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BUREAU OF INDIAN STANDARDS

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भारतीय मानक **मसौदा**

नलकूप की संरचना और परीक्षण — रीति संहिता

(आई एस 2800 *का पहला पुनरीक्षण*)

DRAFT *Indian Standard*

CONSTRUCTION AND TESTING OF TUBEWELLS — CODE OF PRACTICE

(*First Revision of* IS 2800)

ICS 65.060.35; 73.100

Diamond Core And Waterwell Drilling Sectional Committee, MED 21	Last date for receipt of comments is **15 April 2024**

FOREWORD
(*Formal clause will be added later*)

Standards for high capacity tubewells vary considerably from one part of the country to another. To a large extent, the hydro-geological conditions and well drilling methods dictate what materials or procedures are best. This code gives general guidance as regards to drilling, design, construction, and testing procedures for installation of tubewells.

This Indian Standard was first published in 1964 and revised in 1979 by splitting the requirements in two parts one for construction and the other for testing. IS 2800 (Part 1) was revised again in 1991. Further, IS 2800 (Part 1) and (Part 2) was amalgamated in 2019 covering the construction and testing of only tubewell.

This standard is now being revised again to keep pace with the latest technological developments and international practices. Also, in this revision, the standard has been brought into the latest style and format of Indian Standards, and references of Indian Standards, wherever applicable have been updated. The following major modifications have been incorporated in this revision of the standard:

a) The title has been modified;
b) The scope has been revised;
c) Capacity of tubewells have been revised;
d) Drilling methods have been updated; and

e) Selection of drilling method have been updated.

This standard contributes to the Sustainable Development Goal 6 – Clean water and sanitation: Ensure availability and sustainable management of water and sanitation for all.

For the purpose of deciding whether a particular requirement of this standard is complied with, the final value, observed or calculated, expressing the result of a test or analysis, shall be rounded off in accordance with IS 2 : 2022 'Rules for rounding off numerical values (*second revision*)'. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

DRAFT *Indian Standard*

CONSTRUCTION AND TESTING OF TUBEWELLS — CODE OF PRACTICE

(First Revision)

1 SCOPE

This code applies to drilling, construction and testing of medium to high capacity, filter packed tubewells drilled by rotary/percussion methods and used for agriculture, drinking water, industrial and other related purposes.

NOTE — The design engineer should make sure that each option selected does not conflict with other parts of tube well design or construction method.

2 REFERENCES

The standards listed below contain provisions which, through reference in this text, constitute provisions of this standard. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this standard are encouraged to investigate the possibility of applying the most recent editions of the standards listed below:

IS No.	*Title*
IS 2062 : 2011	Hot rolled medium and high tensile structural steel (*seventh revision*)
IS 4097 : 2019	Specification for material (Gravel) for use as filter pack in tubewells (*first revision*)
IS 4270 : 2001	Steel tubes used for water wells –Specifications (*third revision*)
IS 8110 : 2019	Water well screens and slotted pipes - Specification (*third revision*)
IS 9439 : 2022	Glossary of Terms Used in Water-well Drilling Technology (*second revision*)
IS 11189 : 2020	Methods of Tubewell Development (*first revision*)
IS 12818 : 2010	Unplasticized Polyvinyl Chloride (PVC-U) screen and casing pipes for bore/tubewell –Specifications (*second revision*)

3 TERMINOLOGY

For the purpose of this standard, the definitions given in IS 9439 shall apply, in addition to the following:

3.1 Tubewell — Tubewell is a structure installed deep into the ground to obtain large quantity of water from saturated water bearing strata – aquifers. Tubewells constructed in alluvial and valley fill formations comprise a surface casing pipe, a housing pipe and an intake section with screen/slotted pipes and blank casing. It can be with or without filter/gravel pack (artificially packed or naturally packed well).

4 TYPES OF TUBEWELLS

There are various types of tubewells/wells but as explained in 1 only medium/high capacity tubewells are considered here.

Medium capacity	20 to 50 m^3/hr
High capacity	> 50 m^3/hr

5 DRILLING METHODS

There are many alternate methods available for drilling and these can be grouped as under:

Percussion	Rotary	Jetting	Driving
Cable tool	Direct circulation		
Hand boring	Reverse circulation		
DTH/Odex	Air rotary		
Dual rotary	Auger/Bucket		
	Screw		
	Calyx		

However, only following methods are considered relevant for this code:

a) Cable tool;
b) Hand boring;
c) Direct circulation rotary;
d) Reverse circulation rotary; and
e) Dual rotary.

5.1 Cable Tool

In cable tool drilling method boring is done by the percussion and cutting action of heavy string of drilling tools. Repeated lifting and dropping a heavy string of drilling tools in the borehole breaks or crushes consolidated/semi consolidated rocks into small fragments or loosens and breaks the material in unconsolidated formations such as boulders. The reciprocating action of the tool mixes the crushed material with water to form slurry at the bottom of the bore hole. In dry formations water is added to form slurry. Slurry is removed at regular intervals from the borehole by a bailer.

While in the consolidated formations open hole is drilled, in the unconsolidated boulder formations the borehole is generally cased. In the latter case pipe or casing must follow the drill bit closely to prevent caving and keep the borehole open. A drive shoe is attached to the lower end of the casing to prevent damage to the bottom of the casing pipe when it is being driven. Driving, drilling and bailing are repeated until the casing is at desired depth. For deep boreholes when friction increases to the point when further driving of casing is very hard, a string of smaller diameter casing is inserted inside the larger casing and drilling is continued. A number of reductions may be required in certain cases to reach desired depth. This method is most suitable for boulder strata. For borehole for tubewells its depth limitation is around 200 m as beyond this depth the friction losses are too high. This is very slow process of drilling and should be selected only when no other method is likely to succeed.

