## APPENDIX 21.1

## SOIL PERCOLATION TEST

To design a suitable soil absorption system for disposal of effluent from septic tanks, percolation tests shall be carried out, on the proposed site for location of the absorption system, in the following manner.

Six or more test holes spaced unformly over the proposed absorption field shall be made.

A square or circular hole with side width of diameter of 10 cm to 30 cm and vertical sides shall be dug or bored to the depth of the proposed absorption trench. The bottom and sides of the holes shall be carefully scratched with a sharp-pointed instrument to remove any smeared soil surfaces and to provide a natural soil interface into which water may percolate. The holes shall be filled for a depth of 5 cm with loose material to protect the bottom from scouring and settling.

Before the actual readings for percolation tests are taken, it is necessary to ensure that the soil is given ample opportunity to swell and approach the condition it will be in during the wettest season of the year. This is done by pouring water in the hole upto a minimum depth of 30 cm over the gravel and allowed to soak for 24 hours. If the water remains in the test hole after the overnight swelling period, the depth of water shall be adjusted to 15 cm over the gravel. Then from a fixed reference point, the drop in water level shall be noted over a 30 min. period. This drop shall be used to calculate the percolation rate.

If no water remains in the hole, at the end of 30 min. period, water shall be added to bring the depth of the water in hole 15 cm over the gravel. From a fixed reference point, the drop in water level shall be measured at 30 min. intevals for 4 hours, refilling to 15 cm level over the gravel as necessary. The drop that occures during the final 30 min. period shall be used to calculate the percolation rate. The drop during the earlier periods provide infomation for the possible modification of the procedure to suit local circumstances.

In sandy soils or other porous soils in which the first 15 cm of water seeps away in less than 30 minutes after overnight swelling period, the time interval between measurements shall be taken as 10 minutes and the test run for one hour. The drop that occurs in the final 10 munutes shall be used to calculate the percolation rate.

Based on the final drop, the percolation rate, which is the time in minutes required for water to fall 1 cm, shall be calculated.

## APPENDIX 21.2

## DESIGN EXAMPLE OF LEACH PIT

Design example : Twin Leach Pits (Dry conditions) for 5 users :

1. Assumptions :

   a) 9.5 liters of wastewater is generated per capita per day

   b) 5.0 liters of water is used per day for floor washing and pan cleaning

   c) The water table remains 2 meters or more below ground level through out the year for dry pit and 50 cm below for wet conditions

   d) The local soil is porous silty loams and

   e) The pits are designed for 2 year sludge accumulation capacity.

2. The solution.1 :

   a) Calculate the total waste water flow (Q) in liters per day

   Q = 9.5 l/d * 5 users + 5 liters for floor wash etc.,

   = 52.5 liters per day

   b) Assuming a pit of 800 mm internal diameter (inside lining 75 mm thick with brick on edge and effective depth 800 mm, check for infiltrative surface area ($A_f$); this is given by :

   $A_f = \pi dh$

   Where d is the external diameter and h is the effective depth of the pit

   $A_f = \pi \times 0.95 \times 0.8 = 2.39\ m^2$

   c) If the soil is porous silty loams, the infiltrative area required is 52.5/20 = 2.62 $m^2$ ; hence the infiltrative area provided is insufficient. Therefore by choosing a depth of 0.9 m ; the infiltrative area Af will be

   $= \pi \times 0.95 \times 0.9 = 2.69\ m^2$ , which is sufficient

   d) Check for the required solid storage volume (V) for a solids accumulation rate of 0.04 $m^3$ per capita per year, (Table 21.4) for a dry pit with water being used for anal cleansing and for a desludging interval of 2 years and a household size of 5 persons

   $V = 0.04 \times 2 \times 5 = 0.40\ m^3$;

   Whereas, the volume of proposed pit is :

$$\frac{\pi x 0.8 x 0.8 x 0.9}{4} = 0.45 m^3$$

Hence pit propsed has the sufficient storage capacity.

e) Allowing a free space of say 0.225 m, the dimensions of the pit are as follows :

Internal diameter 800 mm
Total depth 1125 mm (900 mm + 225 mm free board)

Since the pit bottom is more than 2 m above the maximum ground water table, the pit will function in dry condition.

Solution.2 :

The ground water table is 50 cm below the ground surface, but all other assumptions are the same as in the above example.

