IS 9694-1 (1987): Code of Practice for the Selection, Installation, Operation and Maintenance of Horizontal Centrifugal Pumps for Agricultural Applications, Part 1: Selection [MED 20: Pumps]

BLANK PAGE

UDC 621.671-111.2 : 631.348.45 (First Reprint AUGUST 1998) IS : 9694 (Part 1)-1987
(Reaffirmed 2002)

Indian Standard

CODE OF PRACTICE FOR THE SELECTION, INSTALLATION, OPERATION AND MAINTENANCE OF HORIZONTAL CENTRIFUGAL PUMPS FOR AGRICULTURAL APPLICATIONS

PART 1 SELECTION

(First Revision)

Pumps Sectional Committee, EDC 35; Horizontal Spindle Pumps Subcommittee, EDC 35 : 2 [Ref : Doc : EDC 35(4595)]

1. Scope — Lays down the general guidelines for the selection of horizontal centrifugal pumps for agricultural applications.

2. Selection Criteria — The following major points shall be considered while selecting a pump:

a) Water requirement,
b) Water source, and
c) Operating conditions.

2.1 *Water Requirements* — For correct selection of a pump, the quantity of water required to irrigate the field shall be known. This quantity depends on:

a) type of soil,
b) type of crop,
c) size of the field,
d) conveyance losses of water, and
e) local climatic conditions.

2.1.1 The general guidelines for irrigation requirements of some of the crops are given in Appendix A for information.

2.1.2 Table 1 gives the area of land irrigated in 8 h pumping. This table also indicates the rate of flow in l/s for obtaining the required depth of water in 8 h of pumping.

2.1.2.1 To allow for conveyance losses of water flowing from the pumps to the fields, it may be advisable to increase by appropriate percentage up to 10 percent the quantity of water required as calculated from Table 1. A worked out example is given in Appendix B.

2.2 *Water Source* — The following are the major sources from where water can be taken for irrigation purposes:

a) Rivers,
b) Canals,
c) Wells,
d) Ponds, and
e) Water stream.

2.2.1 *Pumps for different site conditions* — If the water has to be brought to the fields from a nearby river or a stream or a *nallah*, a horizontal centrifugal pump shall be installed by the side, if there is not appreciable seasonal fluctuations in the water levels. Select the position of pumpset at site in such a way that centre of suction branch is as close to the highest water level as possible. It is recommended to install the pump in such a way as to limit the maximum manometric suction lift to 6 m. If these values are exceeded on any installation, the pump would give reduced rate of flow, develop reduced total head, run on lower efficiency and would get damaged due to cavitation and vibration.

2.2.1.1 If the water level is likely to be such that the recommended total suction lift is exceeded at any time, the pump may run with 'cavitation' or may not discharge water at all. In such cases, where the total suction lift cannot be limited to recommended value, other types of pumps such as vertical turbine or submersible pumps may be used.

2.2.1.2 The suction lift is to be reduced for higher altitudes at the rate of 1.15 m for every 1 000 m above sea level. The temperature correction shall be obtained from steam tables.

Adopted 1 July 1987	© January 1988, BIS	Gr 5

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

2.2.1.3 Centrifugal pumpsets are available as direct coupled units using flexible couplings between the pumps and their prime movers, that is, electric motors or diesel/petrol/kerosene engines, spark ignition engines, etc, and mounted on base plates. These pumpsets can also have a common shaft between each pump and its prime mover dispensing with the use of flexible coupling and base plates, at the same time eliminating all alignment problems between the pumps and their prime movers. Such pumpsets are also known as monoset pumpsets. Both these arrangements of direct coupled and monoset types have their own features with various pros and cons. Centrifugal pumpsets are also available as belt-driven units.

2.2.1.4 When the speed of the prime mover does not match with the required pump speed for direct coupling or it is considered undesirable and difficult to install a prime mover, for example, a diesel engine, alongwith the pump inside an open well on a platform as near the source as possible, a belt drive is adopted between the pump and its prime mover. This could enable the user to allow required distance between the pump and its prime mover, which can also be installed at different levels as necessary and convenient for site conditions.

