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Indian Standard

METHODS OF TUBEWELL DEVELOPMENT

[Pump Sectional Committee, EDC 35; Tubewell Subcommittee, EDC 35 : 4 [Ref : Doc : EDC 35 (3618)]

1. Scope — Lays down the general guidelines and the methods of development of tubewells.

2. Definitions — For the purpose of this standard, the following definitions shall apply.

2.1 *Aquifer* — A geologic formation, groups of formations, or part of a formation that contains sufficient saturated permeable material to yield significant quantities of water to wells and springs.

2.2 *Draw-Down* — It is the distance by which the water level in a well is lowered from static level when pumped at a constant rate of flow.

2.3 *Permeability* — Permeability or hydraulic conductivity of a medium is indicative of the ease with which water can flow through it. It depends on the properties of the medium affecting flow including porosity, packing, shape, and grain size distribution.

2.3.1 The co-efficient of permeability is the velocity of flow through a permeable material at hydraulic gradient unity.

2.4 *Ratio of Submergence* — This is the ratio between the length of the airline under water to the total length of airline.

2.5 *Well Development* — It is a treatment of a well to establish the maximum rate of usable water yield without sand content (beyond permissible limit).

3. Need for Development

3.1 All methods of drilling cause compaction of unconsolidated materials in an annulus of variable thickness about a drill hole. In addition, fines are driven into the formation, drilling mud invasion may also occur there to some extent, and a mud cake may be formed around the hole. In consolidated formations also similar compaction may occur in some poorly cemented rocks, where cuttings, fines and muds are forced into fractures, bedding planes and other openings, and a mud cake forms on the wall of the hole. All these factors reduce the permeability of the formation adjacent to the well and act to reduce the yield.

3.2 Proper well development breaks down the compacted borehole wall, liquefies jelled mud, and draws it and other fines which have penetrated the aquifer or were initially present in it into the well, from which they are removed by bailing or pumping. This creates a stable zone around the screen. This stabilization of the formation adjacent to the well screen practically eliminates sand pumping, and contributes to a more efficient well, longer well life, and reduced operation and maintenance costs.

4. Methods of Development

4.0 Numerous methods of development are available. An important factor in any method is that the development work be started slowly and gently and increased in vigor as the well is developed. All but one method of well development require the application of sufficient energy to disturb the natural formation or filter pack so as to free the fines and allow them to be drawn into the well, and to cause the coarser fractions to settle around and stabilize the screen. This is usually accomplished by the surging of water into and out of the well and the formation. The exception is hydraulic jetting; which depends upon a high velocity water jet discharging through the screen. The jets disturb both-filter and formation and the water, following the path of least resistance, returns to the well above and below the jets, carrying the fines into the well.

The development shall be started as far as possible, from the bottom of the screen because with this the compaction takes place as the work progresses upwards and the overlaying material can move downwards, without much possibility of bridging and should a bridge develop, the development action would usually break it up.

Determination of the adequacy of development is largely a matter of experience and judgement but as a general rule if interrupted over pumping or raw hiding is used as a final method of

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development the degree of development may be estimated from sand samples on each resumption of pumping On initiation of interrupted pumping, samples shall be taken as frequently as possible as soon as discharge starts at each new rate of pumping. Sampling of this type at each rate of discharge will show the time required for maximum sand content to occur and will serve as a guide to subsequent sampling and development.

Shortly after the period in which maximum sand content occurs in the discharge for each new rate of pumping, the discharge will become practically sand free until the well is again surged. As raw hiding continues, the maximum amount of sand content will decrease at each discharge time interval until water of low sand content is discharged.

The known methods of well development are listed as follows:

a) Over pumping,

b) Compressored air,

c) High velocity jetting,

d) Surge block, and

e) Explosives.

4.1 *Pumping*

4.1.1 *Continuous over pumping* — The simplest and most common method of removing fines from the formation close to the well screen is by over pumping. By this it is meant, pumping the well at higher capacity than it will be pumped when in regular service say not less than 50 percent above the designed discharge.

