SECTION 3

Filtration Packs

WAFF/2	Filtration Fittings Kit
WAFX/1	Fabric Kit
WAFUC/5	Upflow Clarifier Kit
WAFRF/4	Roughing Filter for T11 Tank Kit

Shipping Specifications:

WAFF/2	2.20 x 1.20 x 1.10m - GW: 590kgs
WAFX/1	Packed with FF/2Kit - GW: 34kgs
WAFUC/5	1.55 x 1.18 x 1.02m - GW: 429kgs
WAFRF/4	1.40 x 0.93 x 1.02m - GW: 258kgs

Filtration Packs

There are three different types of filter technique covered within this section, they are all used to aid the improvement in the quality of polluted water, ideally relying on gravity to provide a flow through the system.

Filtration Fittings Kit and Filtration Fabric Kit

The filtration fittings kit is used in conjunction with two T95 water tank kits less roof and two T70 tank kits including roof. The T95 tanks are used for raw water storage and are situated at the highest point of the tank chain.

Water is fed into the top of these tanks and drawn off from an outlet at the centre of the second layer, thus allowing larger particles to settle to the bottom.

The T70 tanks are the filter tanks and are fed via a ball valve arrangement from the T95 raw water tanks. Clean water is drawn from the base of the filter tanks, once it has passed through the gravel and sand media and the filter membrane.

The contents of the filtration fittings kit and fabric kit include all necessary valves fittings and pipework including flow monitor, sieves for selecting filter media and slotted drainage pipe for collecting the filtered water and delivering it to the treated water tank.

The pack allows for two filter chains to run in parallel so that a continuous flow of water can be maintained even when one tank chain is being cleaned.

Upflow Clarifier Kit

A raw water tank is used to store water that is to be treated, which is then pumped through a dosing unit where alum sulphate coagulant is added. This is then mixed in two 90 metre lengths of coiled flexi-hose to act as mixing flocculates. The mixture then enters the base of another tank which acts as the upflow clarifier.

A flock blanket forms at a predetermined level within this tank, the level being controlled by the height of a cone within the centre of the tank. Sludge is drawn off from a central sump. Water passing through the flock blanket percolates through ten layers of filter fabric before being drawn off at the top of this tank.

Water can then be stored and chlorinated in a separate storage facility.

Filtration Packs

Roughing Filter for T11 Tank Kit

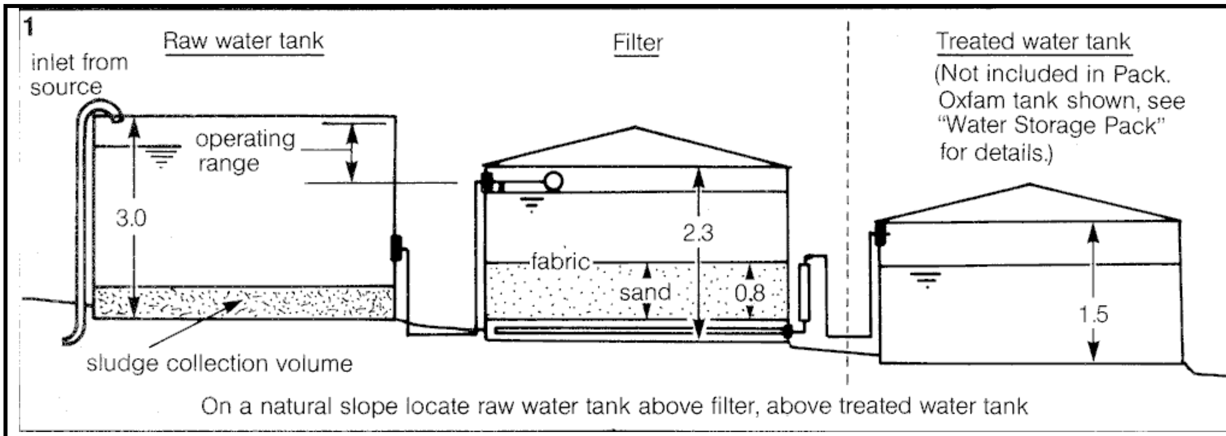
Pumped river water is stored in a sedimentation tank and drawn off through a floating suction arrangement into the various stages of pre-filtration.

The roughing filter consists of a water storage tank of traditional design with a corrugated mesh floor supported above the tank base by short lengths of french drain. These are placed on dishes so as to prevent perforation of the butyl liner. The various gravel layers are placed on top of the corrugated mesh filter, water is fed in below the mesh floor and taken out of the top of the tank.

The treated water is passed into a separate storage facility for disinfection.

Filtration Fittings Assembly Instructions

Siting:



The pack contains four tanks, 2 for raw water storage and 2 for filters. Incoming water is pumped to the raw water tanks flowing by gravity through the filter into a treated water tank which is not included within the pack. The location of the treatment plant is dictated by the proximity to water source, elevation above distribution area and proximity to distribution area, and the following criteria should be born in mind when making a choice.:

- The use of natural slopes should be considered when selecting a site
- An elevated earth platform may held achieve gravity distribution
- Firm ground is essential for the tank base
- A site well clear of debris is desirable
- Distribution pipe lengths should be kept to a minimum

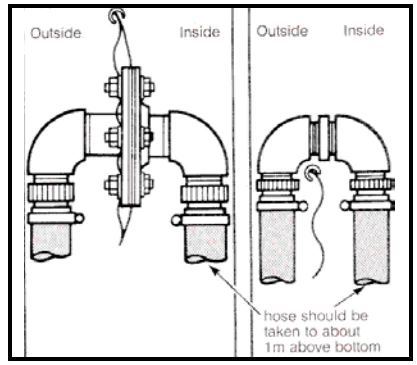
Tanks should be guarded against contamination and damage

Erection of tanks:

See Tank Installation Recommendations on page

Inter-connecting pipework:

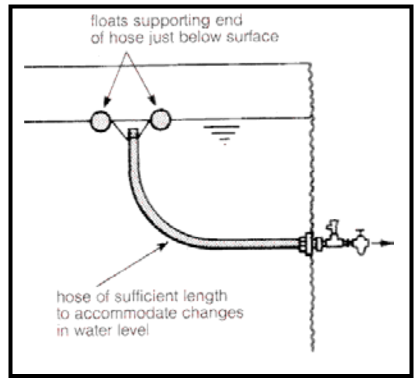
Fittings should be laid out and identified following the plan opposite. Connections between tanks and the source to the raw water and from the filters to the treated water tank are made using hoses and screwed connectors. All other threaded joints should be sealed using PTFE tape.



Hoses should be cut as square as possible and pushed onto connectors, they should be of sufficient length to ensure that strain is not put on the fittings.

Gatevalves are provided to close off the sludge drain outlets.

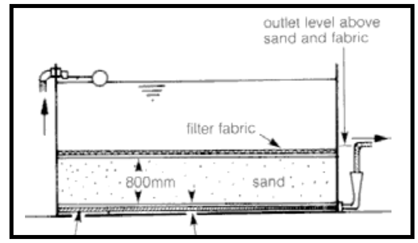
The inlet from the water source to the raw water tanks may be connected either by attaching an elbow to the top tank outlet or by attaching two elbows together and hanging the assembly over the edge of the tank. A hose should be incorporated hanging inside the tank to approximately 1 metre above the tank base to assist turbidity removal.



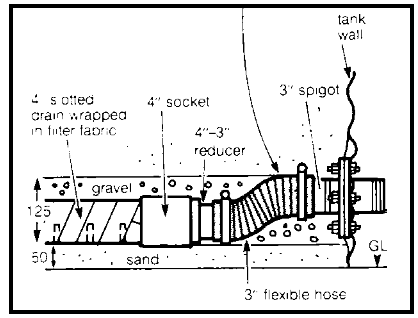
Removal of turbidity will be increased by using a floating outlet as illustrated. It will also be assisted by connecting raw water tanks in series as shown.

Sand Filter Construction:

The filter consists of a 50mm layer of sand spread on the base of the tank onto which a slotted drain is fitted to collect the filtered water. A filter fabric is spread over the surface of the sand and the water level is maintained at a depth of 1.1 metre

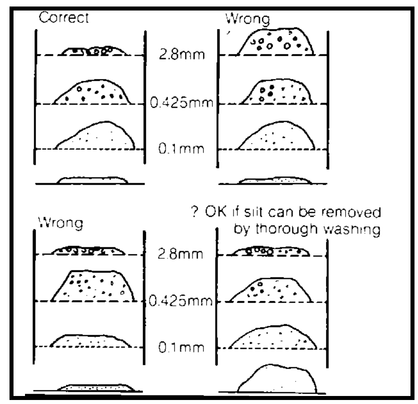


The drain should be surrounded with clean gravel and is connected to the outlet via a short length of 3” hose.



A suitable source of sand should be located and transported to the site.

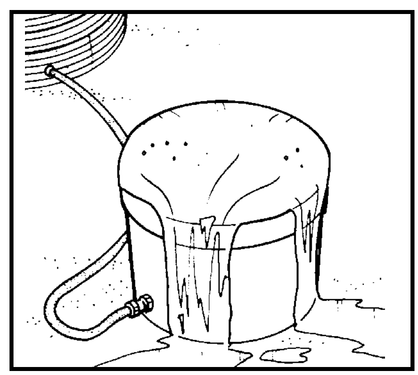
- Effective size between 0.15mm and 0.35mm
- Uniformity co-efficient less than 3
- Maximum size 3.0mm
- Minimum size 0.1mm



A total volume of 55m^3 of sand is needed for both filters, it should be carefully washed in the tank provided.

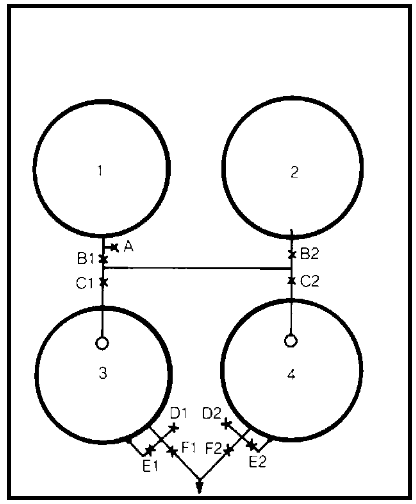
Fill the drum to the brim with sand and now water to carry silt upwards through the overflow for about 5 minutes or until the overflow appears clear.

The filters may be filled to a depth of 800mm, levelled off and covered with the filter fabric provided.



Commissioning:

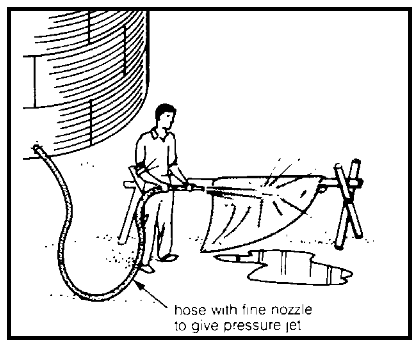
- Fill tank 1 with water, with all valves closed
- Connect 20mm hose from valve A to valve D1 and open both valves in order to commence back filling of filter 3 from below
- When water level in filter 3 has reached above filter fabric close A and D1 and open B1 and C1 so that filling can be completed with a float valve.
- Check that static water level in filter is just below outlet and bend arm of float to adjust
- Direct outlet hose from filters to waste. Open valve E1 to show head loss in transparent hose. Open valve F1 until float in flow meter reads 3,200 litres per hour
- Carry out same steps for filter 4 substituting valve B2 C2 etc. for B1 C1 etc.
- Maintain level of water in raw water tanks and adjust valves F1 and F2 to maintain steady outputs from each filter



The cleaning process will take several days to establish.

After the start of treatment a film of biologically active micro-organisms develops in the filter fabric and the top of the sand which breaks down the incoming decease carrying organisms converting them into water, carbon dioxide and other harmless chemicals.

The straining process will gradually block the fabric and sand, thus lowering the water level in the indicator tube. It will then be necessary to open the outlet valve to maintain the same flow through the filter.



