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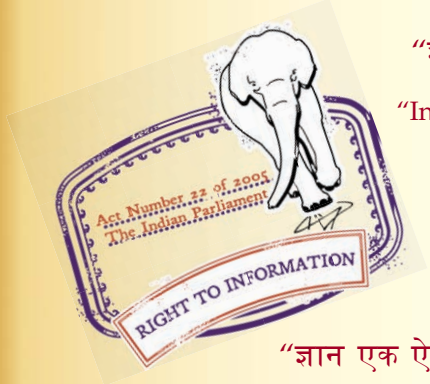
IS 8229 (1986): Specification for Oil-well Cement [CED 2: Cement and Concrete]



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IS : 8229 - 1986
(Reaffirmed 2008)

Indian Standard

SPECIFICATION FOR OIL-WELL CEMENT

(First Revision)

First Reprint JANUARY 2001

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NEW DELHI 110002

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July 1987

Indian Standard

SPECIFICATION FOR OIL-WELL CEMENT

(First Revision)

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(*Continued on page* 29)

AMENDMENT NO. 1 JUNE 1989
TO
IS : 8229 - 1986 SPECIFICATION FOR OIL-WELL CEMENT

(First Revision)

(*Page* 12, *clause* **9.2**) -- Insert the following after **9.2** and renumber the existing clause **9.3** as **9.4**:

'**9.3** The average net mass of cement per bag may also be 25 kg subject to tolerances as given in **9.3.1** and packed in suitable bags as agreed to between the purchaser and the manufacturer.

9.3.1 The number of bags in a sample taken for weighment showing a minus error greater than 2 percent of the specified net mass shall be not more than 5 percent of the bags in the sample. Also the minus error in none of such bags in the sample shall exceed 4 percent of the specified net mass of cement in the bag. However, the average net mass of cement in a sample shall be equal to or more than 25 kg '

(*Page* 12, *clause* **9.4**) — Insert the following NOTE below the clause·

'NOTE — A single bag or container containing 1 000 kg or more net mass of cement shall be considered as bulk supply of cement Supplies of cement may also be made in intermediate containers, for exmaple, drums of 200 kg, by agreement between the purchaser and the manufacturer '

(BDC 2)

Printed at New India Printing Press Khurja India

AMENDMENT NO. 2 JUNE 1991

TO

IS 8229 : 1986 SPECIFICATION FOR OIL-WELL CEMENT

(First Revision)

[*Page* 12, *clause* **9.3.1** (*see also* Amendment No. 1)] — Insert the following new clauses after **9.3.1** and renumber the existing clause **9.4** as **9.5**·

"**9.4** When cement is intended for export and if the purchaser so requires, packing of cement may be done in bags other than those given in **9.2** and **9.3** with an average net mass of cement per bag as agreed to between the purchaser and the manufacturer.

9.4.1 For this purpose, the permission of the certifying authority shall be obtained in advance for each export order

9.4.2 The words 'FOR EXPORT' and the average net mass of cement per bag shall be clearly marked in indelible ink on each bag

9.4.3 The packing material shall be as agreed to between the supplier and the purchaser

9.4.4 The tolerance requirements for the mass of cement packed in bags shall be as given in **9.3.1** except the average net mass which shall be equal to or more than the quantity in **9.4** ''

(CED 2)

Printed at New India Printing Press Khurja India

AMENDMENT NO. 3 NOVEMBER 1991
TO
IS 8229 : 1986 SPECIFICATION FOR OIL- WELL CEMENT

(First Revision)

(*Page* 28, *clause* B-1.2) — Substitute 'up to 25 tonnes' *for* 'of 20 to 25 tonnes'.

(CED 2)

Printed at New India Printing Press Khurja, India

AMENDMENT NO. 4 NOVEMBER 1993
TO
IS 8229 : 1986 SPECIFICATION FOR OIL-WELL CEMENT

(First Revision)

[*Page* 12, *clause* **9.4** (*see also Amendments No.* 1 *and* 2)] — Substitute the following for the existing matter:

'**9.4** When cement is intended for export and if the purchaser so requires, packing of cement may be done in bags or in drums with an average net mass of cement per bag or drum as agreed to between the purchaser and the manufacturer.