When the water is pumped out of the well, there is a tendency of the sand to move in the direction of the well end, and with steady pull in this direction, the finer sand grains will wedge against each other and bridge across openings or voids between coarser grains to a very considerable degree. The only way in which this can be prevented is by 'back washing' which is keeping the water as agitated as far as possible. The method consist in starting and stopping the pump intermittently to produce relatively rapid charges in the pressure heads in the well. This shall be done more effectively with the help of turbine pumps.

The pump is operated with the fullest capacity until it has produced maximum draw-down. It is then stopped, the water recedes rapidly out of the column of the pump and the well is permitted to return to its normal static water level. The procedure is repeated many times until the well is sand free.

Care shall be taken not to start the pump when the shaft is rotating in reverse direction, as this is likely to cause damage to the pump shafts.

4.1.2 *Interrupted over pumping* — The development process shall include development by interrupted pumping. The pumping shall be done with a pump capable of pumping at rates up to two times the design capacity. The pumping should be carried out in at least five steps. These steps shall include pumping rates of $\frac{1}{4}$, $\frac{1}{2}$, 1, $1\frac{1}{2}$ and two times the design capacity, with no check valve or foot valve present. Pumping shall be conducted in five minute cycles, and shall continue a minimum of two hours or until such time as acceptable standards are attained.

4.2 *Compressored Air* — One of the most commonly used method of developing a tube well is by compressed air It shall be used either by back-washing method or by open well or surging method.

4.2.1 *Back washing method* — In the back washing method a 3-way valve is turned to deliver air down the air-line, with the air cock usually open. This pumps water out of the well through the discharge pipe. When the water becomes clear, the supply of air is cut off and the water in the well is allowed to regain its static level. The air cock is then closed and the 3-way valve is turned, so that the air supply is directed down the by pass to the top of the well. This forces the water down out of the casing and back through the screen, breaking down the 'Bridge' of the sand grains When the water has lowered to the bottom of the drop-pipe, it will not go further, because the air will escape out through the pipe.

When the air is heard escaping out of the discharge pipe, or when the pressure stops increasing, the supply of air is cut off, and the air cock is opened again to allow the water to reach static level. The 3-way valve is turned and the air supply again directed down the air line to pump the well. This procedure is repeated until the well is thoroughly developed. It is advisable to run a bailer, if practicable, for final cleaning of the well before installing the pump.

The principles of the back-washing method is to force the water out of the well, through the screen and into the water bearing formation by means of compressed air which is introduced into the well through the top of the housing pipe after it has been closed air-tight by means of flanges and gaskets with holes bored for drop pipe and air line, etc. In this method, the drop pipe shall not be allowed to be lowered below the screen top so that air introduced into the well during back-washing may not air lock the acquifer, preventing normal movement of water. In case setting of drop pipe above the top of the screen, does not provide enough submergence for satisfactory pumping, this method shall not be used effectively. However, excessive submergence of the drop pipe requires large starting pressures, which shall be avoided by reducing the length of the air line.

The diameter of the drop pipe is usually kept about 5 cm less than that of the well pipe and that of the air line usually varies from 2 to 6 cm.

The hook-up of the equipment for closed well method is shown in Fig. 1.

4.2.2 *Open well method* — This method of development is a combination of surging and pumping. Large volume of air is released suddenly into the well pipe which produces a strong surging action. Pumping is done as with an ordinary air lift. The success of this method depends on the skillful application of alternating the surging and pumping as per requirements of the well.

The necessary equipment for this method of development consists of:

a) Air compressor with air receiver of adequate size;

b) Drop-pipe and airline in well with suitable means for raising and lowering each independently of the other.

   Normally the well pipe itself is used in place of drop pipe but as the washed material has also to be pumped out along with the water, if required a separate discharge/educator pipe may be used so that velocity of water pumped out may be sufficiently great to carry with it all the clogged material from the well. Use of drop pipe becomes necessary in case of deep wells;

c) Flexible high pressure hose and pipe line to connect between tank and airline in well;

d) The compressor should be fitted with unloader and the tank must have a relief valve to safeguard against accidental overloading; and

e) Miscellaneous small fitting, such as pressure gauge and a quick-opening valve at the outlet of the tank.