5.2 Hand Boring Method

This method is similar to percussion method in action. But here, instead of a bit the bailer attached to a rope is raised and dropped by manpower to achieve borehole making and once sufficient depth is drilled, the same bailer is lifted to land surface for removal of cuttings. As the drilling progresses the casing pipes are pressed into the ground with load. Sometimes hoisting system is used during removal of bailer. The process of dropping and lifting the bailer could also be achieved by mechanical means. This method when mechanized is suitable for alluvial (soft) strata and depth ranges of 150 to 180 m only.

5.3 Direct Circulation Rotary Method

Under direct rotary drilling method, the borehole is drilled by rotating a bit and cuttings are removed by continuous circulation of drilling fluid as the bit penetrates the formation. The drilling fluid is pumped from a mud pit down through the drill pipe and out through the holes in the bit; the fluid then travels upwards in the annular space between the hole and the drill pipe carrying the cuttings in suspension to the surface, the fluid is channeled into the settling pit/pits where most of the cuttings drop out. Clean fluid flows into the mud pit and it is again pumped back in to the hole.

The circulating fluid forms a coating/film on the borehole wall reducing chances of collapse of the borehole and loss of drilling fluid. It keeps the drill bit cool and clean and also lubricates the bit, bearings, mud pump and drill pipe. The drilling fluid can be air, clean water and scientifically prepared mixtures such as bentonite clay, barite etc. The ability to lift cuttings depends on viscosity and the up-hole velocity of the fluid. A 30-45 m per minute up-hole velocity is good. The higher velocities are better for lifting capacities. This method is suitable for very deep (600 to 1000 m) boreholes in alluvial strata.

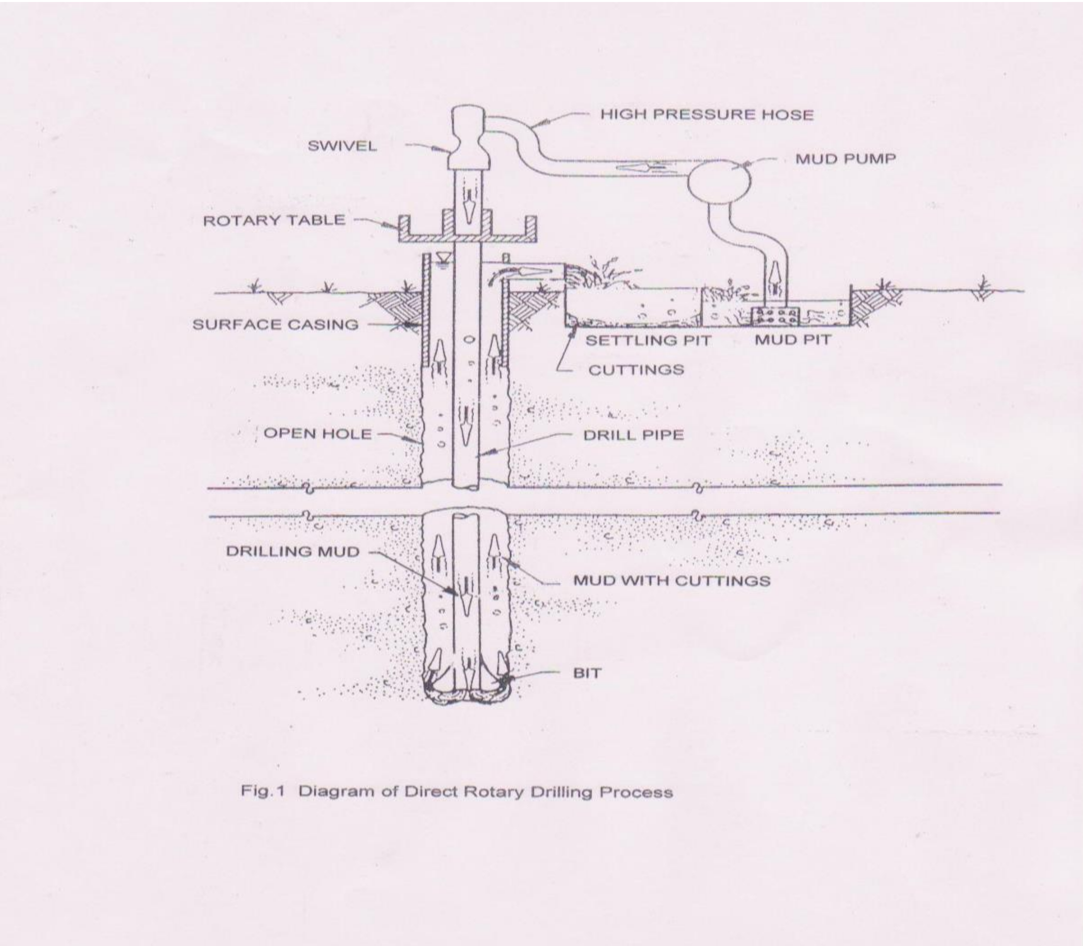


FIG. 1 DIAGRAM OF DIRECT DRILLING PROCESS

5.4 Reverse Circulation Rotary Method

In reverse circulation rotary drilling, flow of drilling fluid, which is generally water, is reversed when compared with direct rotary method. The drilling fluid and its load of cuttings move upward inside the drill pipe and are discharged by the pump into a settling pit. An up-hole velocity of 45 m/min is useful for lifting the cutting load. The fluid returns to the borehole by gravity through a channel and moves down through annular space between the borehole and the drill pipe to the bottom where it picks up the cuttings and reenters the drill pipe through the ports/holes in the drill bit.

