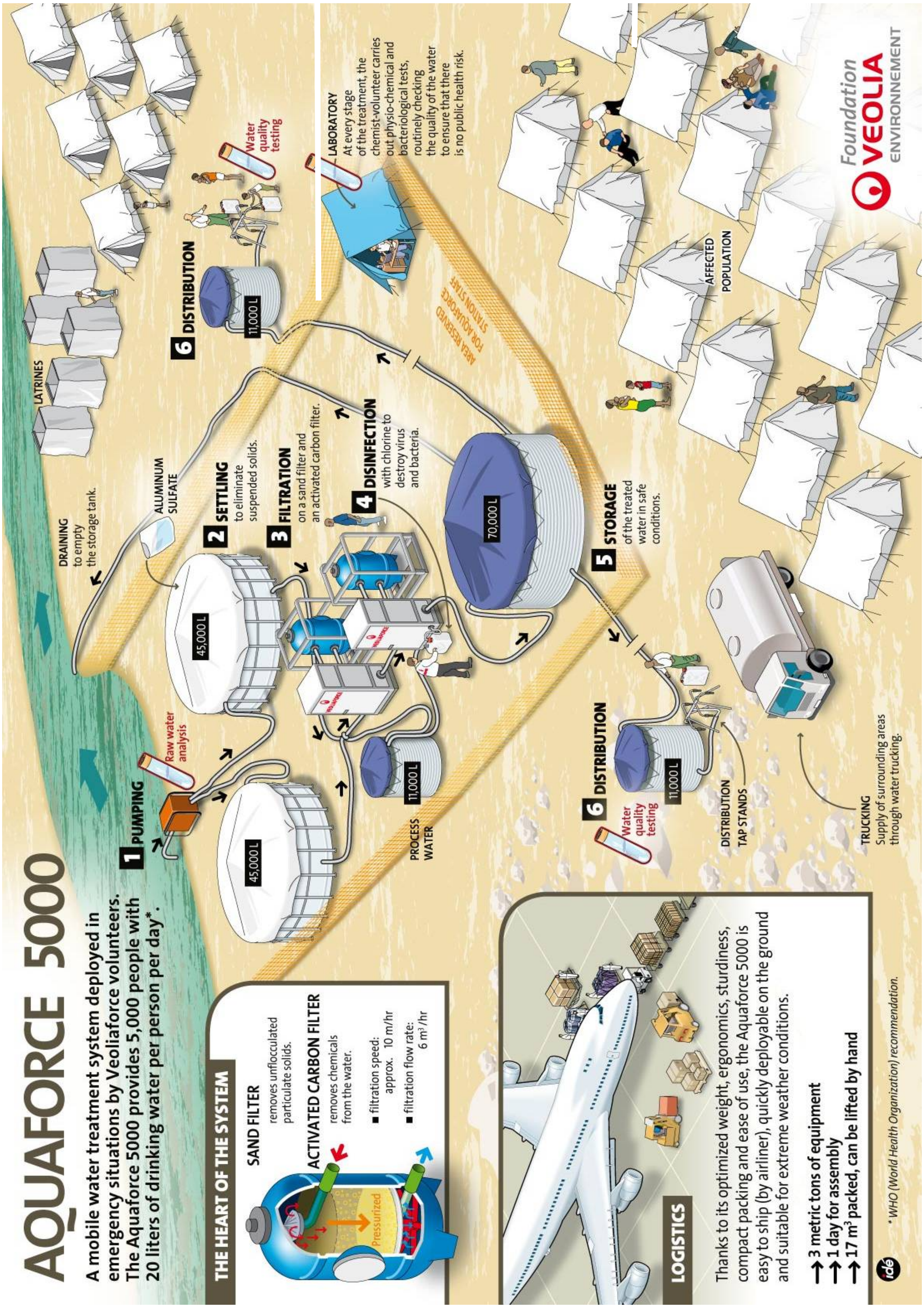
Aquaforce 5000

User guide of a mobile emergency water treatment unit aquaforce 5000

september 2012

Foundation
VEOLIA
ENVIRONNEMENT

Operating and installation manual of a mobile emergency water treatment unit
M5


AQUAFORCE 5000
A mobile water treatment system deployed in emergency situations by Veoliaforce volunteers. The Aquaforce 5000 provides 5,000 people with 20 liters of drinking water per person per day*.
THE HEART OF THE SYSTEM
SAND FILTER
removes unflocculated particulate solids.
ACTIVATED CARBON FILTER
removes chemicals from the water.
filtration speed: approx. 10 m/hr
filtration flow rate: 6 m³ /hr
Pressurized
1 PUMPING
Raw water analysis
45,000 L
45,000 L
DRAINING to empty the storage tank.
ALUMINUM SULFATE
2 SETTLING to eliminate suspended solids.
3 FILTRATION on a sand filter and an activated carbon filter.
4 DISINFECTION with chlorine to destroy virus and bacteria.
11,000 L
PROCESS WATER
70,000 L
5 STORAGE of the treated water in safe conditions.
LATRINES
6 DISTRIBUTION
11,000 L
Water quality testing
LABORATORY
At every stage of the treatment, the chemist-volunteer carries out physio-chemical and bacteriological tests, routinely checking the quality of the water to ensure that there is no public health risk.
AREA RESERVED FOR AQUAFORCE STATION STAFF
AFFECTED POPULATION
6 DISTRIBUTION
11,000 L
Water quality testing
DISTRIBUTION TAP STANDS
TRUCKING
Supply of surrounding areas through water trucking.
LOGISTICS
Thanks to its optimized weight, ergonomics, sturdiness, compact packing and ease of use, the Aquaforce 5000 is easy to ship (by airliner), quickly deployable on the ground and suitable for extreme weather conditions.
3 metric tons of equipment
1 day for assembly
17 m³ packed, can be lifted by hand
* WHO (World Health Organization) recommendation.
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Packing list

Every box is labelled following the nomenclature hereunder. The content of every box is identified by a laminated form with the photo of the contents stuck on the box.

M5 PACKING LIST

Parcel	Codification	Nbr case / pallet	Length	Width	Height*	Pallet	Volume (cm)	Weight (kg)**	Full description
Parcel 1	VF/M5/FILT/UNIT	1	120	80	160	n/a	1,54	120	1 fiber filter on pallet
Parcel 2	VF/M5/FILT/UNIT	1	120	80	160	n/a	1,54	120	1 fiber filter on pallet
Parcel 3	VF/M5/FILT/CTRL	2	120	80	160	n/a	1,54	190	2 control panels for filters
Parcel 4	VF/M5/FILTR/MAT	1	120	80	80	1	0,77	569	25kg activated carbon bag: 6 25kg sand bag: 14
Parcel 5	VF/M5/ENERG	1	120	80	80	1	0,77	230	cf. spreadsheet "Parcel 5"
Parcel 6	VF/M5/FLOCCU/REAC VF/M5/TOOLS VF/M5/TOOLS/BOX VF/M5/DISINF/REAC	3	120	80	60	1	0,58	368	cf. spreadsheet "Parcel 6"
Parcel 7	VF/M5/QUAL/GRAL VF/M5/QUAL1 VF/M5/QUAL2/FOUR VF/M5/QUAL2/SECU VF/M5/QUAL2/GLAS	1	120	80	80	1	0,77	89	cf. spreadsheet "Parcel 7"
Parcel 8	VF/M5/PIPE/SFX55	8 X 25 M	102	102	160	1	1,66	172	200 meters of diameter 55 spiraflex pipe 8X25M
Parcel 9	VF/M5/TANK/VTX45A	1	160	102	52	n/a	0,85	300	45 cm volutex storage tank: structure
Parcel 10	VF/M5/TANK/VTX45B	1	160	102	52	n/a	0,85	125	45 cm volutex storage tank: liner and roof
Parcel 11	VF/M5/TANK/VTX45A	1	160	102	52	n/a	0,85	300	45 cm volutex storage tank: structure
Parcel 12	VF/M5/TANK/VTX45B	1	160	102	52	n/a	0,85	125	45 cm volutex storage tank: liner and roof
Parcel 13	VF/M5/FITTI/M5/GRAL VF/M5FITTI/M5/ASPI VF/M5FITTI/M5/FILT VF/M5FITTI/M5/INFILT VF/M5FITTI/M5/OUTFILT VF/M5FITTI/M5/VIDA VF/M5FITTI/M5/DISTR	1	120	80	80	1	0,77	168	cf. spreadsheet "Parcel 13"
Parcel 14	VF/M5/TANK/VTX11	1	160	102	52	n/a	0,85	186	11 cm Oxfam water tank
Parcel 15	VF/M5/TANK/OXF70	1	147	82	70	n/a	0,84	257	70 cm Oxfam water tank
Parcel 16	VF/M5/TANK/OXF70	1	293	56	82		1,35	390	71 cm Oxfam water tank - steel plates
Parcel 17	VF/DISTRI/STORA/2BLAD10S VF/DISTRI/STORA/2BLAD5T	2	120	80	96	1	0,92	237	Storage bladder of 10 M3 x2 Storage bladder of 5 m3 x2
TOTAL	**Full M5**	**18**	**x**	**x**	**x**	**x**	**16,35**	**3709**	**x**

* : not including the pallet's dimensions (15cm heigh)