9.4.1 For this purpose the permission of the certifying authority shall be obtained in advance for each export order.

9.4.2 The words '**FOR EXPORT**' and the average net mass of cement per bag/drum shall be clearly marked in indelible ink on each bag/drum.

9.4.3 The packing material shall be as agreed to between the manufacturer and the purchaser.

9.4.4 The tolerance requirements for the mass of cement packed in bags/drum shall be as given in **9.3.1** except the average net mass which shall be equal to or more than the quantity in **9.4**.'

(CED 2)

Printed at New India Printing Press, Khurja, India

AMENDMENT NO. 5 APRIL 2000
TO
IS 8229 : 1986 SPECIFICATION FOR OIL-WELL CEMENT

(First Revision)

Substitute 'net mass' *for* 'average net mass' wherever it appears in the standard.

(CED 2)

Printed at New India Printing Press Khurja India

AMENDMENT NO. 6 JUNE 2006
TO
IS 8229 : 1986 SPECIFICATION FOR OIL-WELL CEMENT

(First Revision)

(*First cover page*) — Insert the following above the English title of the Indian Standard

भारतीय मानक

तेल के कुओ हेतु सीमेट की विशिष्टि

(पहला पुनरीक्षण)

(CED 2)

Reprography Unit, BIS, New Delhi, India

Indian Standard

SPECIFICATION FOR OIL-WELL CEMENT

(First Revision)

0. FOREWORD

0.1 This Indian Standard (First Revision) was adopted by the Indian Standards Institution on 12 November 1986, after the draft finalized by the Cement and Concrete Sectional Committee had been approved by the Civil Engineering Division Council.

0.2 Oil-well cement is used by the petroleum industry for cementing gas and oil-wells at high temperatures and pressures. Slurries of such cement have to remain pumpable at these elevated temperatures and pressures for a sufficient length of time and then harden fairly rapidly The two principal uses of oil-well cement are to cement the steel casing to the walls of the well and to seal the porous formations which contain either gas or water that is flowing into oil-bearing formations At present a small quantity of oil-well cement is being produced in the country and appreciable quantities are imported. This standard covers the requirements of oil-well cement required for the Indian Oil Industry which is expanding at a rapid pace, and is intended to provide guidance to the cement producers for the manufacture of this cement.

0.3 This standard was published as an emergency standard in 1976 to meet the immediate needs of the country, in response to a proposal received from the Department of Industrial Development, Government of India. The Cement and Concrete Sectional Committee subsequently decided to regularize this standard and this revision was taken up with this purpose and also to incorporate a few modifications found necessary in the light of experience gained in its use. In this revision four new classes of oil-well cement A, B, C and D have also been incorporated and special class cement has been deleted.

0.4 Mass of cement packed in bags and the tolerance requirements for the mass of cement packed in bags shall be in accordance with the relevant provisions of the Standards of Weights and Measures (Packaged Commodities) Rules, 1977 and **B-1.2** (*see* Appendix B for information) Any modification in these rules in respect of tolerance on mass of cement would apply automatically to this standard.

0.5 In the preparation of this standard, due weightage has been given to the views of manufactures, users and technologists, and considerable assistance has been derived from API Spec 10 Specification for materials and testing for well cements, second edition, June 1984, published by the American Petroleum Institute

0.6 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, 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.

1. SCOPE

1.1 This standard covers nine classes of oil-well cement used for the purpose of securing oil-well pipe casing with the surrounding earth and rocks.

