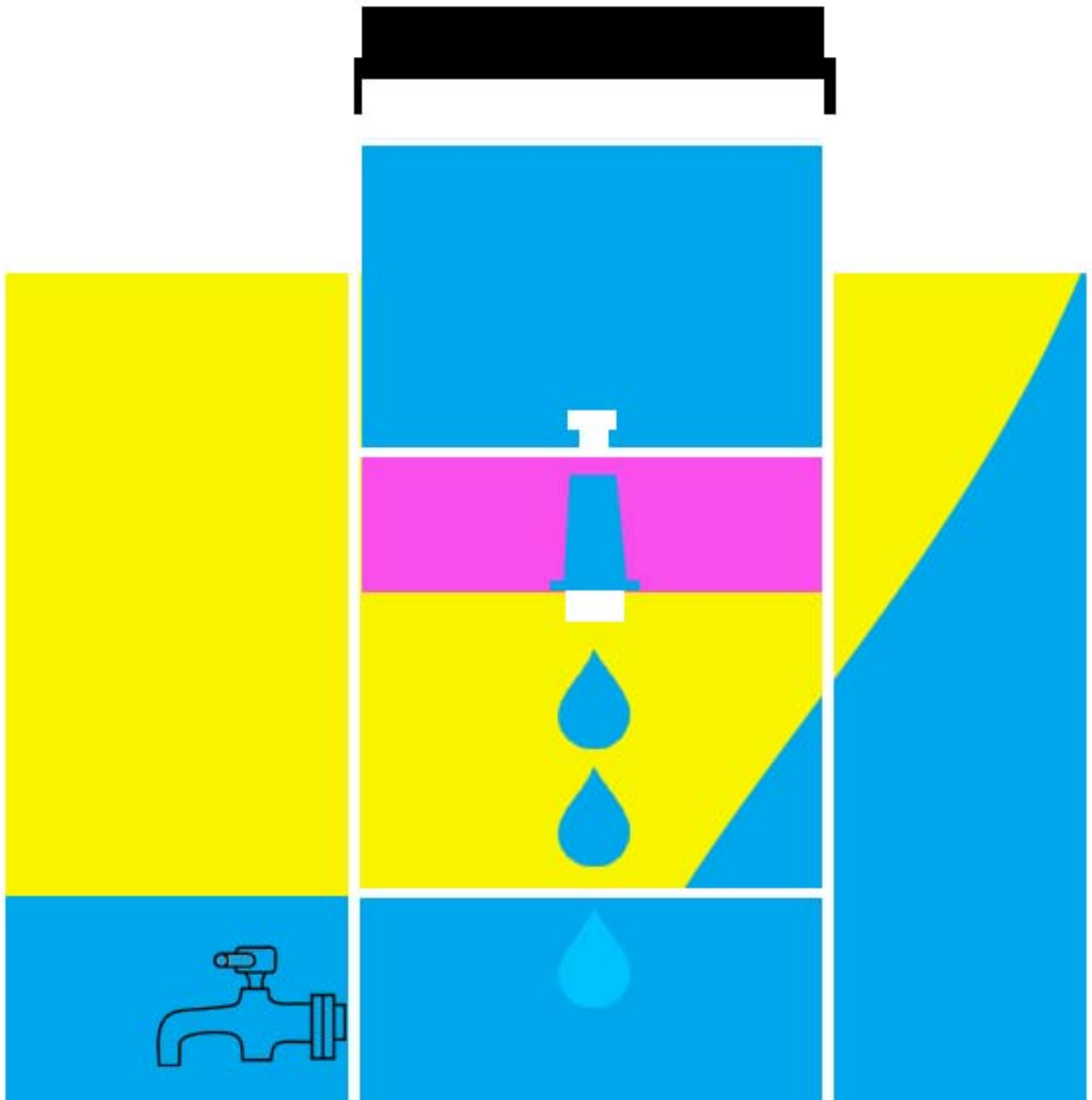


Draft Specifications for Domestic De-fluoridation Filter Unit & Activated Alumina for Defluoridation



Draft Specification for
Domestic (household)
Defluoridation Filter
Unit (DDFU/DDU)

Contents

Introduction	2
The Generic Domestic (household) Defluoridation Filter Unit (DDFU/DDU)	3
Typical Description of a Stainless Steel Domestic (household) Defluoridation Filter Unit (DDFU/DDU)	4
Typical Specifications of Plastic Domestic (Household) Defluoridation filter unit (DDU/DDFU) of 25 Litres capacity	5
Draft Specifications for Activated Alumina (AA)	10
Annex 1: Additional Requirements for Plastic Filters	12
Annex 2: Screening of Activated Alumina in the Laboratory, for use by Manufacturer for Verifying their own Products	16
Annex 3: Regeneration Procedure for Exhausted Activated Alumina at Manufacturers Level	18
Annex 4: Handling of Sulphuric Acid and Caustic Soda during Regeneration of Activated Alumina	20

Draft Specification for Domestic (household) Defluoridation Filter Unit (DDFU/DDU)

Introduction

Fluoride is a normal constituent of most natural waters and its concentration varies depending on the water source. Surface waters seldom have fluoride concentrations beyond 0.3 mg/lit. Geological processes, weathering of fluoride bearing minerals and hydrogeological conditions can lead to higher fluoride levels in groundwater in certain areas, which can become endemic for fluorosis. The usual remedial measures are:

- Basing water supply on a distant safe source
- Using surface water after conventional treatment
- Household rainwater harvesting
- Community based treatment
- Household treatment

Each of the above solutions has situation-specific applicability. The first two alternatives are cost intensive, have long gestation periods and require a sophisticated level of Operation and Maintenance (O&M) capability and are generally not the choice for rural water supply solutions in developing countries. Rainwater harvesting is possible but can only be a seasonal supplementary source during and after the monsoons in India. Hence the preference has been to seek solutions around small habitation based and household level treatment systems for fluoride removal or Defluoridation.

Defluoridation methods can be broadly divided into following categories, each with its own merits and limitations:

- Chemical addition/precipitation
- Adsorption/ion exchange
- Membrane based technologies

Defluoridation using Activated Alumina (AA) has been one of the widely used adsorption/ ion exchange methods water and many reports are available on large-scale installations for townships, requiring supervision and skilled personnel. The quality of treated water from such facilities is assured. However, this approach is not immediately feasible in developing countries, especially in rural areas. Treatment may only be possible at a community level, i.e. treatment systems attached with handpump installations or at the 'point of use', i.e., domestic level.

UNICEF, Delhi supported Indian Institute of Technology, Kanpur since 1991 to develop defluoridation systems based on the use of AA.

The initial intention of the research project was to develop and field test a handpump based defluoridation unit that could be maintained by local communities. Around 1996, the focus of the research changed to finding solutions for domestic defluoridation. This led to the screening of many indigenously manufactured grades of AA for defluoridation application and the development of Domestic Defluoridation Units (DDUs).

Two parameters are considered as important for the application of AA in defluoridation. One is Fluoride Uptake Capacity (FUC) expressed as milligrams of fluoride removed per Kg of AA and the second is reuse potential of activated alumina in multiple defluoridation cycles.

During 1991-2002, more than 15 grades of locally manufactured AA were screened by IIT Kanpur. Under experimental conditions used in their study, FUC ranged from 1500 mg/Kg AA and 2200 mg/Kg AA. Studies were also carried out on the effect of raw water characteristics as well as AA particle size, empty bed contact time on FUC, with selected grades of AA. The main result from these studies was the improvement and availability of activated alumina in the desired particle size range.

