

Oxfam Water Supply Scheme for Emergencies

WATER FILTRATION PACK



John Howard

Oxfam is a partnership of people committed to relieve poverty, distress and suffering in any part of the world.

We believe in the essential dignity of people and in their capacity to overcome the problems they face whether they stem from natural, social, political or economic conditions.

This Pack is one of several devised by The Oxfam Technical Unit to help provide a reliable water supply in emergency situations.

Oxfam Technical Unit
274 Banbury Road, Oxford OX2 7DZ, U.K.
Telephone: (0865) 56777 Telex: 83610, OXFAM G



274-0601-0355

8355
274 860X

Oxfam Water Supply Scheme for Emergencies

This Pack is one of several devised by the Oxfam Technical Unit to help provide a reliable water supply in emergency conditions, such as in refugee camps, relief centres etc. The other Packs cover: water storage (10, 45, 70 and 95m³ tanks), distribution, pumping and well-digging. All are designed using available, easily transported equipment which is simple, rapidly assembled and fully self-contained to provide an adequate, safe water supply at moderate cost. The principles used in these Packs may often be of use also in long-term development water supply projects.

Wherever possible water supplies in emergency conditions should be obtained from underground sources, by exploitation of springs, tubewells or dug wells; no filtration will then be needed. However, if no such source is available, or cannot be developed, the use of surface water from streams, rivers, lakes or ponds becomes necessary.

Usually these surface sources are polluted. The level of faecal contamination can be measured by use of the Oxfam/Delagua Water Test Kit (see *Section H*). Where a doubtful or serious level of faecal pollution exists it is essential first to try to reduce the cause of contamination and secondly to treat the water for human consumption. Several options for treatment are outlined in *Section H*: settlement, chlorination, use of infiltration galleries etc. The Filtration Pack provides a simple, long-term, biological treatment system that requires no chemicals and only easily understood regular maintenance.

The Filtration Pack will enable a considerable improvement to be made in the quality of a polluted water source. It uses settlement and pre-storage, slow sand filtration and treated water storage. If necessary additional treatment of the water may be provided by chlorination of the filtered water. The treatment process and its effectiveness can be monitored by use of the Water Test Kit.

Read this manual through before commencing installation.

SECTION A

Design Data

The Filtration Pack comprises two filters running in parallel, each of which is designed to provide rather more than half the design quantity of water of the other Oxfam Packs, namely 27 litres/person/day for a population of 5,000. The two filters are provided so that a continuous supply can be maintained whilst one of the filters is being cleaned. Thus, when both units are operating at the design rate, enough water is treated for more than 5,000 people.

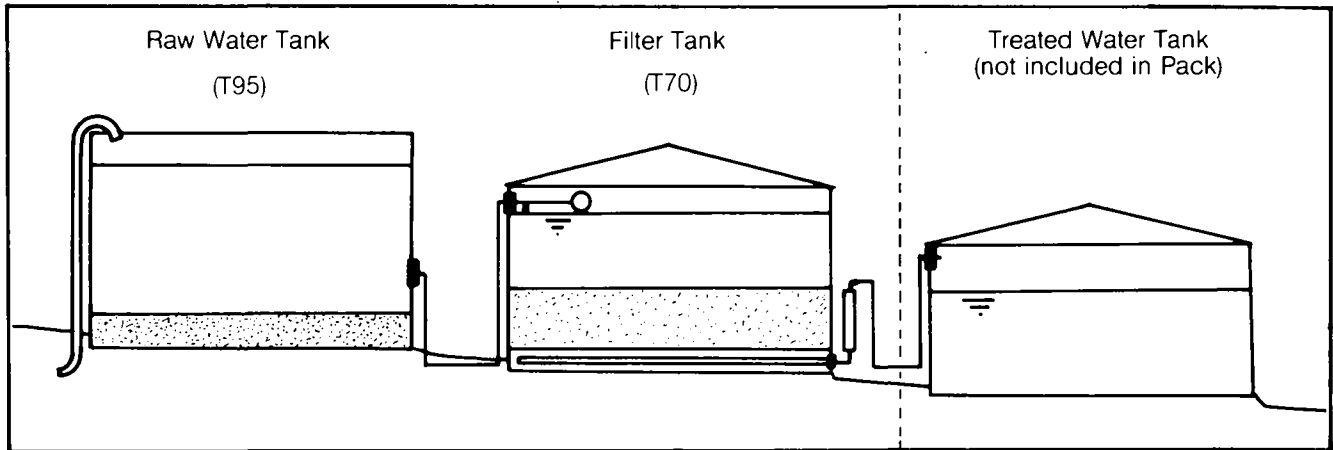
The Pack consists of four tanks made of corrugated, galvanised steel sheets with a flexible, synthetic rubber liner; all of these tanks are of 6.4m diameter. Two are used as raw water storage tanks, are 3.0m high and contain 95m³ of water. The other two tanks are 2.3m high, have a volume of 70m³ and are used to contain slow sand filters. The Pack comes complete with all the necessary pipework and fittings for connection to a supply from a raw water source and to treated water storage tanks, for which the Oxfam Water Storage Pack, using tanks of a similar construction, may be used. The only materials which are required for this installation and which are not included in the Pack are sand and gravel.

The Pack uses the simplest form of water treatment, usually requiring no chemicals and relying on gravity to provide the flow through the system. However it does need some care in its operation and a basic understanding of the biological processes is useful in order to get the most out of it. An explanation of the maintenance

required and the way that the process works is given in *Section G*.

The Filtration Pack will, if operated correctly, very considerably improve both the physical and bacteriological quality of slightly turbid water. Turbidity or cloudiness is generally much reduced by settlement in the raw water storage tanks and any residue is removed by the filters. However the filters will be rapidly blocked by high turbidities. It is suggested that a practical upper limit of turbidity for the incoming water to the raw water tanks is 20 NTU, although occasional levels above this, such as after heavy rainstorms, may be tolerated. If the source water is regularly highly turbid some form of pre-filtration, such as outlined in *Section H*, will be needed. Numbers of bacteria, viruses and cysts, all potentially disease-carrying micro-organisms, are very substantially reduced by biological action within the filters.

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CENTRE FOR COMMUNITY WATER SUPPLY
AND SANITATION (IRC)
P.O. Box 93190, 2509 AD The Hague
Tel. (070) 814911 ext. 141/142
RN: 15N 8355
LO: 274 860X

SECTION B**Filtration Pack Contents**

The Pack consists of seven kits (each of which can be ordered separately) each with an identifying code on the crate or box:

2 No. 95,000 litre raw water tank kits, each comprising:

- Tank sheets, Code No. T95S, (Approximate gross weight and volume 450kg, 1.5m³), containing:

28 corrugated sheets (3 of which cut and drilled for pipe connections, one has blanking plate fitted)

- Tank accessories, Code No. T95L, (Approximate gross weight and volume 309kg, 0.9m³), containing:

21m length of 12mm Ø split plastic capping
 21m length of 25mm Ø split plastic capping
 60 No. 25mm Ø spring clips
 1 No. bag containing 780 No. M10 Ø × 20mm long round head bolts, nuts and washers

1 No. Podger
 1 No. 3" Ø BSP (F) brass gate valve
 2 roll of self-adhesive tape
 2 No. 3" Ø BSP (M) Table E threaded flanges
 2 No. 3" Ø BSP (F) Table E threaded flanges
 8 No. M16 studs 100mm long
 16 No. M16 nuts
 16 No. M16 washers
 4 No. 3" Ø Table E rubber gaskets
 1 No. 1.25mm thick EPDM reinforced synthetic rubber liner + repair kit
 1 No. roll of PTFE tape

- Tank roof, Code No. T95R, (Approximate gross weight and volume 81kg, 0.4m³), containing:

Roofing components comprising:

1 No. 7.5m Ø reinforced PVC cover with 28 No. brass eyelets equispaced around the perimeter

300m of 6mm polypropylene rope
 4 No. plastic column sections 100mm Ø × 1m long

2 No. drilled flange ends
 3 No. straight connectors
 1 No. 7m × 7m 10cm mesh polypropylene net

28 No. retaining hooks with nuts
 1 No. repair kit for PVC cover
 1 No. timber base plate with 4 nuts and bolts
 1 No. screwdriver with self-tapping screws

2 No. 70,000 litre filter tank kits, each comprising:

- Tank sheets, Code No. T70S, (Approximate gross weight and volume 340kg, 1.5m³), containing:

21 corrugated sheets (3 of which cut and drilled for pipe connections, one has blanking plate fitted).

- Tank accessories, Code No. T70L, (Approximate gross weight and volume 254kg, 0.8m³), containing:

21m length of 12mm Ø split plastic capping
 21m length of 25mm Ø split plastic capping
 60 No. 25mm Ø spring clips
 1 No. bag containing 560 No. M10 Ø × 20mm long round head bolts, nuts and washers

1 No. Podger
 1 No. 3" Ø BSP (F) brass gate valve
 2 roll of self-adhesive tape
 2 No. 3" Ø BSP (M) Table E threaded flanges
 2 No. 3" Ø BSP (F) Table E threaded flanges
 8 No. M16 studs 100mm long
 16 No. M16 nuts
 16 No. M16 washers
 4 No. 3" Ø Table E rubber gaskets
 1 No. 1.25mm thick EPDM reinforced synthetic rubber liner + repair kit
 1 No. roll of PTFE tape

- Tank roof, Code No. T70R, (Approximate gross weight and volume 77kg, 0.3m³), containing:

Roofing components comprising:

1 No. 7.5m Ø reinforced PVC cover with 28 No. brass eyelets equispaced around the perimeter

300m of 6mm polypropylene rope
 3 No. plastic column sections 100mm Ø × 1m long

2 No. drilled flange ends
 2 No. straight connectors

- 1 No. 7m × 7m 10cm mesh polypropylene net
- 28 No. retaining hooks with nuts
- 1 No. repair kit for PVC cover
- 1 No. timber base plate with 4 nuts and bolts
- 1 No. screwdriver with self-tapping screws

1 No. filtration fittings kit

● Code No. FF, (Approximate gross weight and volume 304kg, 3.5m³), containing:

- 4 No. 3" Ø BSP (F) brass gate valves
- 4 No. 3" Ø BSP (F) plastic threaded elbows
- 4 No. 3" Ø BSP (M) hexagonal plastic threaded nipples
- 4 No. 3" Ø BSP (F) iron swivel hose connectors to fit 3" hose
- 6 No. 3" Ø BSP (M) iron hose connectors to fit 3" hose
- 16 No. hose clips (bolt type) for 3" hose
- 2 No. 3" Ø BSP (F) plastic threaded caps
- 8 No. 3" Ø BSP (F) × 2" Ø BSP (M) iron threaded reducers (2 spare)
- 2 No. 3" Ø BSP (M) × 1½" Ø BSP (F) plastic threaded reducing bushes
- 10m length of 3" reinforced flexible plastic hose
- 2 No. 3" Ø BSP (M) Table E threaded flanges
- 2 No. 3" Ø BSP (F) Table E threaded flanges
- 8 No. M16 studs 100mm long
- 16 No. M16 nuts
- 16 No. M16 washers
- 4 No. 3" Ø Table E rubber gaskets
- 7 No. 2" Ø BSP (F) brass gate valves (1 spare)
- 5 No. 2" Ø BSP (F) plastic threaded tees
- 8 No. 2" Ø BSP (F) plastic threaded elbows (2 spare)
- 20 No. 2" Ø BSP (M) hexagonal plastic threaded nipples (3 spare)
- 8 No. 2" Ø BSP (F) iron swivel hose connectors to fit 2" hose (2 spare)
- 4 No. 2" Ø BSP (M) iron hose connectors to fit 2" hose (2 spare)
- 12 No. hose clips (bolt type) for 2" hose
- 2 No. 2" Ø BSP (M) hexagonal plastic threaded plugs (spare)
- 2 No. 2" Ø BSP (F) plastic threaded caps (spare)
- 2 No. 2" Ø BSP (M) threaded plastic barrel nipples 400mm length
- 1 No. 2" Ø BSP (M) × ½" Ø BSP (F) plastic threaded reducing bush
- 2 No. 2" Ø BSP (M) × ½" Ø BSP (M) hexagonal plastic threaded reducing nipples
- 40m length of 2" reinforced flexible plastic hose
- 2 No. 2" Ø BSP (F) variable area float flow meters 650–6500 litre/hr
- 2 No. 1½" Ø BSP (M) brass ball float valves c/w float
- 20m length of 20mm reinforced transparent flexible plastic hose
- 8 No. hose clips for 20mm hose
- 6 No. ½" Ø BSP (M) plastic diaphragm cocks with 20mm hose tail (1 spare)
- 2 No. ½" Ø BSP (F) plastic threaded tees
- 10 No. rolls PTFE joint sealing tape
- 1 pot pipe joint lubricant