2. CLASSES

2.1 The cement shall be classified as follows:

a) *Class A* — intended for use from surface to 1 830 m depth, when special properties are not required.

b) *Class B* — intended for use from surface to 1 830 m depth, when conditions require moderate to high sulphate resistant type of the cement.

c) *Class C* — intended for use from surface to 1 830 m depth, when conditions require ordinary to high sulphate resistant type of the cement and high early strength.

d) *Class D* — intended for use from 1 830 to 3 050 m depth, when conditions require moderate to high sulphate resistant type of the cement under moderately high temperatures and pressures.

e) *Class E* — intended for use from 3 050 to 4 270 m depth, when conditions require moderate to high sulphate resistant type of the cement under high temperatures and pressures.

f) *Class F* — intended for use from 3 050 to 4 880 m depth, when conditions require moderate to high sulphate resistant type of the cement under extremely high temperatures and pressures.

g) *Class G* — intended for use as a basic cement from surface to 2 440 m, when conditions require moderate to high sulphate resistant type of the cement and can be used with accelerators and

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

retarders to cover a wide range of well depths and temperatures. No additions other than calcium sulphate or water or both, shall be interground or blended with the clinker during manufacture.

h) *Class* H — intended for use as a basic cement from surface to 2 440 m, when conditions require moderate sulphate resistant type and can be used with accelerators and retarders to cover a wide range of well depths and temperatures. No additions other than calcium sulphate or water or both, shall be interground or blended with the clinker during manufacture.

j) *Class* J — intended for use as manufactured from 3 660 to 4 880 m depth, when conditions require moderate to high sulphate resistant type under extremely high temperatures and pressures and can be used with accelerators and retarders to cover a wide range of well depths and temperatures. No additions other than calcium sulphate or water or both, shall be interground or blended with clinker during manufacture.

3. MANUFACTURE

3.1 Oil-well cement of classes A, B, C, D, E, F, G and H, shall be manufactured by grinding clinker consisting essentially of hydraulic calcium silicates. No material other than one or more forms of calcium sulphate shall be interground with the clinker or blended with the ground clinker during manufacture of the cement However, suitable set-modifying agents (*see* Note) may be interground or blended during manufacture of classes D, E and F cement. Class J cement shall be manufactured to conform to the physical requirements given in Table 2.

NOTE — A suitableset-modifying agent shall be defined as the one which has no deleterious effect on the durability of the hardened cement and causes no retrogression in strength.

4. CHEMICAL REQUIREMENTS

4.1 Oil-well cement of classes A, B, C, D, E, F, G and H, when tested in accordance with the methods given in IS . 4032-1985*, shall comply with the chemical requirements given in Table 1.

5. PHYSICAL REQUIREMENTS

5.1 The oil-well cement shall conform to the physical requirements given in Table 2.

6. ADMIXTURES

6.1 Bentonite, barite and fly ash may be used as admixtures in oil-well cement.

*Method of chemical analysis of hydraulic cement (*first revision*).

TABLE 1 CHEMICAL REQUIREMENTS FOR OIL-WELL CEMENT

(*Clause* 4.1)

Sl No.	Characteristic	Requirement							
		Class A	Class B	Class C	Class D	Class E	Class F	Class G	Class H
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
		Ordinary Type							
i)	Magnesium oxide (MgO), percent, *Max*	6.00	—	6·00	—	—	—	—	—
ii)	Sulphur trioxide (SO_3), percent, *Max*	3·50	—	4.50	—	—	—	—	—
iii)	Loss on ignition, percent, *Max*	3.00	—	3.00	—	—	—	—	—
iv)	Insoluble residue, percent, *Max*	0·75	—	0·75	—	—	—	—	—
v)	Tricalcium aluminate ($3CaO.Al_2O_3$), percent, *Max*	—	—	15·00	—	—	—	—	—
		Moderate Sulphate Resistant Type							
vi)	Magnesium oxide (MgO), percent, *Max*	—	6·00	6.00	6·00	6·00	6·00	6·00	6·00
vii)	Sulphur trioxide (SO_3), percent, *Max*	—	3·00	3·50	3·00	3·00	3·00	3·00	3·00
viii)	Loss on ignition, percent, *Max*	—	3·00	3·00	3·00	3·00	3·00	3·00	8.00
ix)	Insoluble residue, percent, *Max*	—	0·75	0·75	0·75	0·75	0·75	0·75	0.75
x)	Tricalcium silicate ($3CaO.SiO_2$), percent·								
	a) *Max*	—	—	—	—	—	—	58·00	58·00
	b) *Min*	—	—	—	—	—	—	48·00	48.00
xi)	Tricalcium aluminate ($3CaO\ Al_2O_3$), percent, *Max*	—	8·00	8·00	8·00	8·00	8.00	8·00	8.00
xii)	Total alkali content, expressed as sodium oxide (Na_2O) equivalent, percent, *Max*	—	—	—	—	—	—	0·75	0.75

