IS 6295 (1986): Code of practice for water supply and drainage in high altitudes and/or sub-zero temperature regions [CED 24: Public Health Engineering.]

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IS : 6295 - 1986
(Reaffirmed 2001)

Indian Standard

CODE OF PRACTICE FOR WATER SUPPLY AND DRAINAGE IN HIGH ALTITUDES AND/OR SUB-ZERO TEMPERATURE REGIONS

(First Revision)

UDC 628·1/·2(211) : 006·76

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

Gr 4 *November* 1987

Indian Standard

CODE OF PRACTICE FOR WATER SUPPLY AND DRAINAGE IN HIGH ALTITUDES AND/OR SUB-ZERO TEMPERATURE REGIONS

(First Revision)

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Indian Standard

CODE OF PRACTICE FOR WATER SUPPLY AND DRAINAGE IN HIGH ALTITUDES AND/OR SUB-ZERO TEMPERATURE REGIONS

(First Revision)

0. FOREWORD

0.1 This Indian Standard (First Revision) was adopted by the Indian Standards Institution on 31 October 1986, after the draft finalized by the Water Supply and Sanitation Sectional Committee had been approved by the Civil Engineering Division Council.

0.2 This code is intended to give useful guidance to engineering departments and others concerned with the provision of adequate and suitable water supply and drainage systems in high altitudes and sub-zero temperature regions in the country. Large mountainous regions in the northern part of the country inhabited by small communities living under primitive conditions remained unexplored in the past. However, the engineering problems, particularly to obtain acceptable water supply and the disposal of sanitary wastes without nuisance or danger have assumed large proportions consequent to increased defence activities and community developments in these regions. This standard was first published in 1971. The important changes made in this revision are given below:

a) Alternate method to avoid freezing of water in the transmission of water has been included; and

b) Hessian cloth/strip and asbestos coated lagging ropes have been included as insulating material for pipes.

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.

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

1. SCOPE

1.1 This code gives recommendations regarding the factors to be given consideration while planning and designing water supply and sanitation system peculiar to high altitudes and/or sub-zero temperature regions of the country.

1.2 The broad principles involved in the planning and designing of sanitary engineering are not materially different in high altitudes and sub-zero temperature regions but also require suitable modifications to meet the high altitude and low temperature requirements. As such this code elaborates the modifications required for the satisfactory functioning of water supply and sanitation system in these regions of the country. The normal requirements of these services in respect of buildings located in the plains have already been dealt with in IS : 2065-1983* and IS : 1742-1983†.

2. TERMINOLOGY

2.0 For the purpose of this code, the following definitions shall apply.

2.1 Frost Line — The line joining the points of greatest depths below ground level up to which the moisture in the soil freezes.

2.2 Lagging — Thermal insulation on pipes.

2.3 High Altitudes — Elevations higher than 1 500 m above mean sea level (MSL).

2.4 Sub-Zero Temperature Regions — Regions where temperatures fall below 0°C and freezing conditions occur.

2.5 Thawing — The melting of ice or snow by heat.

2.6 Utilidor — Large insulated or heated conduits used for housing water piping, in some instances waste water piping.

3. HIGH ALTITUDES AND/OR SUB-ZERO TEMPERATURE CONDITIONS

3.1 The essential conditions obtaining in these regions may be summarized as low temperature, that is, below 4°C and/or the low barometric pressures, that is, below 0·86 N/mm^2.

3.2 Effect of Low Temperatures

3.2.1 *Physical* — Water is at its maximum density at 4°C. At 0°C it solidifies and turns into ice having expanded approximately one-twelfth of its volume. The viscosity of water and liquids increases with falling

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*Code of practice for water supply in buildings (*second revision*).

†Code of practice for building drainage (*second revision*).

temperatures thus affecting the setting velocities of particles carried in suspension. The kinematic viscosities and density of water at low temperature ranges of 0 to 10°C are given in Appendix A for information.