Underdrain:

- 6 No. 0.15m length 4" slotted plastic pipe
- 2 No. 1.00m length 4" slotted plastic pipe
- 2 No. 1.15m length 4" slotted plastic pipe
- 4 No. 1.25m length 4" slotted plastic pipe
- 8 No. 2.30m length 4" slotted plastic pipe
- 4 No. 3.00m length 4" slotted plastic pipe
- 12 No. 4" plastic push-fit tees
- 14 No. 4" plastic push-fit caps
- 2 No. 4" plastic push-fit sockets
- 2 No. 4" × 3" plastic push-fit reducer
- 2 No. 3" Ø BSP (M) × 3" Ø plain plastic nipple
- 1 No. 50m coil of galvanised wire
- 1 No. piece filter fabric approx. 6.5m²

Sandwashing:

- 1 No. 500 litre heavy-duty plastic drum
- 1 No. 800mm length 2" Ø plastic pipe perforated with 5mm holes and threaded one end c/w 2 No. backnuts, capped other end
- 1 No. set of three interlocking sieves 300mm Ø, mesh size 0.1, 0.425 and 2.8mm

1 No. filtration fabric kit

● Code No. FB, (Approximate gross weight and volume 34kg, 1.0m³), containing:

- 2 No. rolls synthetic filter fabric 21m × 1.6m × 10mm thick (or equivalent)

1 No. tool kit

● Code No. FT, (Approximate gross weight and volume 6kg, 0.01m³), containing:

- 1 No. cranked handle brace for spanner sockets
- 2 No. 17mm spanner sockets for use with brace (1 spare)
- 2 No. 17mm ring/open end combination spanners
- 2 No. 24mm ring/open end combination spanners
- 2 No. 12" screwdrivers
- 1 No. 8" half round file
- 1 No. knife needle file
- 1 No. 8" adjustable spanner
- 1 No. Stillson adjustable pipe wrench 65mm capacity
- 2 No. strap wrenches 200mm capacity
- 1 No. adjustable pipe wrench, 150mm capacity
- 1 No. junior hacksaw complete with 6 blades
- 1 No. retractable-blade knife with 5 blades

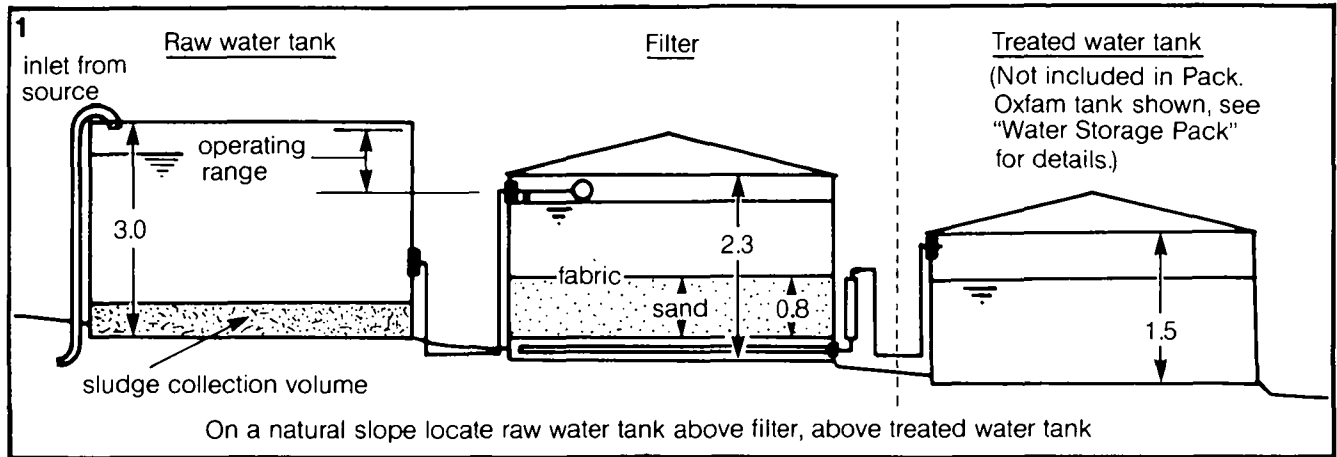
Note: 1 No. Podger provided in each tank kit

Note: See also optional chlorination and scaffold kits detailed in Section H

SECTION C

Tank erection

Siting



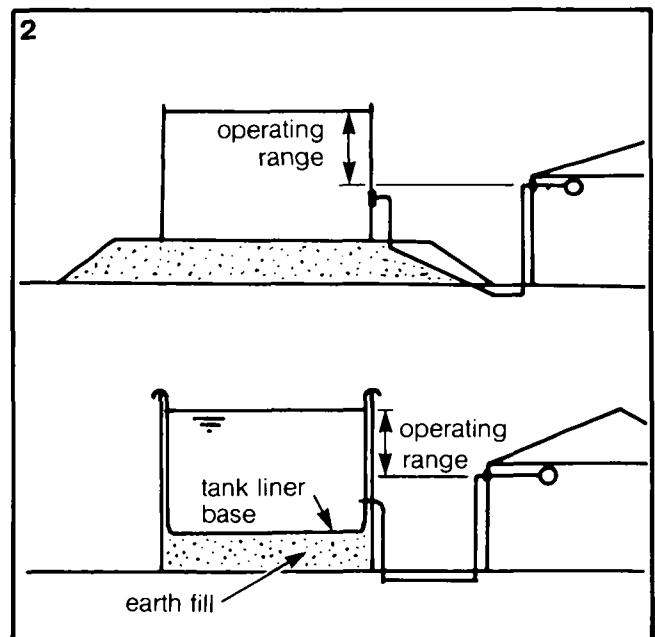
1. The Filtration Pack contains four tanks, two of which act as raw water storage and two as filters. They are all of the same construction as the Oxfam water storage tank, having a diameter of 6.4m but ranging in height from 3.0m for raw water to 2.3m for the filters and 1.5m for treated water. These consist respectively of 4, 3 and 2 rings of corrugated steel sheets.

The incoming water is pumped to the raw water tank and then flows by gravity through the filter to the treated water tank. Ideally the clean water should then be distributed to the users by gravity-fed pipeline. The location of the treatment plant is therefore dictated by conflicting parameters:

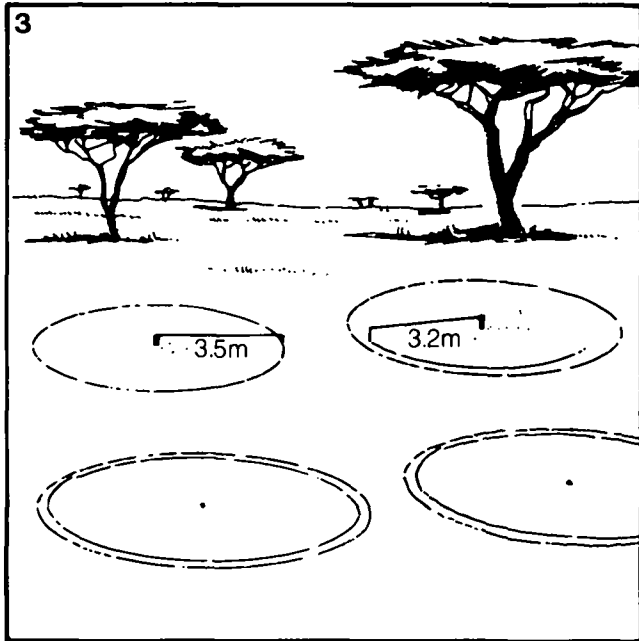
- proximity to the water source
- elevation above the distribution area
- proximity to the distribution area.

Each case will provide a different solution but the following criteria should be borne in mind when making the choice.

- Where possible take advantage of natural slopes by locating tanks above the site to be served.
- It may be worthwhile constructing an elevated earth platform for the whole plant in order to achieve gravity distribution on a site with little natural slope.
- Although the weight of full tanks is relatively small, firm ground is necessary to avoid subsidence. In soft ground take stringent precautions against subsidence due to erosion of foundations or wind pressure. A gravel or concrete foundation ring may be necessary as well as a substantial earth bank around tanks.
- A site well clear of trees is desirable in order to avoid problems of roots, falling branches and canopy drip.
- Distribution pipe lengths should be kept to a minimum to reduce friction losses.
- Tanks must be fenced and guarded against contamination by the users and possible damage.



2. When the raw water tanks and filters are all constructed on a level site the operational depth of water (i.e. that above the inlet to the filters) is limited to 0.8m. This will result in relatively frequent topping-up of the raw water tank in order to achieve a steady yield from the filters. It is therefore always better to build the raw water tanks at a higher elevation than the filters, either by making use of natural slope or by constructing a well-compacted earth platform or by adding an extra ring to the tanks and filling the bottom one with earth.

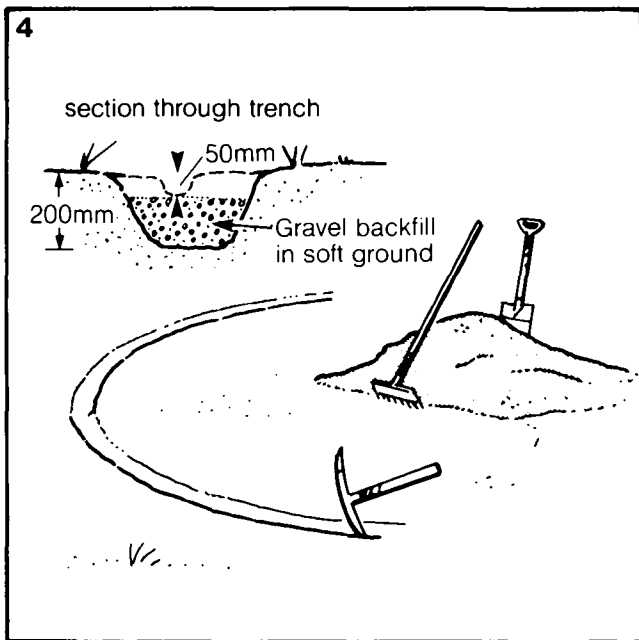


Erection of tanks

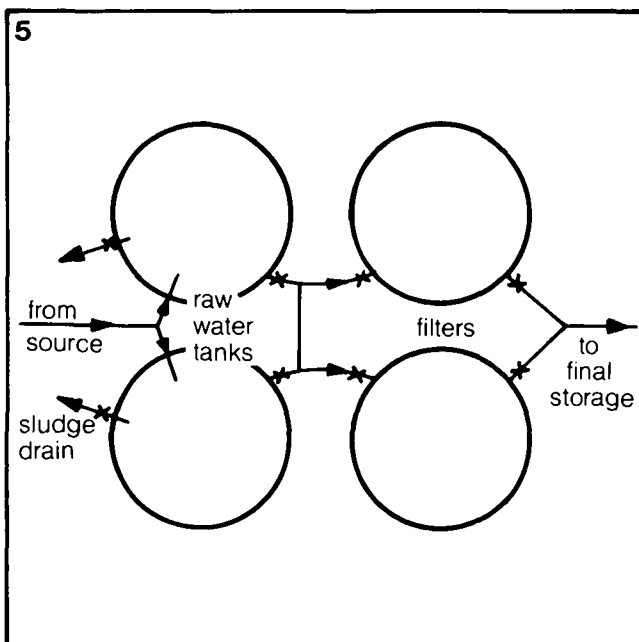
3. Decide upon layout of tanks keeping in mind a minimum practical distance of 1m between tanks and the fact that 40m of pipe are provided for interconnection (see *Section D*) and for connecting to treated water storage.

Using a stick and string mark out circles of 3.5m radius and clear inside of all vegetation, roots, boulders and stones. Ensure that circles are perfectly level and that areas of fill are well compacted.

Using same centres mark out circles of 3.2m radius and dig out a narrow trench on this line about 50mm deep into which the bottom ring can be set. (Prevents liner squeezing out underneath.) If the ground is soft and clayey dig out a 200mm deep trench and backfill 150mm with stones and gravel to support the steel sheets.