		High Sulphate Resistant Type							
xiii)	Magnesium oxide (MgO), percent, *Max*	—	6 00	6 00	6·00	6 00	6·00	6·00	6 00
xiv)	Sulphur trioxide (SO_3), percent, *Max*	—	3·00	3·50	3 00	3 00	3·00	3 00	3·00
xv)	Loss on ignition, percent, *Max*	—	3·00	3·00	3·00	3·00	3·00	3·00	3 00
xvi)	Insoluble residue, percent, *Max*	—	0 75	0·75	0·75	0·75	0·75	0 75	0·75
xvii)	Tricalcium silicate ($3CaO.SiO_2$), percent:								
	a) *Max*	—	—	—	—	—	—	65 00	65 00
	b) *Min*	—	—	—	—	—	—	48·00	48·00
xviii)	Tricalcium aluminate ($3CaO.Al_2O_3$), percent, *Max*	—	3 00	3 00	3·00	3·00	3·00	3 00	3 00
xix)	Tetracalcium aluminoferrite ($4CaO\ Al_2O_3\ Fe_2O_3$) plus twice the tricalcium aluminate ($3CaO.Al_2O_3$), percent, *Max*	—	24 00	24·00	24·00	24·00	24 00	24·00	24 00
xx)	Total alkali content, expressed as sodium oxide (Na_2O) equivalent, percent, *Max*	—	—	—	—	—	—	0·75	0 75

NOTE 1 — When the tricalcium aluminate content (expressed as C_3A) of the class A cement is 8 percent or less, the maximum SO_3 content shall be 3 percent.

NOTE 2 — When the ratio of the percentage of Al_2O_3 to the percentage of Fe_2O_3 is 0 64 or less, the C_3A content is zero. When the Al_2O_3 to Fe_2O_3 ratio is greater than 0 64, the compounds shall be calculated as follows:

$$C_3A = (2\,65 \times \text{percentage of } Al_2O_3) - (1{\cdot}69 \times \text{percentage of } Fe_2O_3)$$

$$C_4AF = 3{\cdot}04 \times \text{percentage of } Fe_2O_3$$

$$C_3S = (4{\cdot}07 \times \text{percentage of CaO}) - (7{\cdot}60 \times \text{percentage of } SiO_2) - (6{\cdot}72 \times \text{percentage of } Al_2O_3) - (1{\cdot}43 \times \text{percentage of } Fe_2O_3) - (2\,85 \times \text{percentage of } SO_3)$$

(*Continued*)

TABLE 1 CHEMICAL REQUIREMENTS FOR OIL-WELL CEMENT — *Contd*

When the ratio of Al_2O_3 to Fe_2O_3 is less than 0·64, an iron-alumina-calcium solid solution [expressed as ss $C_4AF + C_2F$)] is formed and the compounds shall be calculated as follows:

$$\text{ss } (C_4AF + C_2F) = (2{\cdot}10 \times \text{percentage of } Al_2O_3) + (1{\cdot}70 \times \text{percentage of } Fe_2O_3)$$

$$C_3S = (4{\cdot}07 \times \text{percentage of CaO}) - (7{\cdot}60 \times \text{percentage of } SiO_2) - (4{\cdot}48 \times \text{percentage of } Al_2O_3) - (2{\cdot}86 \times \text{percentage of } Fe_2O_3) - (2{\cdot}85 \times \text{percentage of } SO_3)$$