**: not including the weight of the pallet (21 Kg)

Table of contents

Introduction

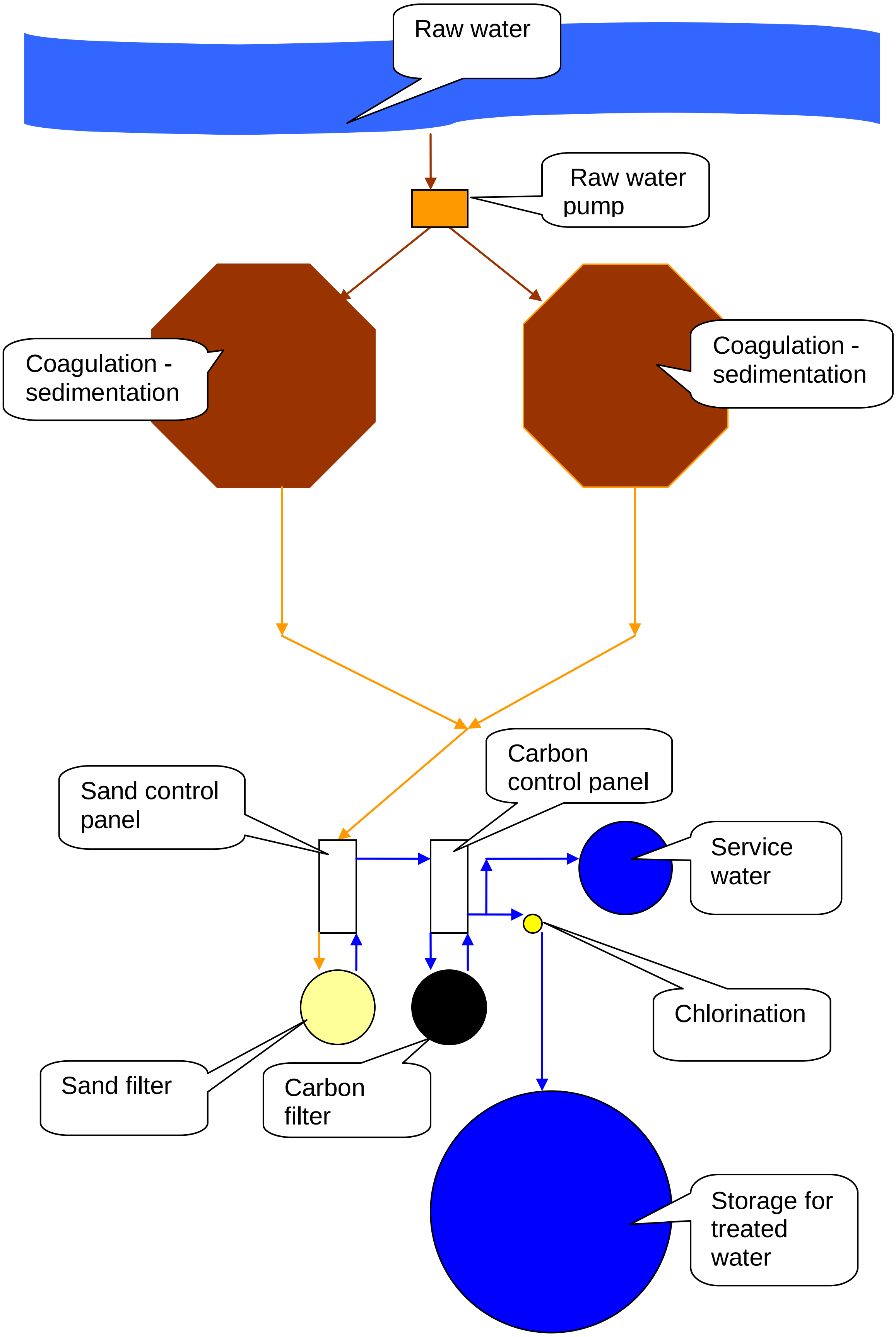
The Aquaforce 5000 (or M5) is an autonomous unit for the production of drinking water to be used during a humanitarian emergency or post-crisis management. It operates using traditional procedures of water treatment: pumping of raw water, coagulation and sedimentation, filtration on sand and activated carbon and chlorination. The M5 unit is designed to provide water to 5000 people per day according to the recommendations of SPHERE.

The M5 module integrates a distribution system through feeder heads and also gives the possibility to undertake water trucking for the transport of treated water to dispersed populations (up to 25,000 litres per day), with the possibility of putting in place five storages with distribution.

Properties of the M5	Details
Process	Pumping of raw water, coagulation-sedimentation, filtration on sand, filtration on activated carbon, chlorination, storage, and distribution.
Production rate	5m^3/h
Total weight	3.7 tons
Volume	17m^3 packed for commercial flights with passengers
Assembly time	About 1 and a half days with the help of a team of 6 to 8
Cost of operation	Low. The M5 module is autonomous; its operation only needs gas oil, whose consumption can be reduced if access to reliable power supply is possible
Compatibility	Connection adaptor ***storz*** included in the kit (standard FICR)
Simplicity of use	Training of the national personnel within one or two weeks
Checking of the water quality	Full physico-chemical and bacteriological analysis laboratory
Total storage capacity	100 m^3: a reservoir of 70 m^3 and 30m^3 of bladders.

I. Description of the treatment unit

1. Overview



2. Clarification

Objective: to reduce the turbidity of water. After clarification the turbidity (i.e. as it enters the filter) should not be more than 15NTU.

Process coagulation and sedimentation: the addition of the coagulant in the raw water allows the particles to aggregate at the bottom and to accelerate their sedimentation. The addition here is done manually, during the filling of the tank with raw water, so as to allow the water and the coagulant to mix. Once the coagulant is added and the tank is filled, the water is left to sit so as to allow sedimentation.
The M5 unit is composed of two sedimentation reservoirs, which allows the sedimentation to be carried out in a discontinuous manner (per batch) all the while producing water in a continuous manner : during the filling of a reservoir, the other one (already settled) serves to feed the filters and then vice versa.

3. Filtration

Objectives:

- The filtration on sand allows the improvement of clarification by eliminating the very fine particles.
- The filtration on activated carbon allows to further refine the clarification, and to eliminate micro pollutants, hydrocarbons, pesticides, etc.

Process: the cleared water is filtered on sand, followed by filtration on activated carbon. As it comes out of filtration, the turbidity of the water has to be less than 1NTU on average and never more than 5NTU (WHO standards).

4. Disinfection

Objective: to eliminate all pathogenic micro-organisms (especially bacteria) so as to avoid all contamination during consumption and hence prevent the development of waterborne diseases (dysentery, cholera, etc.).

Process: the disinfection is carried out using a chlorine injection. This procedure presents the triple advantage of being safe, simple to start, and especially of offering a residual bactericidal effect which helps to avoid any recontamination of the water after treatment (especially during distribution and conservation).
The injection of chlorine is done between filtration and storage, using a liquid fed pump.

II. Installation and operation

Here the installation, start-up, and exploitation of the treatment unit are presented. The different parts that make-up the installation are described in a general manner: the details of the parts that make it up are in the forms on the boxes of the materials. In particular, all that concerns the connectics is on the FITTI box: 1 bag of extensions per step /connection with detailed forms, photos, quantities and a schematic diagram.

CAUTION: all work on the valves has to be done when there is no pressure, when the pumps and generators are switched off, so as not to damage the materials.

1. Choice of the resource

The following list presents the important parameters to be taken into consideration in the selection of the source, it cannot be considered as an exhaustive list but as an aid in the making of the decision:

- The quality of the raw water has a direct influence on the efficiency of the treatment, it is therefore necessary to choose waters that are the least turbid.
- Verify the activities next to the pumping point so as to identify the eventual sources of contamination (human, agricultural, industrial…)
- Ensure that the conductivity does not go beyond the national standards and the WHO standards (1500µS/cm)
- In the case of an underground resource, ensure that the difference of height between the pump and the suction strainer is not more than 7m for a heat pump or 32m for discharge with a submersible pump. Ensure as well that the flow rate from the resource is enough.
- Ensure sufficient accessibility to the source so as to allow the installation of the suction.

Once the station is installed and for the entire duration of exploitation, the state of the resource in terms of water should be monitored regularly so as to adapt the treatment (especially during events that may have an influence on the quality of the raw water, for example heavy rains which increase the turbidity).

2. Determination of the quality of the water

The first operation to be carried out before the start-up of the station is a physico-chemical as well as a bacteriological characterization of the raw water, so as to correctly set the mobile treatment unit. This includes the following measures:

- Basic measures: turbidity, pH, conductivity, temperature, colour and smell. These parameters allow a better setting and a better exploitation of the unit.
- Chemical Characterization: Ammonium hydroxide, Cyanide, Iron, Manganese, Fluorine, Nitrates, Nitrites, Phosphates.
- Bacteriological Characterization

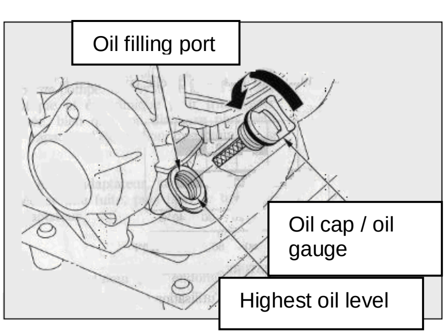
3. Pumps and Generators

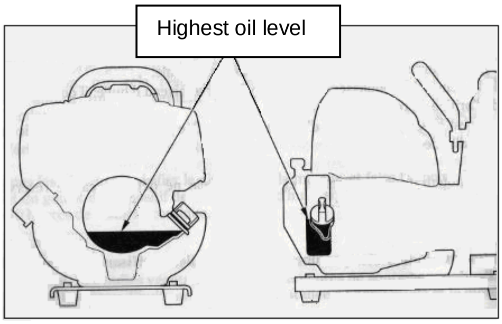
Here, the use a power pump is explained in a simple manner. The use of a generator respects in general the same rules.

For detailed instructions, refer to the guide on specific use of pumps and generators, available with the unit.

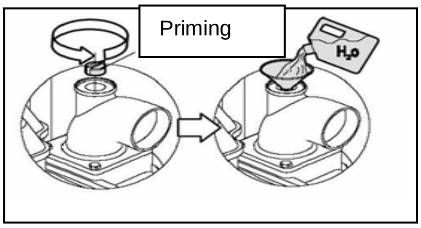
Start-up

- Fill with oil and with fuel. Type of oil to be used: SAE 15W40 : -10^0 C to > + 40^o C

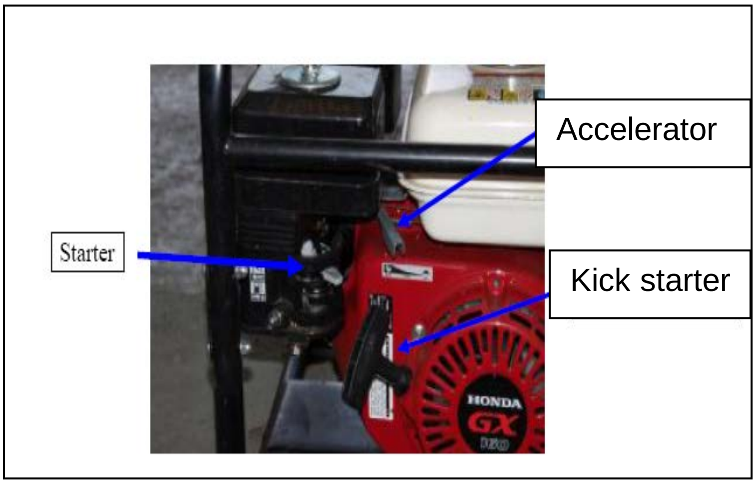




- Fill the body of the pump with water. Caution, the pump should never operate “dry” so as to avoid damaging the material.



- Open the fuel tap :
  - Position the stop switch to "on".
  - Position the starter shutter on "starter" if it is the first time it is being started.
  - Position the accelerator to 1/3 of its rpm.
  - Pull the kick starter – the generator starts – position the starter shutter on "OFF".
  - Let the power pump run at an idle speed for 3 to 4



Safety Rules

- Place the power pump on a flat horizontal surface.
- Do not use the power pump in a humid zone/ use protective material against rain and mud.
- Do not use the power pump in a poorly ventilated area (Danger of Carbon monoxide).
- Do not attempt to fill the reservoir whilst the power pump is running.
- Do not interfere with the cooling.
- Do not smoke while filling up the reservoir.
- Do not touch the spark plug wire or the spark plug when the motor is running (high voltage electricity).

Problems and solutions

Problems	Causes
The motor does not start	-No fuel in the reservoir - fuel supply valve closed - Encrusted Spark plugs - Broken or faulty piston - Fuel supply on OFF - Motor on OFF - No oil - Fuel is not getting to carburettor - The spark plugs are not producing any sparks
The motor jerks	-Faulty spark plugs - Clogged air filter - Problematic carburettor - Closed STARTER
Abnormal Vibrations	-Check the different protection elements (loose tin ware, hood…) - Broken transmission mechanism
The pump does not suck	-Insufficient water quantity - Clogged Strainer - The pipe attachment flange is wrongly placed. - Damaged pipe - Suction is very high.