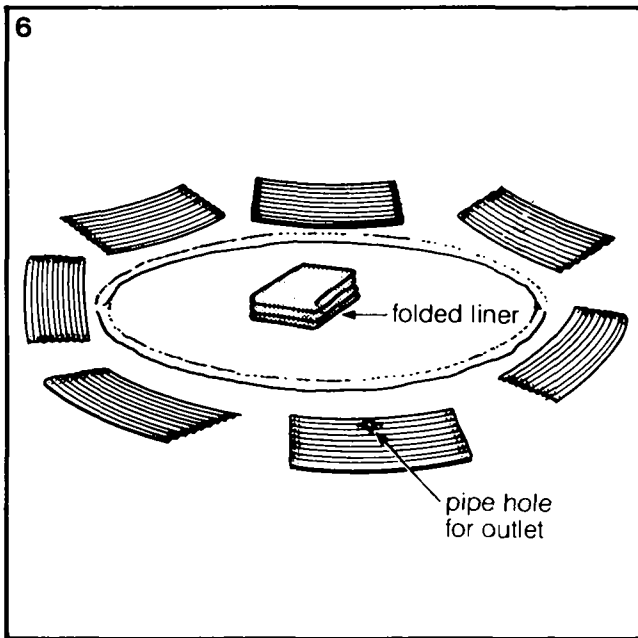
4. If available spread a sand layer up to 50mm deep to cushion liner and prevent damage. Otherwise ensure ground is smooth and free from all sharp projections.



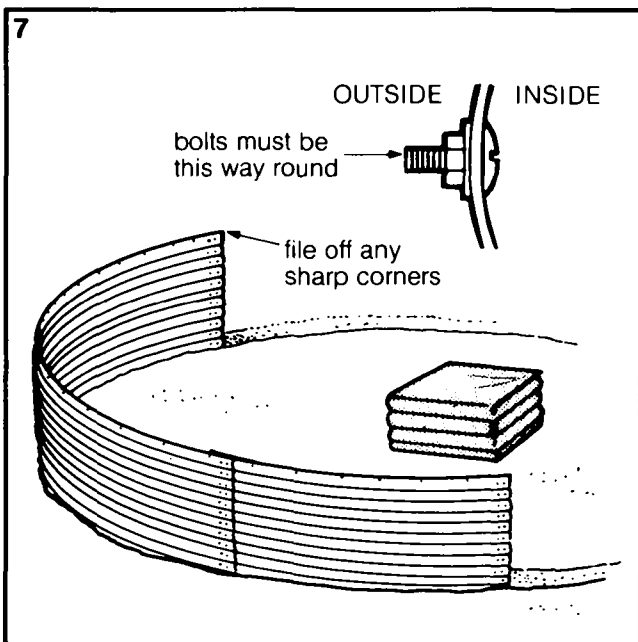
5. Study *Section D*, interconnecting pipework, and decide on correct locations for inlets and outlets. Mark pipework layout on the ground with pegs to show inlets and outlets.

Erection of 2.3 and 3.0m high tanks requires either a step ladder or a simple scaffold platform, neither of which is provided in the Pack unless specifically requested. Obtain or construct at this stage. It is possible to make use of empty fuel drums or the empty crates which contained the tank liners but ensure stability of any such improvised platform.

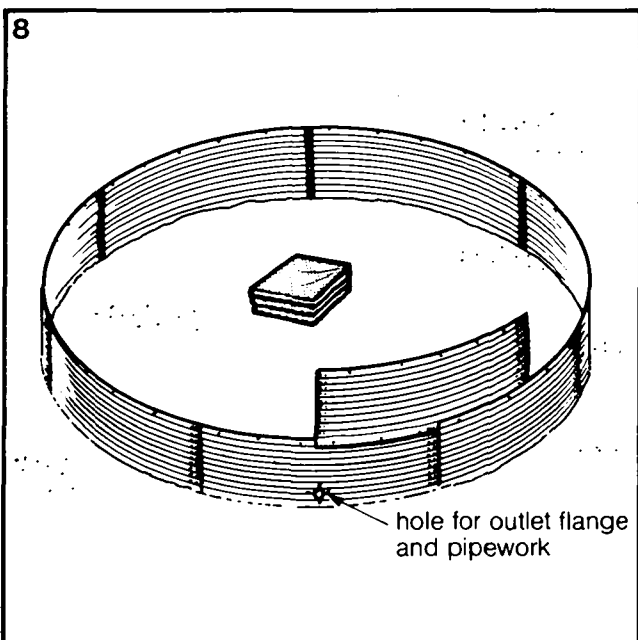
Do not attempt to erect these tanks in windy conditions. Even in calm conditions no tank should be left empty without guy ropes to stabilise it. During construction temporary guys can be run from the top of the tank to the ground or, preferably, erection should be planned so that each tank is partially filled with water as soon as it is completed.



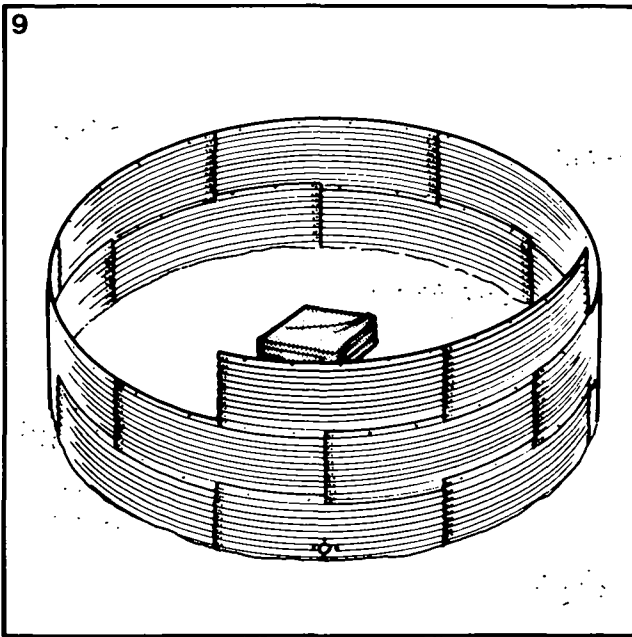
6. It is recommended that erection starts with filter tanks (T70) as these, being lower, are a little easier to erect than raw water tanks. Select the correct components (liner and steel sheets) and place liner on the ground in the centre of the relevant circle. Ensure no oil or petroleum is in contact with the liner (causes damage as well as contamination). Lay the first ring of sheets round circumference with one having a pipe hole at the desired outlet position at the bottom of the sheet.



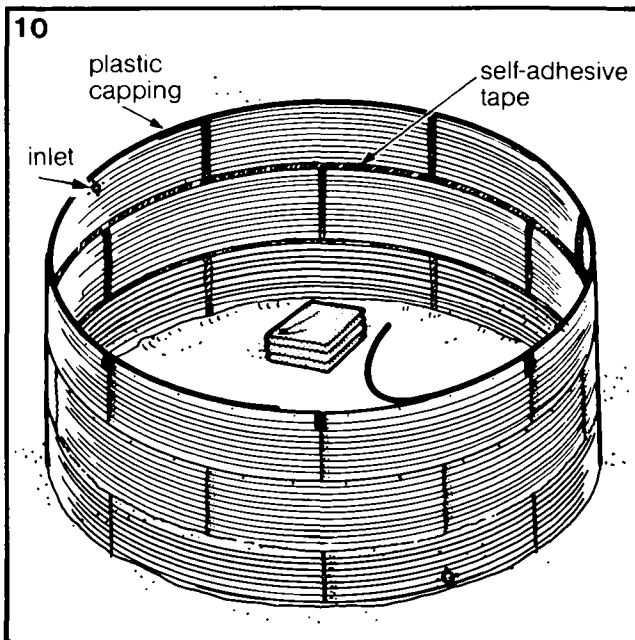
7. Working in pairs, one person inside and one outside the ring, stand first sheet in shallow trench and bolt next one to it **keeping all bolt heads on the inside**. To align the sheets first use the podger (spike) and insert bolts at top and bottom of sheets. Then insert remaining bolts. Do not fully tighten any bolts at this stage.



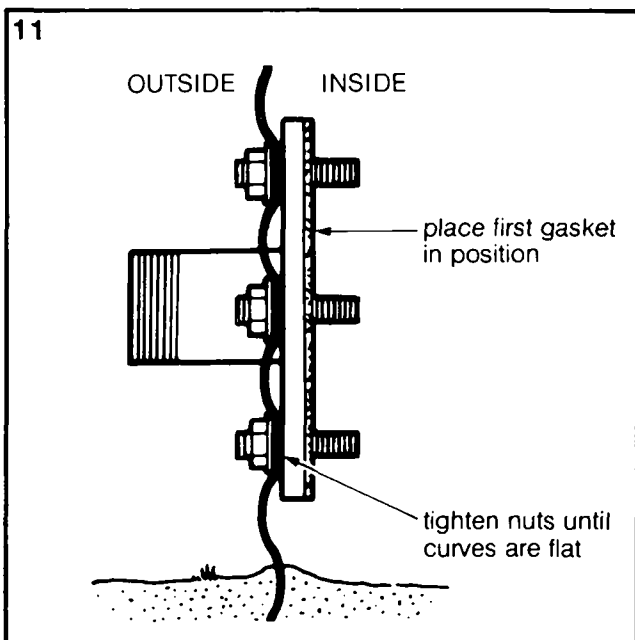
8. Complete first ring of sheets and then erect second ring either bolting inside the first, or, probably simpler, weaving sheets inside and outside alternate sheets of the first ring as shown above. Tighten all bolts in the first ring when the second ring is complete. When tightening check that sheets fit snugly and that any dents or sharp edges that could damage the liner are flattened or filed smooth.



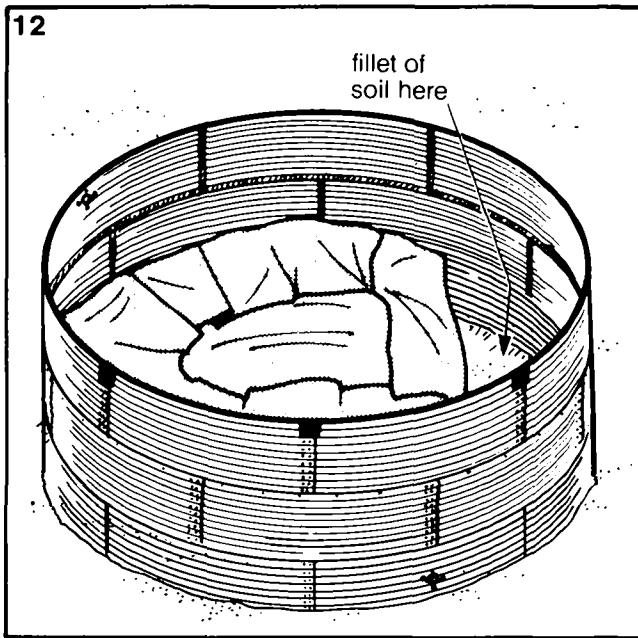
9. Only two or three workers should now be inside the tank as access becomes difficult. Erect third ring in the same way as the second, making sure that a pipe hole is located where the inlet is required at the top of the sheet. Only when this ring is complete tighten the bolts in both the second and third rings.



10. On inside of tank cover joints between sheets with strip of self-adhesive tape (to protect liner). Fit small size of split plastic capping round top of sheets. (Bend capping back to open up split, then roll on and press down evenly round rim.) Trim off any excess at join.



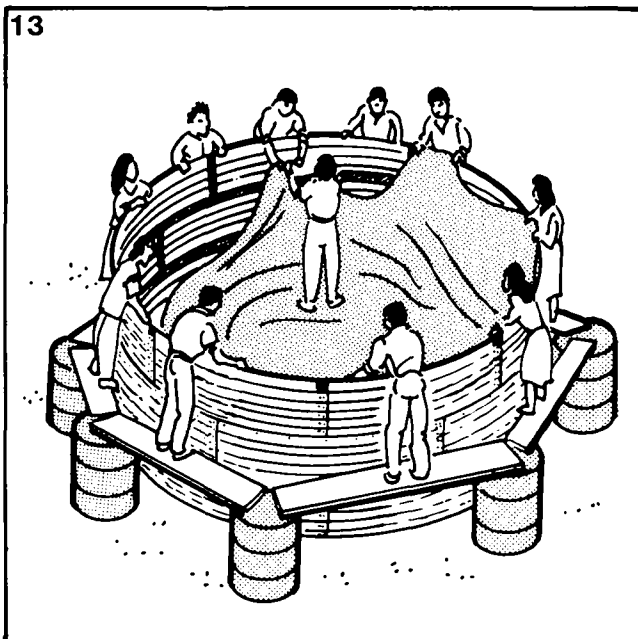
11. Make Stage 1 of each tank to pipework connection as follows: Take the flange with the threaded 3" diameter pipe welded to it and having cleaned their threads and wound PTFE tape onto them screw 4 studs into the threaded holes so that they project 50mm on the same side as the pipe. Use 2 nuts and a spanner if necessary. From inside the tank pass the assembly through the holes in the tank wall. Tighten nuts and washers on the outside flattening the corrugations slightly. Pass first rubber gasket over studs projecting inside the tank.