To prevent caving of the hole the fluid level must be kept at ground level at all times even when drilling is suspended temporarily. This method is not suitable for very shallow water level area (less than 3m). This method is suitable for all water supply wells in alluvial strata to a depth of 150 to 500 m. The wells constructed using this method are highly efficient. Large space and large amount of water requirement are primary need for this method.

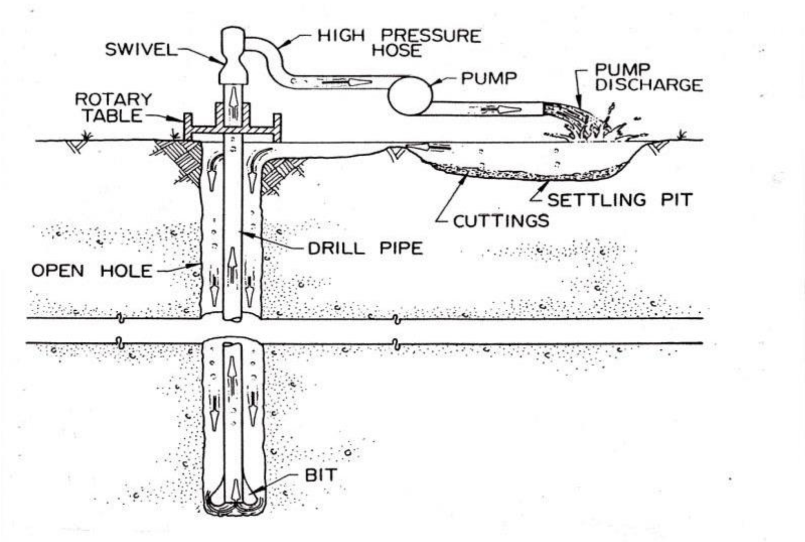


FIG. 2 REVERSE CIRCULATION METHOD OF DRILLING

5.5 Dual Rotary Method

In this method the borehole is cased while it is drilled as is done in percussion method. In the drilling rig there are two rotary tables – one for the bit and the second for the casing. A pneumatic drill is operated at the end of drill pipe which rapidly strikes the rock or formation while the drill pipe is slowly rotated. The cuttings are removed by air pressure and the borehole is cased simultaneously with help of other table. The casing is also kept loose by rotating it.

6 SELECTION OF DRILLING METHOD

The following points must be taken into consideration while selecting the drilling method. A report by the qualified hydro-geologist taking into account these points may help selection of the method.

a) Location of tubewell/borewell based on hydrogeological data;
b) Water requirement for depth and diameter of bore;

c) Accessibility and space at well site; and
d) Availability of water for drilling.

7 NOMENCLATURE OF TUBEWELL PARTS

Typical cross section of the tubewell with all its components are given in Fig. 3 and Fig.4.

The nomenclature of the various parts of tubewell are:

a) Surface casing;
b) Housing/pump chamber pipe;
c) Casing pipe;
d) Screen;
e) Reducer/taper section/reducer seal;
f) Well bottom, bail plug or bottom plug;
g) Centralizer;
h) Gravel/filter pack;
j) Well cap;
k) Well clamp; and
m) Well foundation.

Components of a Tubewell Rotary Drilling

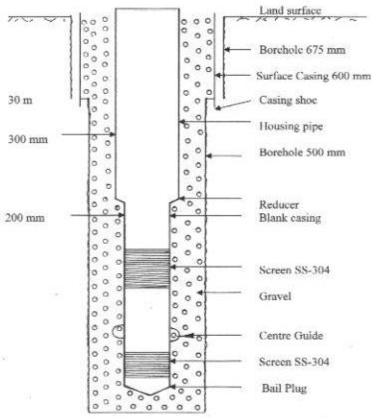


FIG. 3 WELL COMPLETED WITH ROTARY METHOD

Components of a Tubewell Percussion Drilling

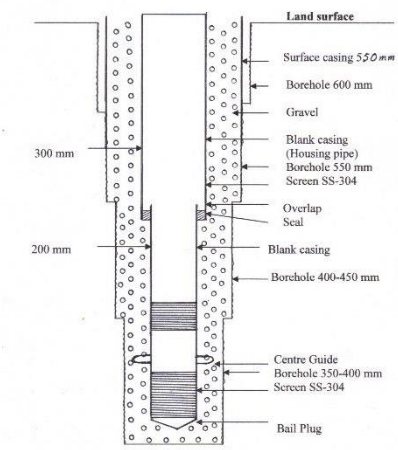


FIG. 4 WELL COMPLETED WITH PERCUSSION METHOD

7.1 Surface Casing

Surface casing material shall conform to IS 4270. Surface casing may or may not be used depending on the local conditions and established drilling practices. It could be permanent or temporary after completing the well. It is very useful in caving areas as it minimizes washing and erosion of the side of a borehole. It also helps in avoiding contamination from shallow aquifers and serves as reservoir for gravel pack. The length of such casing should be limited to 30 m or a good clay bed between 20 and 30 m depth range. The diameter of the surface casing should be as listed below:

Table 1 Surface Casing
(*clause* 7.1)

Sl No.	Housing pipe diameter (mm)	Surface casing diameter (mm)
(1)	(2)	(3)
i)	150	450
ii)	200	500
iii)	250	550
iv)	300	600
v)	400	650

When a permanent surface casing is installed, first an oversize hole is drilled to a good clay bed or about 30 m depth and in it the surface casing is lowered, centered and grouted. After the surface casing has set, further drilling is continued with lower size bit through the bottom of the surface casing.

