IS : 4111 (Part IV) - 1968
(Reaffirmed 1996)

Indian Standard

CODE OF PRACTICE FOR ANCILLARY STRUCTURES IN SEWERAGE SYSTEM

PART IV PUMPING STATIONS AND PUMPING MAINS (RISING MAINS)

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BUREAU OF INDIAN STANDARDS
MANAK BHAVAN, 9 BAHADUR SHAH ZAFAR MARG
NEW DELHI 110002

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Indian Standard

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PART IV PUMPING STATIONS AND PUMPING MAINS (RISING MAINS)

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Indian Standard

CODE OF PRACTICE FOR ANCILLARY STRUCTURES IN SEWERAGE SYSTEM

PART IV PUMPING STATIONS AND PUMPING MAINS (RISING MAINS)

0. FOREWORD

0.1 This Indian Standard (Part IV) was adopted by the Indian Standards Institution on 16 October 1968, after the draft finalized by the Water Supply and Sanitation Sectional Committee had been approved by the Civil Engineering Division Council.

0.2 In a sewerage system ancillary structures like manholes, inverted syphons (where provided) are necessary appurtenances for proper functioning. This part of the standard on ancillary structures in sewerage system gives guidance for design and construction of pumping stations and pumping mains. The other parts of the standard are the following:

IS : 4111 (Part I)-1967 Code of practice for ancillary structures in sewerage system: Part I Manholes

IS : 4111 (Part II)-1967 Code of practice for ancillary structures in sewerage system: Part II Flushing tanks

IS : 4111 (Part III)-1967 Code of practice for ancillary structures in sewerage system: Part III Inverted syphons

0.3 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 : 2-1960*. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

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1. SCOPE

1.1 This standard (Part IV) lays down requirements for location, design, construction, equipment and safety precautions for installation of pumping stations and pumping mains used in sewerage system.

*Rules for rounding off numerical values (*revised*).

2. LOCATION OF PUMPING STATIONS

2.1 General — The area in which the pumping station is situated is fixed generally by the duty it has to perform, but the precise site may vary so as to take into account the following considerations:

a) As pumping stations are frequently in low-lying areas, consideration should be given to the possibility of flooding and information should be obtained as to the highest recorded flood levels in the area.

b) The pumping station site should be above the highest recorded flood level, but when construction on ground liable to flood is unavoidable, it should be so designed that motors are well above the highest recorded flood level and above the coping of the wet well or suction chamber.

c) The site should be selected if possible so that in the event of power failure any overflow which occurs may be diverted or will find its way into watercourse without causing flooding or serious damage to property; however, this should not pollute any watercourse used for drinking water purposes.

2.2 Nature of Ground

2.2.1 Investigations of the nature of the ground should be made before a site is selected, and if the station involves deep excavation trial holes should be dug or boreholes drilled for this purpose. The level of the ground water should be recorded, as a high standing water-level may require special constructional methods.

2.2.2 Where the area is subject to underground working, such as coal or salt mining the site of the pumping station should be selected so as to be free as far as possible from the danger of subsidence.

2.3 Nuisance — A pumping station should be located as distant as possible from the residential properties on account of possibility of complaints for noise or smell.

3. CAPACITY OF PUMPING STATIONS

3.1 Rates of Flow — The variations in the rates of flow depend largely upon whether the station is for sanitary sewage or storm water or both. Pumping station should be capable of dealing with the daily and seasonal variations of the inflow.

3.2 If a pumping station is to be added to an existing system, records of the flow over as long a period as available should be obtained and the conditions to be anticipated in the future estimated therefrom.

3.3 Pumping Capacity — The number and capacity of the pumping units should be chosen so that fluctuations in the pumping rates are not considerable and also so that under normal conditions frequent cutting in and cutting out is avoided. The number of different sized units should be selected after studying the overall economy and should be kept as low as possible to facilitate repairs and to reduce the number of necessary spares to a minimum.

3.4 Stand-by pumps should be installed of sufficient capacity that with any one pump out of service, the remainder may deal with the peak flow.