After a period of 3 to 12 weeks it will be necessary to clean the filter, this may be done as follows:

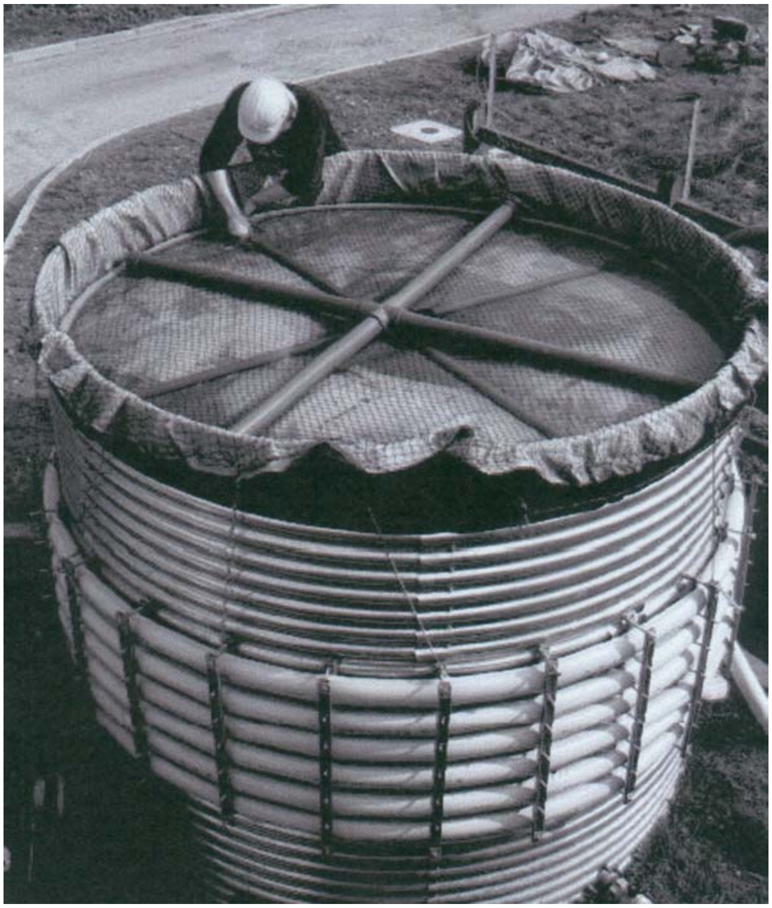
- Clean one filter at a time
- Close valve C, close valve F
- Connect 20mm hose to valve D and open valve, to drain water from filter until level is 200mm below surface of sand. Close valve D
- Climb into filter tank and roll up fabric strips which should be washed with a powerful jet until silt is removed
- It may be necessary to remove a thin layer of sand from the surface of the filter
- Replace filter fabric and refill filter sand by backfilling with water using filtered water from the other filters. Connect a hose from D1 to D2 and open both valves. When water level is above fabric open valve C and close D.
- Whilst microbiology is being re-established filtered water will not be pure so hose should be disconnected from the storage tank and allowed for flow to waste. Open valve F gradually over 24 hours until the flow of 3,200 litres per hour is indicated on the meter.

Daily Operation:

The tanks will require filling up every 8 hours, assuming they are on the same base level as the filters. Therefore it is normally necessary to pump water into the raw water tanks 2 or 3 time per day so that the water level does not drop too much.

Each day the outlet valves F1 and F2 should be adjusted to maintain the required output.

Upflow Clarifier



Wherever possible, water supplies in emergency conditions should be obtained from underground sources, by exploitation of springs, tubewells, or dug wells; as treatment requirements are minimal, because water from these sources is usually low in physical and microbiological contamination. However, in an emergency, such a source may not be available or it may take a long time to develop and the use of surface water from streams, rivers, lakes, or ponds may become necessary. Usually these surface sources are polluted with both physical and microbiological contamination.

The use of chemicals to assist in treatment of water is often necessary where water needs to be provided from these contaminated surface water sources, particularly in the early stages of an emergency. While the use of the roughing and slow sand filtration (see Oxfam filtration equipment manual), should be considered for post emergency situations as these treatment methods are more sustainable and appropriate, the relatively speed and efficiency of using chemical treatment methods justifies their use during the early stages of an emergency response. The principles of using chemicals for water treatment apply, to both household level (small scale) and treatment plant level (bulk centralised production), but the equipment and methodologies discussed in this manual apply primarily to bulk water treatment.

SPHERE recommends maintaining a chlorine residual of 0.2-0.5 mg per litre and turbidity below 5. Where water is not disinfected, there should be no more than 10 faecal coliforms/100ml at point of water delivery. The recommended figure of 15 litres / person / day is used for water supply and this figure is based upon; water requirements for food preparation and consumption, which require higher quality water, as well as water needed for clothes washing and bathing. Where nearby sources of water such as streams and rivers are available and the safe use of these for washing clothes and bathing can be managed, it may be appropriate and necessary to initially size the treatment system on a figure of 10l / person /day. This would provide the water required for food preparation and drinking, i.e. a minimum of 5 litres/person/day and additional water to allow for subsequent increased demand, perhaps due to population expansion. Oxfam uses two basic types/stages of treatment process for treatment of physically and microbiologically contaminated (surface) water:

1. Water (surface) with high physical contamination, i.e. suspended solids (which often has high microbiological contamination too), needs to be treated using plain sedimentation or a combination of coagulation and flocculation followed by (assisted) sedimentation. Thus the primary role of this stage of treatment is to reduce physical contamination – though it does also have a limited ability to reduce microbiological contamination.
2. Water (surface) with low physical contamination but with high microbiological contamination can be treated by disinfection only. Thus the primary function of disinfection is to eliminate microbiological contamination – there is little scope for efficient disinfection with chlorine where there are high levels of physical contamination (<5NTU).

   Note: physical contamination is due to suspended solids - approximate estimates of which are made by measuring turbidity (NTU).

COAGULATION

Coagulation with Aluminium Sulphate

Where high levels of suspended solids exist in the water, reduction of these is necessary in order to be able to disinfect effectively with chlorine and for aesthetic (looks/taste) reasons. Plain sedimentation of solids suspended in water is often slow, but is readily assisted by addition of a coagulant, which causes the solid particles to aggregate (stick) together and so to form larger masses, which settle more rapidly. While effective intake design and plain sedimentation can remove larger particles, colloidal (very fine) matter and organic material such as algae, is often difficult to remove without use of a coagulant.

The coagulant most commonly used by Oxfam is aluminum sulphate powder (Oxfam code FAS), which though not a very strong coagulant, does have the advantage that it can be air freighted easily and is quite commonly available in different parts of the world. However, it does have quite a narrow pH range, operating best between pH 6.5 and 7.5 and outside these limits its efficiency goes down and hence more has to be used to compensate. This occurs as the solubility of aluminium precipitate increases dramatically outside this range, which means that where pH is too high or too low, a floc precipitate will be unable to form easily.

As the addition of (acidic) aluminium sulphate to water lowers the pH (by reacting with its natural alkalinity), there is a risk that water pH may fall outside the optimum range. Where water has insufficient alkalinity or buffering capacity, additional alkali must be provided, usually by the addition of Quick lime, as this will raise the pH of the water. As a guide, around 7 – 14kg of lime added to 95m 3 of water will provide an appropriate level of pH adjustment, though clearly the actual amount should be determined as part of the jar tests.

Coagulants such as ferric chloride and ferric sulphate can be ordered and these operate in a wider pH range, but are more hazardous, making them more difficult to transport by air and they are less commonly available. Coagulant aids can also be used where water is particularly difficult to treat, even by coagulation and Oxfam is investigating the use of these as a start up option in acute emergencies to increase the effectiveness of aluminum sulphate.

Jar tests should be performed to determine the correct dose of coagulant to use. This will probably be in the range between 25 - 150g/m 3 for aluminum sulphate, but will depend upon the raw water to be treated. Details of how to undertake a jar test are given in Section C. There are three main stages in using a coagulant and these can be achieved in a variety of ways, choice being dependent upon equipment being available and local circumstances:

1. Dosing of coagulant
2. Floc formation - flocculation
3. Sedimentation

Dosing of Aluminium Sulphate

There are several options that Oxfam uses for addition of aluminium sulphate (and some other coagulants) to water:

1. By suction side dosing, using the suction side dosing kit (Oxfam code FASD). The coagulant is sucked into the water stream by the pump and undergoes rapid mixing in the pump chamber.

2. By use of a barrel erected at edge of, or in the tank to drip into inlet or outlet flow. Either a 200 litre-oil drum could be used or the equipment in the constant head dosing kit (Oxfam code FCCD).
3. By use of a precise chemical dosing pump (Oxfam code FDO), which is powered simply by a small hydraulic head (minimum of 1m). Though these have been thoroughly tested and a specification prepared for them (see section D), they are not stocked and this manual does not deal with them in any further detail.

Flocculation

Once the coagulant has been added (dosed) to the water supply, the right conditions need to be created to enhance the process of floc formation. Typically after a period of rapid mixing/injection into the water stream (as achieved with suction side dosing where water is churned through the pump chamber), the water/coagulant mix should be gently stirred to permit the smaller flocs to come together. Care must be taken not to have the flocs broken up by too strong mixing. Oxfam uses two basic methods for achieving this:

1. The use of a coiled pipe floculator, especially in conjunction with suction side dosing, is much more efficient way of achieving good flocculation and has been recently introduced to Oxfam.
2. Attaching a 2/3m length of hose onto a coagulant/flocculent tank inlet and fixing this along the circumference of the tank to create a circular stirring motion within the tank during the time in which water is being pumped/fed into the tank. This method is the traditional practice but it is less efficient than the coiled pipe floculator.

Sedimentation (coagulant assisted)

Once the coagulant has been introduced into the water and flocs are starting to form, a period of time is required for these to settle out of the water and form a sediment at the bottom of the tank, enabling clean water to be removed from the clear water above this. The use of specially designed sedimentation tanks complete with special inlet, outlet arrangements and other features, does increase the efficiency of sedimentation and allows a much greater level of process control.

However Oxfam or onion tanks can be used to provide a very basic sedimentation tank which will achieve the separation of most of the flocs from the treated water. Good dispersion of the aluminium sulphate throughout the water to be treated should be ensured before it is introduced to the tanks. Agitation of water in the settlement tanks must be minimised. Aluminium carry over into the water supply should be measured by checking the presence of aluminium with a comparator (available in Oxfam kit, code FMT) at the tank outlet.

Oxfam uses two basic methods of achieving sedimentation:

1. Simple sedimentation in batches, either in Oxfam tanks or Onion tanks. This is the simplest way of achieving this as it requires only basic equipment (i.e. tanks) though it provides little process control, with the risk of both suspended solids and coagulant carry over into the water supply. Once pumping of water into the tank has been completed, water will typically have to sediment between 2 and 6 hours (actual time determined by a jar test) and thus water production rates can be calculated accordingly.

2. Upflow clarification, which is an advanced sedimentation process, usually run on a continuous basis, which allows a considerably greater level of process control. The Upflow clarifier kit has been developed very recently to be able to achieve this and it warrants a further description because it is so new.

The upflow clarifier

Oxfam has developed a completely new piece of equipment for use with water treated by coagulants and this can be built inside an Oxfam T11 tank. The evolution and testing of the Upflow clarifier kit (Oxfam code FUC), which though incorporating treatment technology used in permanent water treatment plants, has a number of unique design features to enable it to be engineered to fit into a “rapid response package”. The upflow clarifier has been designed to fit into a complete water treatment system package, which combined with a pump, aluminium sulphate and chlorine dosing systems, offers a fairly rapid and very robust continuos treatment process capable of dealing with high levels of turbidity. The system will take between half and one day to set up, including time taken to erect the T11 tank and to reach stable operating conditions. The system has been tested and can produce between 7-9m^3/hr, with turbidity reduction from NTU500 to under NTU10, but actual production and performance is dependent upon raw water quality. As it is essentially a sedimentation system, it requires considerably less cleaning and maintenance than pressure filtration systems, which often take less time to set up, but soon loose this benefit with complex cleaning regimes that result when highly turbid water (much above 50 – 100 NTU) is being treated.

The various stages in the Upflow clarifier package are:

- Dosing of aluminium sulphate, either by having a Tee on the suction hose of the pump, or from the outlet of a raw water/sedimentation tank or hydraulic dosing pump, to dose the coagulant into the water to ensure that it undergoes rapid mixing.
- Flocculation by passing through 2 parallel coils of 3” layflat hose wrapped around the Oxfam T11 tank, each 30m long, which act as flocculators by gently stirring the water as it passes through the coils of the pipe.
- Sedimentation in the T11 tank in which the upflow clarifier is built, where some flocs should already be forming.
- Final filtration through a "polishing" fabric filter installed at the top of the tank. Water low in suspended solids will flow out from the top of the clarifier and through the tank outlet.
- Chlorination at the outlet, where chlorine is added by the constant head chlorine dosing device

Disinfection

Chlorine is the chemical most widely used for disinfection of treating drinking because of its ease of use, ability to measure its effectiveness, availability and cheapness. Under the right conditions chlorine will kill all viruses and bacteria, but some species of protozoa and helminthes are resistant to chlorine. WHO recommends adequate protection of the source as the most effective way of dealing with these more resistant helminthes and protozoa by preventing faceal contamination entering the water. Protozoa and helminthes are difficult to detect directly, but where these are thought be a risk, it may be necessary to resort to use of Membrane filters to strain out these organisms (the smallest of these are Giardia cysts at 7-10microns, while Cryptosporidium oocysts are 4-6 microns). However though these are able to produce high quality water, they will not provide much water quantity for a low capital investment and thus the cost of purchasing these may not be warranted where financial resources are limited and the risk of contamination is thought to be low. If the water to be disinfected contains a lot of suspended solids and/or organic matter (i.e. is highly turbid), it will have a high chlorine demand. WHO guidelines recommend that turbidity is less than 1 NTU for chlorination to be effective in destroying all bacteria and viruses, though 5 NTU is a more achievable limit and will be adequate in most cases. It is, therefore, desirable to remove suspended solids as much as possible before the chlorination process begins. This will significantly reduce the amount of chlorine needed and improve its efficiency as a disinfectant.