The pit size is determined by taking the sludge accumulation rate from Table 21.4. Assuming the pit desludging period as 2 years.

Volume of the pit = 0.095 x 2 x 5
= 0.95 Cu.M.

Allowing a free board of 0.225 m. Pit dimensions come as follows :

Internal diameter 1100 mm

Total depth 1225 mm (1000 mm + 225 mm free board)

## APPENDIX 23.1

## OPERATION TROUBLES IN SEWAGE TREATMENT PLANT

| Signs & Symptoms (1) | Possible Causes (2) | Suggested Action (3) |
|---|---|---|
| Pretreatment<br>Unusual or excessive screenings | Increase in domestic sewage or industrial waste | Clean screens more often and report |
| Excessive grit | Roadwashings, ashes or material from building site. | Report and get them diverted. |
| Excessive organic matter in grit. | Velocity is too low and detention period too long. | Reduce the cross-Sectional area of the channel occupied by flowing sewage.<br>Install planks, bricks or tile along sides of channel or reshape or repair outlet weir to proportionally reduce depth of flow for all normal present flow rates; or decrease the number of channels used; or reduce length of channel by moving outlet weir. |
| Carryover of Grit. | Velocity is too high and detention too short. | Remove grit more frequently or increase number of channels or increase cross sectional area of channels. |
| Sedimentation Tank<br>Floating sludge- in all tanks. | Accumulated sludge decomposing in the tank and buoyed to the surface. | Remove sludge more completely and more often. |
| Floating sludge- not in all tanks | Affected tanks receiving too much sewage. | Reduce flow to affected tanks. |
| Bubbles rising in tanks. | Septic conditions | Report and empty tank completely as soon as possible. |
| Contents black and odorous | Septic sewage or strong digester supernatant. | Take action to eliminate septicity by improving hydrualics of sewer system, preareation of organic industrial wastes admitted to the system etc., or improve digester operation so as to have improved quality supernatant; or reduce flow into settling tank or bypass competely supernantant to lagoons etc. till situation improves. |
| Excessive settling in Inlet channels. | Velocity too low | Reduce cross-sectional area by installing inner wall of suitable material along one wall of channel; or agitate with air, water or otherwise to prevent deposition. |
| Excessive suspended matter in effluent - all tanks | Accumulated sludge Flow through tanks too fast ( over loading)<br>Humus sludge or under drainage returned too fast | Clean tanks more often. Report and get the loading reduced.<br>Reduce pumping rate. |
| -not all tanks | Some tanks receiving too much sewage. | Reduce flow to affected tanks |

| | | |
|---|---|---|
| Excessive floating matter in the effluent | Defective scum boards or none. | Repair scum boards or install new ones. |
| Sludge pipes choke | Sludge too thick<br>Sludge contains grit | Clean more often<br>Clean grit chamber more often; if chokage persists report. Change sludge piping if necessary. |
| Intermittent surging of flow. | High intermittent pumping rates. | Adjust pumping rates to keep close to rates of flow or install or adjust baffling to reduce inlet velocity and to have effective flow distribution across the width of tank. |
| Sludge hard to remove from hopper | High content of grit and/or clay<br>Low velocity in withdrawal line. | Reduce grit content; or reduce clay-content; or rod the clogged lines.<br>Pump sludge more often; or change sludge piping. |
| Trickling Filters<br>Filter ponding | Rock or other media too small or not sufficiently uniform in size Organic loading excessive. | Rake or fork the rocks or film surface with light equipment; wash the filter surface with a stream of water under high pressure; or stop the distributor over th ponded area and allow continuous flow of sewage; or dose the filter with heavy application of chlorine (5 Mg/l $Cl_2$ in filter influent) for several hours at weekly intervals or take the filter out of use for one day or longer to allow it to dry out or replace filter media if above methods do not succeed. |
| Filter Files | Develop most frequently in an alternate wet and dry environment. | Dose filter continuously not intermittently; or remove excessive biological growth; or flood the filter for 24 hours at weekly or byweekly intervals (it should be done at intervals frequent enough to prevent the fly completing its life cycle between floodings); or wash vigorously the inside of the exposed filter walls; or chlorinate the sewage (3 to 5 mg/l) for several hours at frequent intervals of 1 to 2 weeks; cr apply DDT or other insecticides. |
| Odours | Anaerobic decomposition of sewage sludge or biological growths | Maintain aerobic conditions in all units including sewer system or reduce accumulation of slime and biological growth; or chlorinate filter influent for short periods when flow is low or reduce unusually heavy organic loadings as from milk wastes. |