NOTE 3 — The total alkali content (expressed as Na_2O equivalent) shall be calculated as follows:

$$Na_2O \text{ equivalent} = (0{\cdot}658 \times \text{percentage of } K_2O) + (\text{percentage of } Na_2O)$$

TABLE 2 PHYSICAL REQUIREMENTS FOR OIL-WELL CEMENT

(*Clauses* 3.1 *and* 5.1)

Sl No.	Characteristic	Requirement									Method of Test, Ref to Cl No. in	
		Class A	Class B	Class C	Class D	Class E	Class F	Class G	Class H	Class J	Appendix A	IS : 4031-1968*
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
i)	Water, percent by mass of cement	46	46	56	38	38	38	44	38	*see* Note 1	—	—
ii)	Fineness (specific surface) by Blaine, m^2/kg, *Min*	225	225	225	—	—	—	—	—	—	—	4
iii)	Soundness (autoclave expansion), percent, *Max*	0·8	0·8	0·8	0·8	0·8	0·8	0·8	0·8	—	—	5.2
iv)	Free water content of slurry, percent by volume, *Max*	—	—	—	—	—	—	1·4	1·4	—	A-2	—
v)	Compressive strength, N/mm^2 *Min*:	—	—	—	—	—	—	—	—	—	A-3	—
	a) With 8-hour curing (*see* Note 2)											
	1) 38°C at atmospheric pressure	1·7	1 4	2 1	—	—	—	2 1	2·1	—	—	-
	2) 60°C at atmospheric pressure	—	—	—	—	—	—	10·3	10·3	—	—	—
	3) Schedule 6 S	—	—	—	3·5	—	—	—	—	—	—	—
	4) Schedule 8 S	—	—	—	—	3·5	—	—	—	—	—	—
	5) Schedule 9 S	—	—	—	—	—	3·5	—	—	—	—	—

(*Continued*)

TABLE 2 PHYSICAL REQUIREMENTS FOR OIL-WELL CEMENT — *Contd*

Sl No.	Characteristic	Requirement									Method of Test, Ref to Cl No. in	
		Class A	Class B	Class C	Class D	Class E	Class F	Class G	Class H	Class J	Appendix A	IS : 4031-1968*
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
	b) With 12-hour curing (*see* Note 2)											
	1) Schedule 8 S	—	—	—	—	—	—	—	—	3·5	—	—
	c) With 24-hour curing (*see* Note 2)											
	1) 38°C at atmospheric pressure	12·4	10·3	13·8	—	—	—	—	—	—	—	—
	2) Schedule 4 S	—	—	—	6·9	6·9	—	—	—	—	—	—
	3) Schedule 6 S	—	—	—	13·8	—	6·9	—	—	—	—	—
	4) Schedule 8 S	—	—	—	—	13 8	—	—	—	—	—	—
	5) Schedule 9 S	—	—	—	—	—	6·9	—	—	—	—	—
	6) Schedule 10 S	—	—	—	—	—	—	—	—	6·9	—	—
	vi) Thickening time (maximum consistency during 15 to 30 minutes stirring period : 30 Bc, minutes, *Min* (*see* Notes 2, 4, 5 and 7)										A-4	—
	a) Schedule 1 S	90	90	90	—	—	—	—	—	—	—	—
	b) Schedule 4 S	90	90	90	90	—	—	—	—	—	—	—
	c) Schedule 5 S (*see* Note 6)	—	—	—	—	—	—	90 (120 *Max*)	90 (120 *Max*)	—	—	—
	d) Schedule 6 S	—	—	—	100	100	100	—	—	180	—	—
	e) Schedule 8 S	—	—	—	—	154	—	—	—	—	—	—
	f) Schedule 9 S	—	—	—	—	—	190	—	—	180	—	—

NOTE 1 — Water as recommended by the manufacturer

NOTE 2 — Test schedules for compressive strength are given in Table 5 and for thickening time are given in Tables 6 and 7. These schedules correspond to those given in API Specification 10-1984 'Specification for materials and testing for well cements', June 1984 issued by the American Petroleum Institute.