Weekly Service

Frequency of periodic servicing To be carried out after the number of months or hours of use indicated giving precedence to the shorter of the two intervals		Every use	First month or 10hrs	Every 3 months or 25hrs	Every 6 months or 50hrs	Every year or 100hrs	Every two years or 300hs
Motor oil	Verify level	o					
	Change		o		o		
Air filter	Verify	o					
	Clean			o(1)			
Spark Plugs	Verify-adjust					o	
	Change						o
Fireguard (where applicable)	clean					o	
Heat radiating fins of the motor	clean				o		
Nuts, bolts, fasteners	Verify (tighten if necessary)	o					
Idling	Verify-adjust					o(2)	
Valve clearance	Verify-adjust					o(2)	
Combustion chamber	clean	After every 300hrs (2)					
Fuel filter	clean						
Fuel reservoir (tank)	clean						
Carburettor pipe	verify	Every 2 years (replace if necessary) (2)					
Oil pipe	verify	Every 2 years (replace if necessary) (2)					
turbine	verify					o(2)	
Set of turbine	verify					o(2)	
Pump's intake valve	verify					o(2)	

Cleaning the Spark plug

The spark plug should be cleaned after every 200hrs of operation. Remove the plug. Brush the electrodes with a wire brush to clean them. With the help of a feeler gauge, adjust the gap (between 0.7 and 0.8 mm). Put back the plug first tightening with the fingers and then using a spark plug spanner.

Cleaning the air filter

Remove the air filter from its place. If it is very dirty, change it. If not, if it is made of paper, blast it with compressed air to remove the impurities. If it is a foam filter clean it with petrol. NB: the more the dust in the air, the more the servicing has to be frequent.

Cleaning the fuel filter

The fuel filter has to be cleaned after every 200hrs of operation.

4. Water intake and Pumping

a. Precautions to take during water intake

- Always set the raw water intake on upstream motion away from human populations and other notable sources of pollution (industrial, agricultural…).
- Always set the drainage (water used for cleaning filters, drainage at points of distribution, etc.) on a downstream motion in relation to the water intake.
- Protect the water intake.

b. Pumping Configuration : series and parallel

The M5 mobile water production unit offers a flexibility of use for pumping of raw water, allowing for the control of the flow rate, or the total Total Dynamic Head (TDH). Two types of assembly are possible, the series assembly or the parallel assembly. The table below shows the specificities of every assembly.

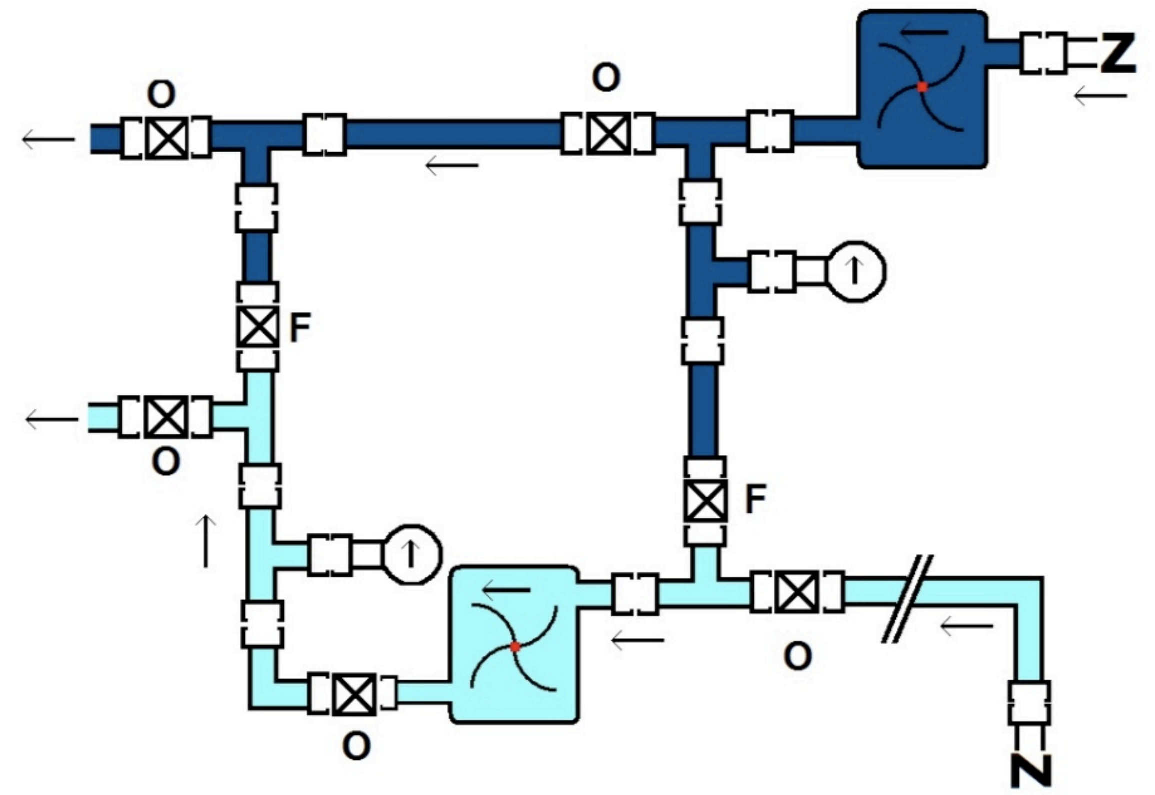
	Parallel	Series
TDH	=	+
Flow rate	+	=

Table 4: Adapt pumping to needs

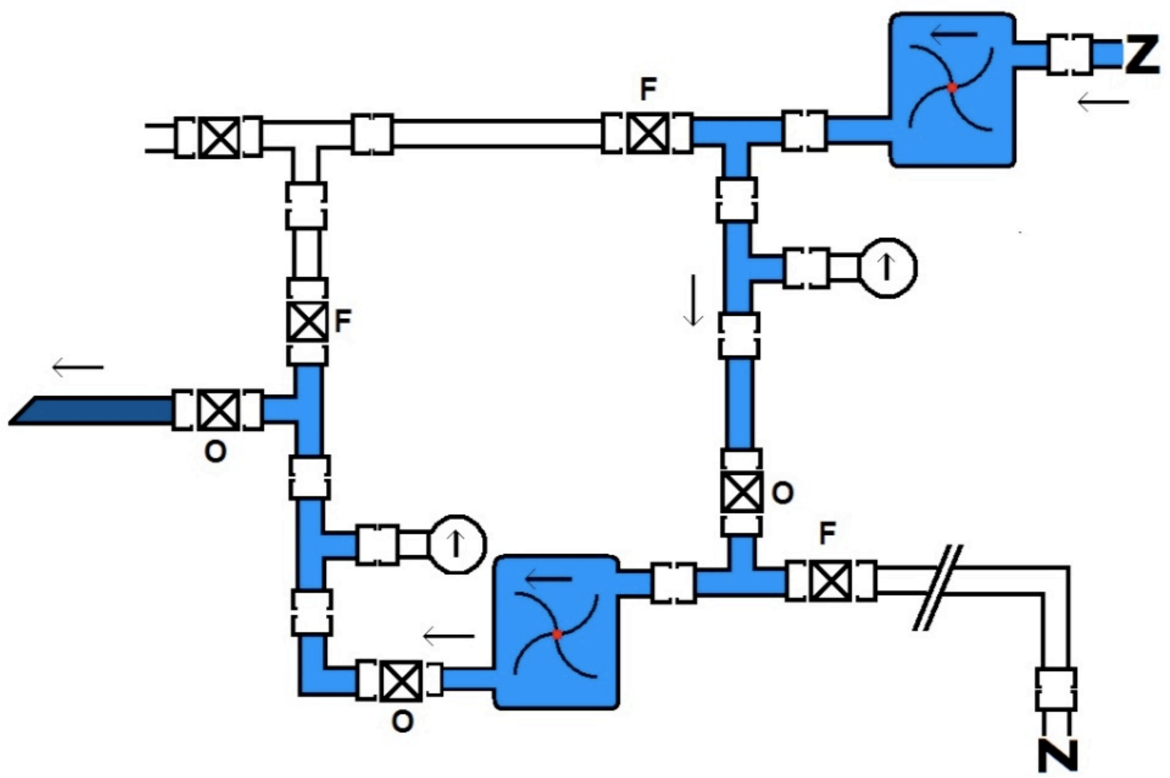
We may hence:

- Choose the parallel assembly so as to fill a reservoir as fast as possible
- Choose the series assembly in the case where the water source is far or lower in relation to the reservoir.

NB: for the parallel assembly, it is considered that there are two distinct pipes. If we wish to link the two umbilical hoses so as to pass the delivery in a single one, it is necessary to <u>adapt the diameter of this single hose, so that it can be able to absorb the entire delivery without causing significant loss of charge.</u>



Parallel configuration



Series Configuration

5. Assembly of the reservoirs

a. *Short Introduction*

The complete M5 line is made up of several reservoirs:

- Two Volutex tanks (Pronal or Labaronne Citaf) of $45m^3$ at the start of the line, used for sedimentation
- A Volutex or Oxfam tank (T11) of $10m^3$ for storage of service water (to be used in the cleaning of filters)
- An Oxfam tank of $70m^3$ to be used for storage of treated water.

b. *Choice of installation area*

- The area has to be as flat as possible, because it has to be perfectly levelled before assembly.
- It is necessary to preferably choose a clear area so as to limit the risk of falling objects which can damage the reservoir (avoid areas next to cliffs, trees…).
- It is necessary to take into account the TDH of the pumps and not to place the reservoir too high in relation to the water source.
- Finally, it is necessary to optimize the distances between the different components of the line, so that they can be as compact as possible.

c. *Preparatory work*

<u>This work should be carried out for all types of reservoirs installed and it is extremely important. Once the reservoir has been assembled, it is very difficult to disassemble it/move it/repair it, it is therefore necessary to undertake the preparatory work with a lot of care.</u>

- Perfectly level the ground (with the help of excavators and picks). Give precedence to excavation rather than filling.
- Make sure that the levelled ground has a larger diameter than that of the tank by least 1 meter so as to have enough working space.
- Remove all the small objects that can damage the liner of the tank: rocks, pieces of wood, pieces of glass…
- If the ground is impossible to level, one may excavate and create a sand bed. However, this technique should not be given precedence, because it is very difficult to correctly compact the sand, and this can lead to the weakening of the equilibrium of the reservoir.
- In the case of a long term installation, we may as well plan for the putting in place of a concrete slab.

d. *Precautions to take during assembly and exploitation*

- Never walk in shoes on the liner (only bare foot), and never walk on foldings (only on perfectly stretched liner).
- If the tank is confronted by a strong wind, fill it to the maximum of its capacity and solidly secure its roof.
- Ensure that nothing is weighing down the roof (ex: rain water, leaves, snow), if there is clear it on a regular basis.