Oxfam uses chlorine in two forms; HTH - calcium hypochlorite granules (Oxfam code FCH) and slow dissolving chlorine tablets (Oxfam code FCT). There are several options that Oxfam uses for addition of HTH chlorine to water:

1. By mixing a 1% solution in a suitable bucket or container and adding to a tank on a batch basis.
2. By use of a constant flow dosing arrangement to drip 1% chlorine solution into outlet flow from a tank, as found in the constant rate dosing kit (Oxfam code FCCD)
3. By use of a precise chemical dosing pump (Oxfam code FDO), which is powered simply by a small hydraulic head (minimum of 1m).Though these have been thoroughly tested and a specification prepared for them, they are not stocked and this manual does not deal with them in any further detail.

The chlorine tablets (Oxfam code FCT), which give a slow release of chlorine over a period of several days, using the floating pot chlorinators (Oxfam code FPP) have quite specific usage where a slow release of chlorine is useful.

Coagulation and disinfection kits

This manual explains how to use/erect the following kits/water treatment chemicals (detailed kit lists are provided in section D):

Code	Description
FAS	Aluminum sulphate (1/2 tonne)
FASD	Alum suction side dosing kit
FCCD	Chlorine constant rate dosing kit
FCH	HTH chlorine powder
FCT	Chlorine tablets (tricloroisocyanuric acid)
FFP	Floating pot chlorinator kit
FUC	Upflow clarifier for T11 tank

The Upflow clarifier will require a T11 tank in which this is built, along with storage tanks for raw and product water storage, and a pump to operate the Upflow clarifier directly or to fill any raw water tank used. In order maximise the speed with which the Upflow clarifier can be deployed; it is recommended that the rapid response pump (PR2) and tank (TRR30) are used, though other Oxfam tanks and pumps are also suitable.

Code	**Description**
T11	11m^3 Tank sheets, liner and roof
TRR30	30m^3 Onion PVC tank
PR2-ALBS	2" Pump Sets, Petrol, Lightweight Pumpset Kit

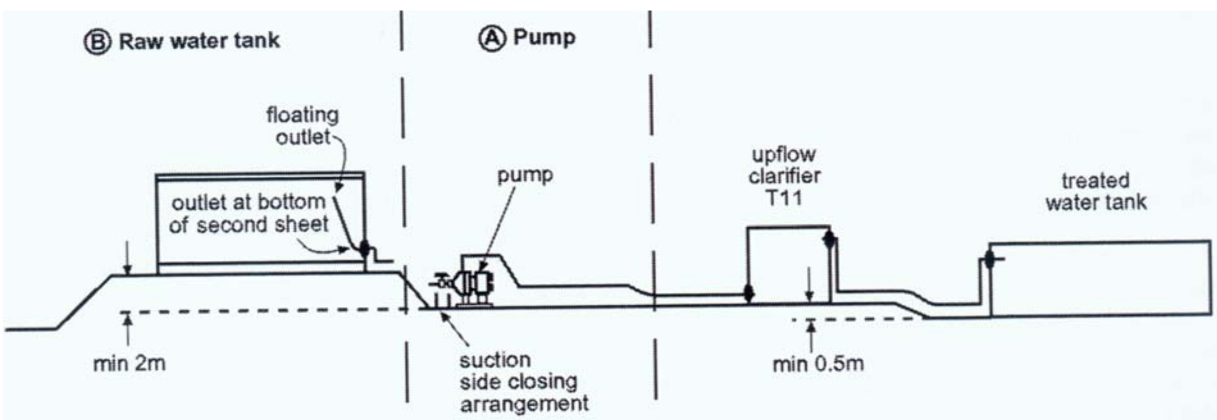
In addition specifications have been prepared for other kits which are much less often used, and though not stocked by Oxfam or their use explained in this manual, further advice can be sort from Oxfam GB emergencies department and they can be ordered if required.

Code	***Description***
FDO	*Chlorine/aluminum sulphate dosing pump*
FEG	*Electrolytic sodium hypochlorite generator*
FMF	*Microfiltration membrane for protozoa removal (specification in preparation)*

Where chemicals, particularly chlorine are being used for water treatment, it is recommended that some form of protective clothing is provided for operatives handling the chemicals. Though not a stocked kit, the following is available at short notice for this purpose.

Code	***Description***
XSO	*Vector/chemical safety outfit for 2 people*

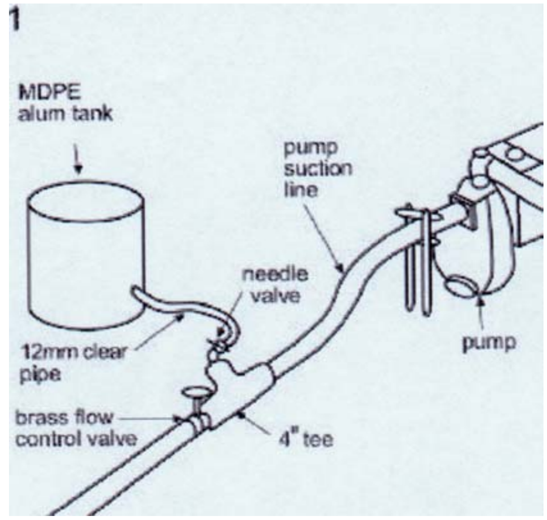
The layout diagram below shows the clarifier in use with a pump (option A), which can be phased out later and replaced with a raw water/header tank (option B).



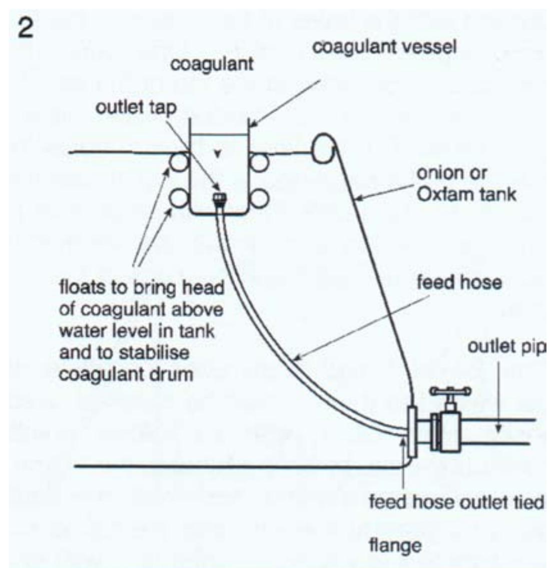
Coagulation

Dosing

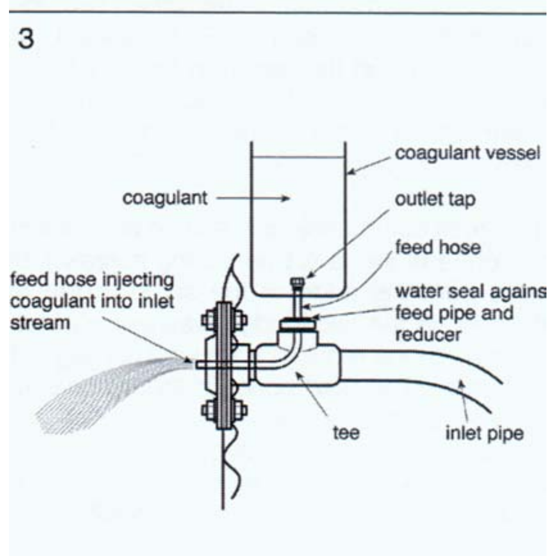
1. (Oxfam code FASD) The suction side doser consists of a coagulant vessel, with a needle valve attached at the outlet. The doser is suitable for use with all Oxfam pumps as the kit is supplied with 2" and 3" reducers for the 4" fittings. A gate valve is supplied on the line for pressure adjustment, which may be required for the smaller P2 and PR2 pumps. (Note that the longer the pump suction line, the greater the risk of air bubbles occurring within the raw water flow.) Though the use of the suction side doser is good as it allows rapid mixing of the coagulant in the pump chamber, continued use for periods of several months is not recommended as the caustic nature of the coagulant will progressively corrode the pump chamber. The overall control of dosing can be achieved by varying coagulant flow with the needle valve or coagulant solution concentration – flow will be estimated by timing the volume discharged from the coagulant vessel. This method of dosing is appropriate where water is being pumped directly into an upflow clarifier (see below) or into an onion or Oxfam storage tank which being used as a sedimentation tank.



2. Where the upflow clarifier is being used and water is being pumped to a storage tank before being emptied into an upflow clarifier, the suction side doser cannot be used, as mixing of the coagulant needs to occur immediately prior to entering into the upflow clarifier. Instead the coagulant vessel (in Oxfam code FASD) can be set up to float directly on the surface of the water and feed coagulant to the outlet of the tank. The end of the feed hose needs to be carefully tied at the entrance of the tank outlet. As the coagulant is released into the stream of water entering into the outlet, limited mixing occurs at this point before going into any coiled pipe flocculators. An optional in line mixer could also be installed to improve mixing.

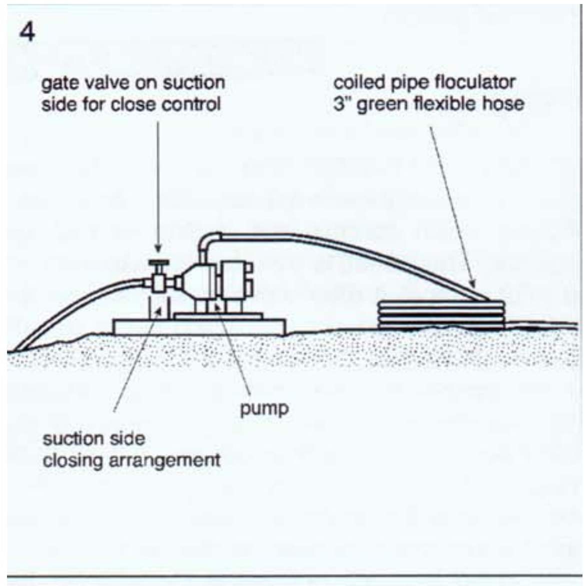


3. Alternatively where a simple form of coagulant assisted batch sedimentation in water storage tanks needs to be undertaken, the coagulant needs to be introduced into the flow of inlet water to provide some limited rapid mixing and the tank then functions as a sedimentation tank. This can be accomplished using the vessel in the chlorine dosing kit (Oxfam code FCCD) which can be positioned in the bracket attached to the top of an Oxfam tank, with the feed line projecting through the Tee and into the incoming water flow and coagulant introduced at a constant rate.



Flocculation

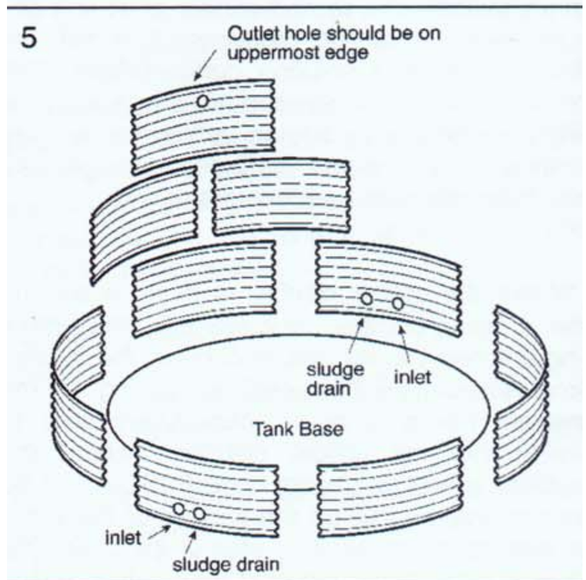
4. The coiled pipe flocculator can be made by coupling together several lengths of 3” green flexible hose. This hose is suitable as it has quite tight radius of curvature and as is it a standard piece of Oxfam equipment. The length should be determined to ensure that water has a residence time between 2 and 6 minutes in the coils.