NOTE 3 — The compressive strength after 7 days shall be not less than the 24-hour compressive strength for Schedule 10 S.

NOTE 4 — The thickening time requirements are based on 75 percent values of the total cementing times observed in the casing survey plus a safety factor of 25 percent.

NOTE 5 — 'Bc' is the Bearden unit of slurry consistency.

NOTE 6 — The maximum thickening time requirement for Schedule 5 S is 120 minutes.

NOTE 7 — Maximum consistency during 15 to 30 minutes stirring period may be limited to 20 Bc for Class G cement by mutual agreement between the purchaser and the manufacturer.

*Methods of physical test for hydraulic cement.

7. STORAGE, SAMPLING, TESTS AND REJECTION

7.1 Requirements in respect of storage, sampling, tests and rejection of oil-well cement shall be as laid down in IS : 269-1976* for ordinary Portland cement.

8. MANUFACTURER'S CERTIFICATE

8.1 The manufacturer shall satisfy himself that the cement conforms to the requirements of this standard, and if requested, shall furnish a certificate to this effect to the purchaser or his representative, within ten days of despatch of the cement.

9. DELIVERY

9.1 The cement shall be packed in bags [jute sacking bags conforming to IS : 2580-1982 'Specification for jute sacking bags for packing cement (*second revision*)', double hessian bituminized (CRI type) multi-ply paper, polyethylene lined (CRI type) jute, lightweight (CRI type) jute, woven HDPE, woven polypropylene or any other approved composite bags] bearing the manufacturer's name or his registered trade-mark, if any. The words 'Oil-Well Cement' and the number of bags to a tonne or the approximate net mass shall be marked legibly and indelibly on each bag. The bags shall be in good condition at the time of inspection.

9.1.1 The bags or packages may also be marked with the Standard Mark.

NOTE — The use of the Standard Mark is governed by the provisions of the Bureau of Indian Standards Act, 1986 and the Rules and Regulations made thereunder. The Standard Mark on products covered by an Indian Standard conveys the assurance that they have been produced to comply with the requirements of that standard under a well-defined system of inspection, testing and quality control which is devised and supervised by BIS and operated by the producer. Standard marked products are also continuously checked by BIS for conformity to that standard as a further safeguard. Details of conditions, under which a licence for the use of the Standard Mark may be granted to manufacturers or processors, may be obtained from the Bureau of Indian Standards.

9.2 The average net mass of cement per bag shall be 50 kg (*see* Appendix B).

9.3 Supplies of cement in bulk may be made by arrangement between the purchaser and the supplier (manufacturer or stockist).

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*Specification for ordinary and low heat Portland cement (*third revision*).

APPENDIX A
(*Table* 2)

METHODS OF TEST FOR OIL-WELL CEMENT

A-1. PREPARATION OF SLURRY

A-1.1 Apparatus

A-1.1.1 *Scales* — The indicated load on the scales shall be accurate within a tolerance of ± 2 g for loads of 2 000 g or more, and within ± 0·1 percent of the indicated load for loads smaller than 2 000 g, except that for new scales the tolerances on accuracy shall be one-half of these values. The sensibility reciprocal shall be not greater than twice the permissible tolerance on scales accuracy.

NOTE — The sensibility reciprocal is obtained by determining the weight required to move the position of equilibrium (rest point) of the balance pointer by one division of the scale.

A-1.1.2 *Weights* — The weights shall be accurate within the tolerance shown in Table 3, except that the new weights shall be accurate within one-half of these tolerances. On beam-type scales, where the weights are on the beam, the indicated weights shall conform to the requirements given in **A-1.1.1**.