DDUs were initially designed on the assumption that 20 litres of treated water was the daily requirement for cooking and drinking for a family. With this criterion, it was expected that 3 Kg. AA would be exhausted in 2 to 3 months if fluoride concentration in water was around 4 mg/lit.

Specification for DDUs and AA have been proposed on the basis of the research work done by IIT Kanpur during 1991-2004 and the application of this information to UNICEF supported pilot projects on Domestic Defluoridation in Andhra Pradesh and Rajasthan during 1996-2002.

Draft Specification for Domestic (household) Defluoridation Filter Unit (DDFU/DDU)

The Generic Domestic (household) Defluoridation Filter Unit (DDFU/DDU)

In generic terms, the Domestic Defluoridation Filter Unit consists of an upper chamber which holds raw or untreated water. This is how water comes into contact with a bed of Activated Alumina (AA) granules and passes out at a slow rate through a small orifice at the bottom of the upper chamber. The AA bed is protected from being agitated every time water is poured into the chamber, by a perforated baffle plate, placed over the layer of AA.

A micro-filter, with slots smaller than the grain size of the AA granules, prevents the AA from passing through the upper chamber along with the water. An orifice at the bottom of the micro-filter regulates the flow of water through the AA bed, assuring proper contact time for the adsorption process, by which Fluoride ions are retained on the surface of the AA granules.

Treated water from the upper chamber collects into a lower chamber and is drawn for use from a tap in the lower chamber. The lower chamber can be designed in a manner that the upper chamber sits on it and provides a snug fitting cover to the lower collection chamber. This assures safety of the treated water.

The containers of a Domestic Defluoridation Filter Unit can be made from deep drawn stainless steel, virgin food grade plastic, high density polyethylene (HDPE), ceramic and earthenware pots or jars, or combinations of these materials. In each case, the micro-filter at the base of the top container must be easy to assemble and remove for cleaning and must form a water tight seal at its joint with the container, when assembled.

Designs for typical Stainless Steel and PVC DDU are provided later.

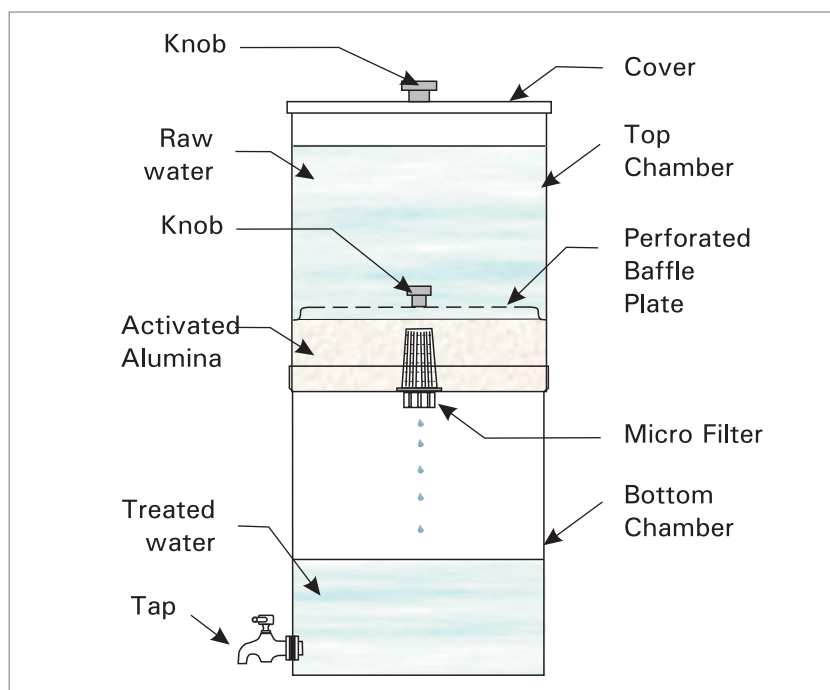


Fig. 1: A Typical Domestic Defluoridation Filter

List of spares to be provided

It is recommended that spare parts for DDUs should be procured at the time of purchase of DDUs, at the rate of 5% of total units ordered.

Sl. No.	Recommended Spare parts
1.	Taps with washer/gasket
2.	Baffle Plates
3.	Knobs
4.	Micro Filter and its sealing washers

Draft Specification for Domestic (household) Defluoridation Filter Unit (DDFU/DDU)

Typical Description of a Stainless Steel Domestic (household) Defluoridation Filter Unit (DDFU/DDU)

Domestic Defluoridation Filter Unit, similar to the attached illustration, will consist of two stainless steel seamless containers, each of 12 to 15 litres capacity made from 22G AISI 304 stainless sheet with a stainless steel baffle plate.

The bottom container should be fitted with a 6 mm (1/4 inch) chrome plated brass tap or a good quality plastic tap for drawing water.

The bottom surface of the top container shall have a hole 25 mm dia. in the centre and shall be fitted with a plastic micro-filter assembly (slot opening <0.2 mm) with 1.5 mm dia. hole in the threaded plug (Fig. 5). The top container shall also have a snug fitting stainless steel cover.

The bottom and top containers should be designed in such a way that the top container has snug-fit seating with the bottom container.

The baffle plate and the cover should be made from 22G AISI 304 stainless steel sheet and shall be fitted with stainless steel, bakelite or plastic knob, attached with a stainless steel screw. The baffle plate shall have 100 nos. equally spaced 1.5 mm dia. punched holes and its diameter should be 2 mm less than the internal dia. of the top container. The baffle plate shall have a vertical rim of 10 mm so that the flat surfaces of the plate does not come into direct contact with the layer of AA.

An instruction manual, for use of the filter and its routine care should be supplied with every filter unit.

Packing

Each SS filter unit should be covered in a polythene bag and packed in a cardboard carton. For bulk packing four individual cartons should be packed in larger cartons. Further, four larger cartons should be packed in a wooden crate. Net weight of the filters and gross weight of each packing unit will be prominently displayed.

- **AA Grade: Specification separately enclosed**
- **Depth of AA in the unit: Between 3-4 cm/Kg**
- **Filtration Rate: 8-10 Litres/hour with a PVC Micro-filter**
- **Amount of AA: Not less than 3 Kg and not more than 4 Kg.**



Fig. 2: Typical SS DDU

Draft Specification for Domestic (household) Defluoridation Filter Unit (DDFU/DDU)

Typical Specifications of Plastic Domestic (household) Defluoridation Filter Unit (DDU/DDFU) of 25 Litres capacity

Domestic Defluoridation Filter Units, as per attached drawing, each comprising of two plastic seamless chambers, each of 12 to 15 litre capacity with plastic splash plate and lid made from virgin, food grade HDPE/PVC/PP/PET conforming to the following Indian Standards respectively amended up to date:

1. IS 10146: 1982 for Polyethylene for its safe use in contact with foodstuff, pharmaceuticals and drinking water
2. IS 10151: 1982 for Polyvinylchloride (PVC) and its copolymers for its safe use in contact with foodstuffs, pharmaceuticals and drinking water
3. IS 10910: 1984 for Polypropylene and its copolymers for its safe use in contact with foodstuffs, pharmaceuticals and drinking water
4. IS 12252: 1987 for Polyalkylene terephthalates (PET & PBT) for their safe use in contact with foodstuffs, pharmaceuticals and drinking water.