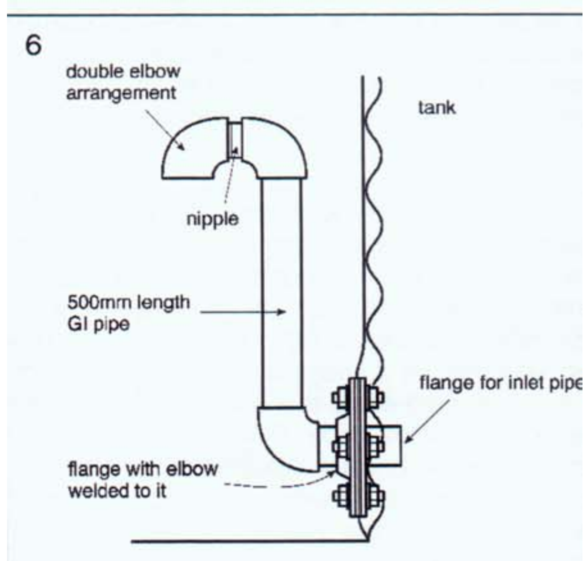
Sedimentation - Upflow clarifier

Assisted sedimentation in Oxfam or Onion tanks is not shown. Kit components are numbered as per the specification list in order to assist assembly.

5. The T11 tank should be erected as per the instruction manual for the T11 tank, but making sure that the two sheets with double outlet holes in, which are for the inlets and sludge outlets, are positioned with the holes at the bottom of the tank, directly opposite each other. One outlet hole should also be provided at the top of the tank in a position conveinent for treated water flow to storage tanks. Cut the liner to have 5 holes in it, four at the bottom and one at the top to match the inlets/outlets. (One tank sheet with single hole in it will remain unused and should be blanked off using a spare blanking sheet from one of the other sheets.)



6. The 2-inlet flange assemblies complete with elbow welded to them should be installed directly opposite each other, with the elbow pointing vertically upwards. In each of these, the length of GI pipe should be inserted and finally the double elbow arrangement screwed into the top to point downwards to allow water to enter tank with down flow velocity component. The other two lower flange assemblies can be completed and tightened up, using flanges from the T11 tank kit. The top flange assembly should have the inside face left off, until the funnel is positioned (see below 8).



7. The metal sump assembly should be positioned in the centre of the tank (measuring approximately 1 metre from the edge of the sump to the tank wall) lining up the two sludge washout sockets in the sump with the remaining unused flanges in the tank sheets. (The third outlet in the sump should be ignored as this will not be used.) The sump depth assumes that the bottom tank sheet is dug 50mm into the ground. On hard ground where excavation is not possible, the sump will need to raised b packing 50mm of wood or flat stones beneath it.

One of the sludge drain pipes, consisting of 1 length of 3" BSP pipe threaded each end, a 3" tee and another length of 3" pipe threaded one end, should be connected firstly into the flange, then the sump slid over the non threaded end of the pipe. The second sludge drain should be installed by screwing the length of pipe into the flange, adding the tee and finally adding the other straight section of pipe, by first sliding it into the sump socket, lining this up with the tee and sump socket, lining this up with the tee and screwing this into the tee. Ensure that these tees for draining behind the cone are aligned horizontally to allow maximum draining of the tank.

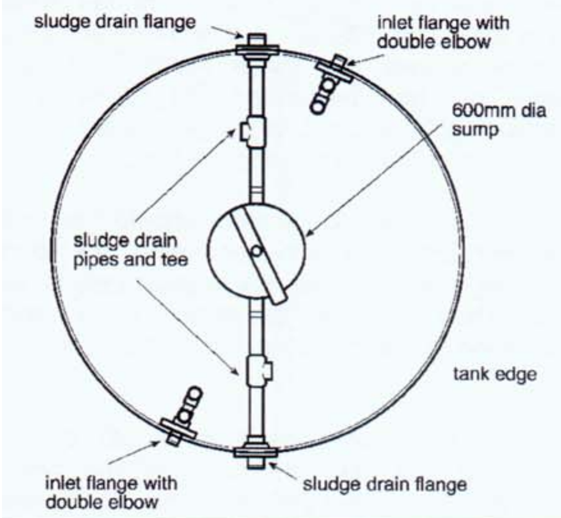
8. The PVC clarifier funnel should be unfolded and with one person standing inside the sump, this should be lowered by about 4 people, with the narrow end of the funnel lowered over the body of the person standing in the sump, until the edge of the funnel is about 100mm above the top of the sump. 19 barrel strainers should be attached to the sump, using the nut and bolt to fix these in an upright position.

The 19 barrel strainers should be adjusted so that they are screwed out to mid point of their adjustable length. They can then be connected from the eyelets in the funnel to the holes in the lip of the sump. (see diagram 10)

The four people should then pull up the funnel until it is fairly taut and the top section pulled over the edge of the tank. This is most easily achieved by pulling down the edge of the funnel with the special tool which hooks into 2 adjacent eyelets, while someone inside the tank lifts the funnel up off the tank lip using the pole/broom handle. Working progressively around the tank, the funnel can be slowly eased into place, till around 100- 150mm of the funnel material is folded down over the outside edge of the tank. This should then be tied off with the elastic (bungy) straps provided, to the eye-nuts on the tank sheets and in the funnel.

9. The PE retaining hoop should be assembled on the ground by using the four pieces of 50mm PE and the threaded plastic rod complete with backnuts. The back nuts should both be screwed into the centre of the threaded rod to allow maximum insertion into the PE pipe. The funnel retaining hoop should be lifted into the tank and positioned in a corrugation about 400mm down from the top of the tank (see diagram 12). Once 10 the correct position in a corrugation has been located, the backnuts should be screwed in opposite directions to expand the hoop firmly into a corrugation. This will have the effect of tightening the funnel even more. Now the funnel should have the outlet hole cut in it and this should be positioned over the flange studs. The outlet flange can now be added and tightened up. Positioning the second flange gasket adjacent to the funnel before positioning the flange.

7



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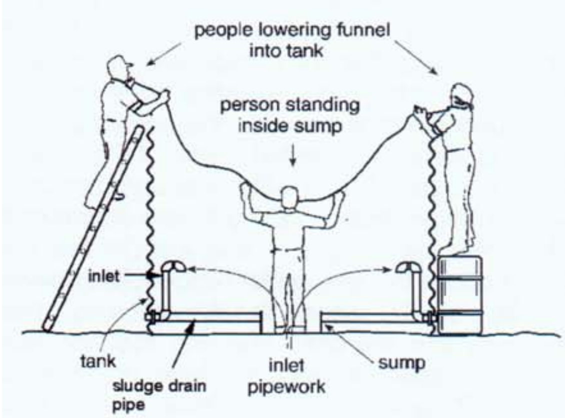

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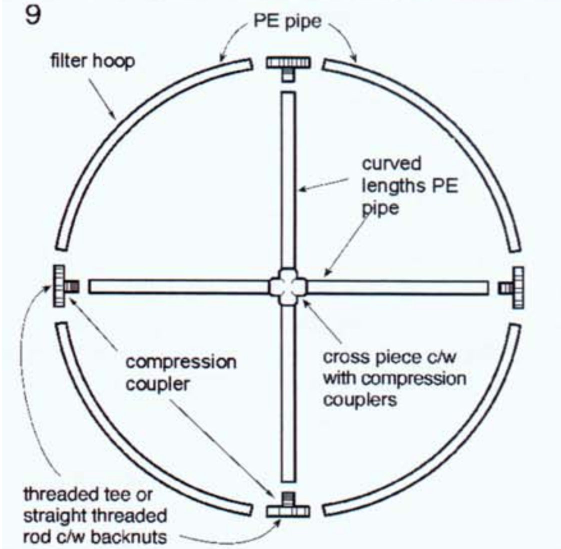
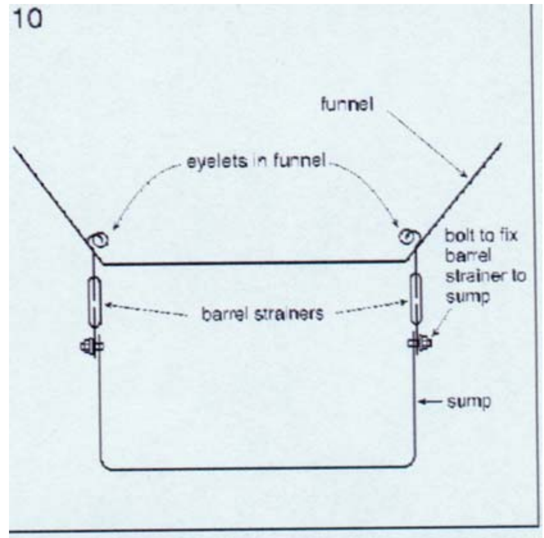
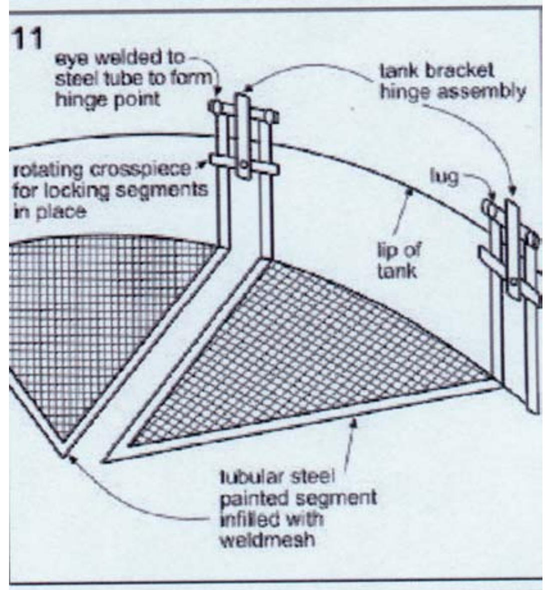


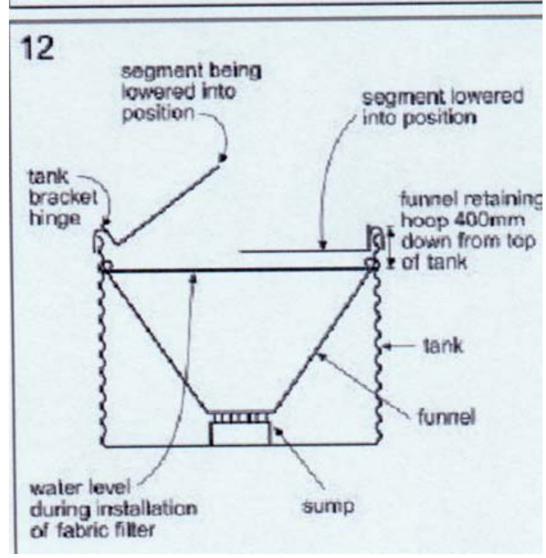
10. The person inside the sump should then make final tensioning adjustments using the barrel strainers to ensure that the funnel fabric is very tight. Then with the assistance of a ladder positioned inside the sump, this person can climb out. Now the funnel should have the outlet hole cut in it and this should be positioned over the flange studs. The outlet flange can now be added and tightened up, positioning the second flange gasket adjacent to the funnel before positioning the flange.

11. The six tank hinge assembly brackets should be loosely fixed to the vertical tank sheet joints. Each of the tubular steel painted segments should have two of the steel tubes complete with eye welded to an end screwed into place. The segment with the outlet pipe support bracket attached (see 15. Below) should be positioned opposite the tank outlet. Then the other segments can be lifted into place and by moving the tank hinge assembly bracket from side to side, the eye on each side can be hooked over a lug attached to the brackets. Note: Ensure that the two segments with the attachment for overhead beam ate placed opposite each other. Once all segments are in place brackets can be bolted tightly to the tank so they don't move.

12. The fabric polishing filter should only be positioned once raw water has been run through the system and the height of the floc blanket determined (see operation and maintenance below). Once this has and the optimum flow set by adjusting the inlet gate valves accordingly, the fabric-polishing filter can be positioned. The water level in the tank should be lowered below where the filter should be positioned, by draining the tank in preparation for filter installation. Lift the 6 segments so that they are all folded out of the tank. Unfold the fabric polishing filter and layout over the top of the tank, cutting 100mm long slots where the hinge assembly brackets occur and tying ropes to the edge of the fabric to keep it folded over the lip of the tank. Fold the segments into the tank, keeping the filter fabric taut on the underside of the segments. Tie the fabric edge to keep it falling into the tank (otherwise progressive blocking of the fabric may result in water by passing the fabric filter if the edge falls into the water).