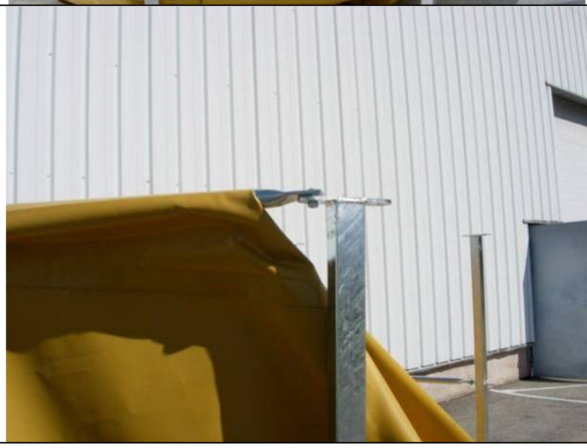
e. *Assembly of Volutex reservoirs*

The Volutex storage reservoirs of 45m³ and 10m³ are used for the storage of water and sedimentation.

Capacity	Height (m)	Diameter (m)	Number of stands	Total weight (kg)
10 m^3	1,5	3	11	105
45 m^3	1,5	6	23	322

Table 3: Main characteristics of the tank

Step	Description	Photo
Assembly of the reservoir		
1	Position the mat on the ground	
2	Position the bottom opposite the ground mat	
3	Position the metallic posts facing their holding spots, as well as the three cross members between every post.	
4	Raise the posts and hold them in place using hooks on the exterior so as not to damage the tarpaulin. These hooks will be used to hold the roof. Hold the posts so that they do not fall on the liner and pass the tie buses in the lower cable cords.	

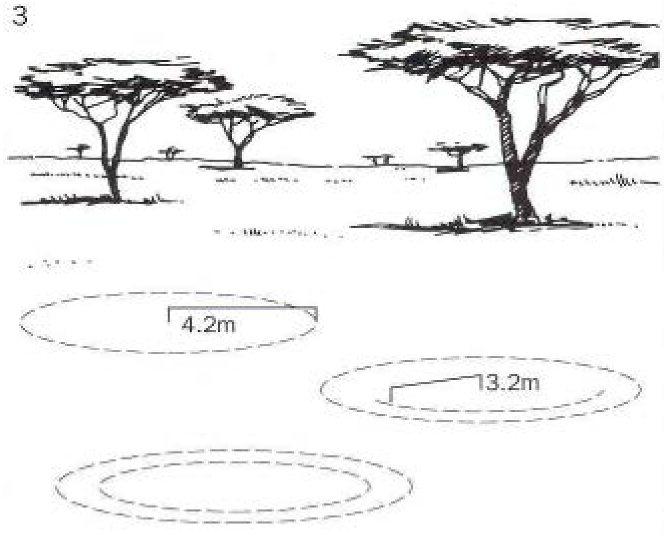
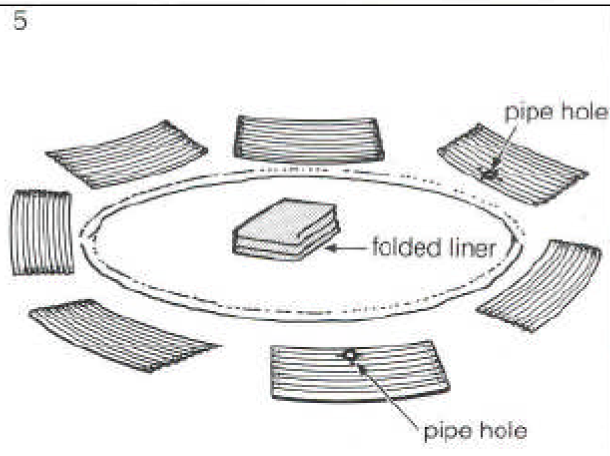
5	Continue holding the posts, and link the lower and middle tie buses at the base **without tightening** the bolts.	
6	Continue holding the posts, pull and attach the tarpaulin in the superior cable cords. Put up the entire structure without tightening the bolts. Once the entire structure is up we can let go of the posts.	
Assembly of the roof		
7	Position and centre the pillar made of PVC in the tank.	
8	String the cords from the upper plate of the PVC pillar towards the exterior of the tank.	

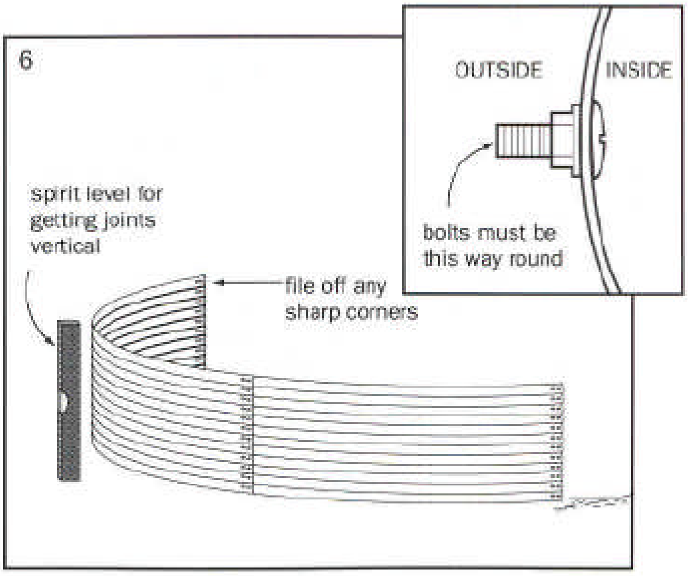
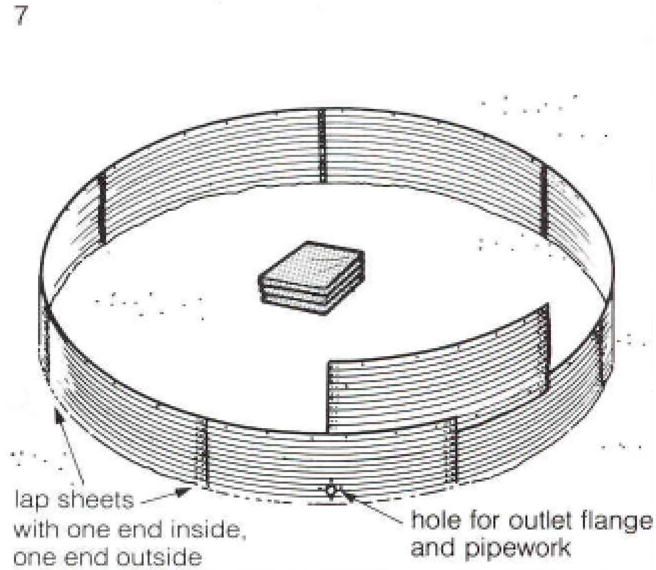
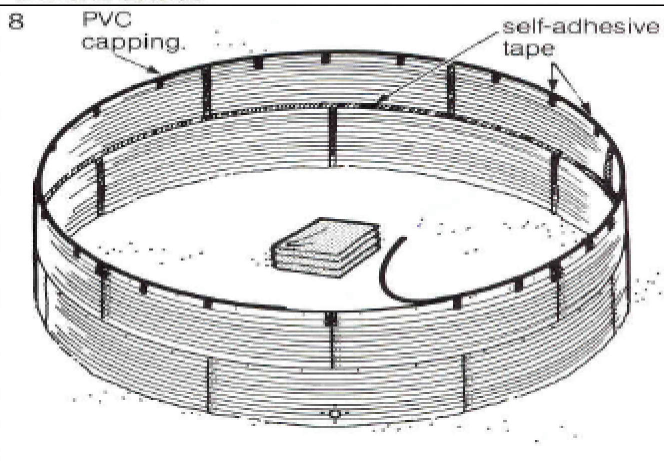
9	Pass the roofing tarpaulin over the pillar and the cords (one or two people should help from the interior)	
10	String and fix the stretching device on the hooks of the pillars.	
Finalization		
11	Fill the tank 1/4 way, then carry out the final tightening.	

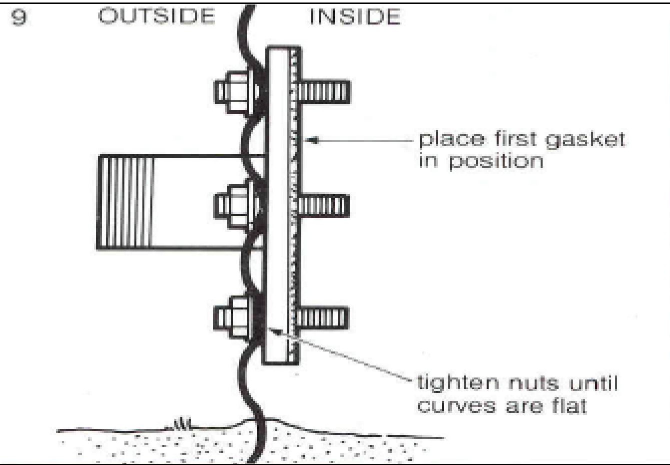
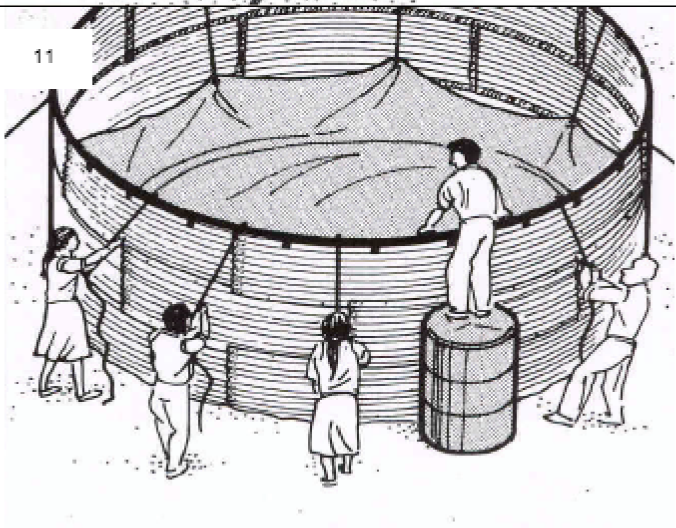
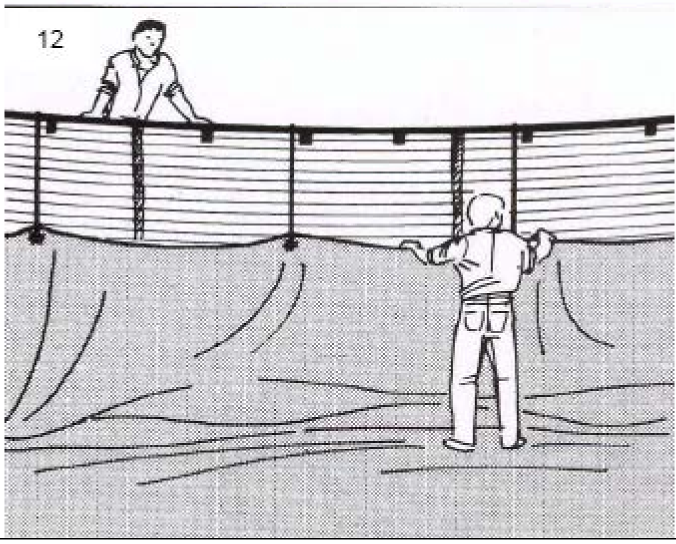
f. Assembly of Oxfam tanks