| | | |
|---|---|---|
| Icing of Filter Surface | Air temp. at or below 0°C; or progressive lowering of temperature of applied sewage by recirculation or uneven distribution of sewage on filter. | Decrease number of times sewage is recirculated; or where two stage filters are used; operate filters in parallel with little or no recirculation; or adjust orifices etc., to improve uniformity of distribution over filter and to reduce spray effect; or erect a wind screen at the filter in the path of prevailing winds; or break up to remove ice frequently. |
| **Activated Sludge**<br><br>Change in sludge volume index | High soluble organic loads in sewage | Decrease aeration liquor suspended solids; or bulking of activated sludge may be controlled by proper application of chlorine to return sludge; or control sludge index by converting digested sludge to activated sludge. |
| Rising sludge (in settling tanks) | Due to excessive nitrification | Increase the rate of return activated sludge from the final settling tank; or decrease the rate of flow of aeration liquor into the tank; or increase the speed of sludge collecting mechanism in the final settling tank to increase the rate of removal of sludge; or decrease nitrification by reducing aeration or lowering the detention period. |
| Frothing | Synthetic detergents cause, frothing. The froth increases with decrease in aeration liquor suspended solids or increase in aeration; or increase in degree of purification of sewage; or increase in atmospheric temperature. | Use water, effluent or clarified sewage sprays in the frothing areas; or apply defoamants in small quantities to tank surface (repeated dosing is necessary) or increase aeration liquor SS concentration. |
| Sludge Digestion<br><br>Fluctuation in sludge temperature | | Pump large quantities of thin sludge at high rate for cooling. |
| Temperature drops in unit with hot water coils. | Sludge solids adhering to coils forming a thick insulating layer preventing heat transfer to digester. | Clean the surfaces of coils or replace this form of heating with an external heat exchanger |
| Temperature constant, gas production drops. | Increase in Scum accumulation; or increase in grit accumulation; or excesssive acid production or acid condition due to<br><br>(a) Organic over loading.<br>(b) Acid Wastes.<br>(c) Toxic metals, Cu, Ni, Cr, & Zn. | Control scum, or control grit; or prevent excessive acid conditions by reducing organic overloads; or reduce acid wastes by pretreatment; or eliminate toxic metals or add lime to keep pH between 6.8 to 7.2, or proper quantity of over digested sludge should be withdrawn from digester |

| | | |
|---|---|---|
| Foaming | Insufficient amount of well buffered sludge in the digester; or excessive additions of raw sludge (with high volatile content); or poor mixing of digester contents; or temperature too low for prolonged periods followed by rise in temperature of digester contents; or withdrawal of too much digested sludge; or excessive scum or grit accumulations | Temporarily reduce or stop raw sludge additions; or add lime to keep pH between 6.8 to 7.2 while other corrective measures are undertaken; or restore good mixing within digester; or raise temperature to normal range; or breakup and remove excessive scum layer; or if large quanitities of oil or grit are present, empty digester. |
| Sludge Drying Beds<br><br>Sludge dries more slowly than usual | Sludge layer too thick<br><br>Second dose applied too late<br><br>Standing water<br><br>Bed surface clogged<br><br>Broken or clogged drains | Put on less sludge.<br><br>Do not apply second dose if first has started to dry off<br>Decant water<br><br>Rake over, skim if necessary and redress the surface.<br>Set them right. |

## APPENDIX 23.2

(1)