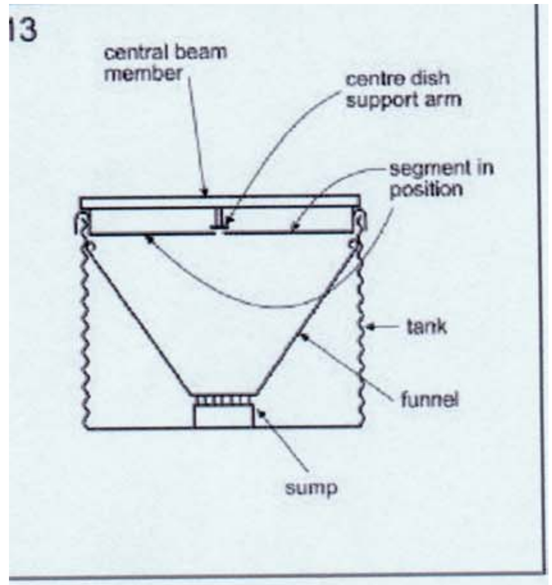
13. On each of the six tank assembly brackets, rotate the crosspiece to lock the segments in place. Assemble the central beam member by attaching the central dish support arm to it and lower this into place, making sure the central dish covers the ends of the segments and bolt the central beam onto the two tank bracket hinge assemblies. This assembly will help prevent the segments lifting in the centre of the tank when the system is in operation.

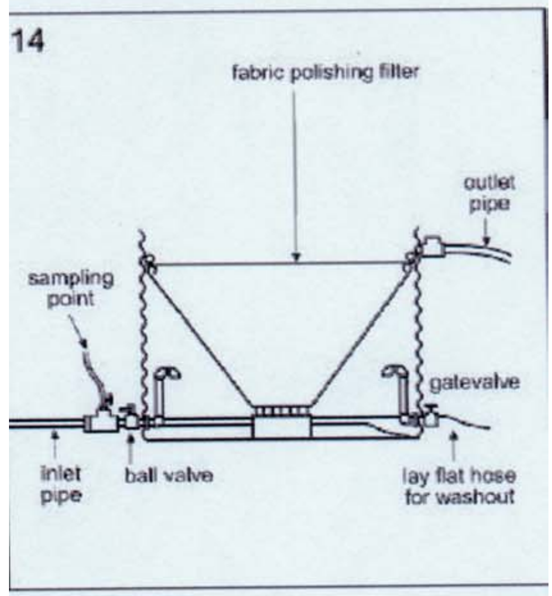
14. Install the gate valves (from the T11 tank kit) onto both inlet flanges. Into one of these valves insert the water sampling arrangement, consisting of a 3” nipple, 3” to ½” reducing tee, c/w with ½” ball valve and ½” hose.

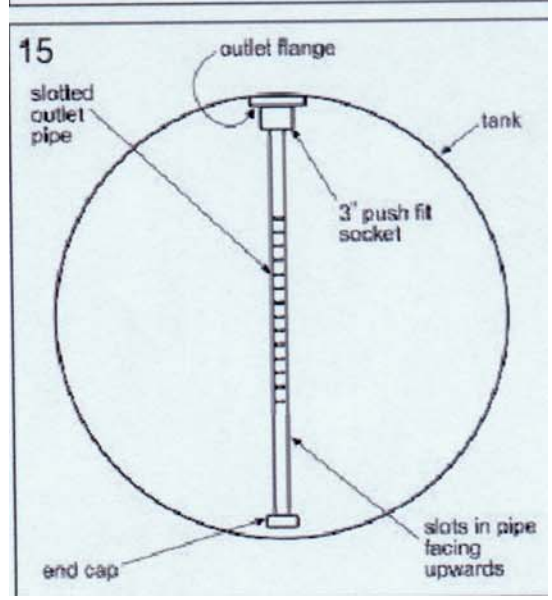
The outlet flange should have a Tee fitted, which is provided with the constant head chlorine dosing device. Then the length of discharge hose can be connected and laid out to storage tanks. (Water can be sampled at the end of the outlet hose where it enters into storage tanks.)

Attach the ball valves onto the outlet flanges for the sludge washouts, ensuring the handle in its open position is pointing away from the tank, and attach the two short lengths of layflat hose to each of these.

15. The 3” BSP outlet socket can be screwed into the flange. The slotted outlet pipe can be slid through the bracket attached to the central dish support arm, also through the bracket attached to the segment and pushed into the outlet socket, keeping the slots facing upwards.

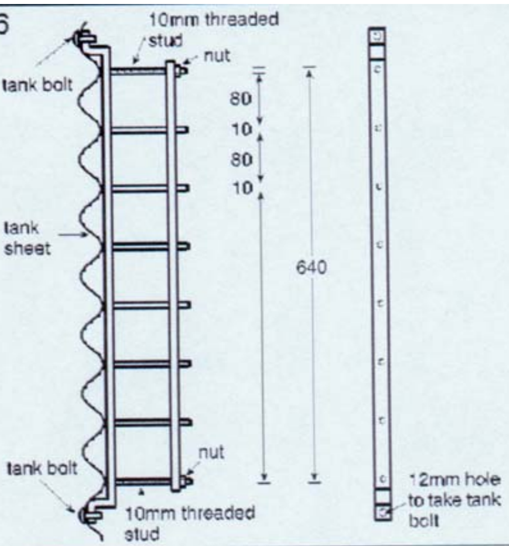






16. The eye nuts can be removed as the funnel is now fixed in position and the 24 layflat hose brackets can be bolted onto the side of the tank adjacent to the second sheet of the tank using the bolts on the horizontal joints. Enough brackets are provided to fix onto every first and second tank bolt, while every third bolt will not have bracket fixed. 48 internally threaded collars are provided to screw onto the tank bolts, where the top and bottom of the layflat crimping brackets are to be fixed to the tank. These
effectively extend the length of the protruding tank bolt to allow the brackets to be securely fixed top and bottom. The adjustable face of this bracket should be
removed in readiness for the hose to be installed. The two long lengths of layflat hose can be unrolled and the 3” hose connectors inserted into each end and one end of each of the layflat hoses inserted into the Tee, which should be positioned according to where the raw water will be provided from.

16



The layflat hose should then be wound around the tank in opposite directions using the hose brackets to “stack” the hose up the side of the tank. Finally the other ends of the hoses should be connected to the clarifier inlets. Care should be taken to ensure that layflat hose is not badly folded or crimped as this will decrease flow and increase head loss. The adjustable bracket face should be fixed in place and this tightened up to leave a gap of about 60mm which will crimp the layflat hose slightly, which assists in Floc formation.

17. The constant head chlorine-dosing device should now be installed. Finally a pump (Oxfam code PR2 or P2) can be connected to the clarifier, complete with suction side dosing arrangement (diagram 1); alternatively the clarifier can be fed water from a raw water tank with aluminium sulphate doser set up (diagrams 2 and 3). The diagram opposite shows the completed tank arrangement.

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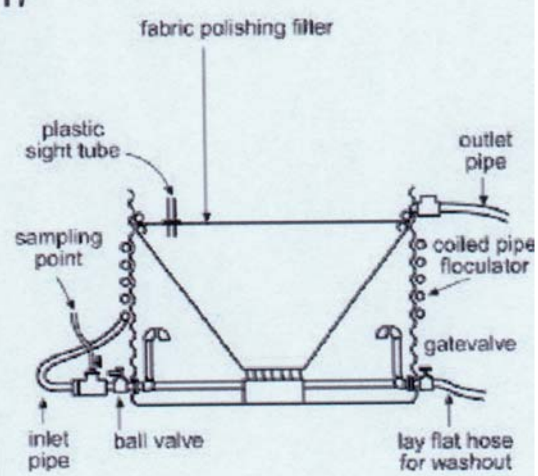
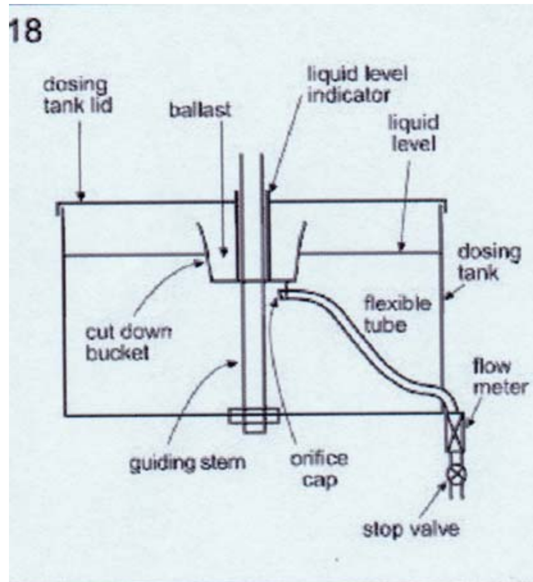
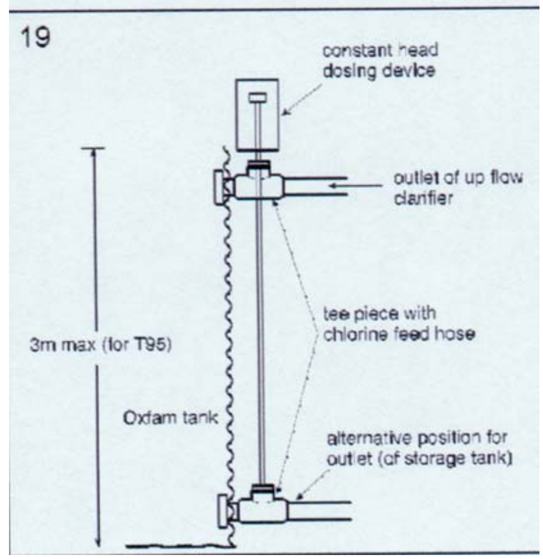


Disinfection

18. Remove constant head dosing kit (code FCCD) from packing case and knock sides off case and runners off the bottom. Make up the 2 Tee sections of frame by bolting each shorter piece to the top of the longer piece and then bolt the two tank brackets to these. Using the longer bolts, fix the packing case base to the top of the Tee sections. Slide the frame assembly onto the edge of the Oxfam tank and using the special tank bolt/nut, fix the bottom part of the bracket to two of the horizontal tank nuts. In the dosing device, insert the bucket guide and level indicator into the hole in the centre of the tank and position dosing tank on top of plywood base, ensuring the backnut on the underside of the tank fits into the hole drilled into the plywood. Flow control in the constant head dosing kit is regulated either by the valve, by the amount of ballast placed in the bucket (use plastic bags provided) or by the orifice cap size. 3mm and 5mm orifice caps are provided and these can be screwed into the pipe at the base of the bucket.



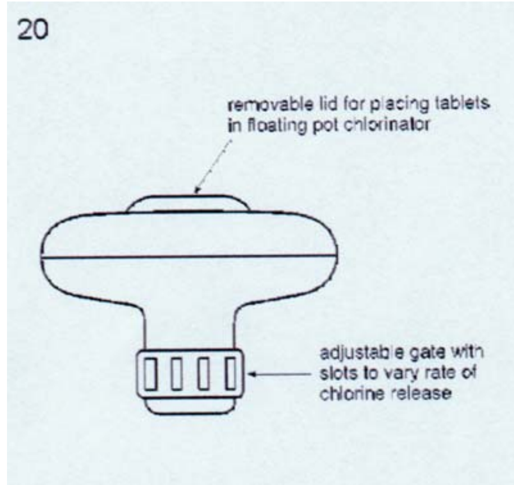
Using the self tapping screws, fix the two flow meters with on/off valve to the side of the frame. Next, using flexible hose, connect the tank outlet to whichever flow meter is required and fix a length of hose from the flow meter to the 3" Tee. This device can be either attached to the outlet of an upflow clarifier (at top of tank) or to an outlet of a water storage tank (at bottom of tank). Where onion tanks are used, the device can be floated directly on the water (as per diagram 2 above) and allowed to discharge from this position, though care will have to be taken to ensure that the correct residual time can be achieved.



19. The HTH chlorine powder (Oxfam code FCH) can be used with the constant head-dosing device (Oxfam code FCCD), which should be attached to the edge of the Oxfam tank. This device can be either attached to the outlet of an Upflow clarifier (at top of tank) or to an outlet of a water storage tank (at bottom of tank). Where onion tanks are used, the device can be floated directly on the water (as per diagram 2 above) and allowed to discharge from this position, though care will have to be taken to ensure that the correct residual time can be achieved. Alternatively, chlorine can simply be batch dosed by mixing in a bucket and added to tanks (not illustrated).

20. The floating pot chlorinators (Oxfam code FPP) are for use with the Chlorine tablets - tricloroisocyanuric acid (Oxfam code FCT) and dose rate can be adjusted by use of a "gate" for the slots on the side, as well as by varying the amount of tablets used in the pot chlorinators. Suspend the holder plus chlorine tablets in the water in a position which should give sufficient contact time to achieve a chlorine residual, but away from the turbulence caused by the inlet pipe. Initially use three tablets for a T45 tank (four for T70, five for T95). These will need replacing in 7-14 days. Check residual chlorine

levels daily and adjust the number of tablets if necessary. ***It is not recommended to drink water chlorinated with these tablets for more than three months***.



Coagulation and Flocculation

Determining the optimum dose – the Jar Test

The purpose of the jar test is to determine the correct dosing concentration for an individual application where effective flocculation is employed. Pouring a bucketful of aluminium sulphate solution into a tank of water and stirring by hand is not "effective flocculation" but is sometimes required in extreme emergencies.