2.2.1.5 Suitable size of pulleys shall be provided on the shafts of such pumps and their prime movers for arranging the required belt drive. For calculating the size of these pulleys, the speed of the prime mover of the pump shall be known.

2.3 *Operating Conditions*

2.3.1 *Total head* — After the required rate of flow of the pump is determined, the user has to find out the total head against which the pump shall have to operate. Total head does not mean only the static vertical height from lowest water level to the highest delivery point. To this static height shall be added loss of head due to friction in foot valve, reflex valve, entire length of suction pipe (both horizontal and vertical), suction bend, delivery sluice valve (if installed), delivery bend and entire length of delivery pipe (both horizontal and vertical) and the velocity head at the delivery point. This frictional head loss depends on the rate of flow of water through a particular size of pipe line and its fitting.

2.3.2 *Operating head range* — The minimum total head corresponding to the maximum water level shall also be worked out for determining the operating head range.

3. Pipe Friction — When water or any other liquid moves through a pipe line, the latter offers some resistance to the flow. This resistance depends on the size, type and condition of the pipe and its fittings, and velocity of flow. The head loss due to friction is given in Tables 2 and 3

3.1 When calculating pipe losses, allowance shall be included for tees, bends, valves and other fittings and obstructions in a particular pipe line. This is done by adding an allowance of straight pipe equivalent to each fitting or by taking resistance coefficient for each fitting. The relevant extracts from IS : 2951 (Part 2)-1965 'Recommendation for estimation of flow of liquids in closed conduits: Part 2 Head loss in valves and fittings' are given in Appendix C.

4. Pipe Size Selection — Before installing an agricultural horizontal centrifugal pump, it is very essential to determine correct selection of the sizes of suction and delivery pipe to be connected to the pump. The prevailing idea that such a pump should always be installed with suction and delivery pipes of the same sizes as pump suction and delivery openings is not sound in every situation. Quite often it involves the farmer in paying higher charges for electrical energy or fuel and oil consumption. In several cases, it makes the pump run with cavitation resulting in reduced discharge, low efficiency and damage to equipment, etc, or at times stop pumping.

For proper selection of sizes of pipes, Tables 1 to 3 of IS : 10804-1986 'Recommended pumping system for agricultural purposes (*first revision*)' shall be referred. An example is described in Appendix A of IS : 10804-1986 for determination of flow rate, head and selection of pumpsets.

5. Foot Valves Selection

5.1 Foot valves conforming to IS : 10805-1986 'Foot valve, reflux valves or non-return valves and bore valves to be used in suction lines of agricultural pumps (*first revision*)' shall be selected and installed in vertical position.

5.2 The shape and height of the housing shall be such that even when the valve is fitted on the pipe, it should be possible to raise the disc or discs sufficiently to provide, at any cross-section, a passage of area at least equal to the bore area of the pipe.

5.3 Strainers shall be robust so as to withstand the normal forces which may come upon while in transit or at the time of installation.

5.4 For satisfactory operation, a foot valve shall not get exposed to atmospheric air when the pump is in operation. It shall also not get submerged in any silt which may gradually get settled down from water on the bottom of the well. It is, therefore, recommended to select the length of vertical portion of pump suction pipe in such a way that the top of the valve is at least 0.35 m below minimum water level in the well and bottom of the foot valve strainer is 0.5 m above the bed (or bottom) and away from sides of the well.

6. Final Selection of Pumps — Once the rate of flow and total head are worked out on the basis of the above guidelines, selection of suitable pump may be made from performance tables or characteristic curves provided by pump manufacturer for various sizes and types of the pumps. The pump which has the highest pump efficiency for the capacity and head required shall be selected. The power of the prime mover required for driving the pump shall be fixed from the data given by the pump manufacturer or from Tables 4 to 7 of IS : 10804-1986.

For selecting a pump, and suction and delivery pipes to be installed with it, main consideration should be the overall efficiency and minimum consumption of power, either electrical energy or diesel oil. The cost is, of course, a consideration but it shall be viewed in relation to its running cost, maintenance expenses, and losses during shut down for repairs.

The Indian Standards applicable to pumps, motors, diesel engines, petrol/kerosene engine, spark ignition engine, valves, pipes and fittings for agricultural pumping sets are given in Appendix D.