No recycled plastics shall be used in the manufacture whatsoever. The chambers shall be transparent/translucent in order to visualize water level in the chambers. The colourants and pigments used shall conform to the limits and tolerances prescribed in IS 9833: 1981 amended up to date subject to the above requirement of transparency.

The unit design shall be such that it is stable when kept in vertical position. The shape of unit shall be as shown in the attached drawing. The suppliers are free to suggest modifications in the design of containers to make them more user-friendly, stable, stronger and durable. The trial design adopted shall be approved by the client.

The lid shall fit securely over the top rim of the tank and shall rest evenly on it in order to prevent the ingress of foreign matter such as insects or dust through the top of the container. The lid shall be fitted with plastic knob attached with a stainless steel screw.

The bottom surface of the top container shall have a 25 mm dia. hole in the centre and fitted with a plastic micro filter assembly (slot opening < 0.2 mm) with a 1.5 mm dia. hole in the threaded plug (Fig. 5). The filter should be easy to remove for cleaning and must form water tight seal at its joint with the container, using rubber washers, when assembled.



Fig. 3: Typical Plastic DDU

A 6 mm (1/4") plastic tap shall be fitted in the lower chamber of container to draw water. It should be capable of delivering water at the rate of 6 lpm when the container is full and the tap is fully open.

The bottom and top containers to be designed in such a way that the top container has snug-fit seating at the top of the bottom container.

The baffle plate should be made from plastic sheet with a plastic knob, with a minimum 500 nos. equally spaced 2.5 mm dia. holes in rectangular pattern. The diameter of the splash plate should be 2 mm less than the internal diameter of the top container.

Draft Specification for Domestic (household) Defluoridation Filter Unit (DDFU/DDU)

Capacity

The upper and lower chamber each shall be manufactured in nominal gross capacity of 12 to 15 lits. The brimful capacity shall exceed the nominal capacity by minimum of 10 percent. The brimful capacity shall be determined by the method prescribed in IS 2798.

Packing

Each DDU should be covered in a polyethylene bag and packed in a cardboard carton. For bulk packing four individual cartons should be packed in larger cartons. Further, four larger cartons should be packed in a wooden crate. Net weight of the filters and gross weight of each packing unit will be prominently displayed.

Workmanship and Finish

The unit shall be manufactured in accordance with good manufacturing practices. The internal and external surface of the containers shall be smooth, clean and free from other hidden internal defects such as air bubbles, pits and metallic or other foreign particles inclusions, burnt, oxidized or unhomogenized matter, flash, rocking bottom, sharp edges etc. The mould parting line and excess material near the top rim of the tank shall be cut and finished to the required level. Defects like air bubbles and pits at mould parting line and at top rim of the upper chamber shall be repaired by hot-air filler rod welding method.

Additional requirements for Plastic Filters

Refer Annex. 1.

Draft Specification for Domestic (household) Defluoridation Filter Unit (DDFU/DDU)

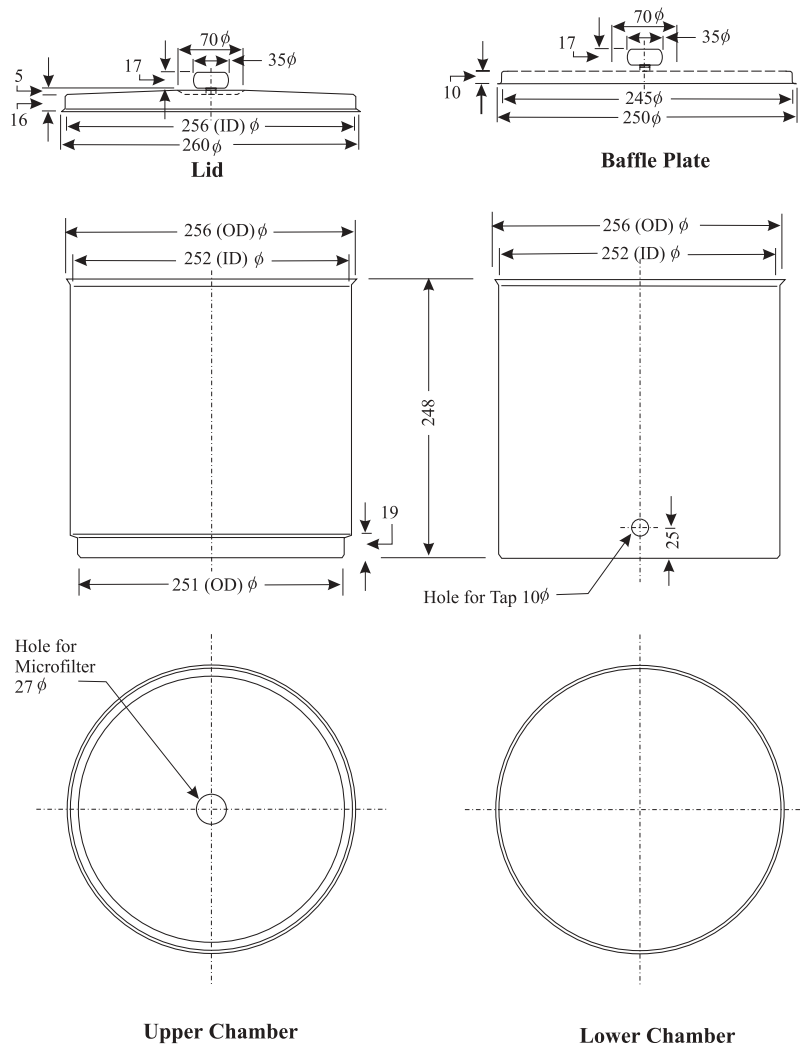


Fig. 4: Typical Design: 12 Lit. Capacity SS Domestic Defluoridation Unit, Upper & Lower Chambers
Note: The above diameter of the upper chamber will require 4 Kg AA (3 Kg AA, with Bulk Density of 0.85 will give a depth of 7.1 cm with a diameter of 252 mm)

Material: SS sheet, 0.7 mm thickness, deep drawn, seamless
Dimensions in mm
Not to Scale

Draft Specification for Domestic (household) Defluoridation Filter Unit (DDFU/DDU)