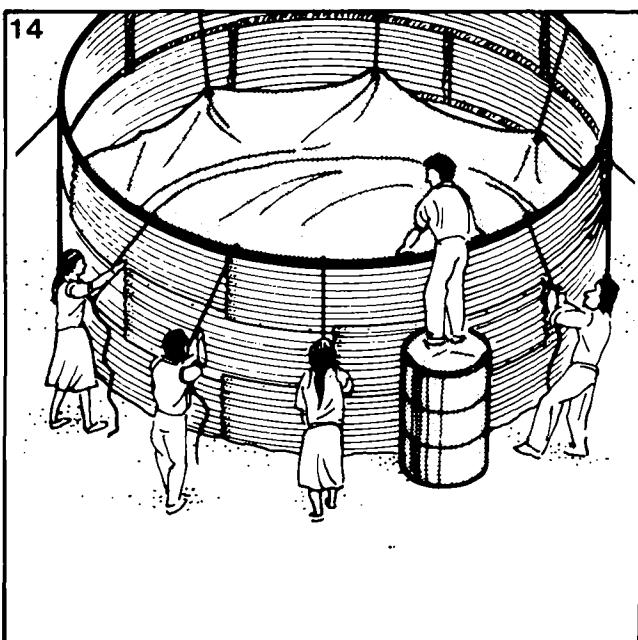
12. Backfill shallow trench in which steel rings are sitting, adding soil or sand to make a fillet on the inside to support liner.

Use two workers (with bare feet or rubber-soled shoes free of any oily contamination) to unfold the liner inside the tank. Hands must also be clean. Carefully pull and smooth out the base area to fit as accurately as possible. The workers inside can, by leaning on the rim of the tank, kick the liner gently into the base of the wall. The seam in the liner between the circular base and the vertical walls should lie against the fillet of soil.

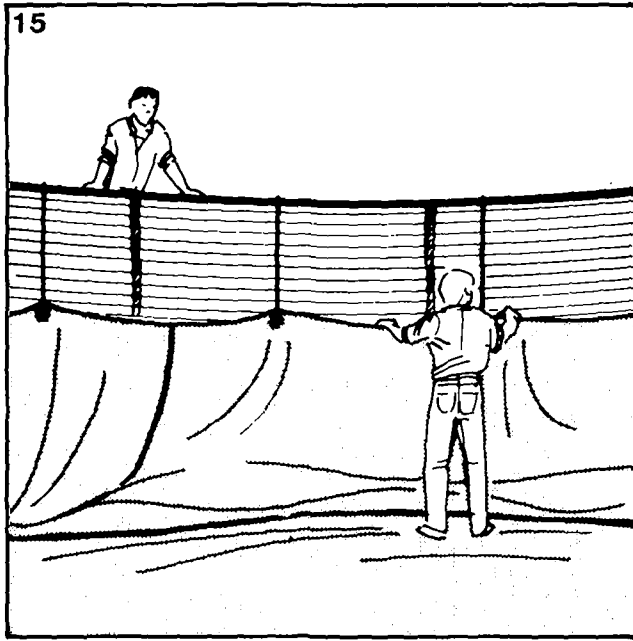
Ensure that the vertical seams in the liner do not coincide with the inlet or outlet holes. If they do, rotate the base slightly.



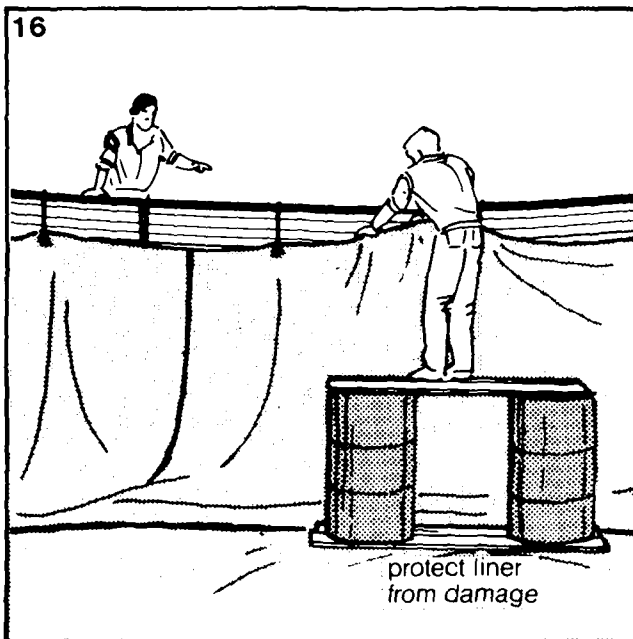
13. Two methods can be used to install the liner into these tanks depending on equipment available. If sufficient platforms can be constructed all round the tank and of such height that workers can lean over the rim to take the liner from those inside proceed in this way, but note that for a satisfactory installation at least ten workers will be needed on the outside.



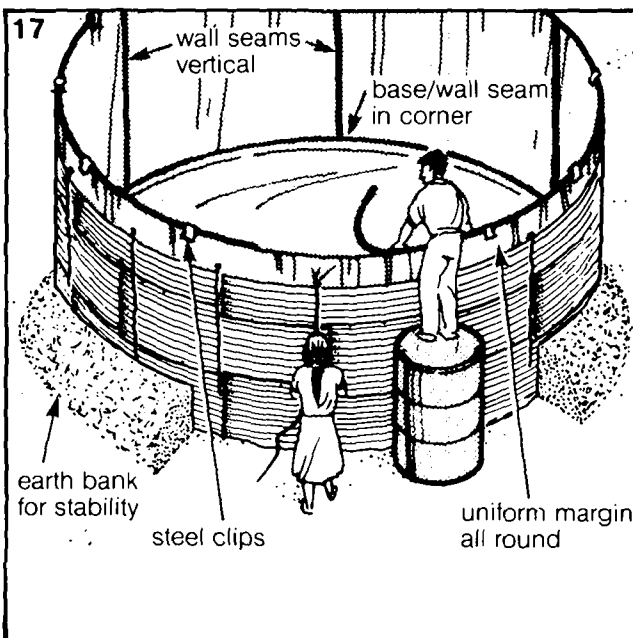
14. Alternatively attach ropes to the eyelets round the edge of the liner. Pass the ropes over the rim of the tank. Directing operations from a ladder, position and number the rope controllers.



15. Start lifting the liner from the inside with the slack being taken up by the controllers on the outside preventing it dropping back. **Do not attempt to pull the liner up by heaving on the ropes from the outside.**

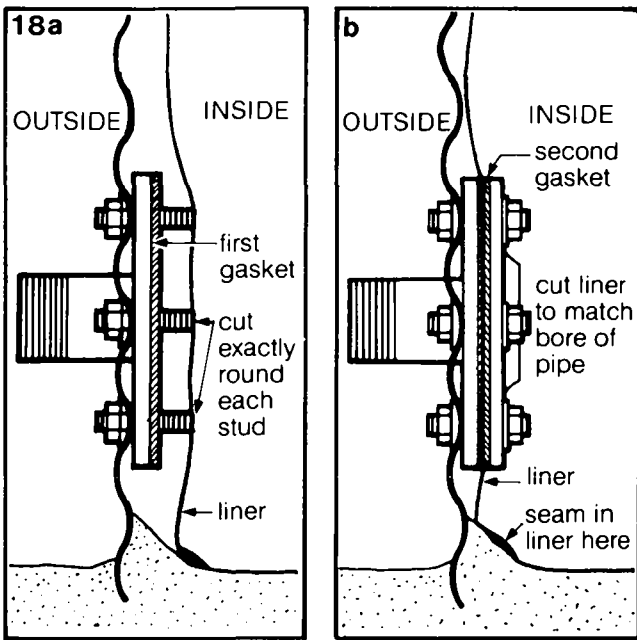


16. Continue to lift the liner from the inside working from a platform of about half the height of the tank, taking care to protect the liner from the pressure of the platform. Continue until the liner has passed over the top and a short distance down the outside. Ensure that plastic capping is not disturbed.



17. Ensure that the base/wall seam still coincides with the bottom of the wall, that the wall seams are vertical and that an equal margin hangs down all round the outside.

Secure the liner in position with the larger size of split plastic capping and then snap on the spring clips over the capping at regular intervals of about 0.5m. If the length of capping has to be trimmed peel back enough to enable cutting to be done well away from the liner. Position a clip close to each side of joint.

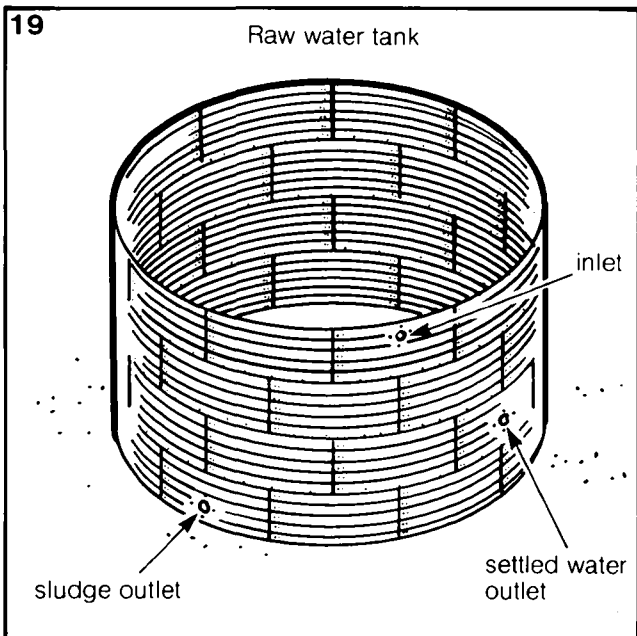


18. Make Stage 2 of each tank to pipework connections as follows: (**Note: do not** complete connection for inlet to filters until all sand is in place and liner in final stressed state)

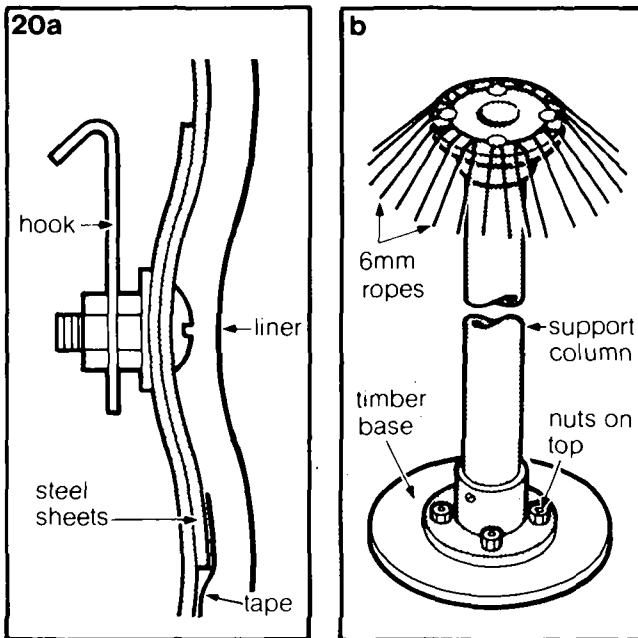
a. With the liner correctly positioned and not under any tension, cut four small circular holes in the liner by pressing it against the end of the studs and cutting round them with a sharp knife. Slide the liner over the studs and against the first gasket.

b. Now pass the second gasket and plain flange over the studs and wind PTFE tape onto the studs (to prevent leakage) before tightening on the inside nuts. Finally, cut liner round inside of plain flange leaving 3" diameter outlet hole.

Immediately after erection of tank ensure its stability by partially filling with water (with outlet capped), by building an earth bank around the base or by use of temporary guy ropes.



19. Proceed as Nos. 6-18 for the second filter tank and for the two raw water tanks. The only differences between the two types of tank are that the latter have four rings instead of three and that three connections can be made to the raw water tanks. These are for inlet (if alternative over-rim inlet is not used), settled water outlet and sludge outlet. The second of these is made by use of the blanked-off hole which is in the centre of one of the sheets.