3.5 In the case of electrically driven pumps, consideration should be given to the possibility of failure of the power supply. Duplication of power lines and switch gears may be desirable in the case of large installations. If serious flooding would result from electrical power failure, stand-by plant using some other source of power should be provided.

4. PUMPS

4.1 Requirement of Sewage Pump — A sewage pump should be reliable and unchokable and accessible for quick maintenance, robust and wear resisting and some measure of overall efficiency may have to be sacrificed to secure these properties.

4.1.1 The type of pump to be installed at each pumping station should be judged on its merits in relation to the rate of pumping the total head, the physical composition of the sewage, septicity and preliminary treatment before pumping.

4.1.2 The types of pump available for handling of sewage may be divided broadly into three groups:

a) Roto dynamic,
b) Reciprocating, and
c) Pneumatic.

4.2 Roto-Dynamic Pumps — Roto-dynamic pumps are more suitable and adoptable for sewage pumping purposes. They should conform to the requirements specified in the 'Indian Standard specification for roto-dynamic special purpose pumps' (*under preparation*) and 'Indian Standard specification for sewage and drainage pumps' (*under preparation*).

NOTE — Until the Indian Standards referred to in **4.2** are published, the requirements shall be subject to agreement between the concerned parties.

4.2.1 The priming of all types of roto-dynamic pumps require special consideration especially when the sewage to be handled may be septic and, therefore, liable to generate gas. It is recommended to locate the pump so that there is a positive head of sewage above the impeller of the pump on the suction side when starting up, particularly on automatically operated pumping stations for intermittent duty.

4.3 Reciprocating Pumps

4.3.1 Reciprocating pumps are not recommended for the pumping of sewage except in special circumstances, such as unusually high head. This type of pump when specially designed to run at slow speed may be used for the pumping of sludge.

4.3.2 The reciprocating pump is heavy, of large dimension in relation to capacity, reliable, highly efficient when first installed, capable of operating with a suction lift and of discharging with very high heads but is susceptible to chocking, heavy wear-and-tear and loss of efficiency through wear and valve jamming. The reciprocating pump may be either of the single-acting or double-acting type, but preliminary treatment to remove abrasive and other solids is advisable in the case of double acting pumps. Reciprocating pumps require essentially slow speed drive and gearing may be required between the pump and the prime mover. They afford very little flexibility in discharge capacity but will maintain a steady rated discharge over a wide variation in head duty.

4.3.3 Sewage should be screened with fine screen in order to prevent chocking of the valve mechanism by solids contained in the sewage.

4.4 Pneumatic Ejectors — The pneumatic ejector is a simple method of pumping sewage where reliability and ease of maintenance are of greater importance than overall efficiency. They are particularly applicable where a small quantity of sewage has to be pumped against relatively small heads, more especially in isolated installations, but are not recommended for larger installations.

4.4.1 The installation usually comprises an automatic self-starting air-compressor, air storage and the ejectors. At least two ejectors should be provided to facilitate repairs, and where breakdown would have serious result a second air compressor should be provided. In residential areas the exhaust from the ejectors should be efficiently silenced. It is possible to serve several ejector stations from one central air compressing station if the distances are not too great.

5. PRIME MOVERS

5.1 Choice of Prime Mover — The prime mover selected to drive a sewage pump should be reliable, robust, efficient, and silent in operation and the choice of plant to be provided at each installation should be judged on its merits in relation to the availability of a power or fuel supply and should be suitable for the type of pumping unit which has been selected as most suitable for the duty to be performed. It will be necessary to balance capital cost, running cost, and maintenance costs for each type of plant before reaching a decision, and consideration should also be given to the effect of possible interruption in the supply of power or fuel from causes outside the sewage authority's control.

5.2 The types of prime mover commonly available for driving sewage pumps are:

a) electric motor; and

b) internal combustion engine (diesel oil, petrol or gas).

5.2.1 *Electric Motor* — The electric motor is a convenient, cheap and reliable prime-mover for all types of sewage pumping and many varieties of electric motor are available to suit particular conditions of duty to be performed by a sewage pump (*see* IS:325-1961* and IS:4722-1968†).