3.2.2 *Chemical* — In general, most chemicals react much slower at temperatures near freezing than they do at normal temperatures. Consequently, longer reaction times are required for satisfactory performance in the treatment units, where chemicals are used.

3.2.3 *Biological* — Low temperatures retard biological activity. Thus, sewage treatment processes, such as septic tanks, trickling filters which depend on biological activities of micro-organisms are affected.

3.3 Effect of Low Barometric Pressures — Low barometric pressures limit pump suction head. Normal barometric pressures met at high altitudes in Srinagar area are given in Appendix B for information.

4. WATER SUPPLY SYSTEMS

4.1 Selection and Source — In general, the site selected for a water source shall be such as to minimize the length of transmission line so as to reduce the inspection and upkeep. Attempt shall be made, feasible, to locate the source near the dicharge of waste heat, such as power plants provided it does not affect the potability of water.

4.1.1 *Melted Ice or Snow* — The use of melted ice or snow as a source of water supply shall be considered only in the absence of alternative sources and where the requirements are low. Extreme care shall be taken in such cases in the handling of ice and prevent it from being contaminated.

4.1.2 *Ground Water* — Ground water is usually warmer than surface water in winter. Well casings shall be properly insulated along the frost penetration depth of the soil, where necessary. When the casing pipe is likely to be disjointed, crushed or damaged due to freezing conditions of the surrounding soils, protection may be given by an additional casing or other equally suitable means.

4.1.3 *Surface Water* — Springs, lakes and rivers/streams form the surface water supply sources in these regions. Shallow lakes and small streams are liable to freeze completely during the winter months depending upon the ambient temperatures. In such cases, they are not suited where continuous supply of water is needed as for permanent habitations. Where seasonal ice cover forms on the lake, the freezing action tends to concentrate mineral and organic content in the unfrozen water and for this reason the water shall be carefully analyzed periodically to determine, whether they are suitable for domestic usage.

4.1.4 Springs and rivers which do not freeze completely offer a continuous source of water supply and shall be preferred for permanent habitations. Intake for river sources shall be placed well below the depth of ice cover, if any, formed during the worst periods. A deep pool of water shall be created over the intake and the intake located well below the water surface, where necessary, so as to minimize icing problems at intake structures. High intake velocities without surface turbulence shall be used for drawing out water when the atmospheric temperature is below 0°C.

4.2 Pumping Installations — Pumps and pumping machinery shall be housed inside well-insulated chambers. Where necessary, arrangements shall be made for heating the inside of pump houses. Pump houses, as far as possible, should be built directly above the intake structures.

4.2.1 *Pump Selection* — The use of centrifugal pump shall be preferred to reciprocating pumps because of the fact that the gland packings soaked in water is likely to freeze when reciprocating pumps are not working and the pump cannot be started unless warmed up. Self-priming pumps shall be used so as to avoid provision of footvalves, which help the formation of ice which, in turn, clog the impeller and damages it (*see* **4.2.4**). For high altitude regions, it is advisable to use always submersible pumps in view of low suction heads available in such places.

4.2.2 *Pump Suction Heads* — Pump suction heads are affected on account of reduced atmospheric pressures at high altitudes. A rate of decrease of 1·15 m, in the allowable suction head shall be made for every 1 000 m elevation above MSL.

4.2.3 *Efficiency of Pumping Set* — An allowance at the rate of fall of overall efficiency up to two percent in case of electric prime movers and up to four percent in case of other types of prime movers for every 300 m altitude shall be made.

4.2.4 *Pump Drainage* — Where the ambient temperature conditions so warrant, provision shall be made to ensure that pumps are drained immediately after shutting down to prevent damage to plant due to freezing.

4.2.5 *Prime Movers* — Electric motor driven pumping set shall be preferred.

4.2.6 *Engine Driven Pumps* — Where blow lamps are used for heating of the pump, compression ignition engine shall be preferred to gasoline engines.