### SCHEDULE OF PREVENTIVE MAINTENANCE

Centrifugal Pumps

| Sl. No. | Name of Section or part to be attended. | Maintenance to be carried out | Frequency/time interval at which inspection and maintenance to be done | Remarks |
|---|---|---|---|---|
| 1. | Bearings | Checking of Temperature with thermometer | Two months | Hot ball or roller bearings point to too much oil or grease; hot sleeve bearings need more oil or heavier lubricant. If does not correct, dissemble and inspect the bearing alignment of pump and driver. |
| 2. | Glands | Changing of Gland packing | Two months | |
| 3 | Bearings | Lubrication (greasing) | Two months | Check for saponification resulting in whitish colour, washout with kerosene. |
| 4. | Gauges | Checking of pressure and vaccum gauges | Three months | |
| 5. | Valves | Changing of gland packing in delivery sluice valve, suction valves, bye pass valve, reflux valve. | Six months | |
| 6. | Exhaust pump and its auxiliaries. | Checking of gland packing & its auxiliaries etc. | Six months | |
| 7. | Impeller | Checking of impeller blades, sleeves, efficiency rings, bearings, neck ring impeller nut etc. | Year | |

(2)

### SCHEDULE OF PREVENTIVE MAINTENANCE

Electrical Motors

| S. No. | Name of Section or part to be attended | Maintenance to be carried out | Frequency/ time interval at which inspection and maintenance to be done | Remarks |
|---|---|---|---|---|
| 1. | Induction Motor stator and Rotor | Opening of end covers dust blowing and checking of air gap | One month | Depending on the working conditions & maintainance staff available |
| 2. | Slip ring device | Cleaning of slip rings and adjustment of carbon brushes short circuiting jaws, oiling of clutch etc | One month | |
| 3. | Bearings | Proper lubrication | Two months | |
| 4. | Windings | Checking of motor after taking out its Rotor, dust blowing, checking of end connections of stator, Rotor and taking insulation test, no load test before putting the motor on load. | Two years | |

(3)

## SCHEDULE OF PREVENTIVE MAINTENANCE
### Power Transformer

| Sl. No. | Maintenance to be carried out | Frequency/time interval at which inspection & maintenance to be done | Remarks |
|---|---|---|---|
| 1. | Checking of silica gel, topping of transformer oil, temperature gauge, vent pipe, voltage tap changing switch | Six months | Check and if required silica gel must be changed before the outbreak of monsoon |
| 2. | Filtration of oil, checking of dielectric strength, checking of viscosity of oil, terminal boxes ( H.T & L.T both), insulators, Neutral Earthing, tightening of nuts bolts, cable sockets stopping of leakages if any through joints. | Year | If the transformer oil withstands insulation test upto 40 KV for one minute it is not necessary to dry and fill the transformer oil. |
| 3. | Checking of its functioning | Year | |
| 4. | Checking of condition of core of the transformer and its windings insulation condition. | 5 years. | |

(4)

## SCHEDULE OF PREVENTIVE MAINTENANCE
### Switchgears ( Air or Oil Circuit Breakers )

| Sl. No. | Name of Section or Part to be attended | Maintenance to be carried out | Frequency/time interval at which inspection & maintanence to be done | Remarks |
|---|---|---|---|---|
| 1. | Oil Circuit breaker or Air Circuit breaker | Checking, cleaning and tightening of nuts, bolts of fixed auxiliary contacts, moving auxiliary contacts, main fixed contacts, main moving contacts No volt coil, overload coil, interlock system, condition of transformer oil, knife switches & insulators, etc. | Six months | |
| 2. | Oil tank | Cleaning & topping of oil & Checking dielectric strength of transformer oil | Six months | |
| 3. | Contacts | Changing of old & sluggish transformer oil of oil circuit breaker. Changing of old & wearing out contacts (fixed moving auxiliaries etc.) | Three years | Depending on the source of power supply & its tripping etc. |

(5)

## SCHEDULE OF PREVENTIVE MAINTENANCE

### Sedimentation Tank with Clarifier and their drive

| S. No. | Name of section or part to be attended | Maintenance to be carried out | Frequency/time interval at which inspection & maintenance to be done | Remarks |
|---|---|---|---|---|
| 1. | Trolley wheels | Lubrication (greasing) | One month | |
| 2. | Reduction Gear Box | Checking and topping of oil level | Three months | |
| 3. | Turn Table mechanism | Checking and topping the oil level | Three months | |
| 4. | Vertical slip Ring Motor | Dust blowing, checking of carbon brushes, bearings etc. | Four months | |
| 5. | Rail/Track | Adjustment of gap between two rails & its alignment etc. | Four months | |
| 6. | Reduction gear | Checking of helical spurgears condition | Six months | |
| 7. | Rubber type wheels iron wheels | Checking of wear & tear alignment & its positioning. | Six months | More frequently in the old installations |
| 8. | M.S. Scrapers | Tightening of nuts & bolts, replacement of broken parts | Year | |
| 9. | Turn table mechanism | Checking of its sprockets chains, steel balls, gear boxes etc., | | |