TABLE 1 AREA IRRIGATED IN HECTARES IN 8 HOURS PUMPING

(*Clauses* 2.1.2 *and* 2.1.2.1)

Depth of Water in mm / Volume Rate of Flow in l/s	25	50	75	100	125	150
(1)	(2)	(3)	(4)	(5)	(6)	(7)
0·50	0.058	0.029	0.019	0.014	0.011	0.010
1·00	0.115	0.058	0.038	0.029	0.023	0.019
1·25	0.144	0.072	0.048	0.036	0.029	0.024
1·60	0.184	0.092	0.061	0.046	0.037	0.031
2·00	0.230	0.115	0.077	0.058	0.046	0.038
2·50	0.288	0.144	0.096	0.072	0.058	0.048
3·2	0.369	0.184	0.123	0.092	0.074	0.061
4·0	0.461	0.230	0.154	0.115	0.092	0.077
5·0	0.576	0.288	0.192	0.144	0.115	0.096
8·0	0.922	0.461	0.307	0.230	0.184	0.154
10·0	1.152	0.576	0.384	0.288	0.230	0.192
12·5	1.440	0.720	0.480	0.360	0.288	0.240
16	1.843	0.922	0.614	0.461	0.369	0.307
20	2.304	1.152	0.768	0.576	0.461	0.384
25	2.880	1.440	0.960	0.720	0.576	0.480
32	3.686	1.843	1.229	1.922	0.737	0.614
40	4.608	2.304	1.536	1.152	0.922	0.768
50	5.760	2.880	1.920	1.440	1.152	0.960
65	7.488	3.744	2.496	1.872	1.498	1.248
80	9.216	4.608	3.072	2.304	1.843	1.536
100	11.520	5.760	3.840	2.880	2.304	1.920
125	14.400	7.200	4.800	3.600	2.880	2.400

Example 1 :

It is required to find volume rate of flow in litres per second for irrigating 0.36 Ha in 8 h pumping for a depth of water of 100 mm.

Procedure :

Enter Table 1 under the column 'depth of water 100 mm' and read 12.5 l/s volume rate of flow corresponding to 0.36 Ha.

Example 2 :

It is required to find the area irrigated in hectares in 8 h pumping for a volume rate of flow of 100 l/s and depth of water of 75 mm.

Procedure :

Enter Table 1 at the row corresponding to volume 'rate of flow of 100 l/s' and read 3.84 hectares under column 'depth of water 75 mm'.

TABLE 2 FRICTION LOSS IN METRES FOR 10 METRES LONG NEW STEEL GALVANIZED PIPE (C = 140)

[IS : 1239 (Part 1)-1979 Mild steel tubes medium grade (*fourth revision*)]

(*Clause* 3)

Volume Rate of Flow l/s \ Nominal Pipe Dia in mm	25	32	40	50	65	80	100	125	150
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
0.50	0.364								
1.00	1.315	0.341							
1.25	1.988	0.516	0.246						
1.60	3.140	0.814	0.388						
2.00		1.231	0.587						
2.50		1.861	0.888	0.282					
3.2		2.940	1.402	0.446	0.126				
4.0			2.120	0.674	0.190				
5.0			3.205	1.019	0.288				
8.0				2.433	0.687	0.313			
10.0				3.678	1.038	0.474	0.131		
12.5					1.570	0.716	0.198		
16					2.479	1.131	0.312	0.111	
20					3.747	1.710	0.472	0.167	
25						2.585	0.713	0.253	0.106
32						4.083	1.127	0.400	0.167
40							1.704	0.605	0.252
50							2.576	0.914	0.381
60								1.281	0.534
80								2.182	0.910
100								3.299	1.376
125									2.081

TABLE 3 FRICTION LOSS IN METRES FOR 10 METRES LONG NEW RPVC PIPE (C = 150)

[IS : 4985-1981 Unplasticized PVC pipes for potable water supplies (*first revision*) (0.6 mPa rating)]

(*Clause* 3)