4.2.7 *Types* — Engines shall preferably be of air-cooled type, rather than water cooled ones so as to avoid using anti-freeze coolants against the danger of freezing of cooling waters in them.

4.2.8 Engines shall be provided with special heat and cold starting devices to guard against starting troubles in winter.

4.2.9 Draining taps of engines and pumps shall be easily accessible and convenient to operate with gloves on.

4.2.10 *Fuels* — Diesel and gasoline suitable at normal temperatures are not suitable at low temperatures. Special fuels, like water grade and sub-zero grade depending on the temperature, shall accordingly be used as specified by the manufacturer of the plant.

4.3 Protection of Storage Water and Treatment — Where ambient temperatures are low so as to cause danger of freezing, proper housing, insulation and protection shall be provided for all processes and equipment. If necessary, means shall be provided for proper heating of the enclosure.

4.3.1 *Water Quality* — Constant check of surface water quality shall be carried out because there is wide seasonal variation in water quality.

4.3.2 *Settling Tanks* — Settling process is greatly slowed down by the increased viscosity of water at low temperatures. Settling tanks operated at near freezing temperature shall provide surface loading rates nearly half that for operation at 20°C. Where possible, settling tanks may be covered for increasing the efficiency.

4.3.3 *Chemical Reaction* — As indicated in **3.2.2** almost all chemicals react much slower at temperatures near freezing than they do at normal temperatures. Jar tests and laboratory tests shall be carried out for efficient operation. Mixing times shall be tripled when water at 0 to 4°C is being treated.

4.3.4 *Chemical Storage* — Structures for storing chemicals shall be constructed as far as possible, adjacent to treatment facilities because low temperature makes unnecessary carrying, hauling and running out of doors undesirable for operating personnel.

4.3.5 *Filtration* — Rapid sand filters and pressure filters shall be preferable where risk of freezing of water exists, since these may conveniently be used inside heated structures unlike slow sand filters which requires large filtration areas. Where near freezing conditions exist, filter areas up to twice that required for warmer water shall be provided. Provision for back washing shall be made by the use of pump rather than by elevated storage. Lower back washing rate will be required than normal requirements.

4.3.6 *Chlorination* — The pressure of chlorine gas at 21·1°C is more than five times as great as it is at — 17·8°C and special considerations should be given to the control of chlorine dosing in these regions. Where necessary, temperature may be maintained between 10°C and 30°C. Where bleaching powder is used, adequate reaction time should be allowed for proper mixing.

4.3.7 *Materials for Treatment Equipment* — Care shall be taken in selecting the different materials used in treatment equipment which shall not be with unequal rates of expansion and contraction.

4.4 Transmission and Distribution — Freezing of the burried pipe may be avoided primarily by laying the pipe below the level of the frost line; well consolidated bedding of clean earth or sand, under, around or over the pipe should be provided. For the efficient operation and design of transmission and distribution work, the available heat in the water shall be economically used and controlled. If heat naturally present in water is inadequate to satisfy heat losses from the system, the water shall be warmed. Where economically feasible, warm water from hot springs or other ground water sources, if potable, shall be mixed with the primary source for this purpose. If found unsuitable for drinking water purposes, such water may be used for heating purposes. Heat losses shall be reduced by insulation, if necessary. Any material that will catch, absorb or hold moisture shall not be used for insulation purposes. Adequate number of break pressure water tanks and air release valves shall be provided in the distribution system. On many occasions in high altitude areas the water supply is from perennial streams/springs and continuous supply would be there. In such cases, if some water is let out continuously from the transmission and distribution system at suitable points specially during the periods when there is practically no demand for water supply, the problem of ice formation in pipes can be prevented. Even if little flow of water is there, there would be significant advantage from the maintenance point of view. HDPE pipes with proper break pressure chambers along with the outlets at suitable positions will prove to be a good transmission/distribution system.