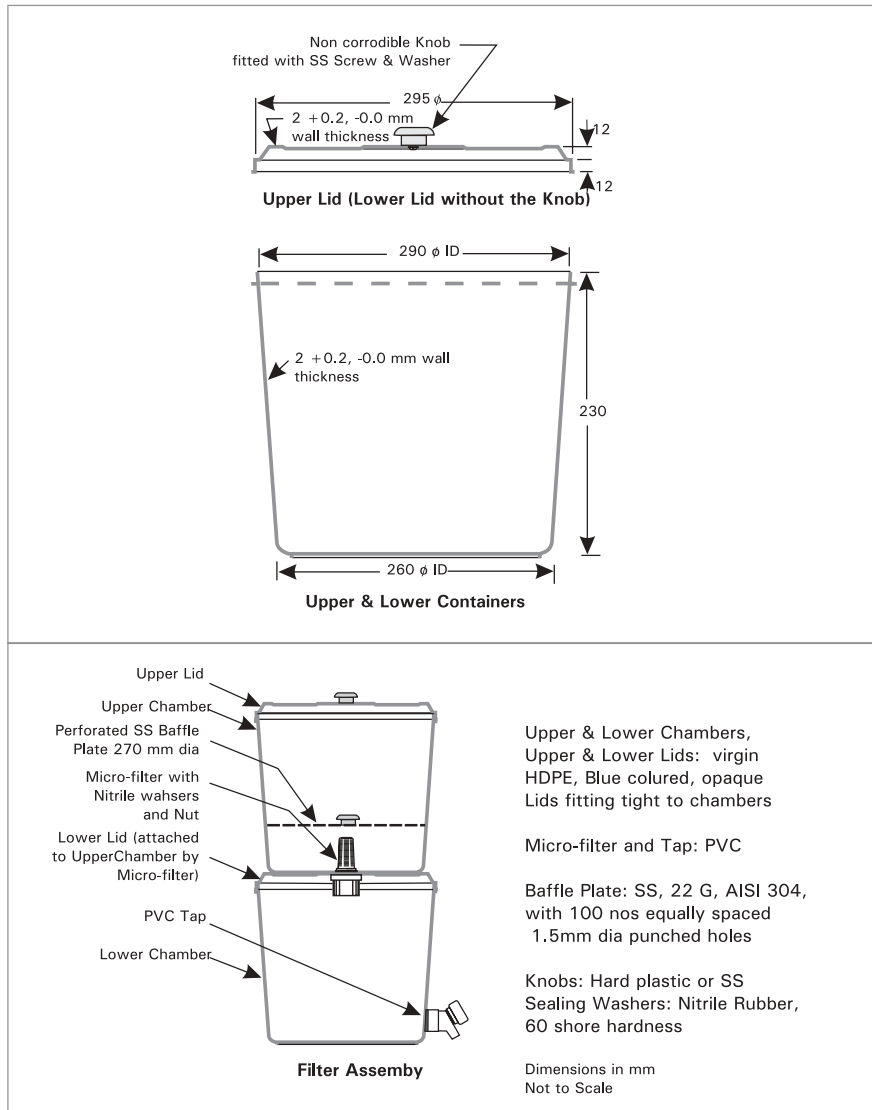


Fig. 5: Typical Design: 15 lit. Capacity, PVC Domestic Defluoridation Filter
Note: This diagram will require 4 Kg AA

Draft Specification for Domestic (household) Defluoridation Filter Unit (DDFU/DDU)

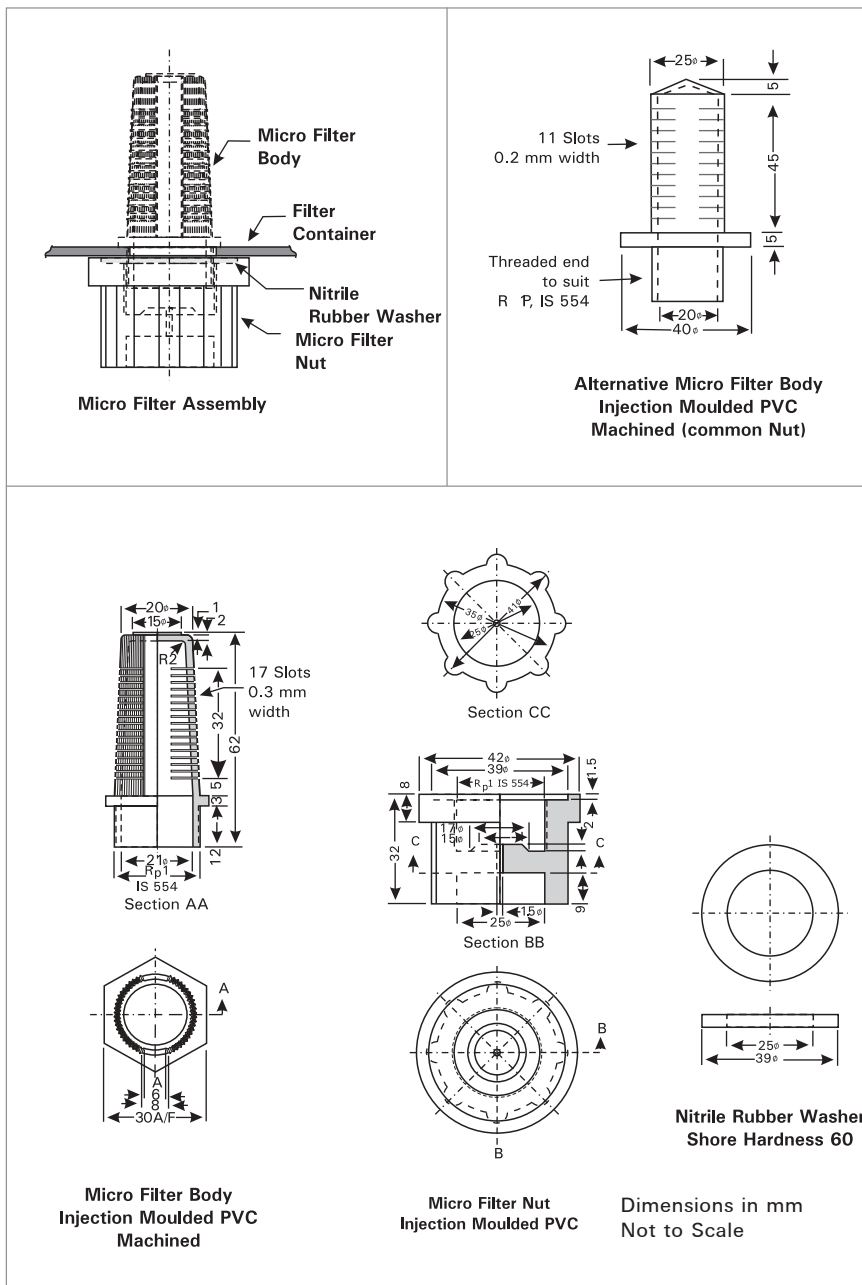


Fig. 6: Micro Filter Assembly & Parts for Domestic Defluoridation Filter

Draft Specification for Domestic (household) Defluoridation Filter Unit (DDFU/DDU)

Draft Specifications for Activated Alumina (AA)

Properties of AA should generally conform to IS: 9700:1991, Grade 1 except that minimum surface area can be 300 m²/g (Refer to Item 9 below)

- 10% < 0.6 mm
- 80% < 1 mm
- Oversize and under size fractions should not exceed 5%.

In addition to the above, the AA should meet the following requirements:

Shape can be spherical/irregular (mechanical grinding not acceptable).

The grain size shall be 0.4-1.2 mm with size distribution as given:

Properties of AA as per IS: 9700:1991, Grade 1 are:

Sl. No.	Characteristic	Grade 1
1.	Moisture, Percent by mass, Max	2.0
2.	pH Value	4.6 - 8.0
3.	Aluminium oxide (as Al ₂ O ₃), Percent by mass, min.	91.0
4.	Water soluble chlorides (as Cl), Percent by mass, Max	0.7
5.	Water soluble sulphates (as SO ₄), Percent by mass, Max	0.7
6.	Sodium and its compounds (as Na ₂ O), Percent by mass, Max	0.8
7.	Adsorption capacity, Percent, Min	20.0
8.	Pore volume, mg/L, Min	0.40
9.	Surface area, m ² /g, Min	350
10.	Bulk density, g/ml, Min.	0.75
11.	Attrition, Loss, Percent by mass, Max.: a) By tamping b) By rotation	0.50 1.50
12.	Bed crushing strength, Percent, Min.	90

Note: Requirements for moisture, adsorption, capacity, pore volume, surface area, loss on attrition and bed crushing strength are critical for adsorbent application.