Roof cover for tanks

Roof covers are provided for all tanks if required but it may be decided that neither raw water nor filter tanks need to be covered. Covering of these tanks will generally only be beneficial if conditions are such that direct sunlight would lead to rapid algal growth and so tend to block the filters very rapidly. If such conditions are anticipated erect the centre support for the roof in the filter tanks before filling with sand and gravel in case the cover is later needed.

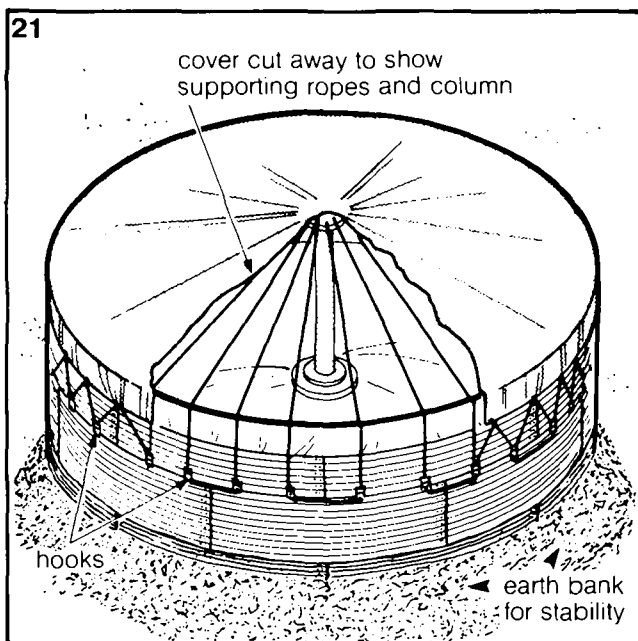
The treated water tanks should always be covered, to avoid the risk of contamination.

The covers for all tanks are similar and are erected as follows:

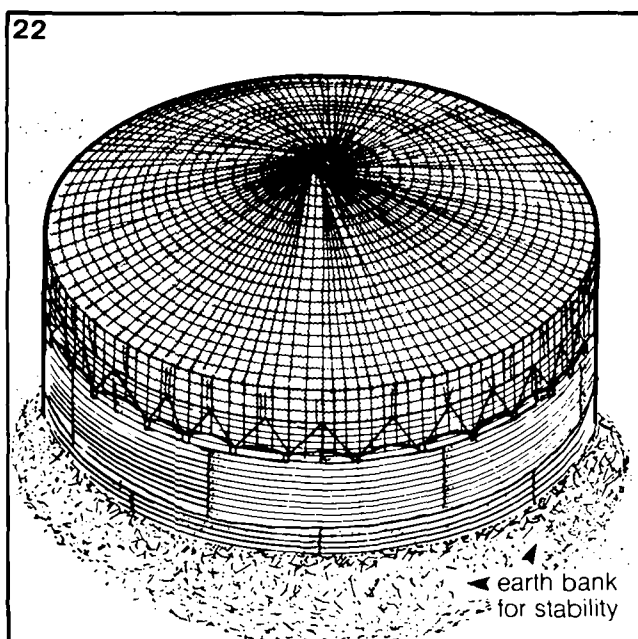
20. (a) Pass metal retaining hooks over bolts through top joint between tank sheets. Space equally round tank, 4 to each sheet. Secure with extra nut provided.

(b) Assemble the support column from pipe sections, connectors and 2 flanged ends. 3.0m high tank uses 4 pipe sections and 2.3m high tank uses 3. Secure connections with self-tapping screws in pre-drilled holes. Bolt the timber base to one flanged end ensuring bolt heads are in countersunk holes and nuts are above to avoid damage to liner.

Tie 6mm rope to top flange, stand column with timber base in centre of tank and tie the rope to each metal hook. Tighten equally to provide support for PVC cover.

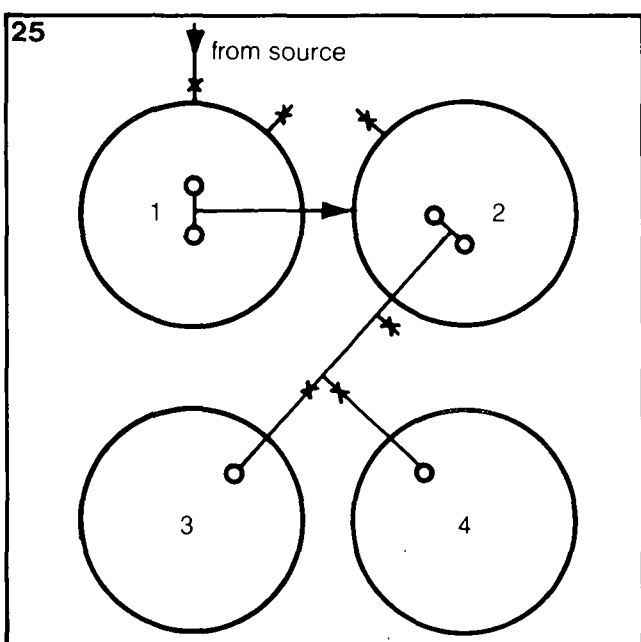
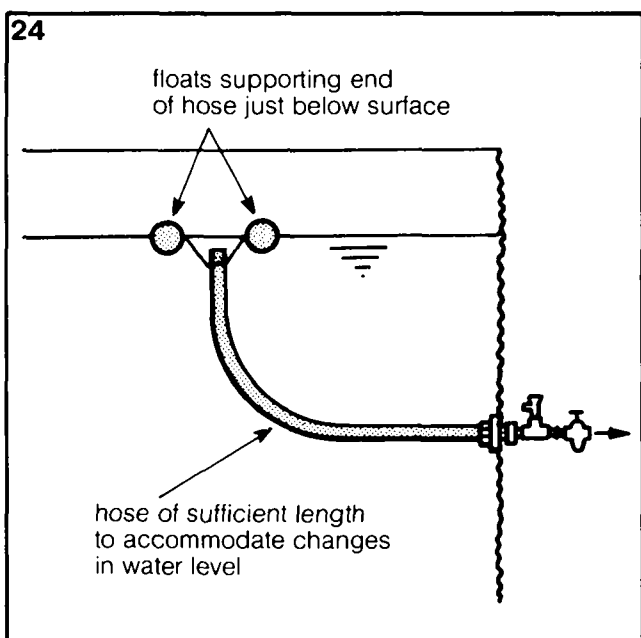
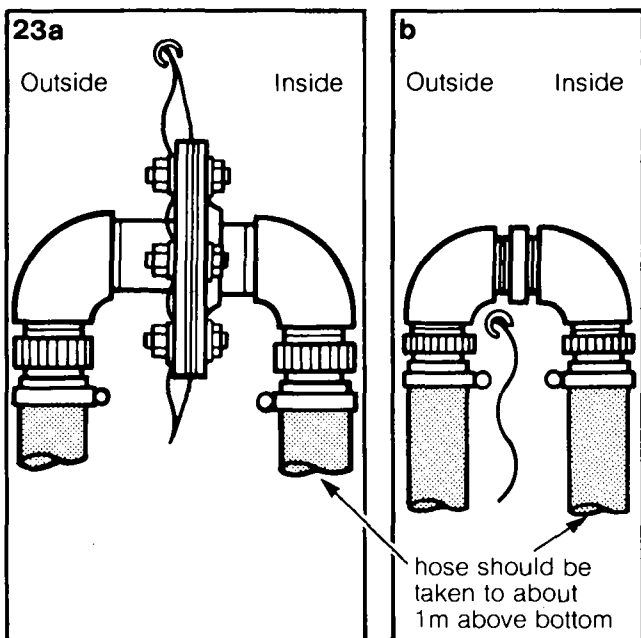


21. Lift circular PVC cover over central column and support ropes. Stretch cover over tank wall and secure to hooks with 6mm rope passed through eyelets.



22. Spread the polypropylene net over the PVC roof cover and secure net to hooks to provide additional protection in high winds.

In use one or more ropes can be released to allow cover to be lifted for delivery pipe access, but re-secure after filling.



SECTION D

Interconnecting pipework

It is strongly recommended that all hoses and fittings are laid out following the plan on page 13 **before** starting to make any connections, so that the correct layout and use of fittings is ensured.

Connections between tanks, from the source to the raw water tanks and from the filters to treated water storage are made using flexible plastic hoses and screwed hose connectors. The hose connectors are sealed by use of rubber washers; all other threaded joints should be sealed by the use of PTFE tape wound liberally onto threads. Before making any threaded joint ensure that threads are clean. Avoid over-tightening plastic fittings as threads can be stripped quite easily.

Cut flexible hose as square as possible using a hacksaw. Place hose clip over hose and push hose fully onto connector using lubricant if necessary. Fit the clip close to the end of the hose. Cut lengths of hose sufficiently long so that no strain is put on joints when hoses are full of water. Improvise supports for hoses so that strain on joints is reduced.

Note: Do not make inlet connections to filters (involving cutting liner) until all filter sand is in place and liner in final stressed state.

A 2.1m length of 20mm clear plastic hose is attached to the outlet from each filter and attached to the top of the tank to act as a head loss indicator.

Raw water tanks

Gate-valves are provided to close off the sludge drain outlets. A length of hose should be connected to these when draining in order to carry water away from the tanks.

23. The inlet from the water source to the raw water tanks may be connected in either of two ways. In either way gate valves should be provided at some point on the incoming pipelines so that each tank can be isolated.

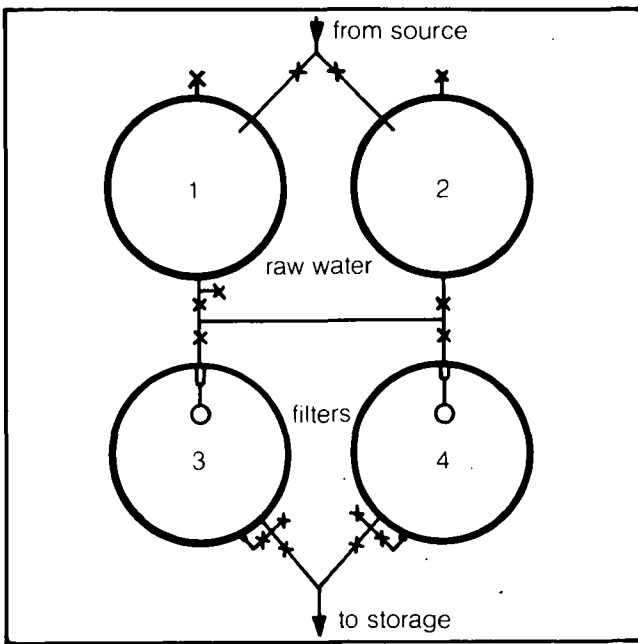
(a) By attaching an elbow to the top flanged tank connector.

(b) By connecting two elbows together and hanging this assembly over the top edge of the tank.

Turbidity removal will be improved by attaching a hose on the inside hanging down to approx 1m above tank base.

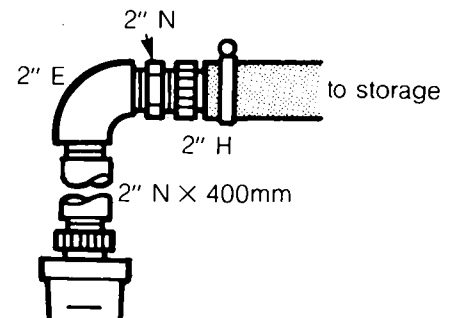
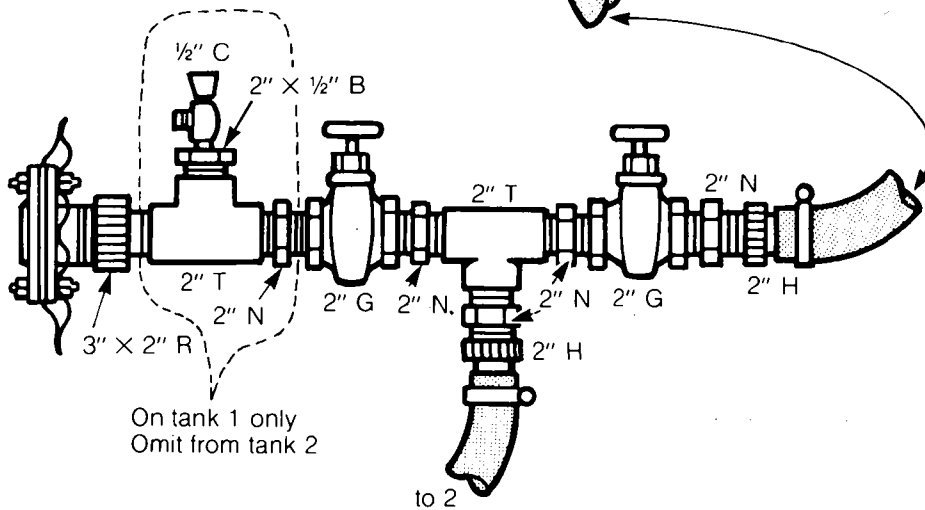
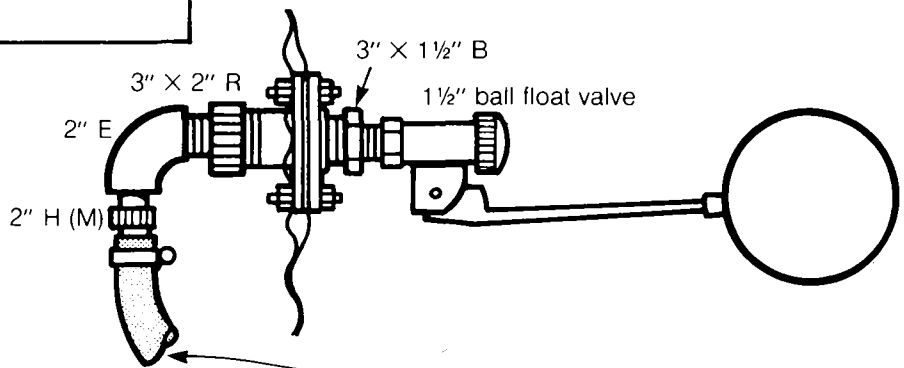
24. The removal of turbidity will be increased by use of a floating outlet from the raw water tank, which may be improvised by use of a length of flexible hose supported on airtight tanks or polystyrene floats.