NOTE — The level of frost line is generally found to be between 0·9 and 1·2 m below ground level in the northern regions of India, wherever freezing occurs.

4.4.1 *Materials for Pipes* — Distribution pipes shall be made of any of the following materials:

a) High density polyethylene pipes (conforming to IS : 4984-1978*),
b) Asbestos cement pipes (conforming to IS : 1592-1980†),
c) Galvanized iron pipes [conforming to IS : 1239 (Part 1)-1979‡],

*Specification for high density polyethylene pipes for potable water supplies, sewage and industrial effluents (*second revision*).

†Specification for asbestos cement pressure pipes (*second revision*).

‡Specification for mild steel tubes, tubulars and other wrought steel fittings: Part 1 Mild steel tubes (*fourth revision*).

d) Cast iron pipes (conforming to IS : 1536-1976*),

e) Unplasticized PVC pipes (where it is laid below frost line) (conforming to IS : 4985-1981†).

NOTE — Where high density polyethylene pipes are used in some cases cylinder of ice is formed inside the pipe near the joints. Extra precaution should be taken near the joints by way of lagging.

4.4.2 *Materials for Insulation of Pipes* — The normal practice in India is to surround the pipe with straw, grass, hessian cloth/strip or jute rapped over with gunny and painting with bitumen; alternatively other materials like 85 percent magnesia, glasswool or asbestos coated lagging ropes may also be used.

4.4.3 *Distribution Methods* — Distribution by barrels or tank trucks shall be employed, where the water requirements are temporary and small. Utmost care shall be exercised from preventing the water from being contaminated by maintaining a residual of disinfecting agent at all times. Hoses, pails as well as the tank shall be kept free from dust and filth during all periods of operation. Where winter temperatures are low, making frost penetration depths great during the winter and where adequate facilities for heating of the water in the distribution system do not exist, the use of tank trucks or barrels for delivery of water shall be considered only for cold weather, while during the warm weather seasonal piping system may be supplemented.

4.4.4 In the conventional distribution system by using a net work of pipelines requiring no auxiliary heat, it is essential that the pipelines are burried well below the frost line. Adequate facilities for draining pipelines in case there is likelihood of freezing of water shall be provided.

4.4.5 Where the frost line is at considerable depth below ground level making it uneconomical to lay the pipeline below the frost line, distribution pipe should be housed inside utilidors.

NOTE — Utilidors, however, are not at present used in India.

4.4.6 *House Service Connections* — House service connections shall be kept operative by the use of adequate insulation at exposed places extending below the frost line. A typical arrangement of providing insulation for house service connections is shown in Fig. 1.

5. WASTE DISPOSAL SYSTEMS

5.1 In general, all the care to be exercised regarding water supply systems shall also be applicable in the case of waste disposal systems. The biological and chemical reduction of organic material proceeds slowly under low temperature conditions consequently affecting the waste

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

†Specification for unplasticized PVC pipes for potable water supplies (*first revision*).