In order that development by this method may be fully successful, it is necessary to have a ratio of submergence of at least 60 percent. The efficiency of development reduces rapidly with submergence less than 60 percent should the air line be too deeper submerged in proportion to the net height of the lift, an uneconomically high pressure will be required to force the air out.

The discharge of the compressor shall be piped direct to the tank without any valve in the line. The discharge from the tank to the well shall be the full size of the airline in the well, or if long, the next larger size, and shall be fitted with a quick opening valve near the tank. A high-pressure hose is used between the discharge pipe from the tank and the airline in the well. This hose shall be at least 4·5 to 6 m long to allow sufficient space for moving the drop pipe and air line up and down.

Before blowing water or drilling mud out of the well, the air-lift shall be operated slowly for a time to make sure that the screen is sufficiently open so that water will come into the well freely, otherwise damage to the screen may take place.

At the start of development the drop pipe is lowered within 600 mm or so of the bottom of the screen, and the airline is placed, so that it is inside the drop pipe by 300 mm or more. If there is plenty of submergence airline needs to be lowered only for enough to get 60 or 70 percent submergence. The air is turned into the airline and the well is pumped in the manner of a regular air lift, until the water appears to be free from sand. The valve between the tank and the airline is then closed, allowing the tank to be pumped full of air up to required pressure. In the meantime, the airline is lowered so that it is 300 mm or so below the drop pipe. The quick opening valve is then thrown open, allowing the air in the tank to rush into the well. There will be a brief but forceful surge of the water and then a 'head' of water will 'shoot' partly from the drop pipe. If the airline is pulled back into the drop pipes as soon as the first heavy load of air has been shot into the well, it will produce a strong reversal of flow up the drop pipe which will quite effectively agitate the water-bearing formation.