25. Likewise turbidity removal will be enhanced by connecting the raw water tanks in series as shown in the drawing.



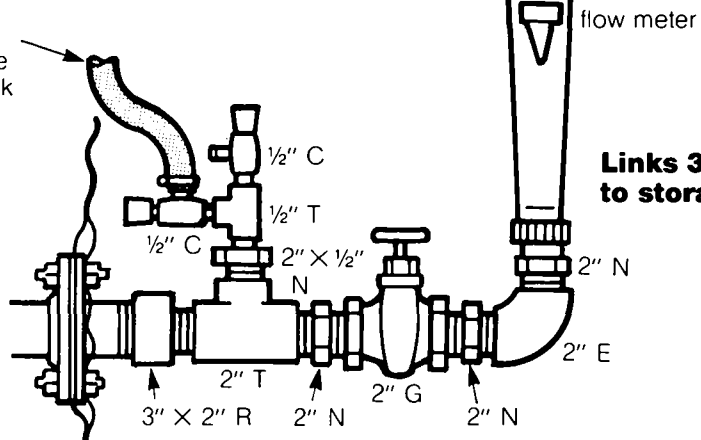
Key to plan:

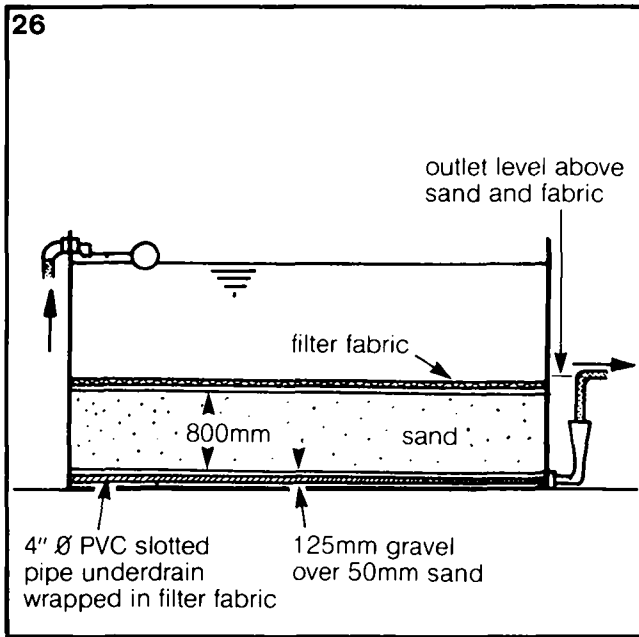
- B = bush
- C = diaphragm cock
- E = elbow
- G = gate-valve
- H = hose connector (female, swivel)
- H(M) = hose connector (male)
- N = nipple
- R = reducer (female to male)
- T = tee



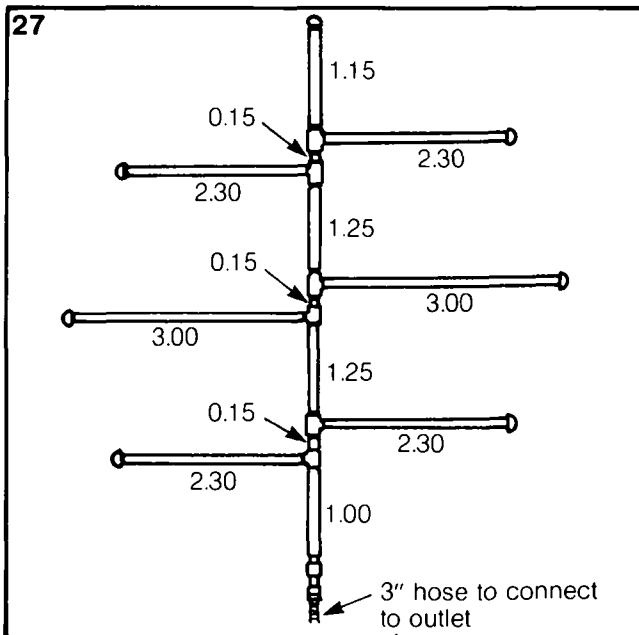
Link 1-3
(Link 2-4 similar but without a 1/2 inch cock on tee.)

Clear plastic head
 less indicator hose
 taken to top of tank

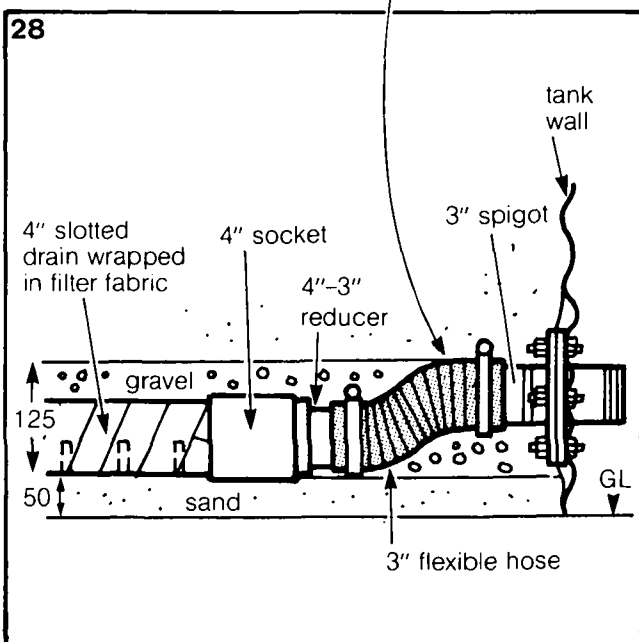


SECTION E**Sandfilter construction**

26. The filter consists of a 50mm layer of sand spread on the base of the tank on which a network of slotted 4" Ø PVC pipe is laid to collect the filtered water. This pipe is wrapped in filter fabric and surrounded by a 125mm layer of gravel above which the filter sand is placed to a depth of 800mm. A special fabric filter, 10mm thick, is spread over the surface of the sand and the supernatant water is maintained at a depth of approx. 1.1m above the sand.

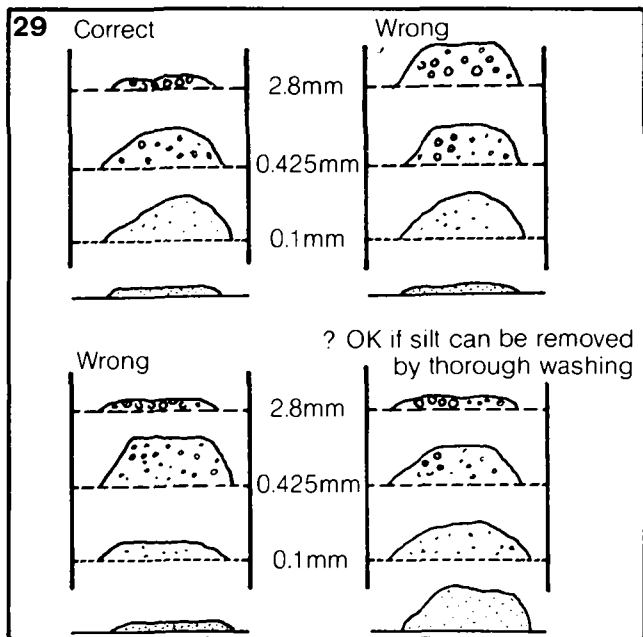


27. First spread a 50mm layer of any clean sand on the base of the tank and then place the underdrain pipe on top of this in the layout shown here. The slots should be on the underside of the pipe so that the water takes the longest path through the gravel. The pipes are simply pushed into the tees without sealing rings as slight leakage through the joints is not a problem. All pipe ends are capped.



28. The drain is connected to the outlet by means of a reducer, a short length of 3" hose and a 3" threaded spigot.

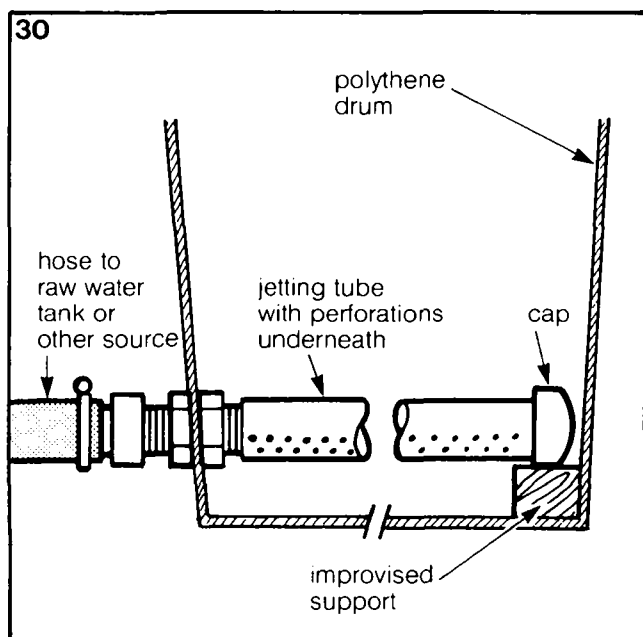
Wrap the drain in strips of filter fabric cut from the piece specially provided and secure with galvanised wire. Surround this with a 125mm thick layer of clean gravel or other inert granular material with a size of between 5 and 25mm.