## APPENDIX 24.1
## MINIMUM LABORATORY EQUIPMENT NEEDED FOR TESTS

| Equipment | Type of Plant | |
|---|---|---|
| | 5 MLD | > 5 MLD |
| Analytical Balance | x | x |
| Autoclave | | x |
| Centrifuge | | x |
| Chlorine comparator | x | x |
| Colony counters | | x |
| Demineraliser | x | x |
| Dissolved Oxygen sampler | x | x |
| Drying over (hot air) | x | x |
| Fume cupboards | x | x |
| Gas liquid chromotograph | | x |
| Hot plates | x | x |
| Incubator 20° C (BOD) | x | x |
| Incubator 30° C (Bacteriological) | | x |
| Kjehldahl Digester Unit | x | x |
| Magnetic stirrers | x | x |
| Microscope, binocular with oil immersion and movable stage counting cell | | x |
| Membrance Filter Assembly | | x |
| Mufflo Furnace | x | x |
| Orsat or equivalent gas analysis apparatus | | x |
| pH comparator (Colorimetric) | x | x |
| pH meter with reference & spare electrodes | | x |
| pH meter protable | x | x |
| Refrigerator | x | x |
| Sedwick Rafter funner | | x |
| Sludge sampler | | x |
| Soxhlet extraction unit | | x |
| Spectrophotometer (atomic absorption) | | x |
| Spectrophotometer with or without U-V rage or photo electric colorimeter | | x |
| Total organic carbon analyser | | x |
| Turbidimeter | x | x |
| Vaccum pump | x | x |
| Water bath (thermostat controlled) | x | x |

Glassware and chemicals as required.

## APPENDEX 24.2

### TESTS RECOMMENDED TO BE CARRIED OUT ON UNITS OF SEWAGE TREATMENT PLANTS

| Treatment Stage/Unit | Total Suspended Solids | Settleable Solids | Dissolved Solids | Mixed Liquou Suspended Solids (ML SS) | SVI for ML | Turbidity | pH | Alkalinity | Volatile Acids | BOD | COD | DO | ORP | Total Kjohldahl Nitrogen |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
| 1. Raw Sewage | X | X | X | | | | X | X | | X | X | | | X |
| 2. Primary Sedimentation Tanks influent and effluent | X | X | | | | | | | | X | X | | | |
| 3. Trickling Filter influent & effluent | X | | | | | | X | | | X | X | X | | X |
| 4. Activated sludge aeration tank influent & effluent | | | | | | | | | | X | X | X | X | |
| 5. Above tank contents | | | | X | X | | | | | | | | | |
| 6. Effluent of Secondary settling tank | X | X | | | | | | X | | X | X | X | | X |
| 7. Influent & effluent of septic tanks Imhoff tanks clarigesters | X | X | X | | | | | | | X | X | | | |
| 8. Above tank contents | | | | | | | X | X | X | | | | | |
| 9. Digester contents | | | | | | | X | X | X | | | | | |
| 10. Primary sludge | | | | | | | | | | | | | | |
| 11. Secondary settled sludge | | | | | | | | | | | | | | |
| 12. Digested sludge | | | | | | | X | X | X | | | | | |
| 13. Sludge digester supernatant | X | | X | | | | X | X | | X | X | | | X |
| 14. Stabilisation ponds influent & effluent | X | | | | | X | | | | X | X | X | | |
| 15. Above pond contents | | | | | | | X | X | | | | X | X | |