It shall be good if this casing is made mandatory in domestic and public water supply wells.

7.2 Housing Pipe or Pump Chamber Casing

This is the upper portion of the cased section of the well and serves as housing for the pumping equipment. In a single string construction of uniform diameter, it comprises all casing above the top most screen. The material of this pipe shall conform to IS 4270. The length of this pipe should be estimated keeping in view the following factors:

a) Present static water level;
b) Minimum water level of record in area;
c) Long term water level trend;
d) Probable draw down;
e) Possible interference with other wells;
f) Required pump submergence; and
g) Ten pipe diameters between the suction cone of the pump and top of reducer.

The other controlling factors are sanitation, stability and estimated useful life of 25 years. The practice of providing screens in the housing pipe should be avoided, if possible.

The housing pipe if not inside a surface casing should be grouted at surface. At all times it must be supported with clamps at surface.

7.3 Casing pipe

It is a part of intake assembly placed against strata from which water is not to be drawn/tapped. The diameter of these pipes should normally be same as that of screen diameter. The material shall conform to IS 4270 and IS 12818 for PVC pipes.

7.4 Screen

The purposes of screen are to stabilize the side of the hole, keep sand out of the well and facilitate flow of water into and within the well. These may be in the form slotted pipes or fabricated screens. The selection of screen and its length shall be as per IS 4270 and IS 8110 and based on sieve analysis, if required.

In the selection of screen following must be kept in view:

a) Required discharge or yield (diameter and length); and
b) Whether the well is natural pack or gravel pack (width of slot opening).

7.5 Taper or Reducer

The taper or reducer pipe joins the housing pipe with the lower intake assembly in a telescopic design. Depending upon the diameter of the housing pipe and diameter of the intake assembly the design is marginally modified. A typical design for 300 mm housing and 200 mm diameter remaining intake assembly is given in Fig. 5. It should be made up of same material as that of pipe assembly. Also, the wall thickness should be same as that of housing or intake assembly. The material shall conform to IS 4270 and IS 12818 for PVC pipes.

7.6 Bail Plug

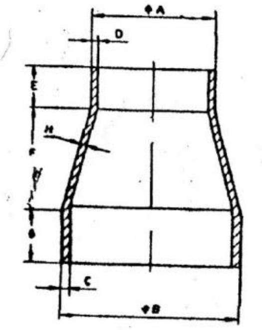
The use of phrase bail plug is not used in right spirit. The bail plugs are used in setting up of screens in percussion method of drilling by expert drillers and that to if the screen length is less than derrick clear height. Currently a bottom pipe attached to the bottom most screen is called bail plug. To ease the lowering of the pipes, this bail plug is made conical at bottom. The diameter of pipe, wall thickness etc. should be same as that of casing pipe. The length of the bail plug should be limited to 3 m. The material shall conform to IS 4270 and IS 12818 for PVC pipes.

7.7 Centring Guides or Centralizers

Centring guides are one of the very important part of the well assembly. Centring guides are essential for centring casing and screens for gravel packing. The design of the centring guides may be as in Fig. 6. Small variation to this can be made by using 40 mm vide 8 to 10 mm thick strap steel for the entire centring guide. The guide should be in a plane around the casing at 90^{o} or 120^{o} interval that is 3 to 4 vertical straps in its circumstance. The length of each guide should be three times it diameter. The diameter of the guide should be 50 mm to 60 mm less than the borehole diameter. The guides should be placed at bottom on bail plug and at about 10 m to12 m interval up the hole to the reducer. Guides may not be placed on the screens if the length of screen is less than 10 m. The material shall conform to IS 2062.

7.8 Well Cap

Fitted on the tubewell to keep it closed after completion of testing of the well and before installation of regular pump. It is threaded to the top of housing pipe. A typical design is given in fig. 7 for 300 mm diameter housing pipe. The material shall conform to IS 2062 and IS 12818 for PVC pipes.



All dimensions in millimetres.

Size of Reducer	*A*	*B*	*C*	*D*	*E*	*F*	*G*	*H*
300×200	237	348	16	12	80	200	100	12
350×200	237	380	16	12	80	200	100	16
400×200	237	430	20	12	80	200	100	16

FIG. 5. REDUCER/TAPER

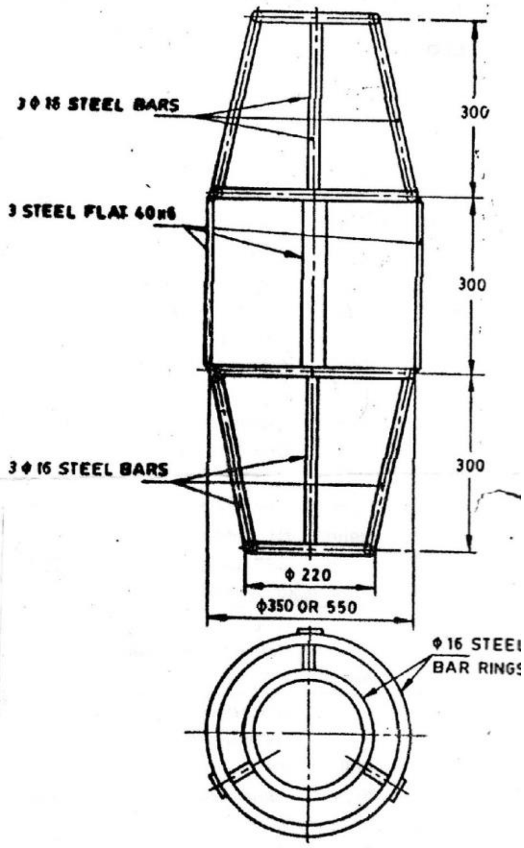
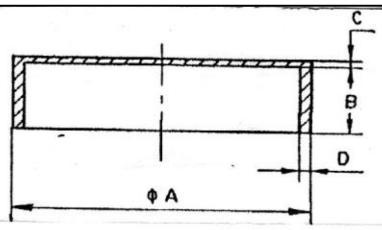


FIG 6. CENTRING GUIDE



All dimensions in millimetres.