5.2.1.1 An electric motor is particularly suitable for adoption at an automatically operated, unattended station, automatic controls having been developed to a high degree of perfection and reliability.

5.2.1.2 The adoption of electricity as the source of power, though reliable in itself, depends on the availability of the electricity supply. Where there is danger of interruption of the supply and the consequent risk of flooding with sewage which is unavoidable if pumping ceases, consideration should be given to backing up the public electricity supply with a stand-by independent generating plant; alternatively a ring main supply ensuring availability of power from two sources may meet the case.

5.2.1.3 Motors used for pumping of sewage shall be of drip-proof type.

5.2.2 *Internal Combustion Engine (Diesel Oil, Gas or Petrol)* — The following are the details:

a) *Diesel Oil* — The diesel engine is a reliable, efficient type of prime mover for sewage pumping, but is heavy, expensive in capital cost and requires heavy foundations, ample housing structure, and the continuous attendance of a properly skilled technician for operation and maintenance. It may be used to drive sewage pumps of all types.

b) *Gas* — The gas engine is comparable in all respects with the diesel engine except that, when operated on a gas supply, the running costs are apt to be high and its operation becomes dependent on the availability of gas from an outside source.

Sewage gas, a bye-product of sewage purification work, may be used as a fuel for a gas engine. Gas engine should be capable of operating on oil as an alternative fuel.

c) *Petrol* — The petrol engine is rarely adopted as a form of prime-mover at a permanent sewage pumping station owing to the comparatively high fuel and maintenance cost.

*Specification for three-phase induction motors (*second revision*). (Third revision in 1970)
†Specification for rotating electrical machines

6. PUMP CONTROLS

6.1 Electrically Driven Pumps

6.1.1 *Automatic* — Automatic control may be provided for either ac or dc motor but overriding and supplimentary manual control should be included in the panel for emergency use. A float controlled switch or other suitable means, operated by the sewage level in the wet well, is used to actuate the main power control panel.

In all cases the motor should have no-volt and overload protection, and the control gear made proof against adjustment or tampering while the current is on, by a mechanical and electrical interlock.

6.1.2 *Manual* — Manual control of electrically driven pumps should be provided separately, incorporated in an automatic control panel or may be the sole means of operation.

Emergency control, that is, stop buttons together with no-volt and overload release as well as controls against phase failure should be fitted in all cases.

6.2 Gas or Oil Engine Driven Pumps — Automatic control may be used for electrical ignition and compression ignition engines, but manual control is recommended for internal combustion engine prime mover.

7. PUMPING STATION

7.1 Site Investigation — This should be carried out in accordance with IS : 1892-1962*

7.2 Sub-Structure — This usually consists of two underground compartments separated by a common wall, namely, a dry well to house the pumping plant, pipe work and control valves and a wet well containing the sewage to be pumped.

7.2.1 *Wet Well*

7.2.1.1 *Capacity of wet well* — Most design principles base detention upon the average design rate flow, but the maximum and minimum rates are the determining factors in sizing the wet well. The desired results may be accomplished if the size of the wet well is such that, with any combination of inflow and pumping, the cycle of operation for each pump will not be less than 5 minutes and a maximum retention time in the wet well not exceeding 30 minutes.

7.2.1.2 *Shape* — The wet well shall be so shaped as to have the suction of several pumps suitably placed apart and drawing from a channel. The shape of the wet well should also conform to the shape of the pump house

*Code of practice for site investigations for foundations.

and one which permits proper spacing of suction pipes, minimizes settlement of solids and avoids formation of scum and dead-pockets.

7.2.1.3 *Floor slope* — The bottom slope should be such as to permit the sludge to gravitate to pump suction and in no case it should be flatter than **1.1**.

7.2.1.4 *Construction* — The structure as a whole should be designed to resist floatation due to external water pressure. Normal materials of construction, that is stone, brick, concrete or reinforced concrete may be used as available after giving due consideration to the type of sewage to be pumped. When the sewage is corrosive a facing of special brick or cement concrete prepared out of acid resistant cement should be provided.