Nominal Pipe Outer Dia in mm / Volume Rate of Flow l/s	40	50	63	75	90	110	125	140	160
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
0.50	0.074								
1.00	0.268								
1.25	0.405	0.134							
1.60	0.640	0.211							
2.00	0.967	0.319							
2.50	1.462	0.483	0.158						
3.2	2.309	0.762	0.250	0.106					
4.0	3.491	1.153	0.377	0.160					
5.0		1.742	0.571	0.242					
8.0		4.161	1.363	0.577	0.237				
10.0			2.060	0.873	0.358	0.133			
12.5			3.114	1.319	0.542	0.201			
16			4.919	2.084	0.856	0.317	0.172		
20				3.151	1.293	0.479	0.260		
25					1.955	0.725	0.392	0.225	0.117
32					3.089	1.145	0.620	0.355	0.184
40						1.731	0.937	0.537	0.279
50						2.617	1.416	0.812	0.421
60						3.668	1.985	1.138	0.590
80							3.382	1.939	1.006
100								2.931	1.521
125									2.299

APPENDIX A

(*Clause* 2.1.1)

GENERAL GUIDELINES FOR IRRIGATION REQUIREMENTS

A-1. Irrigation Requirements — Following are given the irrigation requirements of the some of the crops in hard rock and alluvial areas. The irrigation requirements of various crops in the country varies from place to place depending upon the various factors, such as nature of soil, climatic conditions and rainfall. Therefore, the exact water requirements in a particular area should be worked out in consultation with the local agricultural authorities (*see* Tables 4 and 5).

TABLE 4 IRRIGATION REQUIREMENTS OF SOME CROPS IN HARD ROCK AREAS

Sl No.	Crop	Cropping Period in Days	Depth of Watering in mm	Watering Interval in Days		Irrigation* Requirements in mm
				Summer	Winter	
(1)	(2)	(3)	(4)	(5)	(6)	(7)
i)	Rice	100 to 160	75	7	—	800 to 1 600
ii)	Wheat	90 to 100	75	—	10 to 15	300 to 450
iii)	Maize	100 to 120	50	7 to 10	—	150 to 300
iv)	Gram	150 to 180	75	—	15 to 20	150 to 300
v)	Sugarcane	360 to 540	120	7 to 10	15 to 20	100 to 2100

Note — Sugarcane can be either a 12-month crop or a 18-month crop known as *Adsali*.
*The values given are for reference purposes only.

TABLE 5 IRRIGATION REQUIREMENTS OF SOME CROPS IN ALLUVIAL AREAS

Sl No.	Crop	Cropping Period in Days	Depth of Watering in mm	Watering Interval in Days		Irrigation* Requirements in mm
				Summer	Winter	
(1)	(2)	(3)	(4)	(5)	(6)	(7)
i)	Rice	100 to 160	75	7	—	800 to 1 600
ii)	Wheat	120 to 160	75	—	10 to 15	300 to 400
iii)	Maize	100 to 120	50	7 to 10	—	150 to 300
iv)	Gram	150 to 180	50	—	15 to 20	100 to 150
v)	Sugarcane	300 to 360	75	7 to 10	15 to 20	600 to 800

*The values given are for reference purposes only.

APPENDIX B

(*Clause* 2.1.2.1)

EXAMPLE FOR DETERMINATION OF QUANTITY OF WATER REQUIRED FOR IRRIGATION AND VOLUME RATE OF FLOW IN RELATION TO THE AREA TO BE IRRIGATED

B-1. The rate of discharge required for certain cropping pattern can be worked out by the following formula:

$$Q = \frac{A.I.\ 28}{R.T.}$$

where

Q = rate of discharge in l/s,

A = area to be irrigated in hectares,

*I = intensity of irrigation in cm,

*R = rotation period in days, and

T = working hours of the pump-set per day.

B-2. For example, if $A = 8$ hectares of wheat, $I = 7.5$ cm, $R = 12$ days and $T = 8$ h/day

$$Q \text{ at field level} = \frac{A.I.\ 28}{RT} = \frac{8 \times 7.5 \times 28}{12 \times 8} = 17.5 \text{ l/s}$$

Q at pump site = 17.5 = 1.10 = 19.25 l/s
to take care of
10 percent

APPENDIX C
(*Clause* 3.1)

HEAD LOSS IN VALVES AND FITTINGS

C-1. The head loss, h_f caused by a fully open valve or fitting during the flow of a liquid may be computed from the formula:

$$h_f = K \frac{v^2}{2g}$$

where

K = resistance coefficient for valve fitting,

v = average velocity in pipe of corresponding diameter in m/s, and

g = acceleration due to gravity in m/s^2.