Size of Well Cap	*A*	*B*	*C*	*D*
300	348	80	6	12
350	372	80	6	12
400	430	80	6	16

FIG. 7. WELL CAP

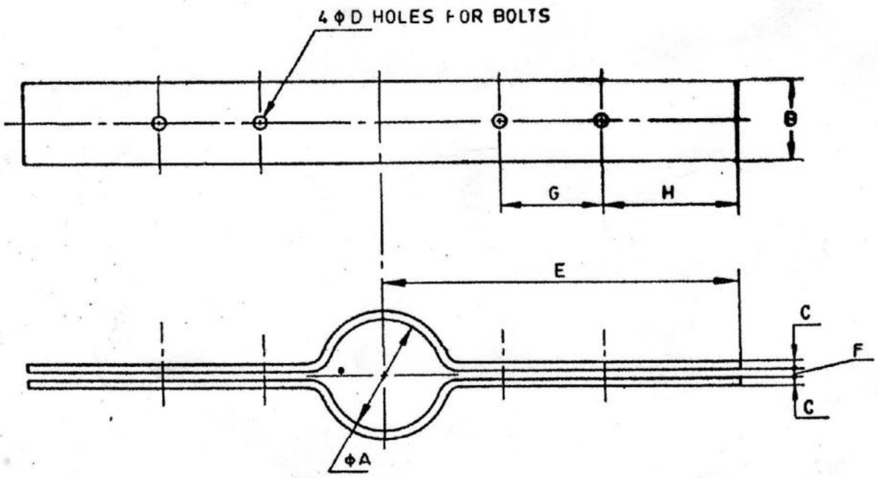


FIG. 8 WELL CLAMP

7.9 Well Clamp

This is fitted to the housing or top most pipe of the well to support the well assembly after it is lowered into the hole. This must be supported at ground with wooden beams initially and finally on cement plug. The material shall conform to IS 2062. A typical design of the clamp is given in Fig. 8.

8 WATER FOR WATER WELL DRILLING

For all water supply wells the water for drilling should be fresh to the extent possible. Use of contaminated water may contaminate the environment of the borehole and later may result in growth of bacteria and encrustation on screens. The use of brackish or saline water hampers the development of electric log and hence must be avoided. Similarly the use of cow dung to prevent caving during drilling must not be practiced as it may totally spoil the quality of well water.

9 FORMATION SAMPLING

The well bore cuttings should be collected at an interval of 3 m for reverse circulation and direct circulation methods of drilling and also at each change of formation material inferred. For percussion, hand boring and odex methods the sampling interval should be 1 m or less as per the demand of the conditions. Based on the samples collected a lithological log should be prepared which can be called a driller's log.

10 ELECTRICAL LOGGING OF BORE HOLE

All boreholes drilled by reverse/direct circulation methods must be logged by geophysical methods. Minimum electric log comprising of self-potential, short normal resistivity and long normal resistivity must be run. These logs shall provide boundaries of the lithological units encountered during drilling and also useful information on formation water quality and to some extent formation compactness and/or grain size of aquifer material. The electric log and driller's log should then be reviewed together to prepare a final lithological log. Only this lithological log should be kept in record and only this must be used for the tubewell design.

11 TUBEWELL ASSEMBLY LOWERING PROCEDURE

The designed tubewell assembly should be fabricated and arranged at surface. Final measurements should be made of each section of assembly. Each pipe should be measured to the accuracy of ± 0.1 percent. The material of the assembly should also be checked at this time. The tubewell assembly should then be lowered into the borehole. During lowering of the fabricated assembly pipes, the entire length of the pipes must be kept in hanging position. The assembly must not be forced down under any circumstance. After completion of filter packing also the assembly should be kept in hanging position by supporting with heavy duty clamp

12 GRAVEL/FILTER PACKING

The gravel shall conform to IS 4097 with subsequent amendments if any. The filter pack material should such that 90 percent of it is larger than slot opening of the screen. And the filter pack material is chosen to retain most of the formation material. If slot opening for natural developed well comes to less than 0.25 mm, a filter material should be used. Also the filter pack material should have uniformity coefficient of around 2 and should not exceed 2.5. Secondly in uniform aquifer material the ratio of D50 gravel to D50 aquifer material should be 5 to 7. Under most conditions the maximum grain size of gravel material should not exceed 10 mm.

12.1 *Thickness of gravel/filter pack*

By experiments it is confirmed that a properly sized pack with a thickness of 12 mm successfully retains the formation particles regardless of the velocity of water passing through the filter pack. Under most conditions the thickness of filter pack should not be more than 200 mm for ease of development. Recommended thickness of gravel/filter pack is 100 mm to 150 mm.

12.2 *Filter placement Procedure*

The placement of filter pack around the well assembly should slow and careful to avoid segregation of particles and bridging in the pack. It should be uniform around the assembly and for this reason it should be poured from at least four directions around the well.