7.2.2 *Dry Well* — Where the dry well is to be constructed in reinforced cement concrete, it should be designed in accordance with IS: 3370 (Part II)-1965* or any other practice as may be approved by the authority. Where other materials are used, walls and floors subject to external water pressure should be rendered waterproof.

7.2.2.1 *Pump foundations* — A separate foundation block should be provided for each pump. When built in concrete, this should be constructed as an integral part of the floor of the dry well, the holes for holding down bolts being boxed to the required depth when pouring the concrete. Any desired decorative facing may be applied after the pump stool or bed plate has been correctly set and grouted in.

7.2.2.2 *Lighting and ventilation* — Adequate lighting and ventilation should be arranged inside the dry well. Mechanical ventilation may be necessary to supplement natural ventilation for enclosed stations (*see* IS: 3103-1965†).

7.2.2.3 Dry well floor should be sloped to a small sump with adequate arrangement for dewatering.

7.3 Super-Structure

7.3.1 *Engine or Motor Room* — Although the term super-structure applies normally to a building erected above the existing ground level, it may be applied to an underground station. Sufficient floor space at both motor and pump level should be provided for dismantling and overhaul.

7.3.2 *Travelling Gantries for Handling Pumps and Motors* — An average travelling crane should be included in the machinery to be installed particularly in large station and arrangements made for its installation before that of the pumps. Chain controls for such a crane shall be of sufficient

*Code of practice for concrete structures for the storage of liquids: Part II Reinforced concrete structures.

†Code of practice for industrial ventilation.

length to permit operation at both motor and pump floor level. A hatch in the roof should be provided where necessary in case of vertical spindle driven pumps.

7.3.3 *Lighting* — The structure should be well-lighted and distribution of lighting points for the pumping station should be such that long flexes are avoided.

7.3.4 *Architectural Finish* — The superstructure of the pumping station should have a pleasing and attractive architectural treatment and a good landscaping for the surround is recommended.

7.3.5 *Precautions Against Nuisance* — Nuisance may be caused by a sewage pumping station by smell, noise, electrical interference, or vibration.

7.3.5.1 To control the smell it is desirable that the sewage be retained in the wet well for the shortest possible time and that screenings be removed as soon as they have accumulated.

7.3.5.2 Noise may be reduced by employing special silent motors, and double windows are of assistance in this respect.

7.3.5.3 Electrical interference may produce complaints from nearby radio set users and may only be eliminated by careful attention to the maintenance of brush and commutator gear and cleanliness of control gear generally.

7.3.5.4 Vibration from modern pumping set on individual foundation blocks should be negligible, but in exceptional cases insulation of the foundation from the building by suitable means should prevent transmission where vibration might occur [*see* IS:2974 (Part I)-1964*].

7.3.6 *Protection of Plant from Flooding* — Flooding of a pumping station may occur because the pumps and accessories have been neglected or because of external circumstances. Suitable overflow arrangements for the wet well should be provided, where feasible, as a protection against flooding due to breakdown of plant or failure of the power supply.

7.4 Flow Recorders — It is desirable to measure the flow at an individual pumping station and it may be arranged either on the connecting sewer, at the inlet to the station, on the rising main, or at the delivery end. At the inlet and discharge ends flumes or weirs may be used and on the rising main venturi meter or orifice plates may be used for the measurement of flow. Recording and integrating devices may be installed on these measuring devices, if required.

7.5 Lay-out of Plant and Pipe Work — Equipment in a pumping station should be sited to permit the ease of operation and maintenance.

*Code of practice for design and construction of machine foundations: Part I Foundations for reciprocating type machines. (Since revised).

7.5.1 *Pumps*

7.5.1.1 *Dry-well pumps* — This is the most suitable methods of installation, as the machines are always accessible and gland packing and other routine maintenance may be achieved without considerable mess and trouble.

7.5.1.2 *Submerged wet well pumps* — This type of installation is not suitable for permanent use for sewage pumping. A typical arrangement is shown in Fig. 1.