C-2. Values of resistance coefficient, K for valves and fittings carrying turbulent flow are given in Table 6. In valves carrying laminar flow, the head loss may be assumed to be negligibly small. Flanged valves and fittings should have lower resistance coefficients than screwed valves and fittings. The lower limits in Table 6 should be used with flanged valves and fittings, particularly with sizes above 10 cm nominal diameter.

TABLE 6 RESISTANCE COEFFICIENTS FOR VALVES AND FITTINGS

Sl No.	Description of Valves and Fittings	Resistance Coefficient (K*)
(1)	(2)	(3)
i)	Inlets or Reducers	
	1) Bell mouth	0.04 to 0.05
	2) Square edged	0.47 to 0.56
ii)	Elbows	
	1) Regular screwed 45° elbow	0.30 to 0.42
	2) Regular screwed 90° elbow	0.55 to 1.50
	3) Regular flanged 90° elbow	0.28 to 0.42
	4) Long radius flanged 45° elbow	0.18 to 0.20
	5) Long radius flanged 90° elbow	0.18 to 0.43
	6) Long radius screwed 90° elbow	0.22 to 0.60
iii)	Bends	
	1) Screwed return bend, close-pattern	0.50 to 1.50
	2) Flanged return bend composed of two 90° flanged elbows	
	a) Regular	0.27 to 0.43
	b) Long radius	0.17 to 0.43
iv)	Inward Projecting Pipe	0.62 to 1.0

(*Continued*)

*The values of I and R for different crops shall be obtained.

TABLE 6 RESISTANCE COEFFICIENTS FOR VALVES AND FITTINGS—*Contd.*

Sl No.	Description of Valves and Fittings	Resistance Coefficient (*K**)
(1)	(2)	(3)
v)	Valves	
	1) Globe valves	
	a) Composition disc globe valve	0.23 to 5.20
	b) Bevel seat globe valve	6.2 to 7.2
	c) Plug disc globe valve	7.2 to 10.3
	2) Gate valves	
	a) Wedge disc gate valve	0.05 to 0.19
	b) Double disc gate valve	0.08 to 0.13
	3) Check valves	
	a) Swing check valve	0.60 to 2.30
	b) Horizontal (left) check valve	8 to 12
	c) Ball check valve	65 to 70
	4) Angle valve	2.10 to 3.10
	5) Y or blow-off valve	2.9
	6) Foot valve	0.3 *Max*
vi)	Standard Screwed Tee	
	1) Branch blanked-off	0.4
	2) Line blanked-off	
	a) Flow from line to branch	0.85 to 1.30
	b) Flow from branch to line	0.92 to 2.15
vii)	Long Radius Screwed Tee	
	Line blanked-off	
	a) Flow from line to branch	0.37 to 0.50
	b) Flow from branch to line	0.50 to 0.52
viii)	Couplings and Unions	0.02 to 0.07
ix)	Reducing Bushing and Coupling Used as Reducer	0.05 to 2.0

Note — Used as increaser loss is up to 40 percent more than that caused by a sudden enlargement.

*k Decreases with increasing wall thickness of pipe and rounding of edges.

APPENDIX D

(*Clause* 6)

INDIAN STANDARDS APPLICABLE TO AGRICULTURAL PUMPS

D-1. The following Indian Standards relate to agricultural pumps:

i) IS : 325-1978 Three-phase induction motors (*fourth revision*)

ii) IS : 780-1984 Sluice valves for water-works purposes (50 to 300 mm size) (*sixth revision*)

iii) IS : 1239 (Part 1)-1979 Mild steel tubes, tubulars and other wrought steel fittings: Part 1 Mild steel tubes (*fourth revision*)

iv) IS : 1239 (Part 2)-1982 Mild steel tubes, tubulars and other wrought steel fittings: Part 2 Mild steel tubulars and other wrought steel pipe fittings (*third revision*)