12.2.1 In percussion method, filter pack is fed between drilling casing pipe and well assembly and at regular interval casing pipe is jacked out. Continue this process till the casing pipe reaches 3 m above the top most screen. Fill gravel above this to 3 m more height. The well is then developed, till water is nearly clear. At this stage the gravel filling and jacking up of casing pipe should be done to finish gravel packing till about 30 m below ground level or where a good clay bed exists around this depth. A clay seal (sanitary seal) of 3 m thickness should be provided here to protect the well against local contamination. Rest of the borehole can be filled by any material.

12.2.2 In the direct and reverse circulation method the borehole should be washed to thin down mud or drilling fluid and then well assembly should be lowered with centring guides at regular interval. The filter pack/gravel should then be placed as given above to finish gravel packing till about 30 m below ground level or where a good clay bed exists around this depth. A clay seal (sanitary seal) of 3 m thickness should be provided here to protect the well against local contamination. Rest of the borehole can be filled by any material. It must be ensured that a minimum of 20 m length of gravel pack is there above the top of the top most screen.

13 SEALING AND GROUTING

13.1 Grouting Surface Casing

All public water supply wells surface casing must be grouted to a depth of 25-30 m from land surface to prevent leakage of contaminants from surface or shallow aquifers. Grouting surface casing involves filling the annular space between the casing and the drilled hole with cement slurry or clay.

13.2 Seal as Packers

In the wells finished by percussion method where reducer cannot be placed for technical reasons, a seal has to be provided between the telescoped intake assembly and housing pipe. This seal is either neoprene rubber or of lead.

13.3 Sanitary/Protection Seal

Where a surface casing is not used a sanitary seal made up of clay, plaster of paris (PoP) or cement in the gravel pack at a depth around 25-30 m should be preferred. A good location can be identified with final lithology where a clay bed exists. In some areas, top aquifers are found to be of inferior quality and there is need for sealing them to protect the water from deep aquifers. From the study of the electric log the depth below which water is of acceptable quality should be determined. A clay bed below this depth should be identified and the seal should be placed in gravel pack against this clay bed. This seal would prevent seepage of water from upper poor quality water aquifers to through gravel pack.

14 DEVELOPMENT OF TUBEWELL

The installed well shall be developed by any one or more methods specified in code IS 11189. The methods and equipment shall be such that the well is developed at a discharge about 1.25 times the required yield from the well. All wells shall be developed by a pump at the end of development process. In the last phase of development, the estimation of sand content and turbidity should be made.

15 ALLOWABLE SAND CONTENT IN WELL WATER

Sediment in well water can be destructive to pumps and water discharge fittings. Development methods reduce or eliminate high concentration of sediment in water well but it is impractical to assume that all sediment can be eliminated, even by most powerful development methods. Recommended limit of sediment in water well are as under:

a) 1 ppm for water directly used for processing of food and beverages;
b) 5 ppm water for homes, municipalities and industries;
c) 10 ppm water for sprinkler irrigation, industrial evaporative cooling system; and
d) 15 ppm water for flood irrigation.

16 STERILIZATION OR DISINFECTION OF THE WELL

The well shall be disinfected or sterilized after the development by pump and before the final test. All wells regardless of the use should be sterilized on completion to prevent or retard the growth of corrosion or incrustation fostering organisms. This should be done by introducing chlorine into the water in the well and the immediate aquifer surrounding the well. The volume of water in the screen and casing should be estimated and sufficient chlorine added to yield a chlorine concentration of 1 000 ppm. The solution should be poured into the well and thoroughly mixed in the well by surging with pump. The solution should remain in the well for at least 6 h during which it should be surged at about 2 h interval. After expiration of contact time, the well should be pumped initially back into the well for about 30 min and later to waste until there is little or no odour or taste of chlorine in the discharged water. It has been found that using hypochlorite of 10 percent concentration, the requirement of hypochlorite is 10 litre for every cubic meter of water in the well to produce.

17 MEASUREMENT OF WELL

The measurement shall cover the following parameters:

17.1 Tubewell depth measurement: the depth of the tubewell shall be deemed to be equal to length of the pipes lowered. The measurement of the depth shall be made by twisted metallic cable strained by a plumb bob or by means of rigid rods.

17.2 Water level measurement static and dynamic (pumping):

17.2.1 *Tape measurement*

This is carried out by a steel graduated tape or cable attached with a plumb bob of suitable diameter and weight. The tape is chalked at the lower end to few meters and is lowered to the estimated depth of water level or a little more. Lower part of the tape enters the water and wets the chalk there. The line of the colour change donates the length of tape immersed in water. Subtracting this length from the reading at the measuring point gives depth to water level from the measuring point. It is always useful to have one 25 mm diameter pipe lowered to the depth of the pump if water level measurements are made during running of pump. In this case the tape should be lowered through this pipe.

17.2.2 *Electric sounder*

It can be double pole or single pole arrangement. Many sounders are available in the market for this purpose. The principle of this is shown Fig. 9. It can be locally fabricated by using an electric bulb in the circuit and connecting negative end to the casing and positive end through electric bulb to an insulated metallic probe through a strong thin wire. This insulated probe has one opening in the side or bottom. The probe when lowered into the well comes in contact with water completes the circuit and lights the bulb. The probe is then pulled out and measured from the opening on probe to the point where the bulb was lighted to give depth to water level.