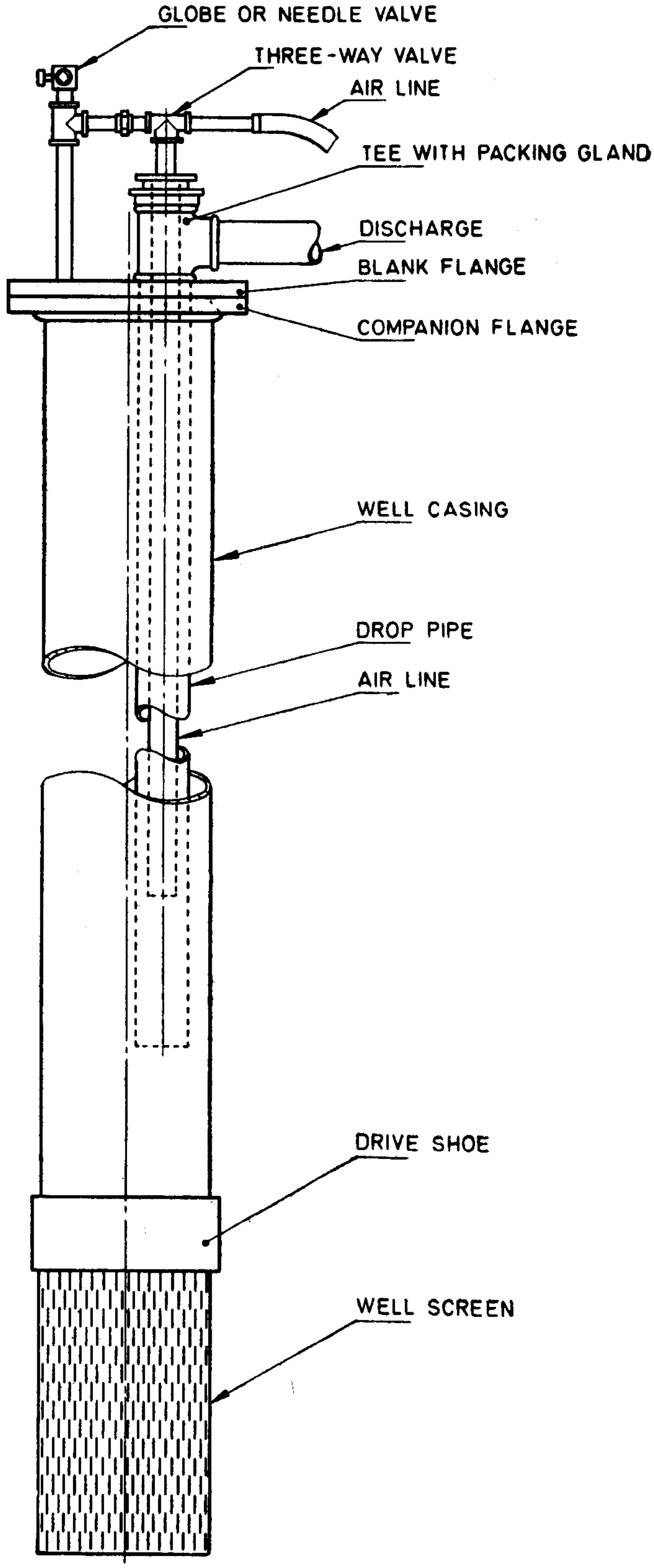

FIG. 1 CLOSED WELL DEVELOPMENT WITH AIR COMPRESSOR

The well is then allowed to pump as an air lift for a short time, and then another 'head' is shot, repeating until the absence of further sand, etc, shows that the development is complete at this point. This procedure may be repeated in stages at convenient places in the screens, which will complete the work and clean out loose sand which might have settled at the bottom of the well.

The compressor shall be capable of developing sufficient pressure to overcome initial head of water in the air line. The recommended size of pumping pipe, and the size of the airline with the pumping rate is given below for guidance.

Pumping Rate l/min	*Size of Pumping Pipe* mm	*Size of Airline* mm
450-700	100	30
700-900	125	40
1 125-1 800	150	50
1 800-3 200	200	65

This method has its own limitations where the yield is very weak and the draw down rapid or where submergence is low.

Hook-up for open well method is shown in Fig. 2.

4.3 *High Velocity Jetting* — Jet development is a recent addition to other common methods of developing wells.

In this method water jets projected at high velccity out through well screen openings effectively loosen fine sand, silt and drilling mud from the water bearing formation. The loosen material moves inside the well screen and is removed from the well by pumping or bailing.

The jetting tool consists of an attachment fitted with two or more evenly spaced horizontal nozzles having 6·2, 9·5 or 12·7 mm orifices. The bottom of the tool is closed and the depth of setting, the choice of the nozzle depends largely on the capacity of the high pressure pump. The main item of equipment needed for this method are the jetting tool, high pressure pump, hoses and connections, 5 cm dia pipe line and a source of water. The size of the pipe for feeding water to the nozzles should be large enough to keep friction losses to a reasonable value. It generally ranges from 4·0 to 7·5 cm depending upon the length of the pipe and discharge it has to carry.

The diameter of the jetting tool shall be about 25 mm less than the inside diameter of the screen. The normal jet discharge (per nozzle) and velocity is as indicated below:

Nozzle Oriffice mm	*Pressure Velocity* m/s	*7 kgf/cm² Discharge* l/min	*Pressure Velocity* m/s	*14 kgf/cm² Discharge* l/min	*Pressure Velocity* m/s	*17·6 kgf/cm² Discharge* l/min
6·2	33·5	77	46	118	55	90
9·5	33·5	172	46	255	55	280
12·7	33·5	305	46	450	55	500

The procedure consists of operating a horizontal water jet inside the well in such a way that the high velocity stream of water shoot out through the screen openings. By slowly rotating the jetting tool and gradually raising and lowering it, the entire surface on the outside of screen gets the vigorous action of the jet. Fine sand, slit and clay are washed out of the water-bearing formation and the turbulance created by the jet rings these fine materials back into the well through screen openings above and below the point of operation. Wherever possible, it is desirable to pump the well lightly at the same time as the high velocity jet is working by using air compressor. The water so pumped can be reused for jet-development after pumping it into a setting tank.