7.5.1.3 *Horizontal shaft pumps* — The horizontal, directly coupled pump set is free from some of the disadvantages of the vertical set and may be preferable when the depth of the installation is, say 4·5 m or less. It requires considerably more floor space than a vertical shaft pump. On the other hand intermediate bearings on the shaft are not required and the set is more easily maintained; however, horizontal shaft pumps are not suitable for wet wells. A typical illustration of horizontal shaft dry well type pump is given in Fig. 2.

7.5.1.4 *Vertical shaft pumps* — The vertical spindle pump has the advantage that the motor may be placed above the flood level to save it from being flooded due to break down of the pump or any other cause. This pump may be driven by a vertical-spindle electrical motor or through gearing from a horizontal prime-mover. The vertical shaft may be of any length; if required sufficient intermittent bearing should be provided to ensure steadiness. The space occupied by such a set is less than that occupied by a horizontal set of similar capacity. A typical arrangement is shown in Fig. 3.

7.5.1.5 *Direct coupled vertically* — Given suitable conditions, the type of pump set in which the motor is directly mounted on a stool bolted directly to the casing of a vertical pump requires less space and may conveniently be controlled at one level. A typical arrangement is shown in Fig. 4.

7.5.2 *Internal Pipe Work*

7.5.2.1 *Pipe connections* — All pipe joints within the pump house should be flanged. Where a number of pumps discharge into a common delivery it is very desirable that connections to the mains should be made in horizontal direction, to avoid accumulation of silt and debris in vertical pipes connected to the pumps.

7.5.2.2 *Valves* — Valves both-sluice and reflex should be as accessible as possible. Sluice valves on horizontal pipe lines should never be inclined at more than 45 degrees to the vertical. Where valve hand wheels are difficult to approach for operation, the spindle should be extended and head-stocks fitted at a convenient level for operation. Such head-stocks may be off set from the valve spindle centre line by inserting suitable

universal joints in the spindle extension. Non-return or reflux valves, should be inserted as near the pump as possible and in a horizontal position.

7.5.2.3 *Use of standard specials* — Standard specials, where used, should comply with IS : 1538-1969*

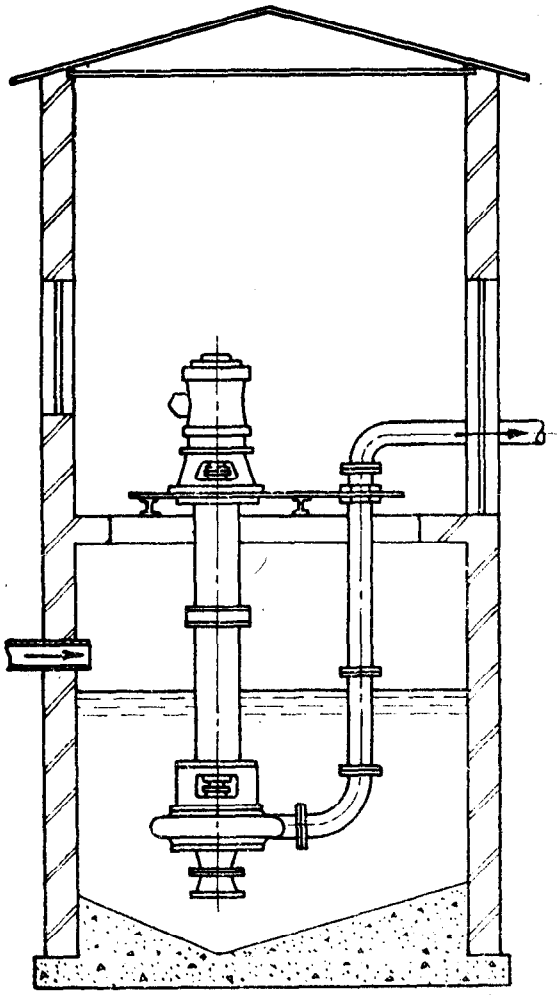

FIG. 1 TYPICAL ILLUSTRATION OF SUBMERGED WET WELL PUMP

*Cast iron fittings for pressure pipes for water, gas and sewage (*first revision*)

7.5.2.4 As a precaution against fracture and for ease of assembly, suitable flexible joint may be used where pipe passes through valve and a puddle flange should be provided, built into the wall.