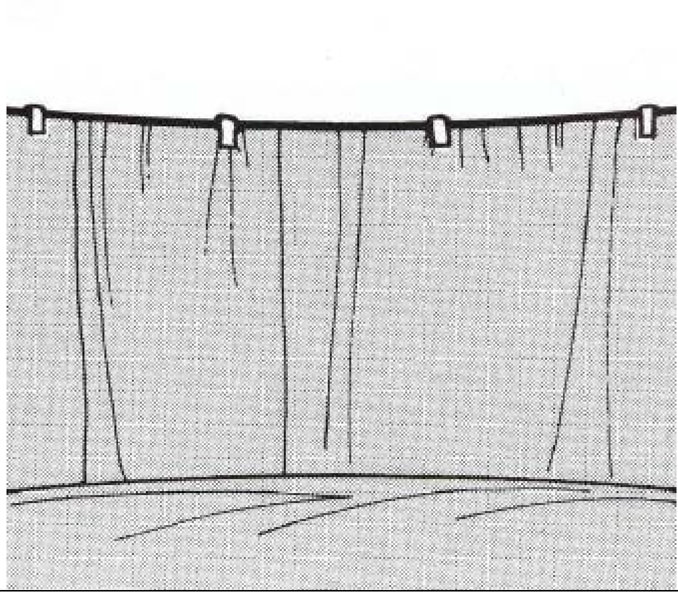
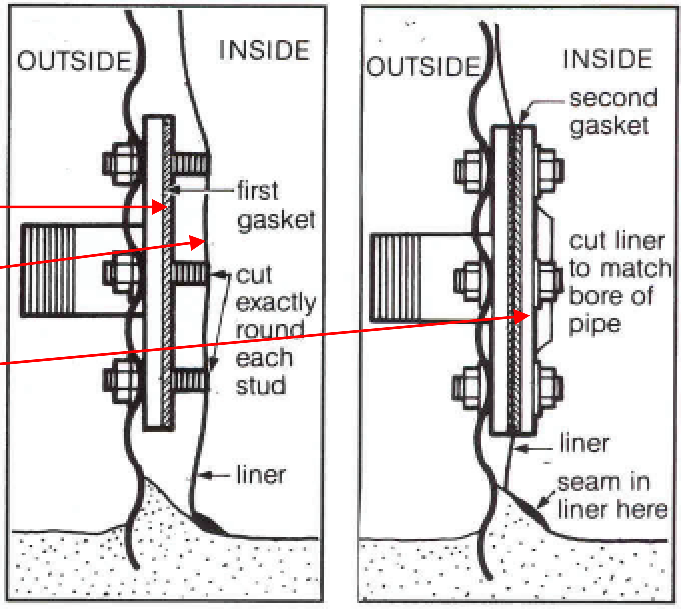
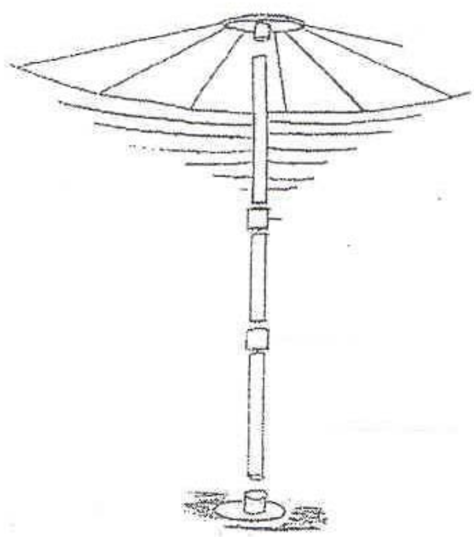
The Oxfam tanks are used for storage of treated water and eventually service water.

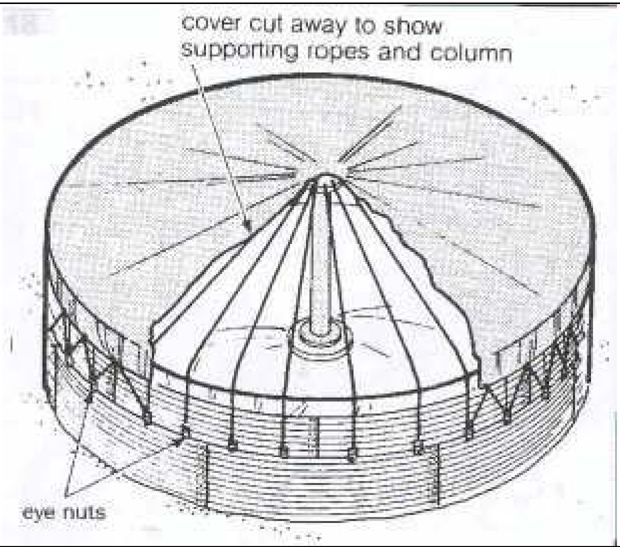
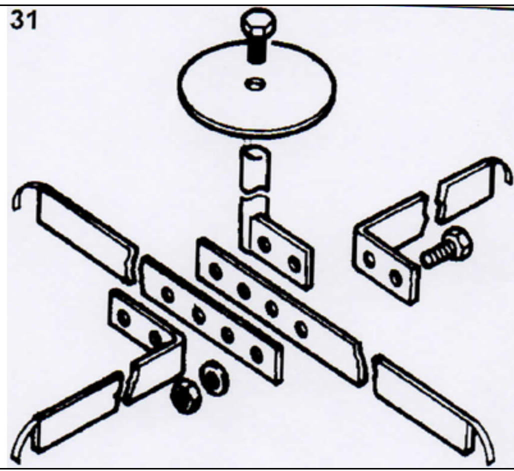
Capacity (m^3)	Height (m)	Diameter (m)	Number of rows	Number of sheet metals
11	2,3	2,5	3	18
45	1,5	6,4	2	14
70	2,3	6,4	3	21
95	3	6,4	4	28

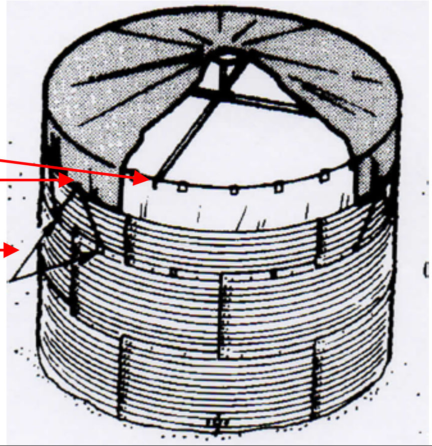
Step	Instructions	Image
1	On the levelled and prepared surface, trace a circle of a radius corresponding to that of the tank, and dig a small trench of a few centimetres in width and depth following the traced circle, so as to wedge in the structure, and stop the liner from passing under and getting torn.	
2	Place the tarpaulin in the centre of the circle, on the ground. Choose the direction to give to the tank (water entrance/ drainage) by placing parts of the structure with holes on the ground. NB: the water drainage hole should be placed at the bottom of the lower row of sheet metals, the water entry hole on the upper.	

3	Work in pairs, one person on the interior of the circle and one on the exterior. Place the first (lower) row of metal sheets. Place the laminated/superimposed metal sheets in an alternating pattern (one end on the interior, one on the exterior). Connect the metal sheets with the help of bolts and nuts. ATTENTION: to avoid tearing the tarpaulin the ends of the screws should be facing the exterior.	
4	Place the second row of metal sheets following the same principle, by placing the metal sheets alternately to the first row. Do the same to the third row.	
5	Once the structure is up, cover all the connections on the interior between the metal sheets and bolts and nuts using self-adhesive tape, so as to protect the tarpaulin. Cover the upper part of the structure as well using a black split PVC capping (use the smaller of the two).	

6	Position the flanges for the valves	
7	One or two people should be on the interior of the structure to unfold the tarpaulin. It is necessary that these person/persons be barefoot so as not to damage it. Attach the cords on the eyelets of the tarpaulin so that the people on the exterior can guide it when the ones on the interior are lifting it. Do not to pull the cords too much.	

8	Once the liner is in place secure it with another split PVC capping, then with spring clips. The liner should then be straight and not too stretched at the base of the structure.	
9	Cutting holes in the liner : Use a hammer and flange studs as cutters. Place the first gasket then the liner against the flange Place the second gasket, then a companion flange, and tighten, before cutting the liner round the inside of the flange. Cut the liner at the centre of the flange	
Erection of the roof T45, T70, T90		
10	Position and centre the support column made of PVC in the tank	

11	String the cords from the upper plate of the support column made of PVC to the exterior of the tank	
12	Lift circular PVC roof over central column and tension cover over tank with the help of ropes passed through eyelets.	
Montage du toit T11		
13	Assembly of metal roof frame T11	

14	Fix the metal frame on the edge of the tank. Lift the cover over the metal frame. Secure in position with rope through eyelets and around retaining eye nuts	

6. Coagulation and sedimentation

Coagulation allows the destabilization of colloidal particles at the bottom by the injection of a coagulant product, and helps their aggregation so as to accelerate their sedimentation. The coagulant used is aluminium sulphate, which must be sufficiently mixed with the raw water. Coagulation will therefore be fast and precede a longer phase of sedimentation.

Sedimentation is done in the Volutex tanks 45m^3 built for this purpose. The tanks are used in batch operation as described in the following steps:

- Determination of the amount of coagulant to be injected: the injected product is aluminium sulphate. The necessary amount is determined using a Jar Test, the methodology of which is given in the appendix.

- Tank 1 :
  - Fill the tank using the raw water pump.
  - Once the tank is filled ¾ way, inject the initial solution of aluminium sulphate at a go then finalize the filling (this allows a good mix and rapid coagulation, without the risk of "breaking the flocs bit by bit" which would happen if the sulphate was injected before the water).
  - Once the reservoir is filled and a good quantity of coagulant is injected, let it rest for the duration sedimentation is taking place (the time required for sedimentation depends on the quality of the raw water, there is therefore no absolute rule, but 4 to 5hrs is a correct indication of time span). We try and achieve a turbidity of less than 15NTU when the water enters the filter.

- Tank 2 [simultaneously – we consider that the water has already been decanted]: Pump the decanted water for filtration on sand. To do this it is necessary to position the suction strainer a few centimetres below the highest level of the water, using a floater, thus helping to only suck the supernatant.

7. Filtration of the water

CAUTION: ANY WORK ON THE VALVES MUST BE DONE AT ZERO PRESSURE (PUMPS OFF)

a. Turbidity

The sand and carbon filtration process allows the amelioration of clarification and eliminates a certain number of chemical products and micro pollutants. The turbidity of the water as it enters the filter should be less than 15NTU, so as to avoid clogging. After filtration, the minimum turbidity of the water should be less than 1 NTU, and the maximum turbidity allowed for a given sample is 5NTU (WHO standards).

b. Management of the control panels

The two filter control panels are so much alike. In addition, a lot of the functional capabilities are used on only one control panel (that of the sand by default). In case a problem arises, we can interchange the control panels, or use certain parts of the other control panel as spare parts.