This will almost certainly lead to excessive aluminium sulphate residuals in the product water (WHO recommends a maximum of 0.2mg/l) although excessive aluminium should not form major threats to community health in the short term. Every water treatment application is different in terms of raw water quality, hydraulic conditions and even coagulant batch properties. Optimum conditions for good flocculation are determined not only by the optimum dose of coagulant, but also by the physical conditions of coagulant dosing and flocculator hydraulics.

Calculations can be made to design efficient flocculators, principally determining retention time and degrees of mixing. These considerations should then influence the jar test procedure adopted and these undertaken in a way to mimic conditions in the water treatment system. It has been found that a dining fork can be used to provide a stirring efficiency equal to that achieved by laboratory equipment, but it must be stressed that other cutlery and kitchen implements are not as effective for reasons related to basic hydraulics.

Procedure for undertaking a jar test:

1. **Make up 1% alum solution**

- 1% alum solution is formed by dissolving 10 grams of granular alum into 1 litre of clean water (mix in less than 1 litre then make up to the final volume). This solution will be referred to as a 1% Oxfam Alum Solution. (To allow measurement by volume to be interpreted as a weight: 1 litre of granular alum weighs 1100 grams and then by use of measuring cylinder in the Oxfam code FMT kit) A baseline alum solution concentration is as follows:

  1% Oxfam Alum Solution = 10,000 mg/1 (10,000ppm) Alum Solution

2. **Collect equipment for jar test, (as in Oxfam code FMT kit):**

- Turbidity is best recorded on a turbidity meter to enable fine distinctions to be made between similarly turbid water.
- The Turbidity tube, Oxfam code FTT and as found in DelAgua kit (Oxfam code FK) does not provide accurate readings, but is probably all that is available.

  Equipment required:
  - 6 No.1 litre jar (beakers)
  - Turbidity meter or turbidity (Jackson) Tube
  - Timer or stopwatch
  - Pipette or fine measuring cylinder
  - Litre measuring cylinder
  - Supply of 1% Oxfam Alum Solution
  - Raw water sample container (at least 6.5 litres)
  - Dining fork for stirring

3. Dose Jars

- Pour appropriate quantities of 1% Oxfam Alum Solution and raw water into test jars to produce the desired concentrations of coagulant.
- Initial starting concentrations of Oxfam Alum Solution in test jars is recommended as 50, 60, 70, 80, 90, 100 mg/1 (i.e. 5, 6, 7, 8, 9, 10ml of 1% Oxfam Alum Solution for each litre ofraw water).

4. Stir Jars

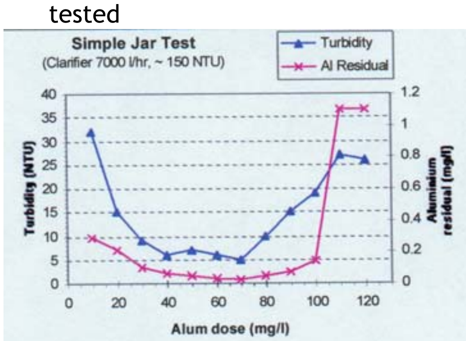
- Stir briskly with a fork for a time equivalent to the transit time in the system (for the spiral pipe flocculator about 2 mins). Periodically stir each jar to ensure that a "whirlpool depression" is continuously visible on the centre of each test jar's water surface.
- Stir gently for a time equivalent to the residence time of the flocculation tank (for chamber behind the funnel in the upflow clarifier typically approx. 30 mins). Periodically stir each jar to keep the emerging flocs gently moving, they should be visible in the water of every beaker, moving gently.

5. Monitor Turbidity

- Allow to briefly settle and then carefully take water samples from the top of each jar to measure turbidity.
- Take turbidity readings for each jar before commencing the test and then at test run times of 2.5, 5, 10, 15, 25 and 40 minute intervals, which requires 6 jars of each concentration to be made up.

6. Plot Results (refer to graph)

- Plot the turbidity results on an X-Y graph with turbidity in NTU as the Y-axis (vertical) and Alum Dose in mg/1 as the X-axis.
- Produce graphs on the same X-Y axes, one for each "test run time" interval (6 No.)
- The graph with a regular profile (typically "bucket shaped") and which also contains the lowest turbidity value on the Y-axis should clearly indicate the optimum coagulant concentration.
- If the highest or lowest concentration tested appears to be the optimum value, repeat the jar test for further coagulant concentrations which induce this value in the middle of the range of concentrations tested



7. Uncertain Results

- Repeat the test to eliminate experimental error. Check all calculations and graph plots.
- Test pH value of the raw and product water to determine if pH adjustment is necessary. The jar test can be used to find the lime or acid dosing rates required. The resulting range of pH values should extend from 4.5 to 8.5. After stirring, flocculation and sedimentation, the optimal pH value is determined from the samples.
- If pH needs to be raised, lime should be added to keep the pH within the optimum range of 6.5-7.5 for aluminium sulphate use. Alternatively if no lime is available or for highly alkaline waters, use extra alum to compensate, but monitor alum carry over in treated water (using comparator in Oxfam code FMT kit).
- Try water treatment making a best guess for coagulant levels on the evidence available.

Dosing Rates

Once the optimum dose has been established, it is then necessary to determine the actual dose rate, i.e. the rate at which aluminium sulphate solution is put into the water stream. In addition the total volume of solution that is required for the tank, which clearly depends upon tank size. The table below should give some guidance on this.

Although the jar test is conducted using a 1% solution, dosing should be made using 10% aluminium sulphate solution. This concentration may need to be raised if large volumes of water need dosing or lowered if very small quantities of aluminium sulphate solution are being used such that the rate of dosing is outside the range of the flow meter on the solution side doser. However it should be noted the while good quality grade aluminium sulphate will dissolve into water at concentrations of up to 20%, where aluminium sulphate is purchased in country and it is a poorer grade, it may be that solubility will be lower than 10% and this should be taken into account.

For a 10% alum solution

Req. dose of alum	Dose rate per 10m3/hr of water flow	Dose rate per 50m3/hr of water flow	Dose rate per 100m3/hr of water flow
30mg/l	3l/hr	15l/hr	30l/hr
150mg/l	15l/hr	75l/hr	150l/hr

The rate of water flow (and thus solution flow) will be greatest at maximum pump output. Details of pump output, which depends upon pumping head are given in the pumping manual, but as a guide the following maximum outputs for pumps at very low pumping heads are possible:
PR2 28 m 3 /hr, P2 38 m 3 /hr
P4/P4H 90 m 3 /hr

Example
The optimum dose rate for a water to be treated has been determined by jar test to be 30mg/l. A suction side doser is to be used with an Oxfam P2 pump, which is pumping into an Oxfam T70 tank, where coagulant assisted sedimentation will occur. What flow rate should be set on the suction side doser and what total volume of alum solution is required?

A P2 pump will pump at max 38 m 3 /hr at zero head, so dose rate of alum will have to match this water flow rate. From the table above for a dose of 30mg/l, a dose rate of 3 1/hr is required for a 10m 3 /hr, i.e. 11.4l/hr for the P2 pump operating under these conditions. This will require the appropriate adjustment of the needle valve on the suction side doser and this should be set to achieve this flow by estimating the rate of discharge from the coagulant vessel on a volume basis.

The T70 tank has an effective volume of 70m 3 and will require around 21 litres of 10% alum solution to dose the tank.

Coiled pipe floculator
Floc is an insoluble metal hydroxide precipitate, produced by the reaction of the coagulant salt (alum) with hardness in the water and which incorporates colloidal or fine particles. It appears as a cloud of small “flakes” within the body of the water. A simple coil of pipe can provide the velocity gradients, (i.e. by creating a circular flow, this induces greater shear in the water and encourages better floc formation) retention times and general conditions suitable to support flocculation, although as with other methods, the raw water quality can influence the overall performance.

The role of the flocculator in a treatment system is to cause collisions between particles in raw water, to which a coagulant has been added, encouraging the build up of floc.

There are only two means of effectively controlling the coiled pipe flocculator, either by adjusting the throughput rate, which affects the velocity (Q=A.v) or varying the length of coiled pipe, which affected the retention time. The standard design approach for a flocculator involves calculating the following: Time in flocculator , recommended value $2<t<6$ minutes. The choice of two parallel lines of 75mm hose is made to keep head losses to a minimum and to ensure symmetry of operating conditions when used with the upflow clarifier. However a single line of 3" green flexible hose could be used in conjunction with a sedimentation tank. The spiral pipe flocculator is a low energy input system, often requiring a strong coagulant, but tests with Aluminum sulphate combined with the coiled pipe flocculator have proved successful.

Sedimentation

Where water treated with a coagulant is undergoing simple sedimentation in an Oxfam or PVC tank, the system will be operated on a batch basis. A typical daily operation schedule might be as follows:

Activity	**Typical Duration**
Pumping/gravitation of water into tank	Depends upon tank size and discharge rate of pump at tank inlet
Sedimentation	2 – 6 hours but depends upon water quality
Emptying treated water into final chlorination tanks	½ - 2 hours depending on tank size and elevation differences

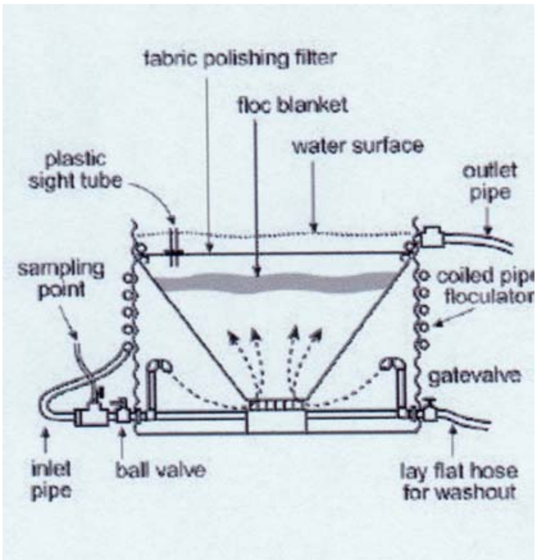
Very often, it will only be possible to get two or perhaps three batches of water from each tank per day and in order to satisfy water demand it may be necessary to run two or more lines of tanks in parallel, so that one can be delivering water for chlorination while another is being filled.

Regular cleaning of the tanks to dispose of the sludge will have to be undertaken, the cleaning interval depending upon the level of sludge buildup in these tanks, which itself is dependent upon raw water quality. It may be necessary to periodically empty the tanks manually by having a person enter the tank to bale/brush floc out of the tank – operatives should be assigned Wellington boots and gloves for this task. Sludge disposal should be undertaken safely and where large volumes are being generated, separation of the floc from as much water as possible using gravel filter beds will help reduce the sludge volume and allow it to be dried before landfill disposal.

Description of Upflow Clarifier Treatment Process

It is useful to include an outline of basic functioning of the Upflow clarifier system process in order to understand how best it is operated. Where an Upflow clarifier is used with a pump, the coagulant is introduced into the pump using the suction side dosing arrangement where Vigorous mixing occurs in the pump chamber. The next stage of the process is to pass water through the coiled floccualtor, which consists of 2 parallel coils of 75mm layflat hose, each 30m long, which act as flocculators, by gently stirring the water as it passes through the coils of the pipe. The pipe is coiled around the T11 tank to provide a circular motion and to keep the pipe in a place to minimise risk of damage. Furthermore this allows the layflat hose brackets to crimp the layflat hose to induce flow patterns that also encourage better floc formation.

By the time the water enters into the T11 tank in which the upflow clarifier is built, some flocs should already be forming. Further slow mixing occurs when the flow enters the tank at the inlets and this subsequently drops down and passes between the sump and the funnel, before starting to rise again inside the funnel. As the water rises up the ever widening funnel, the velocity drops and a point will be reached whereby up-thrust on the floc will be equal to the effect of gravity, such that the floc will stop moving upward and a floc blanket will be formed at this point. As this blanket builds up, further flocs will become trapped in the underside of this blanket and it will thicken with time. Water with considerably reduced floc loading will flow out from the top of this blanket and through the fabric polishing filter, which is present to remove small amounts of floc carry over and then to the tank outlet. Eventually there will be a need to drain down the system to prevent the blanket becoming too thick.



Operation of Upflow Clarifier

The first step in determining the best operating conditions for the clarifier is to determine the aluminium sulphate dose, by undertaking a jar test (see above). The optimum dose is dependent not only on the characteristics of the raw water, but also on the hydraulic conditions of the treatment process. Having determined the correct dose for the coagulant, then a solution of this should be made up.