Draft Specification for Domestic (household) Defluoridation Filter Unit (DDFU/DDU)

The yield of treated water (up to Fluoride < 1.5 mg/L) shall not be less than 240 L/Kg AA and Fluoride Uptake Capacity shall not be less than 2300 mg/Kg AA in the first defluoridation cycle under the experimental conditions specified in Annex 2.

Manufacturers will specify the Fluoride Uptake Capacity in 10th Defluoridation cycle, i.e. after 9 regenerations. The regeneration method to be followed is provided in Annex 3. Safety requirements for handling of reagents during regeneration are detailed in Annex 4.

Loss in Fluoride Uptake Capacity, in 10th Defluoridation cycle, should not exceed 15% of the original.

Treated water should be preferably free of Aluminium. If present, it should not exceed 0.2 mg/L (the maximum

permissible level as per IS: 10500 as measured by standard APHA test procedures).

Loss in weight after 9 regeneration cycles (which could be due to attrition and physical loss or loss during acid and alkali treatment during regeneration) should not exceed 15% of the original weight.

AA should be washed thoroughly with water to remove dust particles and dried before packing.

Standard packing

Sealed heavy duty polythene packets containing 3 Kg to 4 Kg, and then in cardboard cartons of 10 packets to each carton.

Additional Requirements for Plastic Filters

Apart from the specification provided earlier, containers for Plastic Filter should meet the following conditions:

Tensile Strength

Tensile strength at yield shall be determined in accordance with IS 8543 (Part 4/Sec-1): 1984. The tensile strength of the wall of container shall not be less than 12 N/mm².

The test specimens shall be cut from the flat portion of the container at a temperature not exceeding 50°C and then machined.

Flexural Modulus

The flexural modulus shall be determined in accordance with IS 13360 (Part-5/Sec-7): 1995. The flexural modulus of the wall of the container shall not be less than 300 N/mm².

Odour

The container chamber shall be free from any odour, dirt or dust particles.

Overall Migration

The limit of overall migration with water when tested as prescribed in IS 9845: 1986 shall not exceed 60 mg/l of simulant and 10 mg/dm² of the surface of the container.

Performance Requirements

Resistance to Deformation

When cylindrical vertical water container is tested as per method prescribed below, the difference between the circumferential measurements shall not be greater than 3 percent of the original measurements.

Method: The container shall be placed on a flat level base. A circumferential measurement shall be made parallel to the base at a distance of one third the effective height. The container shall be filled up to the effective height at a minimum rate of 23 l/min with water at temperature of not less than 15°C. A continuous film of polyethylene shall be floated over the whole of the surface of the water in the container to prevent evaporation. The container and water shall be maintained at temperature not less than 15°C and after 3 days a circumferential measurement shall be made at the previously determined level. The difference between the two circumferential measurements shall be expressed as a percentage of the original circumferential measurements.

Resistance to Impact

When container is tested accordance with the method illustrated below, the impact shall neither result into cracking nor puncture of the tank.

Method: The container shall be inverted and the base of tank shall be struck with a 25 mm diameter hemispherically ended striker of mass 2.5 Kg falling freely from a height of 3.0 meter. The striker shall be so arranged as to hit the base at its mid-point. Three other impacts shall be made, which shall be as close to the edge or corners of the base as is practical. The shape of the striker shall be such that only the surface of the specified hemisphere comes in contact with the container under the initial blow.

Draft Specification for Domestic (household) Defluoridation Filter Unit (DDFU/DDU)

Drop Impact Test

The container with all the attachments when subjected to the drop test as prescribed in IS 2798 shall not show any sign of cracking. Slight deshaping of the body is permitted.

Leakage Test

Both the chambers of container shall be filled in nominal capacity with coloured water at ambient temperature and closed tightly with the lid. The filled container shall be kept vertically upright for a period of 24 hours. At the end of the test, the container should not show any leakage of water.

Water Potability Test

Potable water stored in the container for 72 hours shall not acquire any unpleasant odour or bitter taste or shall not impair the health when tested according to the method prescribed as follows:

Heat the water to a temperature of $38 \pm 2^\circ\text{C}$ and fill the chambers to its nominal capacity and close tightly. Keep the chambers for a period of 72 hours at ambient temperature. At the end of 72 hours the water shall not give any unpleasant odour and taste. Any visible fungus growth in water shall render the chamber material liable to rejection.

Type Tests

Type tests are intended to prove the suitability and performance of container of a new composition, a new technique, new shape or modified wall thickness. Such tests need necessarily be done, before undertaking mass production when a change is made in polymer composition or method of manufacture or when a new size and shape of water tank is introduced. Type tests for suitability of container material and overall migration as specified above shall be taken as type tests and shall be specially applicable to any modifications in the designs.

Mass

The weight of the unit shall be 3.15 Kg. The tolerance permitted is + 5 percent.

Dimensions

The height and diameter of the unit shall be as per the details shown in the attached drawing. The tolerance on dimensions other than thicknesses shall not exceed +2.5 mm. The tolerance for thickness where specified shall -0.25 mm to +0.30 mm of specified thickness

Table of Dimensions

Sl. No.	Item	Dimension
1.	Upper Chamber	300 mm dia. x 325 mm ht. x 1.5 mm thick
2.	Base Plate of Upper Chamber	3/4 mm thick
3.	Lower Chamber	300 mm dia. x 325 mm ht. x 1.5 mm thick
4.	Base Plate of Upper Chamber	3 mm thick
5.	Tap	12 mm (1/2") size
6.	Splash Plate	298 mm dia. x 3 mm thick
7.	Flow control Orifice in bottom of Upper Chamber	1.5 mm dia.
8.	Plastic filter sieve	100 mm dia. with 0.3 mm dia holes
9.	Lid	300 mm dia. x 1.5 mm thick
10.	Stand	150 mm high x 4 mm thick throughout the circumference of Lower Chamber

Draft Specification for Domestic (household) Defluoridation Filter Unit (DDFU/DDU)

Sampling

The containers shall be selected at random from the lot. To ensure the randomness of selection, methods given in IS 4905 shall be followed. The criterion for Scale of Sampling and Acceptance Number is as follows:

The sample containers selected as per the above Table shall be examined for workmanship and finish and odour. Any container failing in one or more of the requirements shall be termed as defective. The lot shall be accepted under this head, if the number of defective containers in sample does not exceed the acceptance number given in Table-1.

For the purpose of tests for brimful capacity & container weight, five containers for lot size up to 5000 shall be selected at random. Each of the sample container shall be subjected to tests for brimful capacity and weight. There shall be no failure if the lot is to be accepted under this clause.

Any container showing leakage, crack or permanent buckling when subjected to tests shall be taken as defective. The number of defectives shall not exceed the acceptance number given in Table-1 for the lot to be accepted as conforming to specifications.

The sub-sample of size given in Table-1 shall be subjected to tests for dimensions and overall migration. No failures shall occur for acceptance of the lot under this clause.

Additional Requirements for ECO-Mark

General Requirements

The product shall conform to the requirements for quality, safety and performance prescribed.