7.5.2.5 *Suction pipe arrangement* — The minimum distance between the suction pipes within a sump should be five times the diameter, centre to centre or 50 cm between flanges whichever is greater.

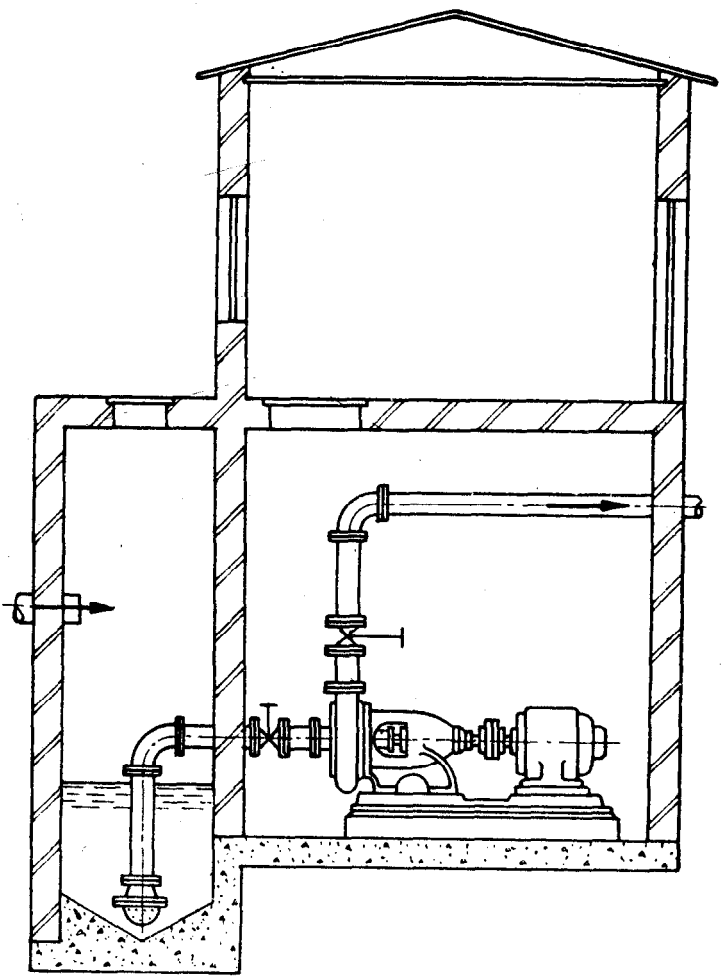

FIG. 2 TYPICAL ILLUSTRATION OF HORIZONTAL SHAFT DRY WELL TYPE PUMP

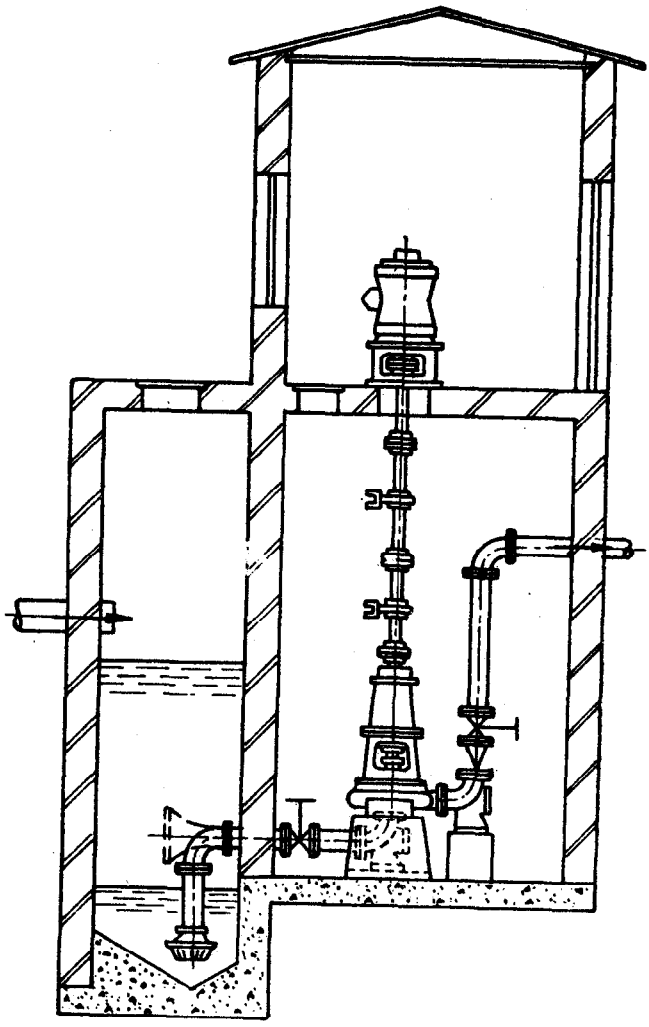

FIG. 3 TYPICAL ILLUSTRATION OF VERTICAL SHAFT DRY WELL TYPE PUMP

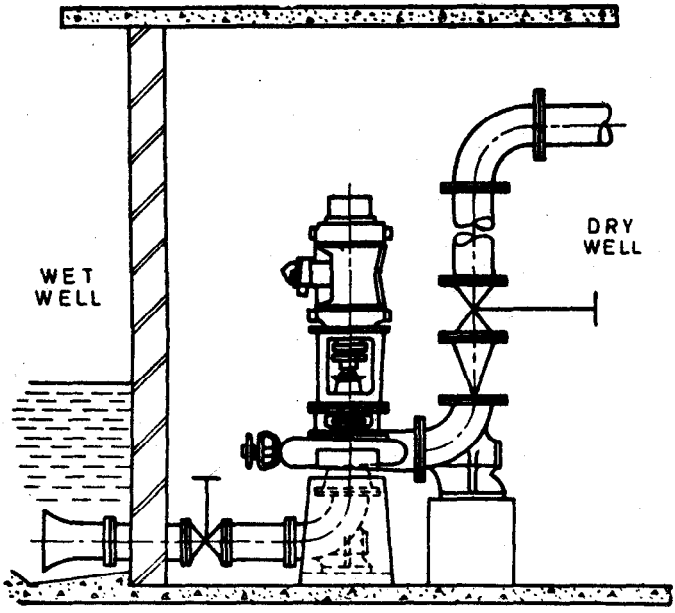

FIG. 4 TYPICAL ILLUSTRATION OF DIRECT MOUNTED VERTICAL SEWAGE PUMP

8. PUMPING MAINS (RISING MAINS)

8.1 Velocity in Mains — In order to avoid sedimentation, the minimum desirable velocity is 0·8 m/s. At the maximum, pumping rate velocity in excess of 1·8 m/s are undesirable. Within the above limits, economic velocity usually falls between 0·8 m/s and 1·2 m/s at the normal pumping rate.

8.2 Duplication of Mains — This may be desirable in the following circumstances:

a) To provide a stand-by rising main in the event of the other mains being temporarily out of action.

b) To accommodate storm water flow which could not be carried in a single main within the limits of velocity given in **8.1**.

c) To permit parallel working of centrifugal pumps where this is proposed but where the characteristic of the pumps do not lend themselves to combined working through a single main.

8.3 Suitability of Joints and Bends — In order to obviate any displacement of the pipeline due to the pressure of flood, each bend should be properly anchored in a block of concrete. Where the main is inadequately covered or is exposed it should be suitably anchored to prevent displacement of the joints under pressure.

8.4 Valves on Pumping Mains — Subject to special circumstances in individual cases, valves should be located as follows:

a) *Reflux Valves* — Immediately above the pump to reduce back surge and water hammer, and should be placed on the horizontal portion of the main. External levers may be provided to facilitate drainage of the pumping main and back washing.

b) *Sluice Valves* — As an isolating valve on the suction side of the pump and also above reflux valve to enable this to be readily isolated in the event of its requiring attention, for example, to clear a clogged seating; also at points on main where required to isolate sections.

c) *Air Valves* — Sufficient number of air valves should be provided at summit points as required.

d) *Wash-out Valves and Hatch Box* — These should be provided at low points where a suitable means is available for the disposal of the drainage and their use should be confined to the emergency.