Once this is established, the pump/raw water tank can be connected up to the coiled flocculator and the solution of coagulant should be dosed into the pipeline, upstream of the coiled flocculator and water run into the tank. It will take about 60 minutes to fill the tank. By the time the water level has filled the tank to the top of the tank funnel, a floc blanket should be forming. The blanket level is affected solely by the flow rate. It is suggested to start flow off at 6500 litres/hour, allowing blanket stability to be reached, before flow is increased to bring the blanket level just below the top edge of the funnel hoop. As the flocs are light and increases of flow cause surges, it will take about 1 hour for the system to run in. It is also recommended that the jar test be repeated if possible at this stage by incorporation of the actual flow and retention times and dosing rates Altered accordingly if required. It should be noted that changes in raw water quality, e.g. after rains, may necessitate changes in the flows through the Upflow clarifier and indeed the dosing rate for the coagulant too.

Breakthrough of the floc blanket may be caused by too high a flow or an incorrect coagulant dose and results in high turbidities, suspended solids and residual coagulant salts in the effluent water. Visual checking of the height and condition of the blanket as flow increases is an important and simple means of assessing the situation, thus a close inspection of the water above the blanket and from samples taken from the outlet, should reveal if there is any floc carry over. If there is a significant amount, then this may necessitate reducing the throughput into the system. A smaller quantity of floc carry over will be retained on the fabric-polishing filter, in which case this can be positioned without further flow adjustment.

Where possible the upflow clarifier should be operated overnight if maximum water production is required and this may require the use of header/raw water tanks if pumps can not be operating continuously ($10m^3$ of storage volume is required for each hour when pumps are not operating). Where it is operated on a batch basis, then the floc blanket will have collapsed from the previous day's operation and this will need to be reformed when the system is started up again. This will require removal of the fabric filter to watch this occurring and the initial product water may need to be run to waste, before the fabric tray is replaced and water made available for supply.

Every so often the system will need de-sludging using the sludge outlets at the bottom of the tank (detailed investigation is currently under way to determine the operating envelope more precisely). This waste needs to be disposed of in a manner that does not contaminate water supplies or undermine stability of tank foundations. The easiest method in the short term will be to dig a suitable drainage channel to take the water off to a drainage pit, where the liquid load can be separated out from the solid flocs, these can be then be dried and disposed of by burial in plastic bags/sheeting. At longer time intervals the funnel may need removing in order to manually clean out the entire tank.

The fabric filter will need cleaning occasionally and this should be removed and thoroughly washed down with a high pressure jet of water from the pump and scrubbing motion. A second fabric filter is provided for use while the first is being cleaned and as a spare.

If clarifiers are used in the water treatment system it should be remembered that their performance improves over a "running in" period of several hours, before hastily concluding that flocculation is unsuccessful. Under optimum conditions of raw water quality, throughput flows of 7 - 9 m 3 /hr or more are possible. Such a system depends on operational knowledge developed under local circumstances and will vary from site to site. In addition, because of the far more effective control of flocculation, much lower metal residuals are likely to be found in the potable supplies compared to a process of sedimentation assisted with coagulants performed in Oxfam tanks.

Chlorination

The most important factor in any use of chlorine is the determination of the concentration of chlorine required in the water, which is about to be consumed by the human user. Chlorine is absorbed by all forms of organic material, which may be present in any water or on water-carrying utensils. It is vital, therefore, that enough is added to leave a residual at the end of the distribution system. Contamination, which is introduced along the distribution system, will thus be destroyed. There are many potential points of contamination or water, both before and after it has been collected by the consumer, but especially when stored in the home.

A minimal residual, of 0.2 – 0.3 mg/litre, is required at the final delivery point. But, because of the potential contamination in the distribution system, it is necessary to dose at a higher concentration of chlorine in the storage tank. This may be as high as 2-3 mg/litre or more, but will need to be determined by experiment and testing of chlorine levels through the delivery chain.

After addition of chlorine, the water needs a certain amount of time (called contact time) to kill the viruses/bacteria in the water and this is usually at least 30 minutes, though sometimes longer is required (see below). Residual chlorine levels should be checked daily and chlorine dosing adjusted as necessary. The level of residual chlorine is very easily determined by use of a simple colour comparator and tablets added to the water. A chlorine comparator is available (Oxfam code FPO) or this also comes in both the Oxfam/DelAgua Water Test Kit (Oxfam code FK) and the measuring and testing kit (Oxfam code FMT).

The "contact time" is normally a minimum of 30 minutes for neutral pH waters. However, the length of contact time required for the active chlorine to be fully effective depends upon many factors of which the most important are pH and water temperature. A higher water temperature will enable the chlorine to work faster. Although most raw water sources have a pH value within the range 6.5 – 8, as the pH levels rise, the disinfecting properties of chlorine start to become weaker and at pH 9 there is very little disinfecting power.

The table below shows how higher pH values can be compensated for by either adding additional chlorine or increasing the contact time.

pH	Required chlorine residual at 20^0C (mg.l)	Minimum contact time needed for effective disinfection (min)
8.0	0.5	30.0
	0.2	206.0
	0.5	82.5
8.5	0.8	52.0
	1.0	41.0
	1.5	27.5
	0.2	412.0
	0.5	165.0
9.0	0.8	103.0
	1.0	82.0
	1.5	55.0

Ascertaining the Required Dose for HTH Powder

To determine how much chlorine to add, the chlorine demand is measured.

1. Prepare a 1% chlorine solution, the quantity depending upon type of chlorine used (see table below). Quantities of Chemical required to make 1 Litre of 1% Chlorine Solution

Source of Chlorine	**Available chlorine %**	**Quantity required (g)**
Bleaching Powder	34	30-40
HTH	70	14
Topical bleach	34	25
Stavilised bleach (Stabochlor)	25	40

2. Take 3 or 4 non-metallic containers of known volume (e.g. 20l buckets).
3. Fill the containers with some of the water to be treated and check the pH of the water.

4. Add to each bucket a progressively greater dose of 1% solution with a syringe:

1st container: 1ml
2nd container: 1.5ml
3rd container: 2ml
4th container: 2.5ml

5. Wait 30 minutes (essential: this is the minimum contact time for the chlorine to react. If the pH of the water is high, this minimum time will increase).
6. Measure the free chlorine residual in reach bucket.
7. Choose the sample which shows a free residual chlorine level between 0.2 and 0.5mg/l.
8. Extrapolate the 1% dose to the volume of water to be treated.
9. Pour the solution into the reservoir/dosing vessel, mix well (during filling) and wait 30 minutes before distributing to consumers.
10. Check chlorine demand at several water distribution points and adjust if required.
11. Recheck chlorine demand periodically and when raw water quality is known to vary, to ensure that the chlorine residual is maintained.

Example for Chlorination of water in a 2,000l reservoir.

Follow steps 1-5 above.
The free residual chlorine levels of the water in the buckets, measured half an hour after adding 1, 1.5, 2 and 2.5ml of 1% chlorine solution respectively are as follows:

1: 0.0mg/l
2: 0.1mg/1
3: 0.4mg/1
4: 1.0mg/l

The dosing rate chosen therefore will be that for bucket number 3 (result between 0.2 and 0.5mg/l). Thus if it needs 2ml of 1% solution to chlorinate 20l of water at the correct dosage, then it needs 100 times as much to chlorinate 2,000l, i.e. 100 x 2ml = 200ml of 1% chlorine solution.

Note

- The taste of chlorine in water is no proof of the presence of free residual chlorine (it could be combined residual chlorine).
- Metal consumes chlorine, so never prepare strong solutions in metal containers (unless they are enameled or painted).

Dose for Use of Slow Dissolving Tablets

Chlorine tablets (Oxfam code FCT), containing trichloroisocyanuric acid, can be used in the following quantities 3,4 or 5 tablets (for T45, 70 and 95m 3 tank sizes) and should last for 7-14 days, assuming the tanks are filled once daily, depending on water quality see table below.

1	200 gramme tablet will treat 36,000 litres/day at 5ppm
2-3	200 gramme tablets will treat 45,000 litres/day at 1ppm
3-5	200 gramme tablets will treat 70,000 litres/day at 1ppm
4-7	200 gramme tablets will treat 95,000 litres/day at 1ppm

Safety When Using Chlorine

***All forms of chlorine used as water disinfectants can be dangerous if not stored and handled in the correct manner*.**

The following simple rules must always be followed and any particular advice and precaution supplied with a specific product should likewise be closely followed:

- Only trained and authorised personnel should be allowed into the chlorine store.
- Chlorine is caustic, i.e. can cause burning and must not come into contact with skin or clothing. Thus protective clothing such as gloves, goggles and overalls or apron is advisable.
- Chlorine should be stored under dry, cool dark conditions, preferably raised above ground. Keep all containers closed and covered with a tight fitting lid when not in use.
- Avoid breathing chlorine dust as it is an irritant to the nose and lungs.

Roughing Filters

The roughing filters kits are built in T11 tanks and designed so that the raw water flows upwards, which greatly improves their cleaning efficiency by using gravity to backwash accumulated solids built up I the filter. Efficiency is further improved by placing media on a raised floor with a void below it.

The number of roughing filters required depends upon raw water quality and required production capacity and this should be assessed/calculated and appropriate designs drawn up before construction starts. For optimum performance roughing filters should be run at a maxim um surface-loading rate of $0.6m^3/m^2$/hour. (This through put can be visualised as the average velocity at which water passes through the filter). This means that each T11 tank should be run to product $3.2m^3$/hr. They can be run at lower through puts but there is little difference in percentage removal of suspended solids between 0.3 and 0. $6m^3/m^2$/hour. However the efficiency drops off above 0. $6m^3/m^2$/hour. Flow meters have not been provided in this kit as they are prone to blockage with high suspended solids loading. Flow rates will need to be determined manually.

Roughing filters are often required to be built with a number in series (each tank a stage) using progressively finer media n each tank. Raw water quality will determine how many stages, ie how many roughing filter tanks will be required: the more stages used (usually no more than three) the greater the cleaning effect on the water. If the water is fairly clean a single stage filter, or one with three different sized media layers in none tank, may suffice. Small scale pilot studies will indicate the best design of the system. Such trials should take into account seasonal variations in water quality.

As a guide, roughing filters should aim to produce water that is <20 NTU if water is then being passed through a slow sand filter of <5 NTU if it is to be disinfected with chlorine. Where different sized media are used, it is typical to select coarse, medium and fine sized media. These can be configures in one multi-layered roughing filter, or with one media size in each tank, giving a three-stage system. A roughing filter based upon three layers in one tank might look like this (with the coarsest layer on the bottom):

Media Size	**Grading**	**Depth of Layer**
5-10mm	Fine	300mm
10-15/20mm	Medium	300mm
15/20-25/30	Coarse	600mm

Note: Care should be taken if using sharp edged stones, that the tank liner is not damaged.

The larger suspended particles in the water, and much of the finer ones, are removed by the coarse media layer. As this layer has the greatest volume of material to absorb, it is the thickest of the three layers. If poor raw water quality requires the construction of a three-stage (ie three-tank) system then the tanks should e constructed in series, using one media size in each tank. The coarse media tank is placed upstream.

Guidance on how many filters may be required can be drawn from the following:

A roughing filter built three layers in one tank has a removal efficiency of 85% at $0.3m^3/m^2$/hour and 75% at $0.6m^3/m^2$/hour. Three roughing filters in series have a removal efficiency of 87-92% when operated at 0.3-$0.6m^3/m^2$/hour (all for turbidity range 30-500 NTU).
Note: The above figures should be used as a rough guide only. True treatment requirements should always be determined by conducting pilot tests on the actual raw water to be treated.

The design of the roughing filter will depend on the method used to treat the water against microbiological contamination before consumption. For example, three roughing filters in series will reduce suspended solids from 50 to 5 TU, a level sufficiently low to allow chlorination, while a single multi-layer roughing filter will take water from 80 to 20 NTU, allowing treatment by slow sand filter.

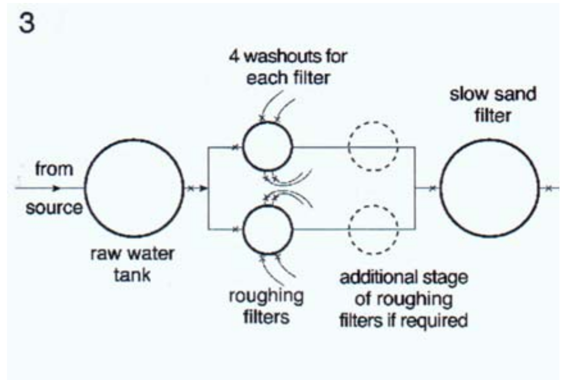
A stable suspension with a large amount of organics, eg algae or colloidal matter or colour, may be difficult to treat with a roughing filter and will sometimes require the addition of coagulants such as aluminium sulphate) upstream of the filter.