The manufacturer shall produce to BIS the consent clearance as per the provisions of *Water (Prevention & Control of Pollution) Act, 1974* and *Air (Prevention & Control of Pollution) Act, 1981* along with the authorization, if required under *Environment (Protection) Act, 1986* and the Rules made there under while applying the ECO-Mark. The manufacturer shall produce documentary evidence with respect to the compliance of regulation under *Prevention of Food Adulteration Act, 1954* and *Drugs and Cosmetic Act, 1940* and the Rules made there under, wherever necessary.

The product must display a list of critical ingredients in descending order of quantity present expressed as percent of the total. The list of such ingredients shall be identified by BIS.

The product packaging shall display in brief the criteria based on which the product has been labeled as 'Environment Friendly'.

The material used for product packaging shall be recyclable or biodegradable.

Table - 1

Lot Size	For Visual Examination		For Tests		No. of Samples for Dimensions and Overall Migration
	Sample Size	Acceptance Number	Sample Size	Acceptance Number	
Upto 500	13	1	5	0	2

Draft Specification for Domestic (household) Defluoridation Filter Unit (DDFU/DDU)

Product Specific Requirements

For the manufacturer of this product one or more of the virgin material covered in the following Indian Standards shall be used:

IS No.	Title
10142 : 1999	Polystyrene (crystal and high impact) for its safe use in contact with foodstuff, pharmaceuticals and drinking water
10146 : 1982	Polyethylene for its safe use in contact with foodstuff, pharmaceuticals and drinking water
10151 : 1982	Polyvinylchloride (PVC) and its copolymers for its safe use in contact with foodstuffs, pharmaceuticals and drinking water
10910 : 1984	Polypropylene and its copolymers for its safe use in contact with foodstuffs, pharmaceuticals and drinking water
11434 : 1985	Ionomers resins for its safe use in contact with foodstuffs, pharmaceuticals and drinking water
11704 : 1986	Ethylene/Acrylic acid (EAA) copolymers for its safe use in contact with foodstuffs, pharmaceuticals and drinking water
12247 : 1988	Nylon-6 polymer for its safe use in contact with foodstuffs, pharmaceuticals and drinking water
12252 : 1987	Polyalkylene terephthalates (PET & PBT) for their safe use in contact with foodstuffs, pharmaceuticals and drinking water

Marking

Each container shall be marked or labeled with the following information:

- Name and/or trademark of the manufacturer
- Nominal capacity, in ml

Recycling symbol in line with IS 14534

Screening of Activated Alumina in the Laboratory, for use by Manufacturer for verifying their own Products

This method is specified for testing different lots of activated alumina of those grades, which have been tested in the laboratory for ten defluoridation cycles in domestic units and found acceptable. Simulated water is used for testing of AA in a column mode for one Defluoridation cycle.

1. Activated Alumina : 500 gm.
2. Particle Size Range : 0.4 -1.2 mm
3. Experimental Set up : See Fig. 7
4. Simulated Water : Good Quality Chemicals
(Analytical Reagent Grade) to
be used

Weigh chemicals and dissolve in around 2 L distilled water with stirring. Add this solution to 48 L distilled water. Total vol. is 50 L. Adjust the pH to 7.8 ± 0.2 with 1 N HCl. Check the alkalinity, hardness and sulphate and fluoride of simulated water using standard procedures. Determined values should be within expected values $\pm 10\%$ for other parameter and expected value ± 0.5 mg/L for fluoride.

Sl. No.	Chemical	Amount (gm/50 L)	Expected Concentration (mg/L)
1	Sodium Bicarbonate (NaHCO_3)	34.4	409 (Alkalinity as CaCO_3)
2	Sodium Sulphate (Na_2SO_4)	4.0	55 as SO_4^{--}
3	Calcium Chloride(CaCl_2)	5.5	100 (Hardness as CaCO_3)
4	Sodium Silicate ($\text{Na}_2\text{SiO}_4 \cdot 5\text{H}_2\text{O}$)	2.7	15 as SiO_2
5	Magnesium Chloride(MgCl_2)	5.0	106 (Hardness as CaCO_3)
6	Sodium Fluoride (NaF)	1.1	10 as Fluoride

*Deionised water can be used for making the simulated water.
The conductivity of deionised water should be $< 20\mu$ mho/cm at 25°C*

Draft Specification for Domestic (household) Defluoridation Filter Unit (DDFU/DDU)

Procedure:

- Wash 500 gm activated alumina in tap water, to remove dust particles as well as fine particles originating from possible disintegration of AA due to heat generated during initial contact of AA with water before transferring to the PVC column.
- Fill the column up to 1/3rd height with simulated water.
- Slowly add washed Activated Alumina into the column.
- Fill the plastic bucket (Fig. 6) with 10 L simulated water and adjust the flow rate to 20 ±1 ml/min using flow control device.
- Allow 10 L Simulated water to pass through the column. This will take around 4-5 hr.
- After around 3 hr. idle time, pass another 10 L of simulated water under similar conditions.
- Check the flow rate and adjust to 20 ml/min ±1 ml.
- This can be started in the evening and allowed to continue late in the night.
- Do not pass more than 20 L per day
- Collect a sample for fluoride analysis after 50 L water is passed through the column and then after every 20 L.

Fluoride Analysis:

Analyze fluoride using ion specific electrode and ion meter. Periodically determine Fluoride concentration in inlet water (simulated water) and in treated water.

Calculation of Fluoride Uptake Capacity (mg Fluoride Uptake/ Kg AA)

$$[V \times (10 - 0.75) \times 2]$$

Where V= volume of water, treated up to 1.5 mg/L

Where 10 is the initial fluoride concentration in the simulated water, (mg/L) and 0.75 is taken as the average fluoride concentration (mg/L) in the treated water in a defluoridation cycle, the factor 2 is to convert fluoride uptake capacity to per Kg AA as 500 gm AA is taken for testing.