## APPENDEX 24.2 (Contd...)

### TESTS RECOMMENDED TO BE CARRIED OUT ON UNITS OF SEWAGE TREATMENT PLANTS

| Treatment Stage/Unit | Ammoniacal Nitrogen | Nitrate | Phosphates | Heavy Metals | Toxic Substances | Total Solids (%) | Volatile Solids (%) | NPK Ratio | Colour and Texture | Specific Gravity | Colour and Texture of sludge | Microscopic Examination for flora & fauna | Microbial Growth Rate | Oxygen Uptake Rate | Algal Cell Concentration | Others as Specified |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 |
| 1. Raw Sewage | X | X | X | X | X | | | | | | | | | | | |
| 2. Primary Sedimentation Tanks influent and effluent | | | | | | | | | | | | | | | | Bio-Assay Tests |
| 3. Trickling Filter influent & effluent | X | X | | | | | | | | | | | | | | |
| 4. Activated sludge aeration tank influent & effluent | | | | | | | | | | | | | | | | MPN of coliforms for treated effluent only |
| 5. Above tank contents | | | | | | | | | | | | X | X | X | | |
| 6. Effluent of Secondary settling tank | | X | | | | | | | | | | | | | | |
| 7. Influent & effluent of septic tanks Imhoff tanks clarigesters | | | | | | | | | | | | | | | | |
| 8. Above tank contents | | | | | | X | X | | | | | | | | | |
| 9. Digester contents | | | | | | | | | | | | | | | | |
| 10. Primary sludge | | | | | | X | X | | | X | | | | | | |
| 11. Secondary settled sludge | | | | | | X | X | | | X | | | | | | |
| 12. Digested sludge | | | | | | X | X | X | X | X | | | | | | |
| 13. Sludge digester supernatant | | | | | | | | | | | | | | | | |
| 14. Stabilisation ponds influent & effluent | | | | | | | | | | | | | | | | |
| 15. Above pond contents | | | | | | | | | X | | | | | | X | |

OTHER TESTS

1. Sludge from Septic Tanks, Imhoff Tanks etc — Microscopic examination for Ova, Cysts, Pathogens
2. Digester Gas — Complete Gas Analysis
3. Chlorinated Effluent — Chlorine residual

# APPENDIX 25.1

## DESIGN EXAMPLE FOR VENTURIMETER

**Problem** : Design of Venturi Meter using the following data :

1. A venturimeter will be provided in the force main. The force main is 92 cm (36 in.) in diameter.
2. The tube beta ratio (diameter of throat/diameter or the force main) shall be equal to 0.5
3. Maximum and minimum flow ranges are 1.321 and 0.152 $m^3/s$. respectively.
4. The flow measurment error shall be less than ± 0.75 percent at all flows.
5. The head loss shall not exceed 15 percent of the meter readings at all flows.
6. The selected venturimeter shall be capable of mesuring flows of solids bearing liquids.

**Solution** :

$$Q = \frac{A_1 A_2 \sqrt{2gh}}{\sqrt{A_1^2 - A_2^2}} \qquad (1)$$

Where: Q = pipe flow $m^3/s$.

$H_1$ = upstream peizometric head, m

$H_2$ = throat peizometric head, m

$A_1$ = force main area, $m^2$

$A_2$ = throat area, $m^2$

h = $H_1 - H_2$, m

Under actual operating conditions and for standard meter tubes, including allowance for friction, the above equation reduces to

$$Q = C_1 \, K A_2 \sqrt{2gh} \qquad (2)$$

Where

$C_1$ = Velocity, friction or discharge coefficient (dimensionless)

K = Coefficient (dimensionless)

$$= \frac{1}{\sqrt{1-(\frac{A_2}{A_1})^2}} \qquad (3)$$

$$= \frac{1}{\sqrt{1-(\frac{D_2}{D_1})^4}} \qquad (4)$$

$D_1$, $D_2$ diameter of pipe and throat, m. For Standard Venturi meter the diameter of the throat is one third to one half of the pipe diameter and the value of k lies between 1.0002 and 1.0328. The value of $C_1$ generally ranges from 0.97 to 0.99.

The value of $C_1$ is normally provided by the manufacturer.

**Unit Sizing and Calibration Curve** :

1. Determine constants.
   The venturimeter tube has $D_2/D_1$ = 0.5
   Throat diameter $D_2$ = 46 cm.

$$\therefore K = \frac{1}{\sqrt{1-0.5^4}} = 1.0328$$

2. Develop calibration equation from equation 2
   Assume $C_1$ = 0.985

$$Q = 0.985 x 1.0328 x \frac{\pi}{4} x 0146 m^2 \sqrt{2 x 9.81 x \frac{m}{s^2} x \sqrt{h}}$$

$= 0.7489 \sqrt{h}\ m^3/s.$

3. Develop calibration curve :

Assigning different values of differential head recorded by the meter, the pipe discharge can be obtained from equation. At maximum peak design and minimum initial flows of 1.321 and 0.152 Cu.M/s the differential meter readings will be 3.111 and 0.041 m respectively (122.48 and 1.61 in.). The calibration curve is shown in figure. If mercury is used in the glass tube, then the differential pressure readings must be adjusted for the specific weight of mercury (13.58).