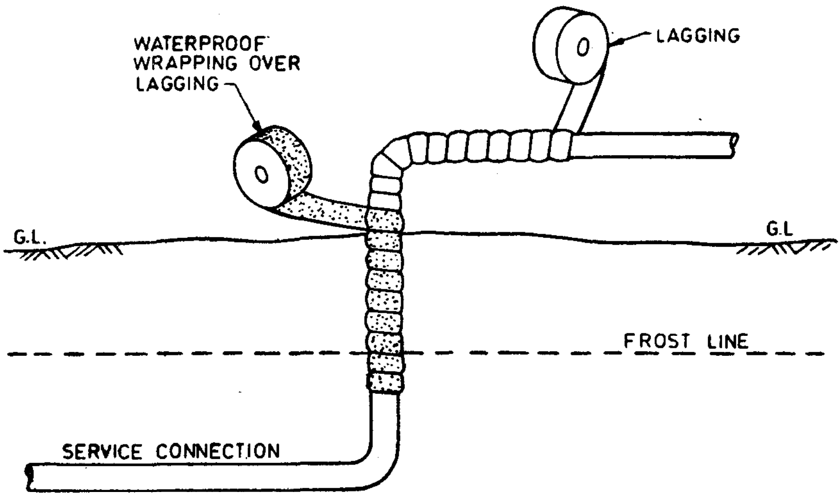

FIG. 1 INSULATION DETAILS AT SERVICE CONNECTION

disposal systems. The waste disposal methods described in **5.2, 5.3** and **5.4** shall be used only where it is not practical to install water carriage systems.

5.2 Box and Can Systems — Where box and can systems are employed, adequate arrangements shall be made for the cleaning and disinfection of can after it is emptied of its contents. The excrement from the can shall be disposed of by burial in isolated spots far from habitation or by incineration, where feasible. Can shall be fitted with tight fitting lids for use when the can is carried for emptying.

5.3 Trench or Pit Latrines — Trench or pit latrines shall be used only where soil and sub-soil conditions favour their use. Whenever they are used, they shall not be closer than 18 m from any source of drinking water, such as well, to mitigate the possibility of bacterial pollution of water.

5.4 Chemical Toilets — For the successful functioning of chemical toilets, they shall preferably be installed in heated rooms or enclosures.

NOTE — Chemical toilet essentially consists of small cylindrical tanks with a water-closet seat for the use of about 8 to 10 persons. A ventilation pipe is fitted to the seat. A strong solution of caustic soda is used as a disinfectant. It kills bacteria, liquefies the solids and thus checks the decomposition of organic matter. The tank is provided with a drain plug from which liquid runs to a soak pit at the time of disposal.

5.5 Water Borne Sanitation Systems — Water borne sanitation systems shall be used, where practicable. Sanitation systems for the collection of sewage should be constructed in such a manner that maximum heat is retained by insulation, if necessary. Where utilidor is used for water distribution, consideration shall be given for placing sewers also in the same utilidor for protection against low temperature, but great care should be exercised in preventing water mains becoming contaminated on this account; where this is adopted, the bottom of the water pipe at all points shall be at least 300 mm above the top of the sewer line at its highest point.

5.5.1 *Sewerage* — Under normal circumstances, sewers shall be laid below the frost line. Manholes shall be made of air-tight construction so as to prevent the cold air from gaining access inside and freezing the contents. The trenches for sewers shall be loosely filled with earth after laying sewers since loose soil is a better insulator than compacted soil. Consequently, sewer laid under traffic ways and other places, where soil compaction may be expected, are required to be given adequate insulation. Where feasible, sewers shall be so located that the trench line is not in shadow, when the sun is shining. Concrete, cast iron and stoneware pipe conduct heat relatively rapidly and as such should be adequately insulated.

5.5.2 *Septic Tanks* — Septic tanks can function only when it can be ensured that the contents inside these do not freeze during low temperature. For this purpose the septic tanks shall be located well below the frost line. The location of manhole opening shall be marked by staves. Fencing around the septic tanks shall be provided for discouraging traffic over it. As the rate of biological activity is reduced by 50 percent for every 10°C fall in temperature, the septic tank capacity shall be increased by 100 percent for operation at 10°C over that for operation at 20°C.

5.5.3 *Seepage Pits* — Seepage pits can function only when the soil and sub-soil conditions are favourable. Frozen soil extending to a great depth would preclude the use of such disposal devices in view of the lower water absorption capacity. The discharge of effluent should be made below the frost line.

5.5.4 *Sewage Treatment Plants* — Design modifications for sedimentation, chemical and biological processess as indicated (*see* **4.3.2**, **4.3.3** and **5.5.2**) are also applicable to sewage treatment plants for satisfactory functioning.