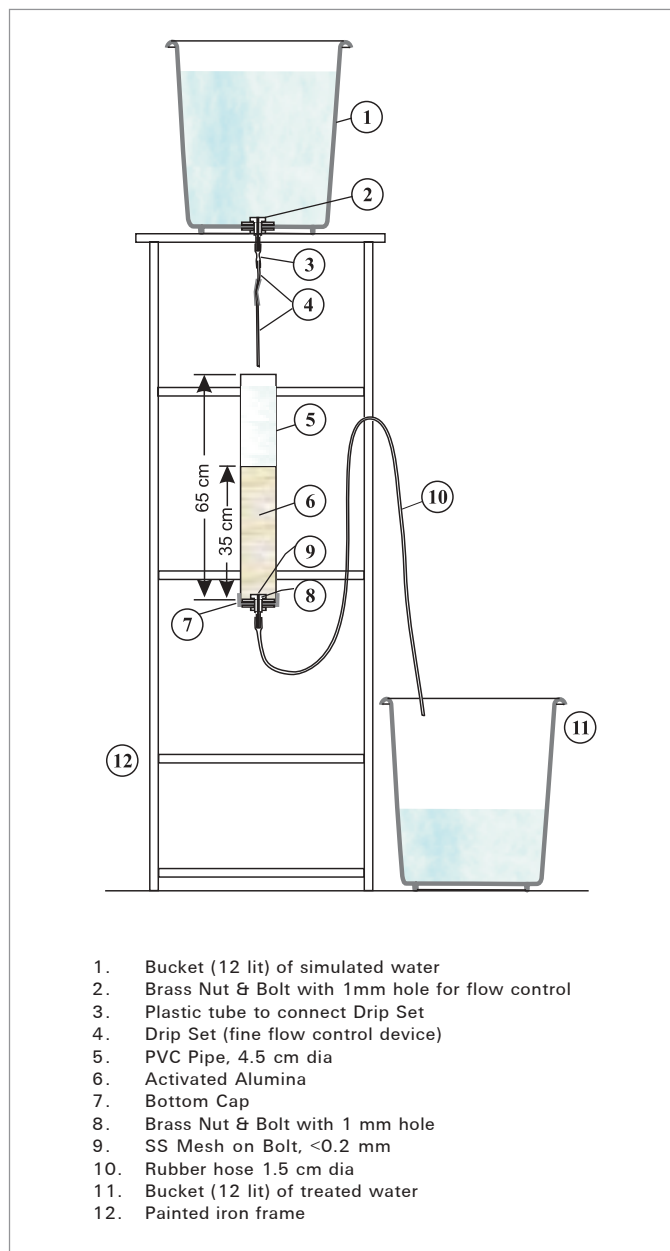


Fig. 7: Schematic Diagram of Testing Column

Regeneration Procedure for Exhausted Activated Alumina at Manufacturers Level

Effective regeneration of exhausted Activated Alumina and its reuse in multiple Defluoridation cycles dictates the economic sustainability of this technology for the defluoridation of drinking water. Treatment with caustic soda followed by neutralization with acid has been found to be the most effective method for the regeneration. Procedure for the regeneration is described in this section.

Preparation of Regenerants

Tap water can be used for regeneration purposes.

Alkali Regenerant (1%): Weigh 16g caustic soda and add it slowly into a plastic container (3L capacity) having 1.6 L of water. Stir with a plastic rod to dissolve the pellets.

Acid Regenerant (1%): Transfer 16ml of conc. sulphuric acid from the bottle to a plastic measuring cylinder. Pour the acid slowly from the side of plastic container (3L capacity) having 1.6 L of water.

Never add water to acid. This results in extreme heat generation leading to accidents.

Regeneration Unit: Brass nut and two bolts along with two washers are fixed in a plastic beaker (2 L). An aperture of 1mm is provided in the nut and bolt system for the flow of regenerants. (Fig. 2) A piece of PVC hollow pipe (2 cm dia. X 2 cm height) is placed so as to cover the brass nut in the regeneration unit, to provide air gap. This facilitates better flow of the regenerant.

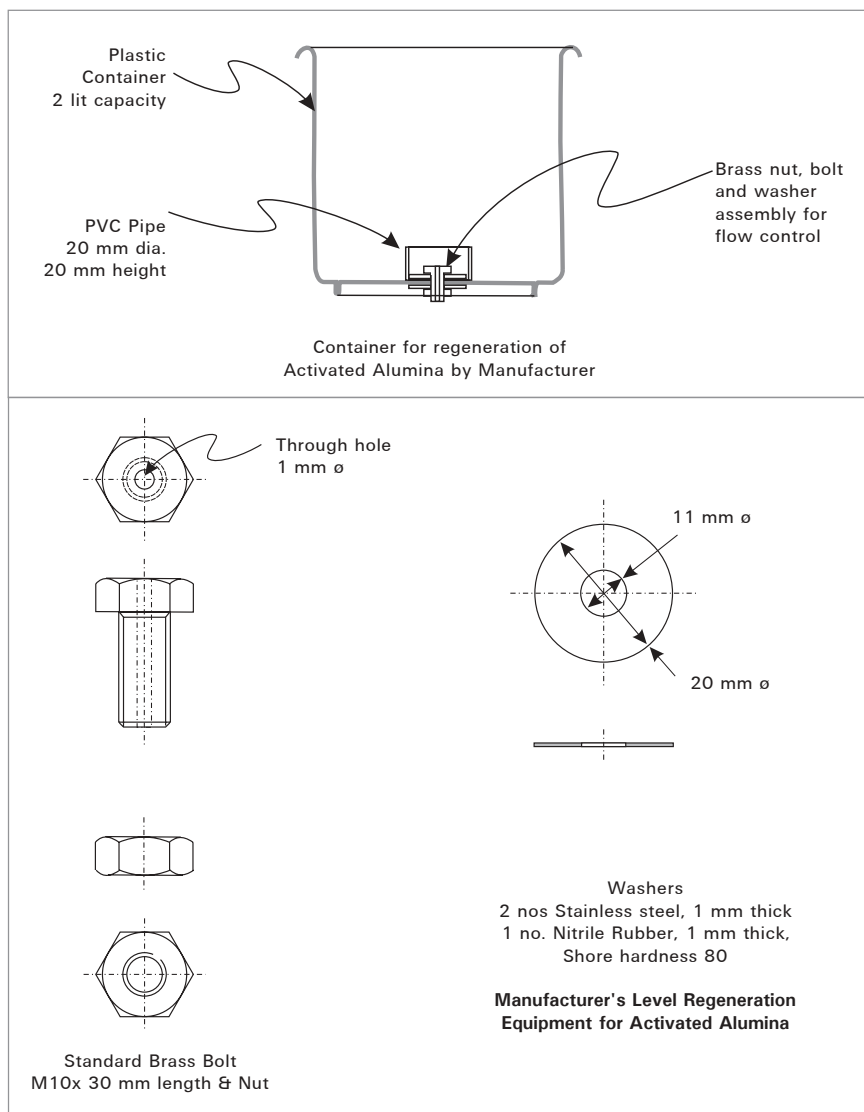


Fig. 8: Regeneration Unit for Exhausted Activated Alumina from Column Unit

Draft Specification for Domestic (household) Defluoridation Filter Unit (DDFU/DDU)

Regeneration Procedure

Alkali Treatment:

- Transfer exhausted Activated Alumina from the column to a nylon bag (width of aperture, 0.106 mm).
- Dip the nylon bag in alkali regenerant and agitate thoroughly for proper contact of activated alumina with alkali.
- Transfer the nylon bag, with AA, to the Regeneration Unit. Pour the alkali into this unit. Alkali trickles through activated alumina bed. It may take around 15 min to pass 1.6 L alkali.
- Draw excess alkali from the bag and pass 1.6 L of water through AA bed.

Acid Treatment:

- Transfer the nylon bag from "Regeneration Unit" to the plastic container containing 1% H_2SO_4 . Agitate the bag to ensure proper contact of activated alumina with acid.
- Place the nylon bag back in "Regeneration unit" and pour the acid into this unit.
 - After acid is drained out from the unit, lift the nylon bag to check the pH of the drained water. This should be in the range of 4-5.

Final Washing

Wash the activated alumina (contained in the nylon bag) by passing water until pH is around 6-6.5.

Now AA is ready for reuse and can be transferred back to the column for subsequent Defluoridation cycle.