**Head loss Calculations :**

In a venturimeter tube, due to gradual contraction of the approach section, the head loss is considered negligible. Likewise, due to short length of the throat, the head loss in this section can be neglected. The head loss in the recovery section is estimated from:

$$h_L = \frac{K V_2^2}{2g}$$

Where $h_L$ = head loss through the venturimeter, m
K = 0.14 for angles of divergence of $5^{\circ}$

At maximum and minimum flows of 1.321 and 0.152 $m^3/s$, the head losses are calulated as follows

$$h_L\ at\ maximum flow = \frac{0.14}{2 x 9.81}\left[\frac{1.321}{\frac{\pi}{4} x (0.46)^2}\right]^2 = 0.45 m$$

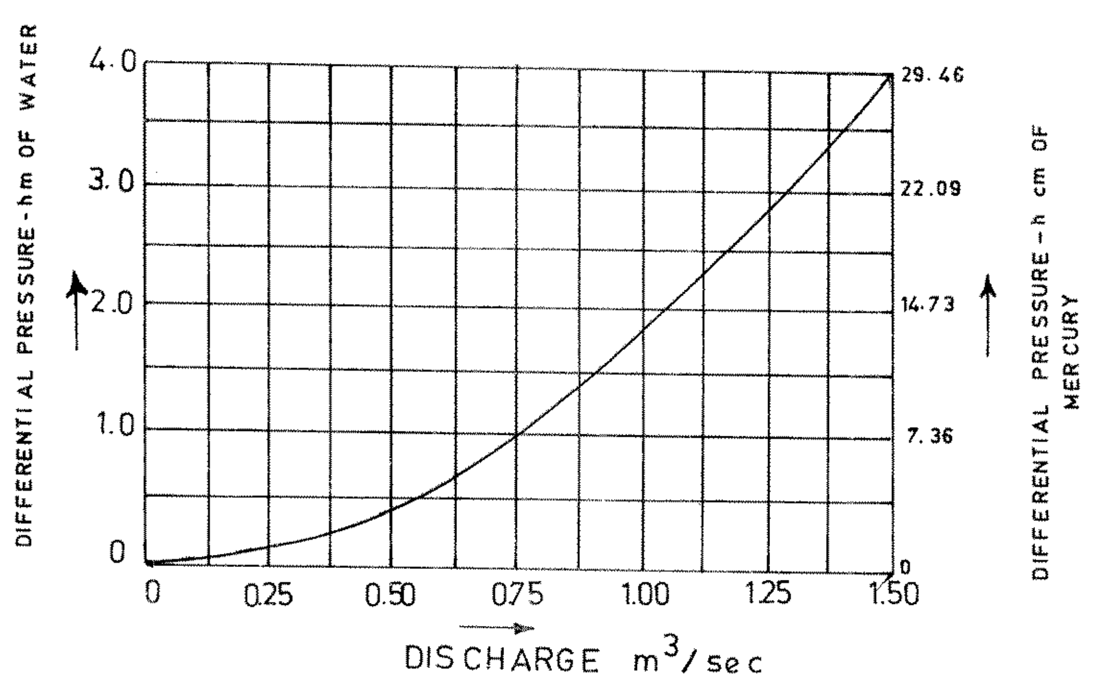
## APPENDIX. 25.1

$$h_L \text{ at minimum flow} = \frac{0.14}{2 \times 9.81}\left[\frac{0.152}{\frac{\pi}{4} \times (0.46)^2}\right]^2 = 0.006m$$

These head loss values are 14.8 percent of the differential readings of the meter at respective flows.

Head loss when the flow is 50 mld. or 0.578 m$^3$/s.

$$= \frac{0.14}{2 \times 9.81}\left[\frac{0.578}{\frac{\pi}{4} \times (0.46)^2}\right]^2 = 0.086m$$




CALIBRATION CURVE OF THE VENTURI - TUBE METER

## APPENDIX 27

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