8.5 Materials and Construction

8.5.1 *Grey Cast Iron (Vertical Cast or Spun)* — They should be of a suitable class to withstand the hydraulic pressure and external loads. The cast iron pipe should conform to IS : 1536-1967* or IS : 1537-1960† and the fittings should conform to IS : 1538-1969‡.

8.5.2 *Steel Pipes* — Where steel pipes are used, increased wall thickness and protective internal lining may be necessary to allow for possible corrosion and the pipe should be wrapped with a protective sheathing (*see* IS : 1239-1964§).

8.5.3 *Asbestos Cement Pressure Pipes* — Asbestos cement pressure pipes should conform to IS : 1592-1960‖.

8.5.4 *Reinforced Cement Concrete Pipes* — Cement concrete pressure pipes where used should conform to IS : 458-1961

*Specification for centrifugally cast (spun) iron pressure pipes for water, gas and sewage (First revision).

†Specification for vertically cast iron pressure pipes for water, gas and sewage.

‡Specification for cast iron fittings for pressure pipes for water, gas and sewage. (First revision)

§Specification for mild steel tubes and tubulars (*revised*) (Second revision issued in two parts).

‖Specification for asbestos cement pressure pipes. (Since revised).

¶Specification for concrete pipes with and without reinforcement. (Second revision in 1971)

9. SAFETY MEASURES

9.1 General—The pumping station shall have all necessary safety precautions incorporated in the design and construction.

9.2 Wet Well

9.2.1 This should not be directly connected by any opening to the dry well or super-structure to prevent explosive gas leakage.

9.2.2 It should be properly ventilated by suitable vents or mechanical means directly to outside if required.

9.2.3 Cast iron step iron should be suitably provided [*see* IS:4111 (Part I)-1967*].

9.3 Dry-Well and Super-Structure

9.3.1 All vertical drops in floor level should be protected with hand-rails and especially when the depth of the well exceeds two metres.

9.3.2 Electrical equipment and wiring should be properly insulated and grounded, and switches and controls should be of non-sparking type. All wiring and devices in hazardous areas should be explosion-proof.

*Specification for ancillary structures in sewerage system: Part I Manholes.

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‡Peenya Industrial Area 1st Stage, Bangalore Tumkur Road BANGALORE 560058	38 49 55 38 49 56
Gangotri Complex, 5th Floor, Bhadbhada Road, T. T. Nagar, BHOPAL 462003	6 67 16
Plot No. 82/83, Lewis Road, BHUBANESHWAR 751002	5 36 27
53/5, Ward No. 29, R.G. Barua Road, 5th Byelane, GUWAHATI 781003	3 31 77
5-8-56C L. N. Gupta Marg (Nampally Station Road), HYDERABAD 500001	23 10 83
R14 Yudhister Marg, C Scheme, JAIPUR 302005	6 34 71 6 98 32
117/418 B Sarvodaya Nagar, KANPUR 208005	21 68 76 21 82 92
Patliputra Industrial Estate, PATNA 800013	6 23 05
T.C. No. 14/1421, University P.O., Palayam TRIVANDRUM 695035	6 21 04 6 21 17

Inspection Offices (With Sale Point):

Pushpanjali, First Floor, 205-A West High Court Road, Shankar Nagar Square, NAGPUR 440010	2 51 71
Institution of Engineers (India) Building, 1332 Shivaji Nagar, PUNE 411005	5 24 35

*Sales Office in Calcutta is at 5 Chowringhee Approach, P. O. Princep Street, Calcutta 700072 — 27 68 00

†Sales Office in Bombay is at Novelty Chambers, Grant Road, Bombay 400007 — 89 65 28

‡Sales Office in Bangalore is at Unity Building, Narasimharaja Square, Bangalore 560002 — 22 36 71

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