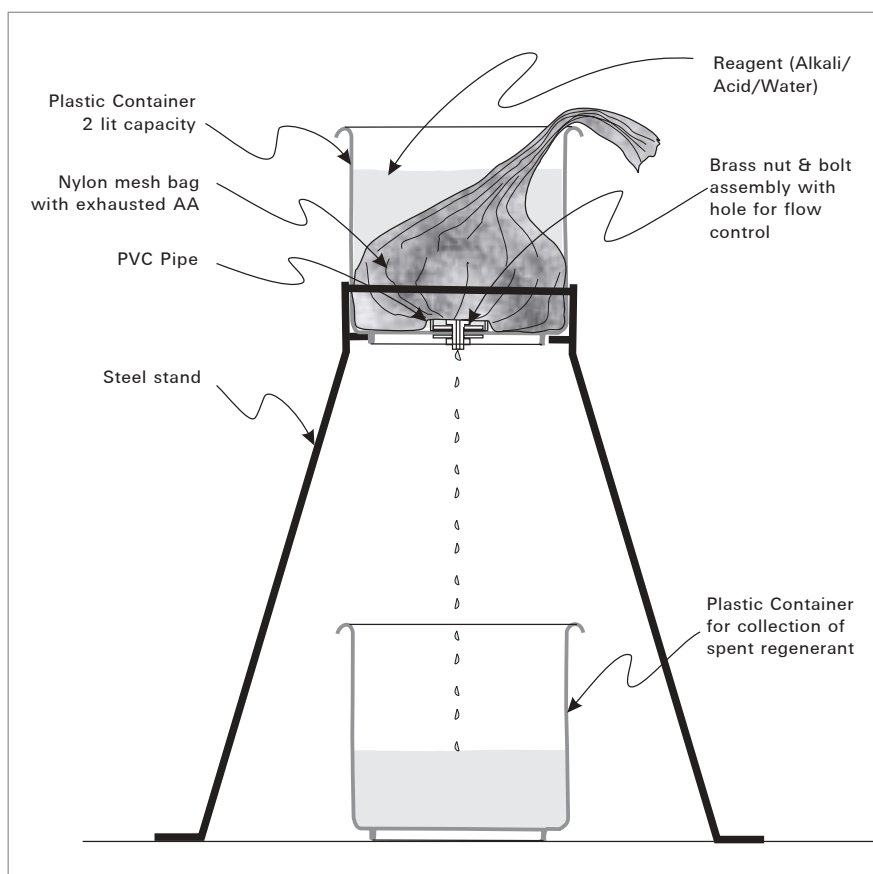


Fig. 9: Set Up for the Regeneration of Exhausted Activated Alumina from the Column Unit by Manufacturers

Handling of Sulphuric Acid and Caustic Soda during Regeneration of Activated Alumina

Precautions and Safety Measures

Sulphuric acid and Caustic soda are chemicals used for regeneration of exhausted Activated Alumina from Defluoridation units at the domestic level. Owing to their hazardous nature, the transportation, storage and use of these chemicals can result in accidents. Hence, it is important that the properties of these chemicals, the risks involved in their handling and the precautions and safety measures to be taken, are properly understood and well known.

The chemicals can enter the body orally or by inhalation. Contact with skin causes burning sensation and can even result in burns and wounds. These chemicals can affect the eyes, nose and skin directly.

Sulphuric acid is liquid in nature and Caustic soda is solid (in form of pellets or flakes). Both these chemicals, when used for regeneration, are of commercial grade. Sulphuric acid is available in glass bottles whereas Caustic soda is available in sealed boxes/ containers.

Chemicals should be stored in a dry, airy place, under lock and key and away from the reach of animals and people, especially children. The chemicals should always be kept covered and should not be kept very close to each other. Care should be taken that the bottles or the boxes are not held by the lid or the neck while carrying from one place to another. Instead both hands should be used for the purpose. In case of more than two chemicals, trays or buckets should be used.

For cleaning of the table or the floor in case of spillage of chemicals, the following things should be readily available: Brush (1 no.), Mopping cloth (1 no.), Goggles (1 pair), Gloves (1 pair), Plastic bags for waste disposal, Polythene bag (1 no.), lime/ sand/ mud, First-aid box (1 no.).

Draft Specification for Domestic (household) Defluoridation Filter Unit (DDFU/DDU)

Precautions while using Sulphuric acid:

- Sulfuric acid is extremely dangerous and can cause burns. Care should be taken that it does not come in contact with the skin.
- All the materials required should be kept ready before using the chemicals. Watches, rings and metal bangles should be taken off and gloves should be worn. In case the regeneration operator is wearing a full sleeved shirt, he should fold up the sleeves before working. Women should tie up their hair and dupattas etc. so as to prevent any contact with the chemicals. Gloves and goggles should necessarily be worn while the acid is being poured and the solution is being prepared. After opening the bottle, the cork should be removed gently to prevent any spillage onto the face or hands.
- The acid should be poured slowly into the measuring cylinder and filled up to the mark. The acid should then be carefully poured into the water from near the edge of the bucket.
- Water should never be poured into the acid as could lead to accidents. It should always be the other way round; the acid should be poured into the water instead.
- In case the acid comes in contact with the skin, the affected part should be washed thoroughly with water and an anti-burn cream should be applied. In case, of eyes, they should be washed repeatedly with water for 10-15 minutes, since absence of immediate action can lead to blindness.
- In case of spillage of acid on the floor, lime should be spread over it immediately so as to prevent spreading of acid and spoiling of the floor. Ash/sand/mud balls can also be used to cover the acid if lime/soda/ash is not available. It should be seen that no one ventures near the affected area.
- Putting ash/lime over spilt acid leads to effervescence and rise in temperature. The sludge should therefore be collected in a plastic bag with the help of a plastic spoon or dust collecting pan only after two minutes.
- It may be difficult to remove acid remnants from leather articles like belts, shoes and caps even after repeated washing. Such articles should be discarded. Even clothes spoiled by acid spillage should be removed and should not be worn without washing.

Things not to do

- **Water should never be poured directly on spilt acid. Cotton or jute cloth should not be used for wiping up the spilt acid.**
- **The spilt acid should also not be covered with any jute bag or paper or cloth as this can lead to fire accidents.**
- **No iron or aluminum article should come in contact with the acid as it can lead to explosion.**
- **Empty acid bottles should not be used for any other purpose.**

Draft Specification for Domestic (household) Defluoridation Filter Unit (DDFU/DDU)

Precautions while using NaOH/Caustic soda (Solid)

- Caustic soda can cause burns, hence should not be allowed to come in contact with skin.
- Caustic soda (pellets or flakes) spilt on the floor should be collected using a broom
- Rubber gloves should be used while collecting Caustic soda (pellets or flakes) from the floor.
- After the Caustic soda is removed, the floor should be washed thoroughly.
- Rubber gloves and goggles should be used while Caustic soda is being lifted, weighed or mixed in solution.

- In case of the Caustic soda (pellets, flakes or solution) coming in contact with the skin, the affected part should be washed thoroughly with water and 2% Acetic acid solution. An anti-burns cream should also be applied.
- Medical advice should be taken if necessary.
- The Caustic soda bottle/ container should not be left uncovered as contact with air/moisture may spoil the chemical.
- Caustic soda should always be weighed in a plastic or glass container.
- After the weighing is completed, the container used for the purpose should be washed and cleaned thoroughly.
- 100 gm Caustic soda should be put in a bucket of water and stirred slowly using a plastic/glass rod till complete dissolution takes place.
- The bag containing Activated Alumina should be very gently immersed in the Caustic soda solution so as to avoid spillage.

Things not to do:

- **The Caustic soda bottle/ container should not be kept uncovered or in a wet place and should be kept away from contact of water.**
- **No oil or cream should be used if the chemical enters the eyes.**
- **Caustic soda should not be put directly on the plates of the weighing balance for weighing. Instead containers should be used.**
- **Caustic soda should be removed from the bottle/container using a spoon and never by the hand.**
- **Empty Caustic soda bottles should not be used for any other purpose.**