4.4 *Surge Blocks* — An effective method for developing the well is surging created by the rapid up and down motion of a plunger, operated in the casing pipe provided above the screened portion of the well. The rapid motion of the plunger causes forceful reversal of the movement of water, which prevents the bridging of finer particles. The repeated application of the surging force draws fine particles from the acquifier and thus porosity and permeability of the zone around the screen is increased.

A surge plunger is most used tool for development particularly in wells drilled by cable tool methods and tubewells of natural gravel pack well where strainers have been used.

Yet there in another method which is called 'Swabbing' in which the swab is lowered into the casting to any selected point and then pulled upwards to produce an inward flow. Swabbing therefore, helps in taking out the fine material drill in consolidated rock aquifers, but are very seldom used in screened wells. Sand pumps may also accomplish effective development of shallow wells with cable tool methods.

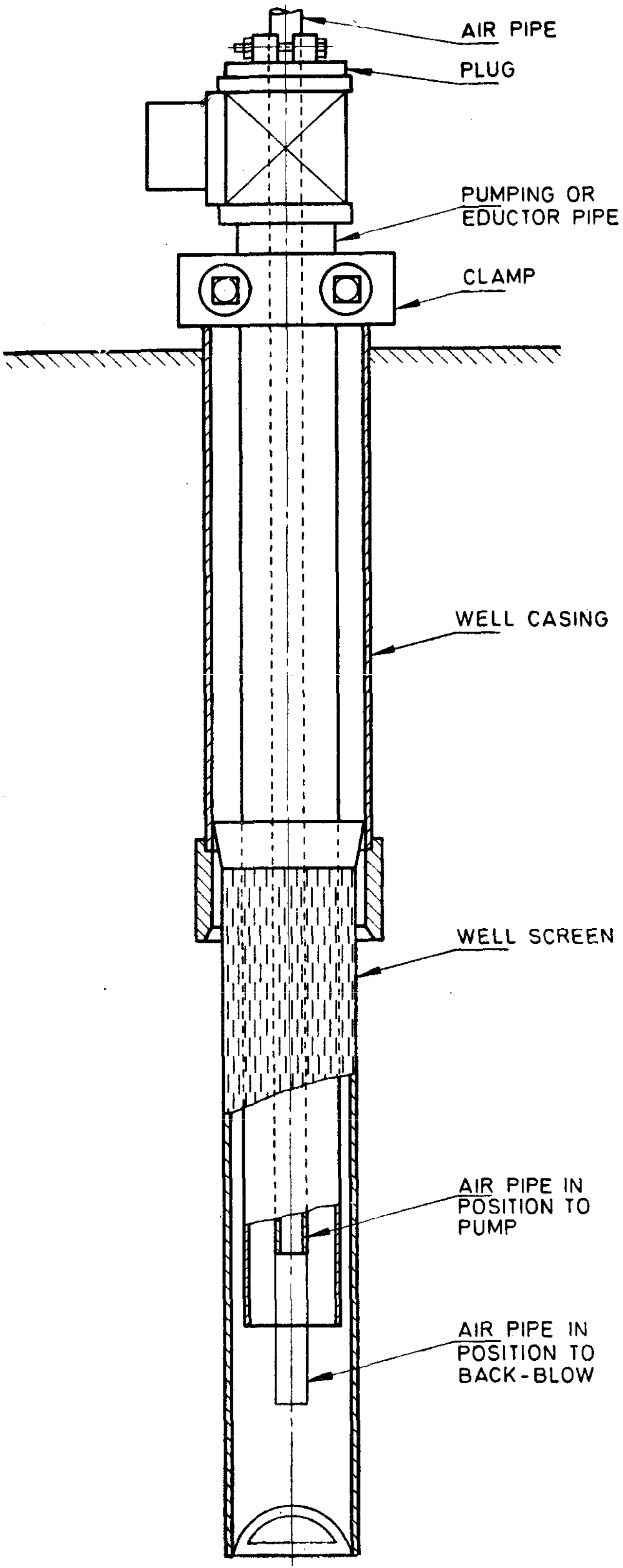

FIG. 2 OPEN WELL DEVELOPMENT WITH AIR COMPRESSOR

Where the aquifer contains many clay streaks use of plunger block is not recommended because this can cause the clay to plaster over the strainer surface and thus clog the strainer resulting in reduced discharged. Sometimes the strainer give away due to high differential pressure when the strainer is clogged with clay.