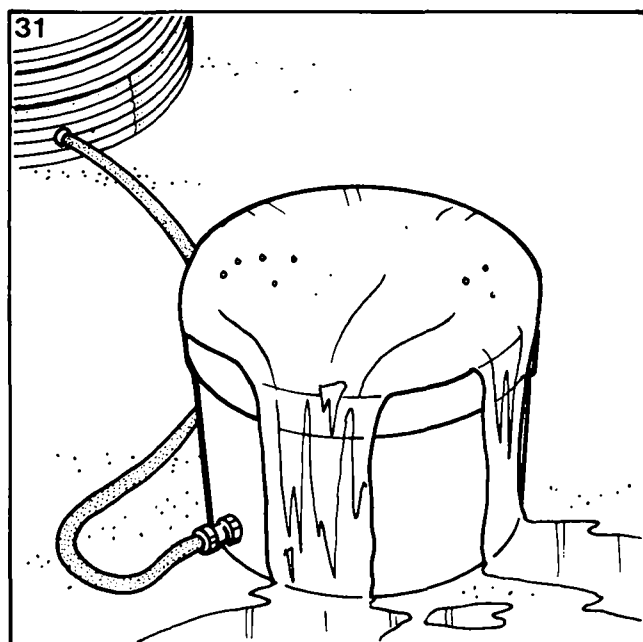
29. Whilst the tanks are being erected a suitable source of filter sand should have been located and transported to the site. The preferred specification for the sand is:

- effective size (sieve size through which 10% of sand passes) between 0.15 and 0.35mm
- uniformity coefficient (ratio of sieve sizes through which 60% and 10% of sand passes) approximately equal to or less than 3
- maximum size 3mm
- minimum size 0.1mm

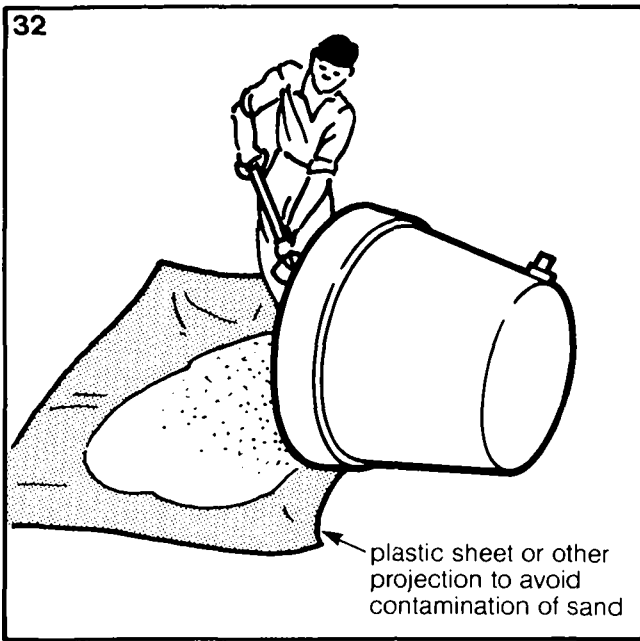
Strict adherence to this sand specification is not necessary. Test representative samples of naturally occurring sands by first washing to remove fines, silt and organic material. Then dry and sieve the sample through the stack of sieves provided (0.1, 0.425 and 2.8mm). If approximately equal quantities are retained on the 0.1 and 0.425mm sieves the sand is acceptable. If a large majority of the sample is retained on either the 0.1 or 0.425mm sieves the sand should be rejected. If a large proportion passes through the 0.1 mm sieve this small material should be removed by careful washing, but such sand should be avoided if possible. It is only necessary to sieve a sample, not all the sand for the filters.



30. All naturally occurring sands need to be washed to remove fines, silt and organic contamination before use in filters. A total volume of 55m³ of washed sand is needed for both filters. Washing is carried out using the drum provided, taking water from the nearly full raw water tank or any other pressurised water source. First assemble the jetting tube in the bottom of the drum as shown above. Connect this to the tank outlet using a 2" hose and connectors.

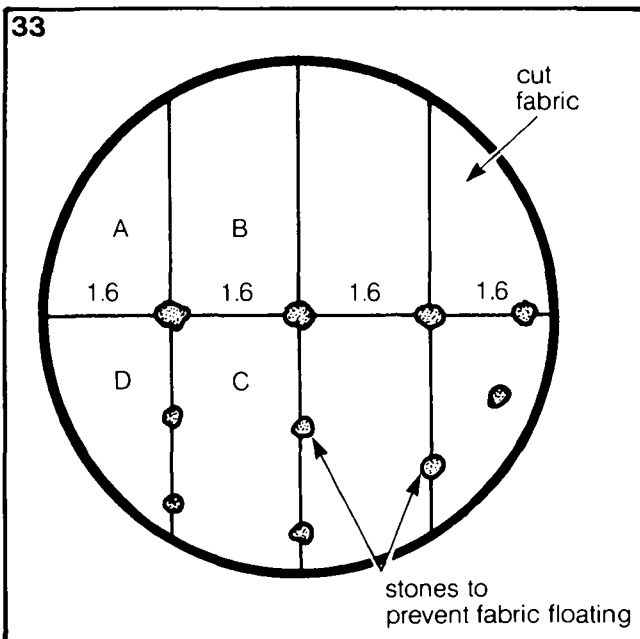


31. Ensure that excess water will drain away from the tanks. Fill drum to the brim with sand and level off. Slowly open valve at the tank outlet to allow water to flow into the drum, fluidise the sand and so carry the silt upwards and away in the overflow. Open valve fully and allow to flow for about five minutes or until overflow appears clear. If a large proportion of original sand has been removed top-up and wash again in order to conserve water.

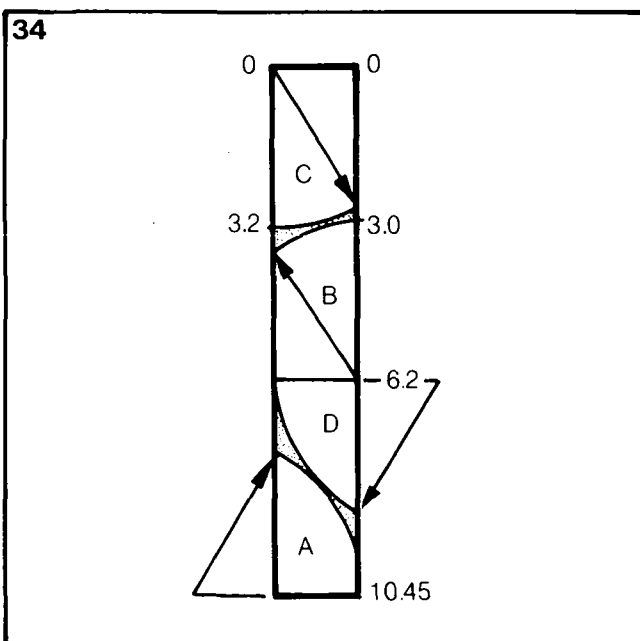


32. Disconnect hose from drum and allow water to drain out. Shovel the first half of the clean sand out of the drum and tip the remainder out. Avoid contact between the clean sand and the ground.

Before filling the filters with sand fill with water to well above the outlet flange in order to check for any leaks.



33. Fill filters to a depth of 800mm of sand. This will take a long time and much labour if done entirely by hand. When complete and the surface has been levelled off, a single layer of filter fabric is placed on the surface of the sand. The fabric is supplied in rolls 1.6m wide and has to be cut, using a sharp knife with the fabric laid out on a clean hard surface, to the shape of the tank.

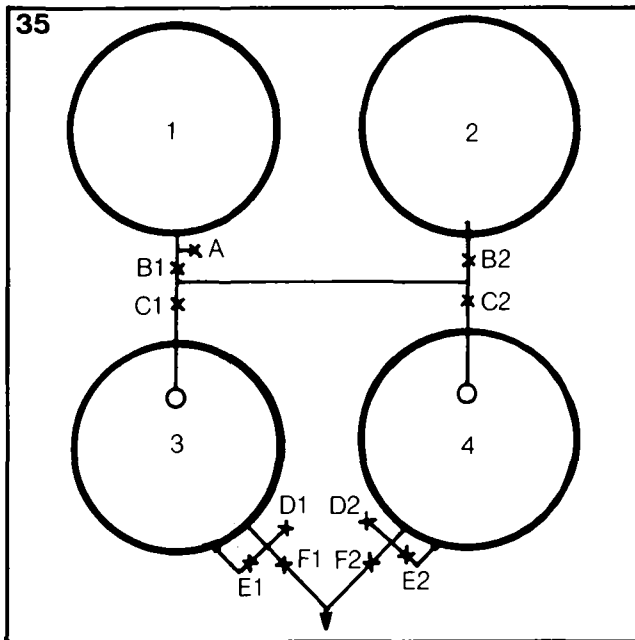


34. The roll supplied is sufficient to provide the 8 pieces of fabric required for each filter if it is cut accurately. Using a piece of string and a marking pen, mark the 3.2m radius circles required as shown here and cut the pieces accurately. When laid on the sand the fabric must be weighted down, particularly at the joints, with pieces of stone of sufficient size to prevent the fabric floating when the filter is filled with water.

SECTION F

Commissioning

When the construction of the filters is complete, they are filled with sand and the filter fabric is spread on the sand, the commissioning is carried out as follows:-



1. Fill tank 1 with water from the source, with all outlet valves closed, taking care not to allow the tank to overflow.
2. Connect 20mm hose from valve A to valve D1, and open both valves in order to commence back filling of filter 3 from below.
3. When water level in filter 3 has reached above the filter fabric (check that fabric is not floating, add weights where necessary but do not attempt to stand on sand as you will sink) close A and D1 and open B1 and C1 in order to complete filling from above through float valve.
4. Check that static water level in filter is just below outlet from the float valve, bend arm of float to adjust.
5. Outlet hose from filters must be directed to waste, not into treated water tanks, well away from tanks in order not to undermine the tank foundations. Open valve E1 to show head loss in transparent hose. Gradually open valve F1 until the top of the float in the flow meter is steady at 3200 litres per hour.
6. Check that all pipe joints are watertight. Repair any leaks.
7. Carry out the same steps 2-6 for filter 4 substituting valves B2, C2 etc. for B1, C1 etc.

Maintain the level of water in the raw water tanks above the static level in the filters and adjust valves F1 and F2 to maintain steady outputs of 3200 litres/hr from each filter.

The biological cleaning processes in the filters will take several days to establish themselves. If

you have a microbiological testing kit test the quality of both raw and filtered water and only connect the filter outlets to the treated water storage tanks when you are satisfied with the quality (preferably 0 faecal coliforms/100ml). If, after 10-15 days, no improvement in quality is noted and coliforms are still present in the filtered water connect to storage and consider chlorination (see Section H).

If water is urgently required chlorinate filtered water immediately upon starting the flow through the filters. Cease chlorination when you are satisfied that filtered water quality is satisfactory.

If no testing facility is available locally allow 15 days for establishment of the filters before connecting to the storage tanks and thence to distribution. If the raw water is highly contaminated have the filtered water quality checked at a laboratory. If in doubt chlorinate the filtered water in the storage tanks.

Never chlorinate the water in the raw water tanks as this will kill the biological process in the filters and so render them useless.

SECTION G

Operation

The Filtration Process

In order to understand fully the operating principles of a slow sand filter it is necessary to have a basic knowledge of the way in which the filter acts both biologically and physically. The treatment process is totally natural and is simply dependent on the maintenance of the correct environment for the growth of certain 'good' micro-organisms on or near the surface of the sand filter. Soon after the start of the treatment process a film of these biologically-active micro-organisms develops in the filter fabric and the top of the sand which breaks down the incoming disease-carrying organisms, converting them into water, carbon dioxide and other harmless chemicals. At the same time a large amount of suspended matter (which causes the cloudy or 'dirty' look of the water) is retained in the fabric and sand by simple straining.

The continuous straining process will gradually block the pores in both fabric and sand which allow the water to pass through. This is shown by a lowering of the water level in the head loss indicator tube on the outside of the filter tank, whilst the water level above the sand remains the same. In order to maintain the same flow through the filter it is necessary to open the outlet valve. After a certain time (generally 3-12 weeks, dependent on raw water quality) the valve will be fully open and the filter will be so blocked that it is no longer possible to get enough clean water out of it. It is then necessary to clean the filter (see page 18).

The following factors are important for satisfactory operation:-

1. The surface of the filter fabric must never be exposed to the air, it must always be submerged in the water.
2. There should be a continuous flow of water through the filter at as uniform a rate as possible, not more than 6000 litres per hour. If the flow through the filter stops for more than a very short period the biological cleaning process will very rapidly cease. The capacity of treated water storage should therefore be sufficient to balance peaks in demand.
3. The depth of water above the filter surface should preferably be kept at about 1.0m.
4. The active microbiological layer on the surface of the filter takes some time to become established and effective. It is partially removed in cleaning the filter. Therefore filtering is not as effective for a short time after cleaning.

Daily operation

At a filtration rate of 3200 litres per hour per filter the water level in the raw water tanks will drop at 0.1m/hr. Therefore it is necessary, if the tanks are constructed on the same base level as the filters, to fill them up every 8 hrs in order to maintain a flow into the filters. If they are not filled up the water level in the filters will drop at the same rate but flow will cease before the water surface reaches the fabric, as the outlet pipe is constructed above this level. Therefore it is normally necessary to pump water into the raw water tanks two or three times each day in order to maintain this standard flow rate and not to let the water level in the filters drop too much. This demonstrates the usefulness of raising the base of the raw water tank above that of the filter, so increasing the operational depth and reducing the frequency of filling the raw water tanks.

Each day the outlet valves F1 and F2 should be adjusted to maintain the required output and the level of water in the head loss indicator tube noted.