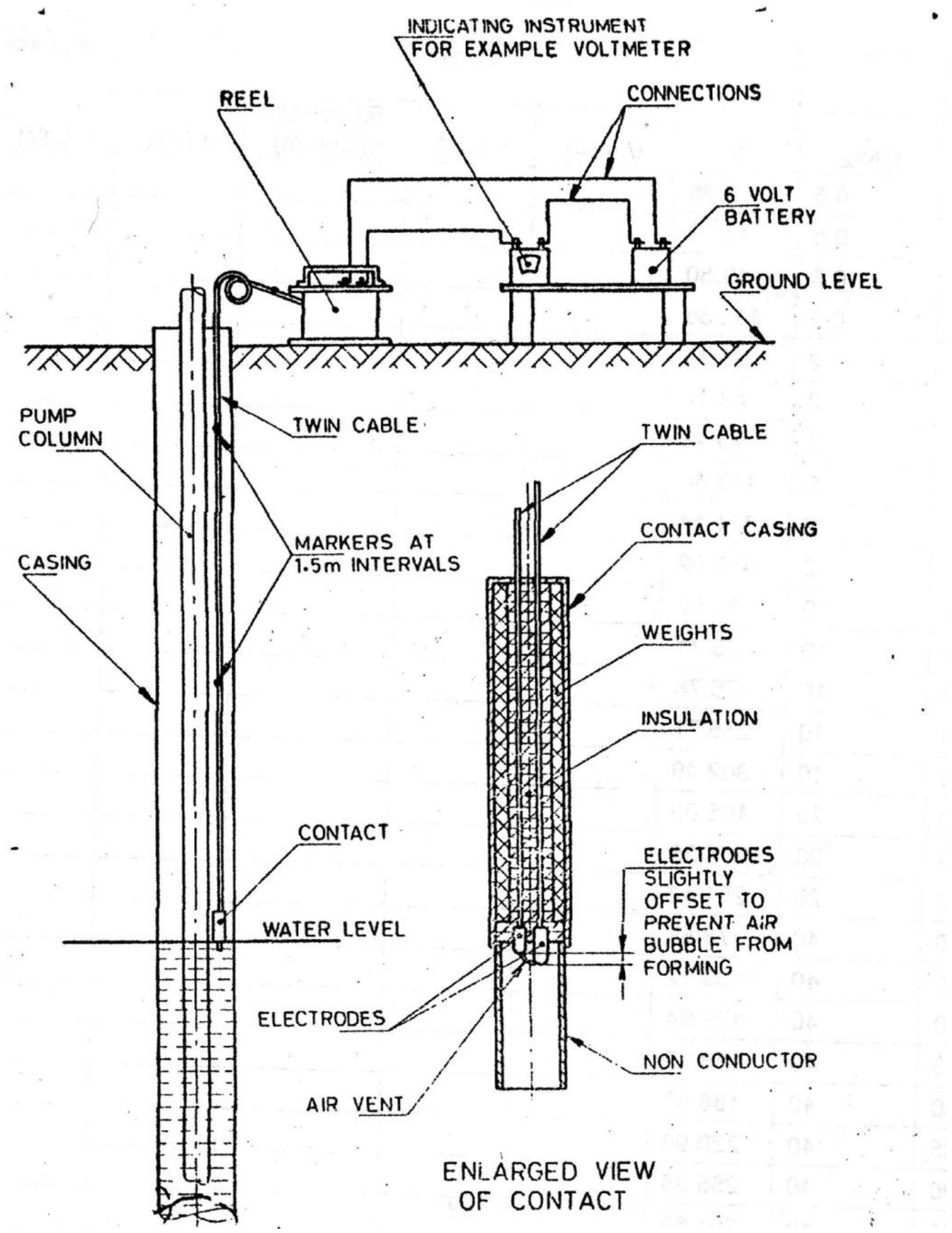


FIG. 9 ELECTRICAL APPARATUS WITH DOUBLE POLE CONTACT FOR WATER LEVEL MEASUREMENT

17.2.3 *Air Pressure line Method*

This consists of a tube positioned between the casing and the pump column pipe and extended to the depth of pump, a calibrated pressure gauge graduated in meters of water and an air pump and non-return air valve. All the items are installed on the well as Fig.10. The air is then pumped till maximum reading is observed on the gauge. This reading (A) indicates that all water is displaced from the airline that is the water column above the bottom of airline. The depth to water level then calculated as total length of airline minus A.