After the sand has been drawn in by the surge block the well is cleaned by using a hailor and the process is repeated till the well is totally sand free. Total time involved for developing may range from four hours for a small well to 3-4 days on large well with longer screen.

The size of the plunger shall be kept such that it does not fit in the casing pipe. It shall be able to pass within the pipe and its fittings freely. The plunger may be run on a continuous string of pipe or a part string with a cable adopter at the top. The surging plunger is lowered into the casing about five metres below the water. The movement of the plunger should be restricted in the portion above the screen in the casing pipe. After lowering, it is stroked to produce surging effect. The stroking may come off the beam of a percussion drill or off a cat head or by hand tripping. Some time, hoisting mechanism is used for this. Initially, the surging shall be stated slightly and gradually increased till it reaches the maximum limit of the system. Through bailing between the runs of the plunger is very important for efficient development. The surging and bailing out is carried out till little sand is driven into the well. In case of wells with long screens, surge plunger may, however, be operated inside the screen for effective development.

A typical surge block is shown in Fig. 3.

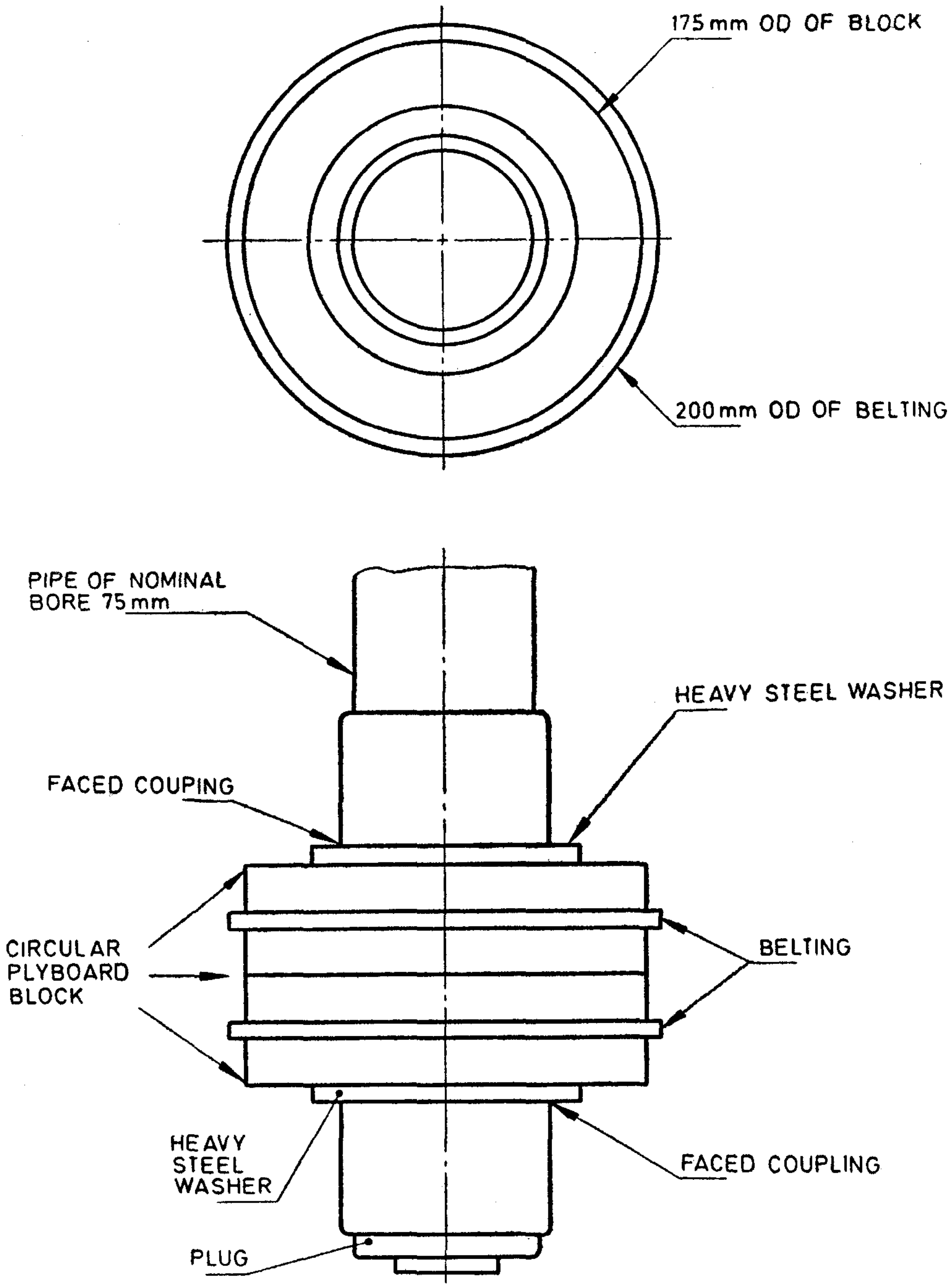

FIG. 3 SURGE BLOCK

4.5 *Explosives* — These are sometimes employed to develop and enlarge cervices and fissures in tubewells drilled in hard rocks. Charges of 14 to 230 kg are used according to the hardness of the rock and the depth at which the charge is to be detonated.

5. Criteria for Proper Development of Tubewells — Development work is an essential operation in the completion of drilling job. It consists of steps to remove the finer material and opening up the passage in the formation so that water can enter the well through the screen more freely. Proper development is said to have been satisfactorily done when:

a) The stabilization of the sand formation has taken place, that is, there is no further sinking of gravel and the discharge is sand free; and

b) Permeability of the formation is increased by removing finers utilising proper development method.

6. Recommended Methods of Development — Information pertaining to various methods of development of tubewells is given below:

SUMMARY OF RECOMMENDATIONS FOR DEVELOPMENTS OF VARIOUS TYPES OF WELLS

Sl. No	*Method of Development*	*Tubewell Up to and Including 150 m in Allurial*		*Tubewell Above 150 Up to and Including 300 m in Allutial*		*Tubewell Above 300 Up to and Including 800 m in Allutial*		*Boulders and Febbles*	*Hard Rock (DTH)*	*Remarks*
		Artificial Gravel Pack	Natural Pack	Artificial Gravel Pack	Natural Pack	Artificial Gravel Pack	Natural Pack			
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
i)	Over pumping	Effective	Effective	Satisfactory	Satisfactory	—	—	Most effective	Most effective	In case of hard rock areas only pumping at normal discharge should be carried out
ii)	Compressed air	Satisfactory	Satisfactory	Satisfactory	Satisfactory	Not very effective	Not very effective	Sarisfactory	—	Over pumping should follow the development with air compressor wherever needed
iii)	High velocity jotting	Satisfactory	Satisfactory	Very effective	Very effective	Very effective	Very effective	Not effective	Not effective	Simultaneous pumping of silt and clay with air compressor is recommended
iv)	Surge Block	Satisfactory	Satisfactory	Satisfactory	Satisfactory	Satisfactory	Satisfactory	—	—	This is not recommended where streaks of clay and fine sand formation are encountered
v)	Explosives	—	—	—	—	—	—	—	Effective	This usually increases the capacity of water veins and fractures

EXPLANATORY NOTE

The irrigation by means of tubewell has come to stay. Large number of tubewells are commissioned every year to irrigate the fields and for other purposes. Development of a tubewell after drilling over should be done to give maximum yield. This standard gives the methods of development and the situations where each development method should be employed.

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