Filter cleaning

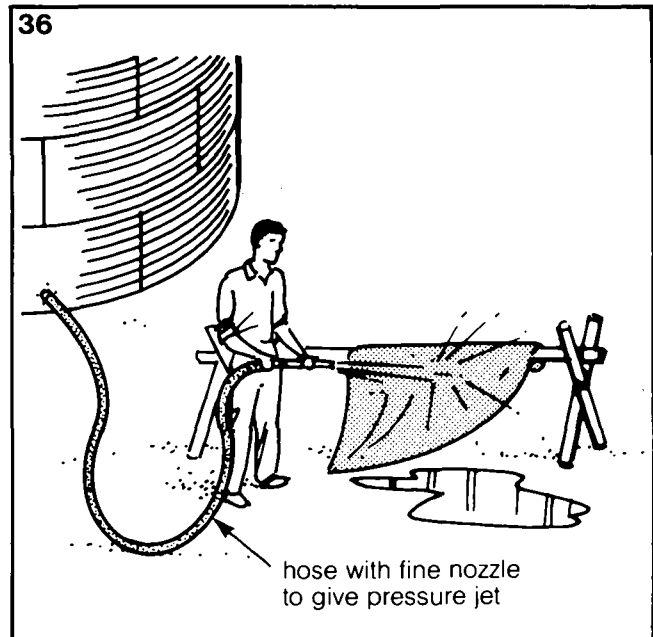
When it is no longer possible to obtain the required output and the outlet valve is fully open it is necessary to clean the filter.

One filter should be cleaned at a time, the necessary output being maintained from the other. The whole cleaning and re-establishment process takes about 3 days so that if both filters are becoming blocked at the same time the first one must be cleaned several days before the other is likely to become unusable.

The cleaning process is as follows:-

1. Close valve C on inlet to filter. Close valve F. Connect 20mm hose to valve D and direct end of hose well away from tanks. Open valve D and drain water from filter until water level is 200mm below surface of sand, as indicated in head loss indicator tube. Close valve D.

2. Enter filter tank with care using timber boards to spread weight. Remove stones and weights from filter fabric. Roll up fabric strips and remove from tank. Treat fabric with care and it will last for a long time.



3. Wash fabric by draping sheets over a support and spray with a powerful jet until all silt is removed. A short hose may be connected to the raw water tank outlet A or, preferably, a pumped supply used for this washing.
4. In some conditions, and in all filters occasionally, it will also be necessary to remove a thin layer of sand from the surface of the filter as this becomes blocked both with inorganic debris and with micro-organisms. Avoid this until it is essential for satisfactory operation. Use flat-bottomed shovels to remove only about 10mm of sand, taking great care not to damage the tank liner.
5. Replace the filter fabric as before, weighting down with stones.
6. Refill the filter sand by backfilling with water, but use the 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.
7. Whilst filter microbiology is being re-established the filtered water will not be pure. Therefore disconnect filter outlet hose from the storage tank and allow it to flow to waste. Open valve F gradually over a period of 24 hrs until a flow of 3200 litres per hour is indicated on the meter. This is particularly important if some of the sand has been removed, as this harbours most of the 'good' micro-organisms.
8. After 2 days, or when the filtered water quality test shows it to be satisfactory, reconnect to the storage tank.
9. Repeat process 1-8 for the other filter.

Eventually, after several years' operation, the sand thickness in filters may have been reduced

to 500mm. This is the minimum for effective filtering. At this stage more washed sand should be added and the full microbiological commissioning repeated.

If the raw water contains a large amount of suspended solids this will be deposited in the raw water tanks. As this builds up it should be removed from the base of the tanks by simply opening the bottom outlet, with a hose connected to take the sludge away from the tank foundations. If the sludge is too thick to flow through the outlet it may be necessary to drain down most of the supernatant water and mix the sludge by hand with water.

Note: Sunshine may encourage the growth of algae in the transparent flow meters. This can be avoided by covering the meter in a piece of 4" Ø pipe.

SECTION H

Options

Water Quality Testing

The Oxfam/Delagua portable water testing kit is an essential tool for water quality monitoring and is of particular use where a Filtration Pack has been installed. The kit is fully equipped to monitor the following six parameters:-

Faecal coliform count:

this is the indicator of faecal contamination, the main source of water-borne disease. It is measured by means of membrane filtration and a battery-operated incubator.

Turbidity:

the degree of cloudiness and concentration of solids. Measured by a visual tube method.

Conductivity (E.C.):

a measure of the concentration of salts in the water.

Temperature

pH:

acidity/alkalinity

Chlorine concentration

The kit is fully self-contained in an easily carried and rugged case weighing about 8kg and comes with all materials necessary for several hundred tests. It can therefore be used in remote, rural situations.

Training in the use of the kit is essential in order to achieve valid results.

Information about the kit is available from:

Delagua, PO Box 92, Guildford, Surrey GU2 5TQ, U.K. Tel. (0483) 572823 Telex 859331 UNIVSY G

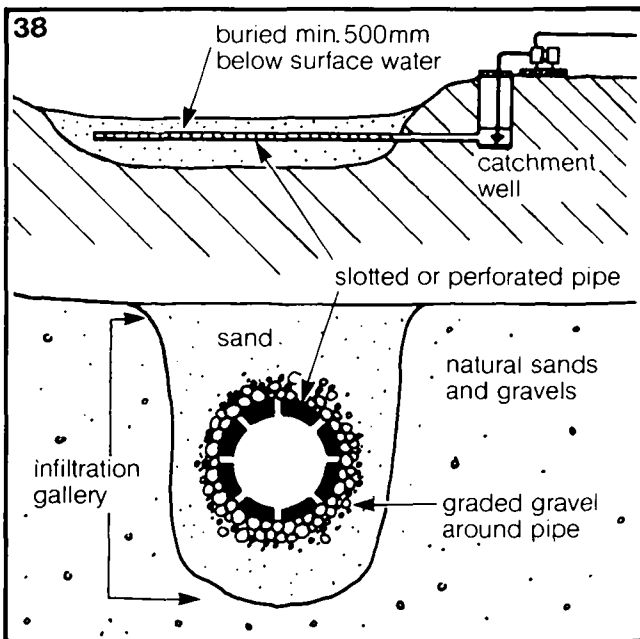
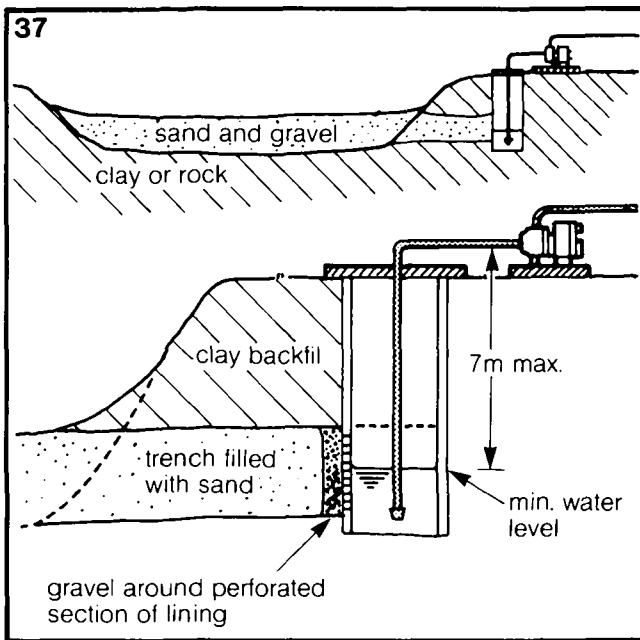
Treatment of Highly Turbid Water

As stated in *Section A* the highest practical turbidity for water to be treated by this Pack is about 20 NTU. Above this the filters will become blocked very rapidly, so some form of pre-treatment will be necessary. Such pre-treatment will usually also reduce the level of contamination of the water as dangerous micro-organisms are often associated with the solid particles. Various options exist:

Sedimentation:

natural sedimentation of solids suspended in water is often slow, but is readily assisted by addition of a coagulant, such as aluminium sulphate (alum). This chemical naturally causes the solid particles to aggregate together and so to form larger masses which settle more rapidly.

Such alum-assisted sedimentation may be carried out in the raw water tanks of this Pack by fixing up a simple system for dosing the water in the tanks regularly with alum dissolved in water. Good dispersion of the alum throughout the water to be treated should be ensured before it is introduced to the tanks. This is easily carried out by drip feeding an alum/water solution into a



small tank erected on the inlet pipeline to the raw water tanks. Agitation of water in the settlement tanks must be minimised.

The dose of alum necessary for a particular water will have to be determined by experiment but is likely to be in the range 25-150 mg/litre or 25-150 g/m³.

If the water is very highly turbid a large amount of sludge will be generated, which may be impossible to remove through the 3" bottom outlet of these tanks. In this case it will have to be removed by hand and it may be necessary to add special sedimentation tanks before the raw water tanks in the Filtration Pack system.

Use of infiltration galleries:

Often the best way of exploiting a surface water source, and one which improves both the physical and microbiological quality, is by taking water from the sediments found in a river bed. This method will yield water even when there is none evident on the stream surface, as much is stored in the sediments. Two methods are illustrated here:

37. By construction of a well in the river bank which is surrounded by gravel and connected to the porous river sediments by a sand-filled channel.

38. By use of a slotted or perforated pipe laid under the river bed. The pipe is surrounded by graded gravel and sand and collects water from both the surface and the sediments. It leads water to a collection chamber in the river bank from which it is pumped. The yield may be increased by construction of a sub-surface dam, a wall across the river bed, which blocks the sub-surface flow, downstream from the infiltration gallery. Such a dam will also protect the pipe from movement.

Roughing filtration:

Either horizontal or vertical filtration through a bed or beds of gravel may also be used to remove a proportion of the suspended solids. Some means of backwashing of such filters is necessary as the filtration process is entirely physical and the filters rapidly become blocked.

Chlorination

Chlorination is the most commonly used means of disinfection of water. Chlorine destroys virtually all disease-carrying micro-organisms. The most important factor in any use of chlorine is the determination of the concentration 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 the water or on water-carrying utensils. It is vital therefore, that enough is added at the point of addition 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 of water both before and after it has been collected by the consumer.

A minimal residual, of 0.2-0.3 mg/litre is thus required at the final delivery point. But, because of the potential contamination in the distribution system and the likelihood of chlorine absorption by the container, 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 throughout the delivery chain.

Chlorine can be added to water in several different forms. The most commonly used is calcium hypochlorite, which comes in either powder or granular form, both of which are easily added to storage tanks such as in this Oxfam Pack system. Alternatively chlorine is available as sodium hypochlorite in liquid form (bleach) which may likewise be added directly to the tanks. A third method is the use of the tablets often used for disinfection of swimming pools, containing trichloroisocyanuric acid. These can be suspended in the storage tank in a perforated container. The necessary dose of any of these forms of chlorine will have to be determined by experiment as the residual will be dependent on the quality of the water being disinfected. After addition of chlorine the water should be left for a minimum of 30 minutes, and preferably several hours, 'contact time' before being drawn off for use.

Handling and storage of all forms of chlorine is potentially hazardous so strict precautions, following the suppliers' instructions, must be observed.

The level of residual chlorine is very easily determined by use of a simple colour comparator and tablets added to the water. A test kit comes in both the Oxfam/Delagua Water Test Kit and the chlorination kit which is described here:

Chlorination kit

● Code No. SCL, (Approximate gross weight and volume 11kg, 0.04m³), containing:

- 1 No. box of chlorinating tablets
- 3 No. holders for suspending the tablets in water
- 1 No. chlorine concentration measuring kit

Scaffold

A collapsible tubular scaffold platform, useful for erection of high tanks and for use as a permanent platform for monitoring treatment and for dosing of alum etc, is available through Oxfam. It can be erected to give a working platform at any height up to 3.7m and is specified as follows:

1 No. scaffold kit (3.7m)

● Code No. OC, (Approximate gross weight and volume 45kg, 0.5m³), containing:

- 1 No. Lyte aluminium climber tower comprising one base module, one height module and one platform module complete with braces, hand-rails, stabilisers and platform board.

Final reminders and recommendations

- Try to site the tanks so that both the filtration and distribution will occur by gravity - choose an elevated location for tanks.
- Ensure tank sites are well drained and not likely to flood.
- All tanks should be securely fenced and guarded to prevent children and others access.
- Ensure stability of tanks, particularly when empty or in high winds by using guy ropes and by banking earth around lower sections of tanks.
- Use tank roof covers on treated water tanks and keep well lashed down.
- Take great care not to damage filter tank liners when installing sand and gravel and when cleaning filters.
- When treating turbid waters remove as much turbidity as possible before filtration by:
 - providing as much raw water storage as possible
 - putting raw water tanks in series
 - providing floating outlets from raw water tanks.
- Arrange special clothes washing and bathing facilities, as well as livestock watering points, all using unfiltered water in order to economise on filtration.
- In order to conserve treated water supplies arrange for distribution system to be shut down at night, and, if necessary, for specified periods during the day. This will reduce wastage.





Hans Hartung