Example: during normal operation, only the pump in the in the sand control panel is used. In case a problem arises with this pump, it is possible to uninstall it and install the carbon filter control panel one in its place.

c. Start-up and exploitation of the Filters

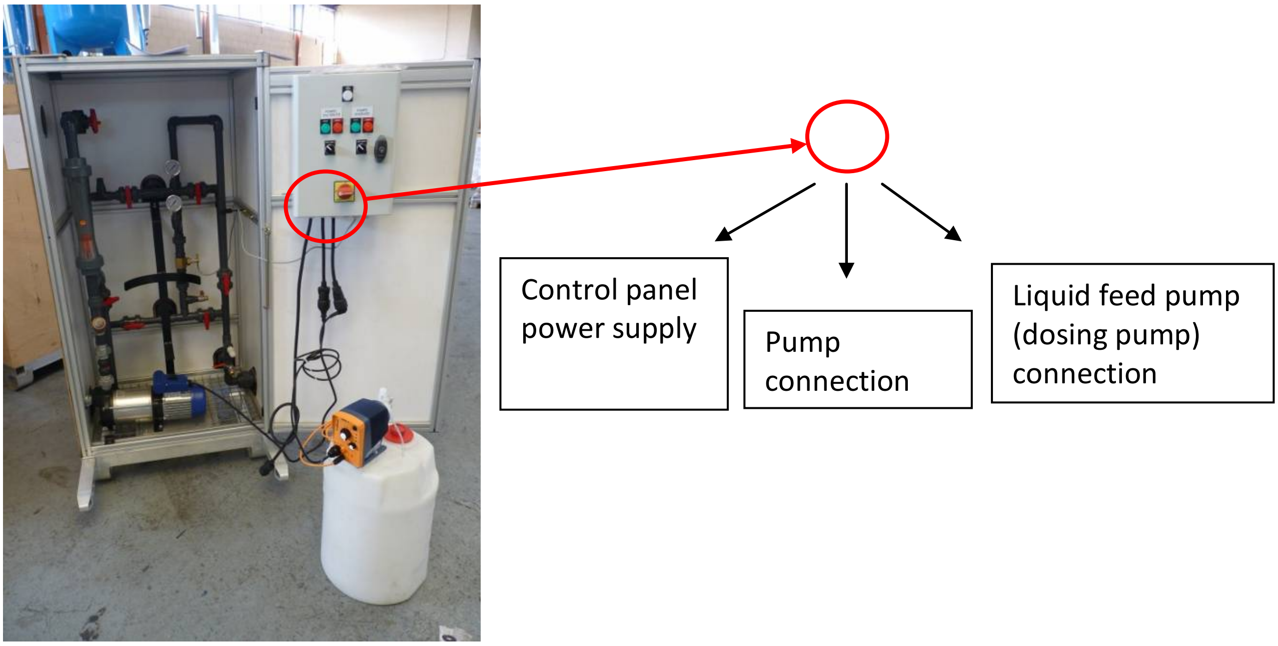
- The operating flow rate of the filters has to be constant at $5m^3/h$, it is important to regularly verify that. The pressure should also be verified regularly and should never be more than 2.5 bars (beyond that, a deflecting valve located at the top of the filters drains out water to reduce the pressure).
- During the first start-up, the filters should be purged of air as they are being filled up, using the deflecting valve at the top of the filters.
- During the first start-up and at every start-up after every wash, the first waters should be drained in the sewage (so as to eliminate the fine sand and carbon particles) and to verify the turbidity at the exit before restarting normal filtration.

d. Operation of the filters

The line contains two filters and two control panels (one for every filter). The operation is described below using labelled photos.

Control panel of the filter, at reception

Electrical control Panel. It contains at reception the manuals for the liquid feed pump, the circuit diagram of the control panel, the upper deflecting valves of the filters, and the handle of the control panel door.



Assembled control panel ready for use

The filter control panels have valves (photo below) to be opened or closed depending on the desired operation.

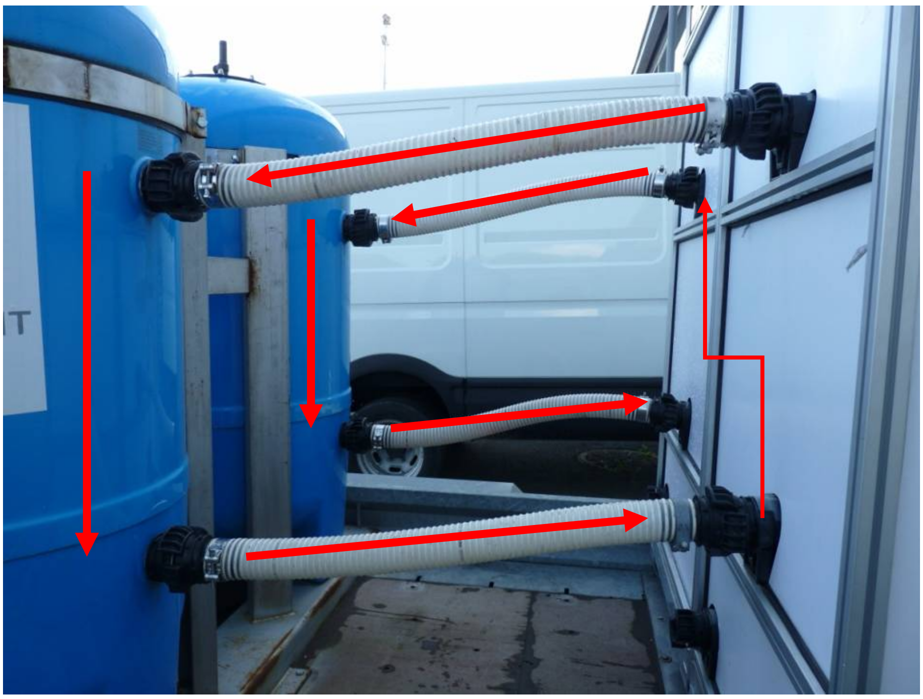

Opened valve


Closed valve

Filter and control panel seen from the exterior, at the reception point of the station.

Operation

Water is pumped from the sedimentation tank by the pump of the sand filter control panel. It then passes through the sand filter, then the carbon filter, every time entering through the top of the filter and exiting at the bottom.



Electric control panel

Starter switch for the raw water pump

Starter switch for the liquid feed pump

Main starter switch

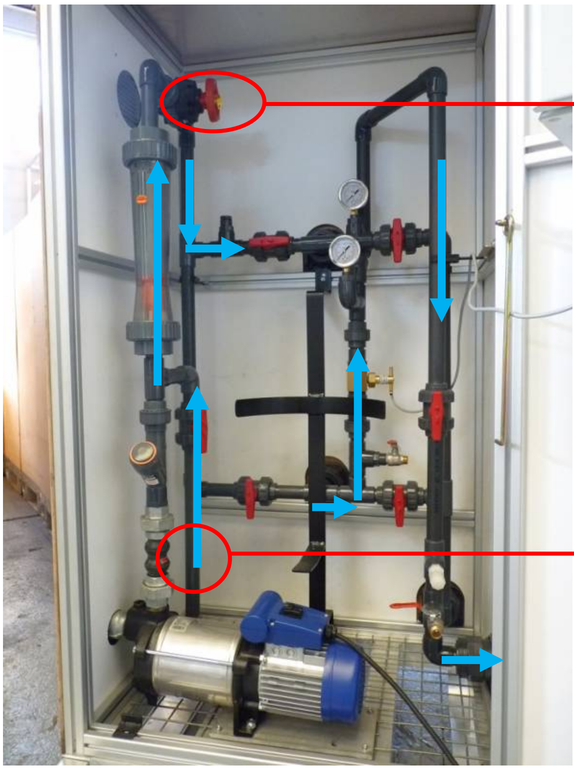
Configuration of the control panels

Sand Filtration

Diaphragm valve for precise setting of the flow rate (5m^3/h for filtration)

Water intake through the pre-filter. 40mm brass diameter.

Activated carbon filtration



8. Disinfection through injection of chlorine

Injection of chlorine is done using a liquid feed pump, supplied by an initial chlorine solution. The user guide for the liquid feed pump is available in the M5 module, stacked in the filter control panels. A short description of their operation is given in the appendix.

The quantity of chlorine to be injected depends on the quality of the filtered water, and is calculated by carrying out a chlorine demand, described in the appendix.

- Before beginning the storage of filtered water, turn the installation and retrieve the filtered water so as to carry out the chlorine demand.
- Once the calculations have been done and the pump is set, start it from the start of the filtration, so that the stored water can be sufficiently chlorinated.
- During the initial run, and on a regular basis thereafter, carry out a bacteriological test (see method on appendix) so as to ensure a proper disinfection operation.
- Regularly check the quantity of residual chlorine in the distributed water so as to guarantee a <u>residual chlorine quantity of between 0.1 and 0.5mg/L (SPHERE Standards).</u>

<u>NB: in a humanitarian context, the heat, congestion and lack of hygiene make the risks of developing diseases very high, a proper chlorination is therefore essential.</u>

9. Storage of treated water

- Storage of treated water is done in an Oxfam tank of $70m^3$. The tank is supplied from above. The outlet for the water to be distributed is at the bottom.
- It is important to ensure maximum protection of the treated water, so as not to recontaminate it (secure the roof; avoid falling objects, infiltration of pollutants (oil, gasoil, etc.)).
- It is also possible to store water in bladders. Several capacities exist (1, 2, 5 or $10m^3$) and the bladders can be permanent or removable (fitted with straps and harness) and transportable by trucks, capable of supplying distant ramps. Attention, the bladders must be placed on levelled ground, where any object that can pierce has been removed (rocks, wood…). Once filled, they have to be inspected to avoid any voluntary or accidental damage.

10. Distribution of treated water

From the storage we can supply different types of distributions.

- The standard Aquaforce5000 has 2 ramps and 6 taps. The ramps should be placed below the storage tank, at a minimum of 1m, so as to ensure minimal pressure. In the case of long distances between the ramps and the tank, we may eventually place a suppressor so as to compensate for the loss of charge. It is necessary to ensure that the ramps are accessible to the population, and that the zone allows the installation of a proper drainage so as to avoid flooding the zone.
- It is also possible to supply the trucks with the objective of doing water-trucking, which allows for distribution of water at distant points.

11. Exploitation of the installation

a. Regular checks

A certain number of checks on the installation should be carried out on a regular basis so as to guarantee the best exploitation:

- Regularly check the generators (see procedure)
- Regularly check the pumps (see procedure)
- Regularly check the water levels in the decanting tanks:
    - In the decanting tank that is filling up so as not to overfill it.
    - In the decanting tank that is supplying the filters so as to stop suction before getting to the residual mud at the bottom of the tank.
- Regularly clean the decanting tanks.
- Regularly check the pressure at the entry and exit of the filters (an increase at the entrance and decrease at the exit may for example point to clogging).
- Regularly check the filtration flow rate.