Having assessed the production requirement and undertake the pilot study with the raw water in question, the appropriate media size(s) can be selected, the number of T11 tanks and roughing filter kits ordered and a system layout plan drawn up. Work can then proceed on construction.

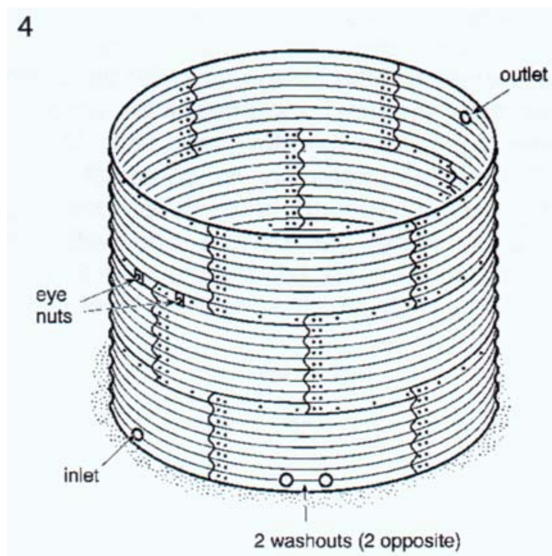
Roughing Filter Construction

Where roughing filters are required these can either be built in between slow sand filters and raw water tanks, or constructed for use in other treatment systems. The roughing filter kit and the instructions below relate to its use with the slow sand filter kit.

Suitable media should be identified and washed before any other work takes place. This is important as it can take many days/weeks to arrange if there are no suitable media sources available nearby. The selection of the media size and number of filters should be determined by the design process. Media can consist of gravel, broken stones or burnt clay bricks, ***however care should be taken not the select laterite or any other iron bearing stone, as this will cause the filters to cement up and not function***. The shape or roughness of the material has little impact on cleaning efficiency. It is far more important to ensure that material is washed thoroughly and is free from organic material. Suitable drainage arrangements need to be made for regular disposal of wash water such that water sources are not contaminated, or that wash water erodes tank foundations. A sludge pit/soakaway would be one solution.



3. Where roughing filters are built as part of a slow sand filtration system, the layout of pipework and number of T11 tanks will need to be determined and these positions marked on the ground. The direction of washout pipes should also be established. Typically parallel lines of roughing filters will be required for each slow sand filter tank, each consisting of one or more roughing filter stages.



4. The roughing filter fittings kit is designed to build a roughing filter inside an Oxfam T11 tank (only the post 1996 versions, all of which are 2.6m in diameter and have the extra holes drilled in two of the tank sheets for additional outlets). It can either be built into an already erected T11 tank by cutting the liner to take the extra (washout) flanges, or put in once a new T11 tank has been erected. Erection instructions for the T11 tank should be followed, excepting for a few small variations listed below

5. The roughing filter is designed to have four outlets/washout valves and the two tank sheets with two blanked off holes should be positioned opposite each other with the holes at the bottom of the tank and such that they allow the most convenient disposal of waste water. Three of the flanges and two 3" ball valves are supplied in the FRF kit, while the fourth flange and two more gate valves are available in the T11 tank kit for the purpose. The inlet flange in the T11 tank kit should be positioned in the sheet with a single hole in it, such that it is located at the bottom of the tank. Both the flange and the gate valve for this are provided as part of the T11 tank kit. The outlet should be located at the top of the tank in the most convenient position as required.

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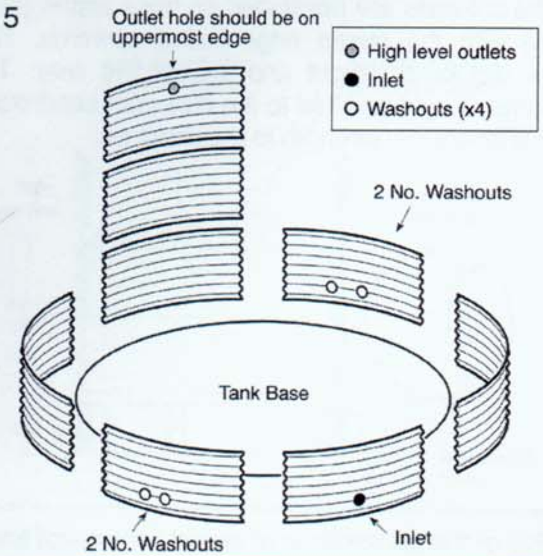

6. Before the liner is put up for the first time, the inside of the tank should be filled up with sand or soft soil (ensuring that there are no sharp stones in it) to a depth of about 50mm, or just below the bottom edge of the flanges. The sand should be carefully levelled. Where a roughing filter is being installed in a pre-erected tank, the liner may need to be dropped down inside the tank in order to take off any blanking plates covering holes in sheets and to position the additional flanges for washouts in the sheets. At this stage the opportunity should be taken to support the liner with sand/soil as explained above. This will ensure that the amount of water that is below the flange invert (lowest water draining point) is kept to a minimum. This permits more efficient desludging of the tank during flushing/cleaning operations.

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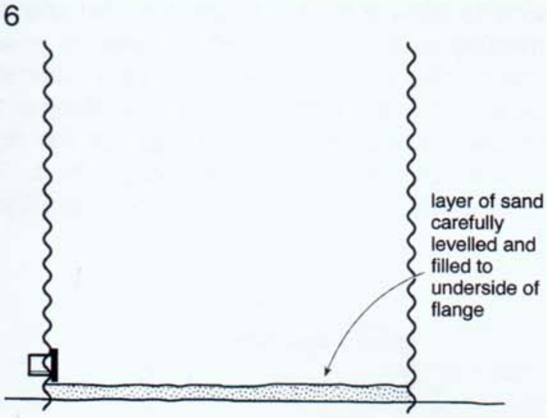

7. Once the tank liner is in position, the sheet of PVC should then be laid out on the base of the liner. The base plates and columns, which come in two different sizes, should then be laid out according to the diagram and corresponding to the PVC sheet template showing column positions. Note that the larger columns are to be positioned away from the angle iron edges of the six sections of the raised floor.

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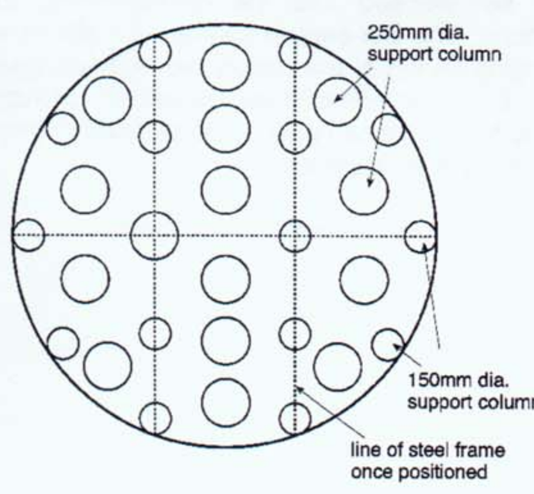
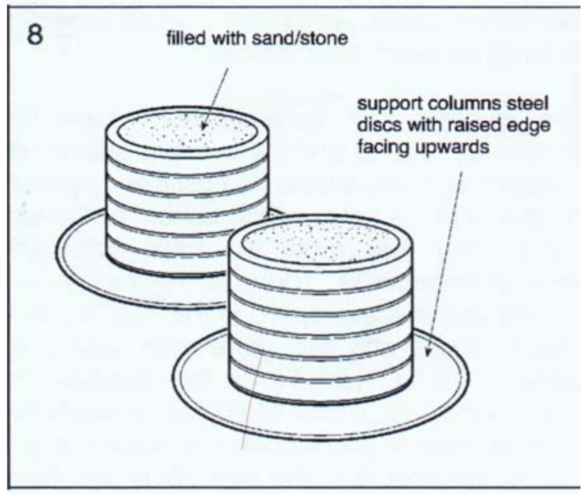
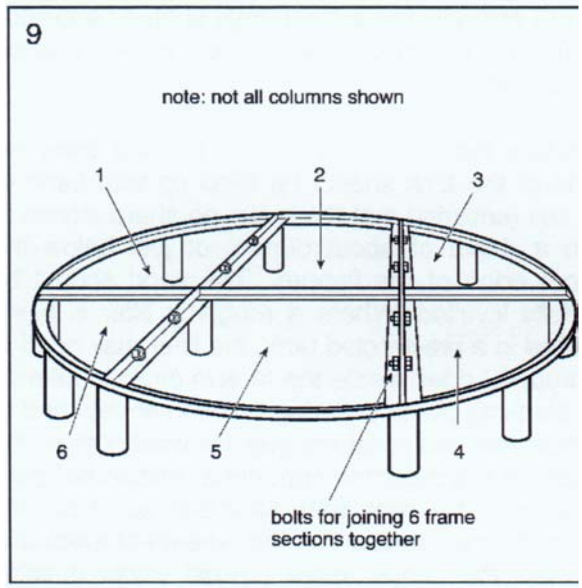


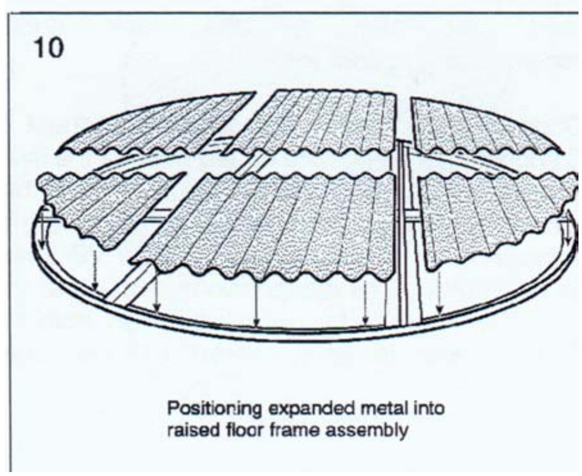
8. The columns are positioned on base plates (steel discs) with the raised edge facing upwards. This helps distribute weight and protect the liner. The columns should be filled to the brim with sand/stone to give additional strength to the structure.



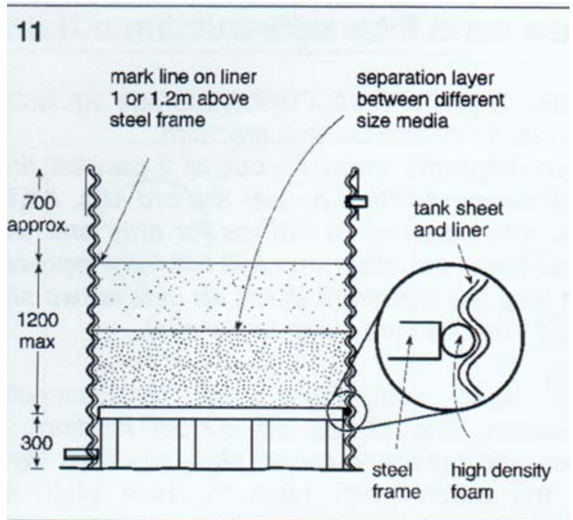
9. Five of the six sections of raised floor metal frame should then be carefully positioned on top of the columns one buy one, leaving out one of the middle sections to allow a worker to stand in the space of the missing section. Care must be taken to ensure that the smaller columns are positioned underneath the joints and at the edge of the five sections of the raised floor to maximise the strength of the floor, which will have to carry a very large load. The sections of raised floor can then be bolted together.



10. Some sections of corrugated expanded metal can be dropped into the corresponding frame sections. The last section can now be added while standing on top of the corrugated expanded metals and bolted in. The final section of corrugated expanded metal can now be positioned to complete the raised floor assembly.



11. the 9m of high density foam strip should be wedged between the corrugation and adjacent to the edge of the frame. This ensures that media will not drop down between the liner and the edge of the frame during initial filing and once some media ahs been introduced this will form a bridge between the liner and frame. A line should be marked around the liner at a distance above the raised floor of 1m (for single media size filter) or 1.2m (for multi layer filter). This will be used to determine the height to which the media should be filled. The selected media can then be put into the tank. Care should be taken in using sharp edged angular stone in the roughing filters as the sides of the liner may be punctured during filing with stone. Where a multi layer system is used, it could be useful to separate out the different media layers using a non woven fabric or wire mesh (not included in the kit), as this will prevent media from becoming mixed during manual cleaning operations when media has to be removed. Additional stones should NOT be added to take the media lever higher, as the raised floor structure will not be strong enough and may collapse.



12. The roof should be added to cover the media in order to reduce algae build up. Finally a gate valve should be fitted to the inlet flange, and the two other gate valves and two ball valves should be fitted to the washout flanges. A drainage channel should be dug each side of the tank and to enable waste water from the washouts to run to a suitable soakaway and the layflat hose length cut to suit the position of the trench - 26m is provided in total for this. The kit includes tee with sampling taps and hoses for inlet and outlets and these should be fitted as shown. These sampling taps will be used for monitoring water quality and filter performance.