5.5.5 Lavatories and bath-rooms shall be kept heated to avoid freezing of water inside traps and flushing cisterns.

6. FIRE HYDRANTS

6.1 Hydrants may be protected against freezing by covering them by box and the box should be quickly removable.

6.2 Non-freezing grease should be used in the stuffing boxes of the hydrants.

6.3 The frozen hydrants may be thawed by the use of salt, calcium chloride and methods applicable to the frozen pipes. Use of live steam and blow lamp may be simple and quick method in this case.

6.4 A suitable valve to drain the water in the fire hydrants may be used.

7. ECONOMIC FACTORS INVOLVED AT HIGH ALTITUDE REGIONS

7.1 The cost of transportation of stores to high altitudes is enormous. Consequently preference shall be given to the use of materials of lighter weight to facilitate easy haulage.

7.2 Meagre manpower resources for use in construction and operation of sanitary engineering works in high altitude areas shall be recognized.

7.3 Labour cost go up considerably due to decreased human output in high altitude regions on account of low oxygen content in the atmosphere.

7.4 Adequate spares should be maintained to meet emergencies as non-availability of materials and equipment, difficult accessibility of the areas and modifications required for severe weather conditions.

APPENDIX A

(*Clause* 3.2.1)

KINEMATIC VISCOSITY AND DENSITY OF WATER AT LOW TEMPERATURES

A-1. The kinematic viscosity and density of water at low temperatures of 0 to 10°C are given in Table 1 for information.

TABLE 1 KINEMATIC VISCOSITY AND DENSITY OF WATER AT LOW TEMPERATURES

Temperature	Kinematic Viscosity (V) ($100 \times V$) Stokes (cm^2/s)	Density g/cm^3
(1)	(2)	(3)
0	1·792	1
1	1·731	1
2	1·673	1
3	1·619	1
4	1·567	1
5	1·519	1
6	1·473	1
7	1·428	1
8	1·386	1
9	1·346	1
10	1·308	1

APPENDIX B

(*Clause* 3.3)

BAROMETRIC PRESSURES AT HIGH ALTITUDES

B-1. Normal barometric pressures in millibar* corresponding to different altitudes from 1 500 to 5 100 geopotential metres above mean sea level at an interval of 200 gpm over Srinagar based on combined morning and afternoon rediosonde data for the period 1962-65 are given in Table 2, this data may also be used for regions around Srinagar (Kashmir-Leh area).

TABLE 2 BAROMETRIC PRESSURES AT HIGH ALTITUDES

HEIGHT IN GPM (AMSL)	MONTHS											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
1 500	858	850	850	850	845	841	840	840	848	851	851	852
1 700	840	832	832	830	829	828	822	822	830	834	833	832
1 900	818	810	811	810	809	806	802	802	810	815	813	812
2 100	800	791	792	792	790	789	786	786	791	795	795	791
2 300	780	770	772	772	770	769	769	769	772	777	775	772
2 500	761	750	752	754	751	751	750	750	753	759	756	752
2 700	743	730	734	739	734	732	730	732	738	740	738	732
2 900	725	712	718	719	718	718	714	717	719	721	720	717
3 100	709	695	699	700	700	700	699	700	701	703	701	699
3 300	690	679	680	683	682	682	680	682	683	685	683	680
3 500	671	659	661	666	663	665	662	665	669	669	667	661
3 700	656	641	646	650	649	650	648	650	651	651	650	648
3 900	639	628	629	632	631	633	631	634	635	635	632	630
4 100	624	607	612	617	616	619	617	619	619	619	618	612
4 300	610	595	599	601	601	602	601	603	603	602	602	599
4 500	592	578	580	586	585	589	587	590	589	589	585	580
4 700	578	563	568	570	570	573	572	575	574	572	571	568
4 900	562	550	552	558	557	560	559	561	560	558	557	551
5 100	549	536	539	543	544	548	547	549	549	545	542	538

NOTE — The above data are based on the information supplied by Indian Meteorological Department.

*1 millibar = 10·197 2 kgf/m².

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