v) IS : 1520-1980 Horizontal centrifugal pumps for clear, cold, fresh water (*second revision*)

vi) IS : 1536-1976 Centrifugally cast (spun) iron pressure pipes for water, gas and sewage (*second revision*)

vii) IS : 1537-1976 Vertically cast iron pressure pipes for water, gas and sewage (*first revision*)

viii) IS : 1710-1972 Vertical turbine pumps for clear, cold, fresh water (*first revision*)

ix) IS : 3589-1961 Electrically welded steel pipes for water, gas and sewage (150 to 2 000 mm nominal size) (*first revision*)

x) IS : 4038-1979 Foot valves for water works purposes (*first revision*)

xi) IS : 4985-1981 Unplasticized PVC pipes for potable water supplies (*first revision*)

xii) IS : 5120-1977 Technical requirements for rotodynamic special purpose pumps (*first revision*)

xiii) IS : 6595-1980 Horizontal centrifugal pumps for clear, cold, fresh water for agricultural purposes (*first revision*)

xiv) IS : 7347-1974 Performance of small size spark ignition engines

xv) IS : 7538-1975 Three-phase squirrel cage induction motors for centrifugal pumps for agricultural application

xvi) IS : 8034-1976 Submersible pumpset for clear, cold, fresh water

xvii) IS : 8544 (Part 2)-1977 Motor starters for voltages not exceeding 1 000 V: Part 2 Star delta starters

xviii) IS : 9079-1979 Monoset pumps for clear, cold, fresh water for agricultural purposes

xix) IS : 9137-1978 Code for acceptance tests for centrifugal mixed flow and axial pumps — Class C

xx) IS : 9694 (Part 2)-1980 Code of practice for the selection, installation, operation and maintenance of horizontal centrifugal pumps for agricultural applications: Part 2 Installation

xxi) IS : 9694 (Part 3)-1980 Code of practice for the selection, installation, operation and maintenance of horizontal centrifugal pumps for agricultural applications: Part 3 Operation

xxii) IS : 9694 (Part 4)-1980 Code of practice for the selection, installation, operation and maintenance of horizontal centrifugal pumps for agricultural applications: Part 4 Maintenance

xxiii) IS : 10572-1983 Methods of sampling for pumps

xxiv) IS : 10804-1986 Recommended pumping system for agricultural purpose (*first revision*)

xxv) IS : 10805-1986 Foot valve, reflux valves or non-return valves and bore valves to be used in suction lines of agricultural pumps (*first revision*)

xxvi) IS : 10981-1983 Code for acceptance tests for centrifugal, mixed flow and axial pumps — Class B

xxvii) IS : 11170-1985 Performance requirements for constant speed compression ignition (diesel) engines for agricultural purposes (up to 20 kW)

xxviii) IS : 11346-1985 Testing set-up for agricultural pumps

xxix) IS : 11501-1986 Engine monoset pumps for clear, cold, fresh water for agricultural pumps.

EXPLANATORY NOTE

One crop a year based on annual rainfall is now almost a past history in India. Canal irrigation and pumping sub-soil water now enables Indian farmers to get almost three crops per annum in most of the States of the country.

The gravity flow canal water to the fields can be regulated easily to cover various types of crops requiring different quantities of water at different watering intervals. However, in case pumps are used for lifting water to the fields from rivers, canals, ponds, wells and underground streams, the rate of flow of the pump has to be determined before hand for selecting proper pumpset. The farmer has also to decide which type of pump, that is, horizontal, centrifugal, vertical turbine or submersible would be most suitable for economical use in his field.

This standard was first published in 1980 and on the basis of the experience gained, the Committee felt the need of revision of the standard. Major changes in this revision are:

a) the conveyance losses have been reduced to 10 percent; and

b) friction losses (C grade) for pipes have been taken as 140 and 150 for GI and RPVC pipes, and the resistance coefficients for valves and fittings modified.

This standard is issued in the following four parts for its easy reference:

Part 1 Selection
Part 2 Installation
Part 3 Operation
Part 4 Maintenance.

Printed at Simco Printing Press, Delhi. India