- Regularly check the level of the tank with the initial chlorine solution, so as to avoid insufficient chlorination.
- Regularly check the level of water in the storage tanks (service water and produced water) so as to ensure a permanent sufficient level.

b. Inspection of water quality

- It is important to follow the evolution of the quality of the raw water and to anticipate any change of state caused by for example climatic changes and eventual pollution.
- It is also imperative that, during the start-up and regularly thereafter, to carry out water quality measurements at different stages of purification, so as to ensure proper operation of the installation. The table below gives indications on how to go about this.

Stage	Parameters and frequency of measurement
Raw water	Turbidity, pH, conductivity, temperature, colour, ammonia, daily, in case there is an event that may alter the quality of the raw water.
Decanted water	Turbidity, pH, colour, aluminium: at the end of every sedimentation, before filtration.
Filtered water	Turbidity, pH, colour, aluminium : after every batch of decanted
Treated water	pH, turbidity, colour : daily free residual chlorine : very regularly (at least twice or thrice per day, more if it too hot) Bacteriology : weekly, in case there is a problem on chlorination

Table 7: parameters to be checked at every stage of purification.

III. Maintenance of the unit

Service the sand and carbon filters:

CAUTION: ALL MANIPULATION OF VALVES MUST BE DONE AT ZERO PRESSURE

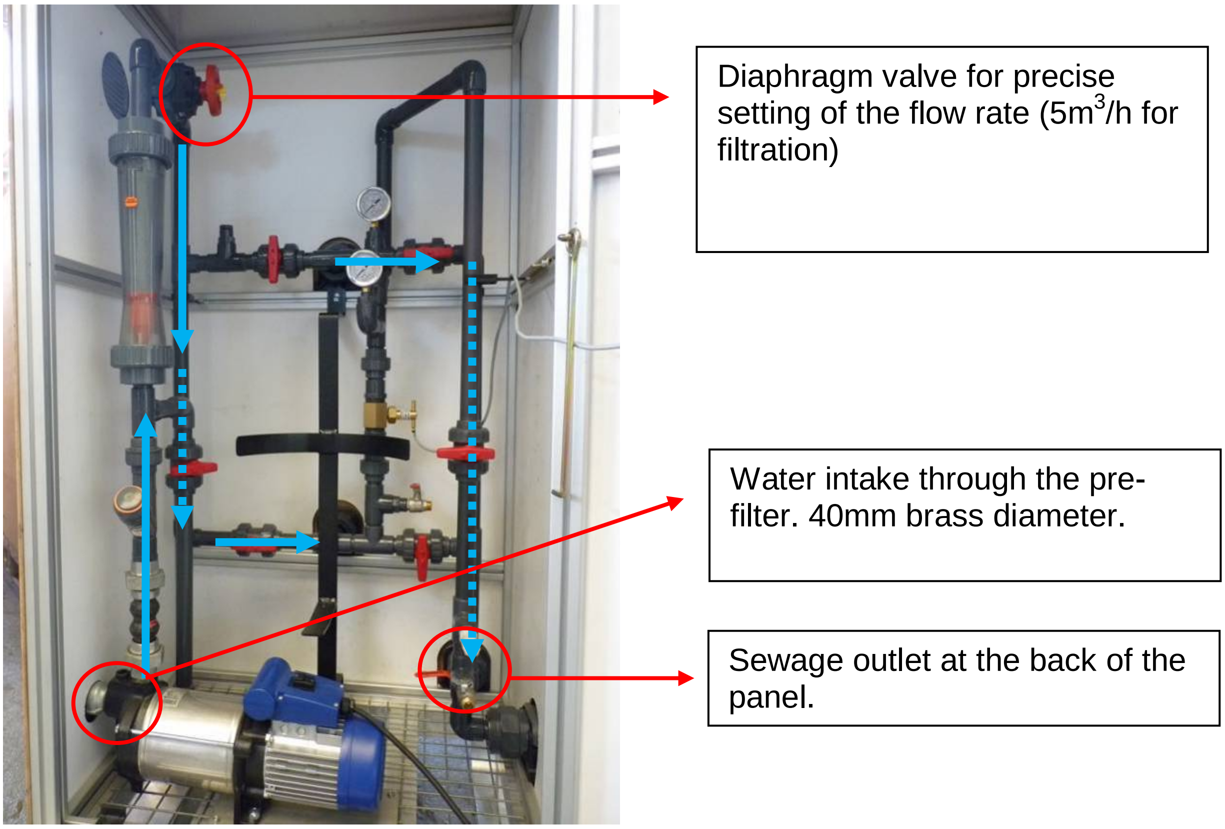
It is necessary to regularly wash the filters to avoid clogging. The cleaning is done in the « opposite direction » of the normal operation (backwash), with the service water, stored for this purpose in the 10m^3 tank.

Operation:

Service water is pumped to the filters using the pump in the sand filter control panel. ATTENTION: every filter is washed separately, but only the pump in the sand filter control panel is used. The water used to wash the filters should be drained and deposited away from the source (on the downstream in the case of a river).

Cleaning the sand filter

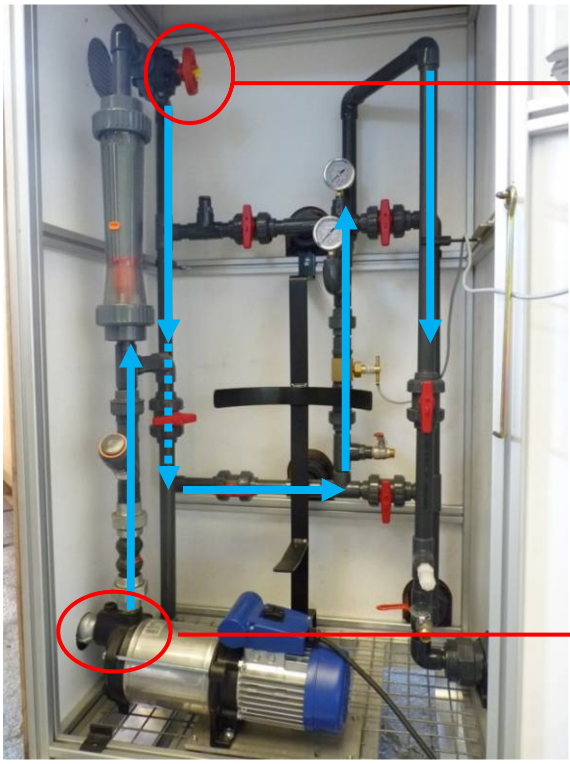
Service water is pumped using the control panel pump. Configuration:



Cleaning the carbon filter

Service water is pumped using the sand filter pump. It is therefore necessary to configure the sand filter control panel so that water passes directly without going through the filter.

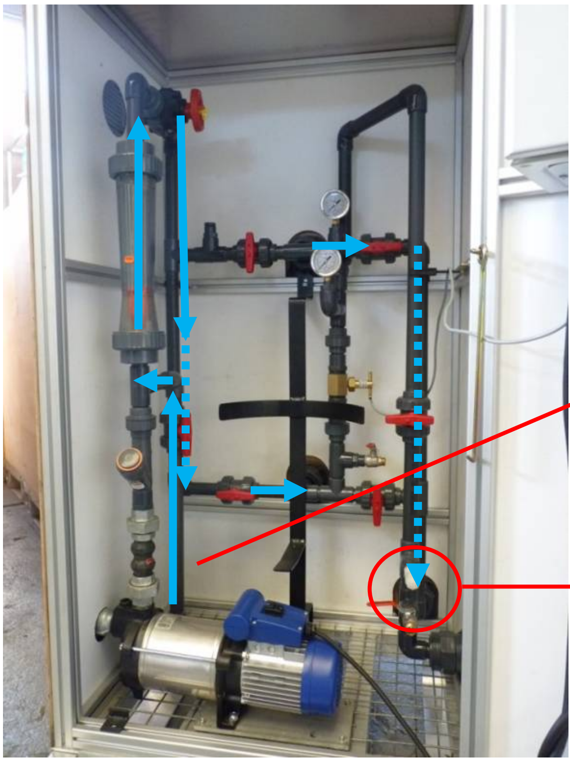
Sand control panel for carbon backwash



Diaphragm valve for precise setting of the flow rate (2m3/h for cleaning the carbon- the flow rate should be set at the sand control panel)

Water intake through the pre-filter 40mm brass diameter.

Carbon control panel



Water intake through the symmetrical coupling 2''

Sewage outlet at the back of the panel.

The cleaning flow rate should use the supply valve. For the carbon filter, the flow rate has to be lower, because a high flow rate will lead to the suspension of fine particles that may obstruct the strainer:

- Cleaning flow rate on the sand filter: Q = 5m^3/h.
- Cleaning flow rate on the activated carbon filter: Q = 2m^3/h.
- Use of service water.

Cleaning frequency depends on the quality of the raw water. By way of indication:

- Cleaning of each filter is a must before the first operation
- Cleaning may then be done on a daily basis, or more frequently if the water is very turbid
- Cleaning must be done if an indicator (pressure, flow rate, turbidity of the filtered water) indicates that the filters are clogged.

CAUTION: during the restart of the station after cleaning, it is necessary to dispose off the first water to the sewage, so as to eliminate the suspended particles by the cleaning.

IV. Disassembly and storage of the unit

Keep the user guides in a safe place for other uses!

1. Disassembly and storage of tanks

Disassembly: After use, the tanks can be disassembled following the steps described previously in a backward manner. However it is necessary to take care so as not to separate the tarpaulin from the other elements of the structure. Once disassembled, the tarpaulin should be disassembled on the outside and the outside, with a neutral and accepted chemical product, and then it is imperative to dry it before its storage.

Storage conditions:

- Avoid humidity
- Ensure adequate aeration
- Avoid exposure to sunlight
- Store far from chemicals

2. Sand and activated carbon filters

The sand and the activated carbon should be removed from the filters carefully so as not to damage the strainers. The filters should thereafter be dried, cleaned then stored.

3. The mobile laboratory

The glassware should be carefully washed and dried before being carefully wrapped. All the measuring equipment should be stored in a clean area, the least humid as possible and at a temperature of between 5 and 40 degrees. The batteries should be removed from the electronic gadgets.

4. Generators and pumps

It is important to empty the water, oil and petrol in the generators and power pumps before storing them for a long duration. It is also important to rinse the pumps with clean water before storing them for a long duration.

See the specific procedure for pumps and generators for more precisions.

Appendices

1. Reminder of essential SPHERE recommendations for drinking water and sanitation

Distribution of drinking water

- Minimum 15 litres of water / day/person
- 1 water point for 250 people maximum
- Maximum distance between residence and water point: 500m
- Maximum wait time of 15 minutes at a water point
- Minimum flow rate of 7.5 L/minute per water point
- Make arrangements for drainage and disposal of water at distribution points

Quality of drinking water

- Verification of odour, colour and taste
- Turbidity < 1NTU on average and never above 5NTU.
- 6,8 < pH < 7,8
- Conductivity < 2000µS/cm
- 0,1 < Residual chlorine < 0,5 mg/l
- Faecal coliforms: 0 FC / 100ml

Sanitation

- Maximum of 20 people per latrine
- Maximum distance between residences and latrines: 50m
- 1 shower for 100 people (separation Male/female)
- Avail soap
- Make arrangements for drainage and disposal of water

2. JAR TEST

Test principle: to determine the quantity of aluminium sulphate to inject in the raw water so as to obtain the fastest sedimentation possible all the while minimizing the injected quantity (so as to reduce the fall in pH and the presence of residual aluminium in the treated water).