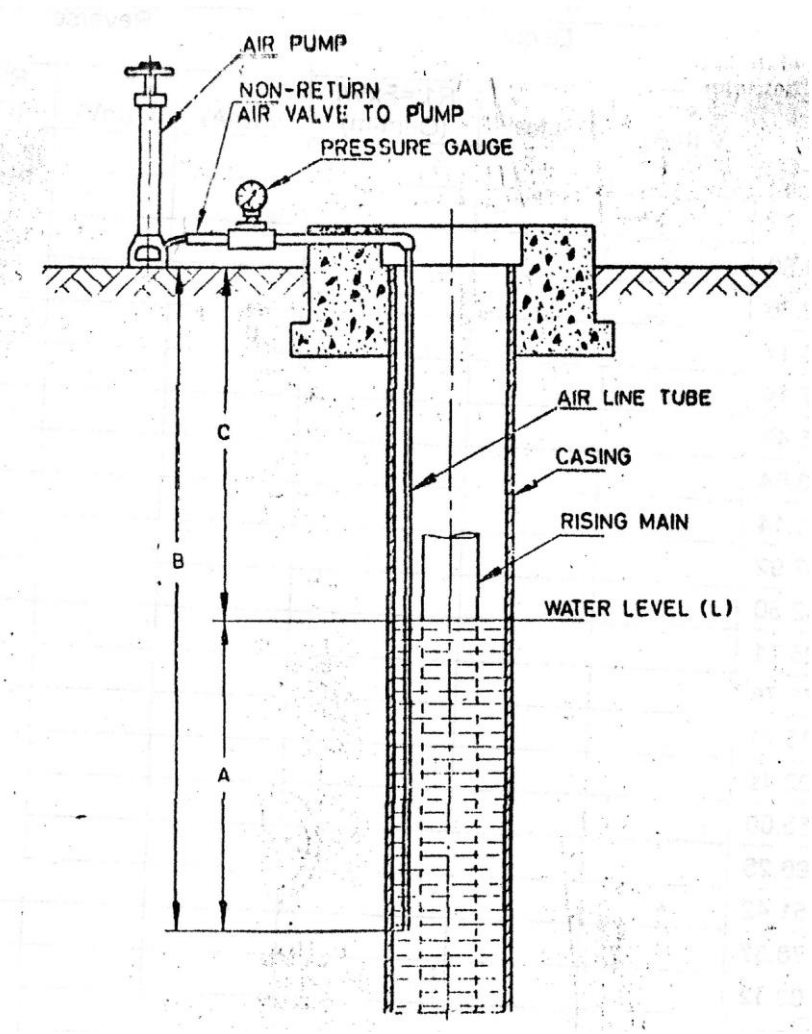


FIG. 10 AIR PRESSURE LINE APPARATUS FOR DETERMINING THE WATER LEVEL IN A TUBE WELL

17.3 Discharge Measurements

Discharge measurements should be done with any of the following methods:

a) A water meter – it is most accurate;
b) Orifice weir method – very accurate; field setting shown in Fig 11;
c) V-notch – accurate enough for high discharge rates; and
d) Containers – good for very low discharge rates.

17.4 Sand/Sediment Content Measurement in Well Water

The sediment concentration should be determined by averaging the results of five samples taken at the following times during final continuous pumping test of at least two hours. 15 min after start of test, 30 min after test, 60 min after start of test, 90 min after start of test and near the end of the test. The total quantity of sample should be flow rate multiplied by 0.05 for 1 500 litre/min the sample volume should be 1 500 × 0.05 = 75 liters. It means each part of sample should be 15 litre. The sample should be taken from the entire flow of pipe and not only the bottom or top. From this sediment content should be determined and represented as parts per million or mg/litre.

17.5 Verticality/Plumbness and Alignment

The housing pipe or the pump chamber casing should be straight and aligned but need not be plumb. For this a 12 m long dolly should pass freely through the housing pipe without hanging. The dolly should be rigid and fitted with 30 cm long rings on either ends of the dolly and also in the centre. The outside diameter of the rings should be 15 mm less than the inside housing pipe diameter. If the dolly passes freely to the bottom of the housing pipe it can be considered straight for all purposes.

The plumbness or verticality was important when turbine pumps were in use. But now as most water wells use submersible pumps verticality is not so important; instead the alignment and straightness is important. The pumps can be installed if the well housing pipe is straight though may be out of plumb.

18 WELL TESTING FOR YIELD AND DRAW DOWN

At the end of well development by a pump a yield test should be conducted to calculate specific capacity and efficiency of the well. This should be done under guidance of a qualified engineer or hydrogeologist. The yield test should be run at preselected three discharge rates. The discharge rates should be at 60 percent, 80 percent and 100 percent of the rate at which the well has been finally developed. Arrangements to measure the discharge rate and the water levels must be kept ready. Let the well be idle for more than 12 hours. Take water level at the start of the test and call it static water level or water level prior to the test. Start the pump and note down the time and adjust the rate of discharge to the lowest rate. Run the pump for 60 min and measure pumping water levels at 10 min interval during this period. Then raise the rate of discharge to second level and repeat the process and similarly for the third rate of discharge. Record the data in Table 2. Higher specific capacity of the well in the second or third step as compared to first or second step i.e. it is higher at higher rate of pumping, indicates that the well was still developing during the testing period. In such a case the efficiency cannot be determined.

Table 2 Step Draw Down Test Results
(*clause* 18)

Step No.	**Period of step (min)**	**Discharge rate lpm (liters/min)**	**Static water level (m)**	**Pumping water level at end of step (m)**	**Draw down dd (m)**	**Specific capacity (3/6) (lpm/m dd)**
(1)	(2)	(3)	(4)	(5)	(6)	(7)
i)						
ii)						
iii)						

19 WATER QUALITY

The samples should be collected at the end of each step of step draw down pumping test in sterilized plastic bottles. Depending upon the parameters to be analyzed the volume of sample should be decided. Representative of the chemical lab should normally collect the sample as per requirement. Or the sample should be collected as per his instructions. Separate samples should be collected for bacteriological and chemical. Some elements have a tendency to precipitate when it comes in contact with air. Such samples should be fixed or treated immediately after collection.

20 HANDING OVER OF TUBEWELL

The drilling agency on completion of installation of the tubewell shall submit a well completion report on their letter head that shall include the following:

a) Location of the tubewell;
b) Date of start of drilling;
c) Date of completion of drilling;
d) Method of drilling;
e) Total depth of the borehole drilled;
f) Diameter of the finished borehole with depth ranges in meters;
g) Electrical logging/geophysical logging report;
h) Final Lithological log with depth range, thickness and type of formation;
j) Length and diameter of various pipes. Such as surface casing, housing pipe and casing pipe;
k) Length and type of screens with slot width;
m) Filter pack material, grade, volume used;
n) Sealing and grouting, nature and depth range;
p) Development methods deployed and periods thereof;
q) Development discharge by pump;
r) Method of sterilization and volume of chlorine solution used;
s) Clear depth of the well;
t) Pumping test data as per Table 2 in 18; and
u) Diagram of tubewell assembly.