Measurement of pH

It is very important to follow the evolution of pH using the Jar test. In addition the addition of aluminium sulphate leads to a drop in pH. One should therefore choose the lowest accepted treatment rate so as to remain within a desired pH range (between 6 and 7.5).
Generally, the treatment rate of aluminium sulphate is between 0 and 150g/m ^{3}. Above this treatment rate, if the water is very troubled, it is necessary to pay attention to both the pH as well as the injection mode of the coagulant.

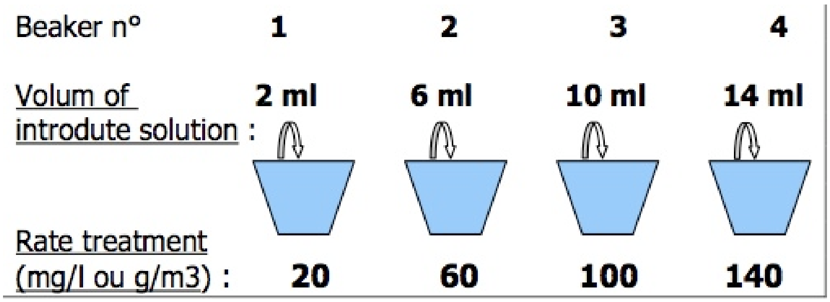
Material:

- An analytic balance
- A turbidity meter
- A pH-meter
- 4 beakers of 1L
- 3 pipettes (2, 10 et 20mL)
- A mixing container (1L)
- Coagulant (17% of Aluminium sulphate)

Procedure:

NB: in the case of aluminium sulphate, we speak in terms of the quantity of the commercial product, whatever the composition of the product.

- Prepare an initial solution of aluminium sulphate at 0.1% (1g/L) of the commercial product.
- Draw some water from the raw water, raise the turbidity and the pH
- Put 1L of the raw water in every beaker.
- Add increasing doses of aluminium sulphate in each one of the beakers, of between 2mL et 14mL, so as to obtain concentrations of between 20 to 140 mg/L



Rapidly shake the beakers for a minute then let it rest on slow mix for 20 minutes. Measure the turbidity of the supernatant in each one of the beakers.

- Capture the doses that allow the obtaining of the lowest turbidity.
- Among these doses, capture the lowest (the one that helps minimize the injection of the coagulant, and therefore the pH variation).
- Measure the pH so as to ensure that is within standards.

3. Chlorine Demand

Chlorine demand principle:

During the injection of chlorine in the water, a part of the chlorine is going to be consumed by various reactions (with bacteria, nitrogen…). It is therefore necessary to determine what quantity to add so as to obtain the desired residual quantity, i.e the remaining quantity after all these reactions, which will have the expected bactericidal effect. For water intended for human consumption, <u>the desired result is a free chlorine residue of between 0,1 and 0,5 mg/L.</u>

NB: The injected chlorine reacts first with ammoniacal nitrogen (NH_4). The quantity of chlorine to be injected to obtain the desired free residual chlorine therefore depends on the quantity of NH_4 present in the water. The desired amount of chlorine should be about 10 times more than that of the quantity of NH_4 so that all the NH_4 can be degraded and that the free chlorine can start to concentrate itself.

Carrying out of test

Material:

- A chlorine analyzer
- A pH-meter
- 4 beakers of 1L
- A precision weighing scale
- 3 pipettes (2, 10, 20 mL)
- A mixing container (1L)
- Calcium hypochlorite (HTH)

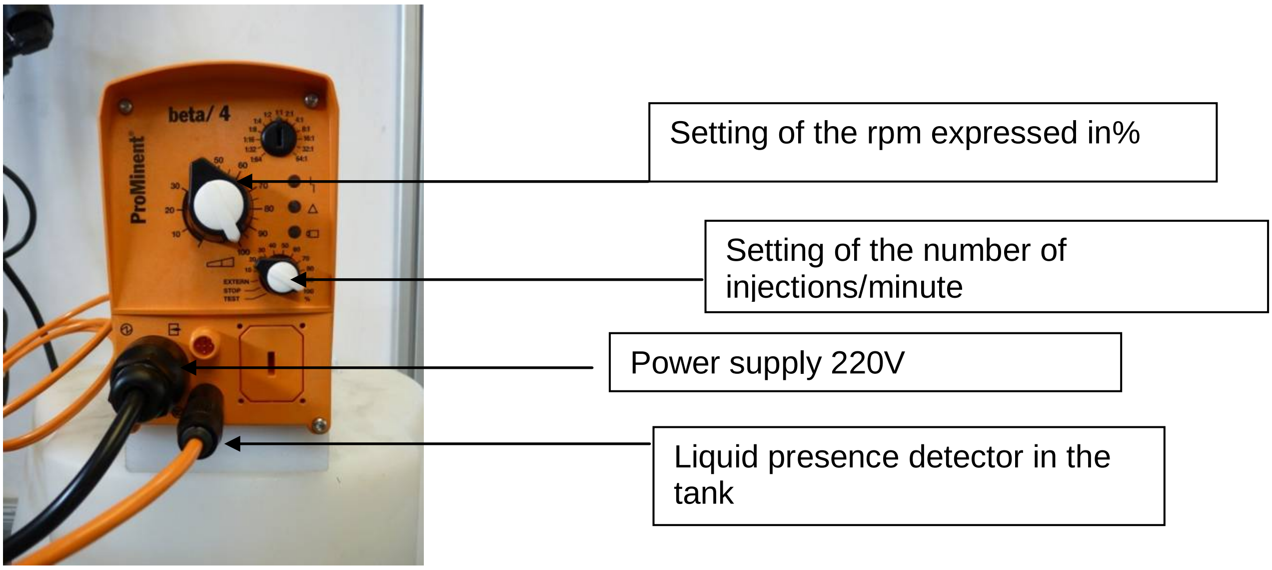
Procedure:

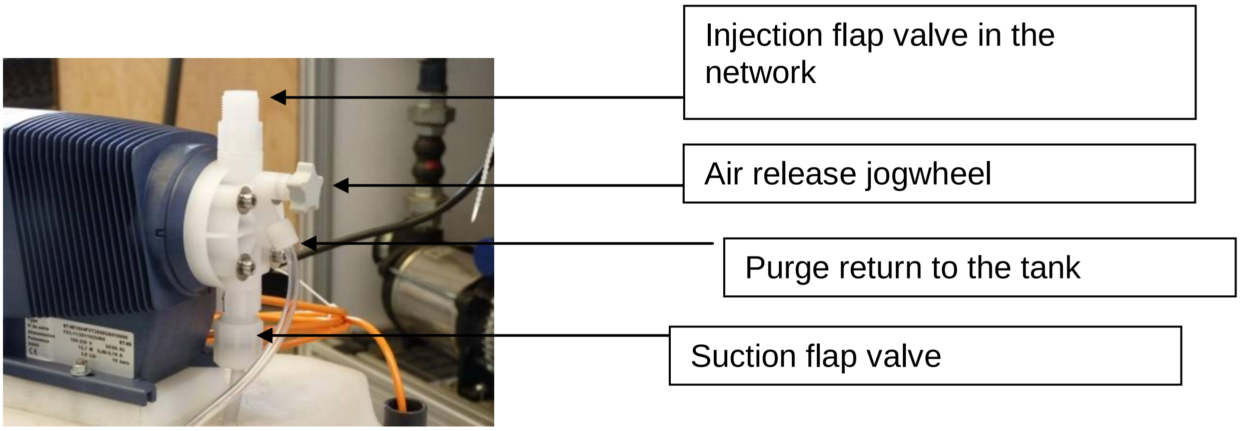
- Prepare the initial solution of chlorine: 1kg of HTH 70% contains 700grammes of chlorine. 10/0.7=14.3 therefore to obtain a litre of the initial solution :
    - Solution at 1% (10g/L) : pour 14.3g of HTH in 1L of demineralised water
    - Solution at 0,1% (1g/L) : pour 1.4g of HTH in 1L demineralised water
- Pour in 4 clean containers 1L of filtered water, then increasing doses of the initial solution at 0.1 % (1mL=1mg of chlorine).
- Shake for a few minutes and then let it mix away from light
- Measure the free chlorine with the help of a chlorine analyzer.

<u>The free chlorine measured should comprise of about 0.1 and 0.5 mg/L.</u> If it is outside this range of values, the test has to be redone, while adding or decreasing the quantity of the initial solution injected.

4. Setting and use of the liquid feed pump.

Model: electromagnetic liquid feed pump with a Beta membrane 3.9l/h to 10bar.
Given below is a simple user guide of the liquid feed pump. The complete manual is available with every M5 unit.





The rpm has an influence on the quantity of the product injected. The setting of the number of injections determines the number of injections carried out per minute. These two parameters allow for a fine setting of injection rate. Ideally a concentration of the injected solution should be adapted so as to have a mean range of these settings, which allows finer settings and a greater adaptability.

The liquid presence detector protects the pump in case there is no liquid in the reservoir. The pump may function without this option, it is therefore important to constantly inspect the level of the solution in the reservoir.

ATTENTION: the flow rate indicated on the pump is only given for reference for a service pressure on the network of 10bars. The expulsion of the M5 towards storage having not been equipped with a pressure control and being done at low back pressure, the charts cannot be counted on at 100% to carry out the setting of the pump; <u>the best way is to therefore personally measure the rate of injection</u>.

To do this, the time taken by the pump to suck a given quantity of the solution can be measured, following the given procedure:

- Injection unit connected at the exit of the carbon filter, air release jogwheel closed, rpm cursor at 50%, cursor number of injections on stop, suction unit plunged in a one litre graduated test glass filled with water.
- Start of filtration (water produced may be pumped to the service water tank), start the liquid feed pump by positioning the injection rate cursor at 100 (maximum speed).
- Check the quantity of water sucked in the graduated test glass in mm multiply by 60 to have a correct reading of the rate of the pump in 1h, on maximum speed.

The best is to do this calculation at an rpm of 50%, and not to further change the rpm, so as not to redo the calculation. It is preferable to modify the number of injections per minute.

1st start:

- Pump connected to the power, air release jogwheel opened, rpm cursor at 50, number of injections cursor on test.
- Let the pump release the air until water starts running through air vent.

Injection of chlorine:

- Prepare the chlorine solution in the reservoir of the liquid feed pump
- Start of filtration (the water produced will be directed to the storage tank)
- Start of the liquid feed pump with the rpm cursor on 50, the cursor of the number of injections to be set following the quantity of water to be produced.

It is necessary to regularly check the free chlorine rate in the storage tank, and adapt the settings if need be

Aquaforce 5000
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