TABLE 3 PERMISSIBLE VARIATION IN WEIGHTS

WEIGHT	VARIATION
(1)	(2)
g	g ±
1 000	0·50
500	0 35
300	0 30
200	0 20
100	0·15
50	0·10

A-1.1.3 *Graduated Glass Cylinders* — The graduated glass cylinders shall be large enough to measure and deliver, in a single operation, the required volume of mixing water at 27 ± 2°C. The variation in volume shall not exceed ± 0·2 percent. The graduations shall be sub-divided to at least

5 ml The main graduation lines shall be in complete circles, and shall be numbered The intermediate graduations shall extend around a minimum of one-fifth of the circumference, and the smallest graduations shall extend around a minimum of one-seventh of the circumference of the cylinder.

A-1.1.4 *Mixing Devices* — The mixing devices for preparation of cement slurries shall be small two-speed propeller-type mixer of 1 000 ml capacity, capable of rotating at 4 000 rev/min or greater at no load at 'slow' speed, and 10 000 rev/min or greater at no load at 'high' speed; and a large multiple-speed propeller-type mixer of 4 000 ml capacity, capable of rotating at 6 000 rev/min or greater at no load at 'slow' speed, and 14 000 rev/min or greater at no load at 'high' speed. The propeller blades shall be constructed of corrosion-resistant metal. The mixing containers shall be constructed of either corrosion-resistant metal or glass.

A-1.2 Procedure

A-1.2.1 *Screening* — The sample of cement to be tested shall be passed through an 850-micron sieve conforming to IS : 460 (Part 1)-1985*, in order to break up lumps and remove foreign materials. The materials retained on the screen shall be weighed, the mass recorded as percent of the total cement sieved, and a notation made as to its characteristics. These materials shall then be discarded.

A-1.2.2 *Mixing Water* — For reference tests, freshly distilled water or distilled water essentially free of carbon dioxide shall be used For routine tests, any potable water may be employed. The mixing water shall be measured in a graduated glass cylinder or weighed by means of scales and weights.

A-1.2.3 *Temperature of Water and Cement* — The temperature of water and cement prior to mixing shall be 27 ± 2°C.

A-1.2.4 *Percentage of Water* — The percentage of water by mass to be added for each class of cement shall conform to the values given in Table 4. No water shall be added to compensate for evaporation, wetting, etc.

NOTE 1 — The addition of bentonite to cement requires that the amount of water be increased. It is recommended, for testing purposes, that 5·3 percent water be added for each 1 percent bentonite in all classes of cement. For example Class E cement slurry having a water-cement ratio of 0 38 to which is added 3 percent bentonite; will require an increase in water-cement ratio to 0 539.

NOTE 2 — The addition of barite to cement generally requires that the amount of water be increased. It is recommended, for testing purposes, that 0·2 percent water be added for each 1 percent barite For example, a cement slurry having a normal water-cement ratio of 0 38 and weighted to 2·20 g/m³ by addition of 60 percent barite, will require an increase in water-cement ratio to 0·50

*Specification for test sieves: Part 1 Wire cloth test sieves (*third revision*)

TABLE 4 REQUIREMENTS FOR PREPARATION OF SLURRY

(*Clauses* A-1.2.4, A-1.2.5 *and* A-1.2.6)

Class of Cement	Volume of Slurry	Mixer Size	Mixing Time at 'High' Speed	Composition of Slurry		
				Amount of Water		Amount of Cement
				Percentage by mass of cement	Mass	
(1)	(2)	(3)	(4)	(5)	(6)	(7)
	ml		s	percent	g	g
A and B	600	Small	35	46	355	772
	2 000	Large	30	46	1 183	2 572
	3 000	Large	45	46	1 775	3 859
	4 000	Large	55	46	2 367	5 145
C	600	Small	35	56	383	684
	2 000	Large	30	56	1 276	2 279
	3 000	Large	45	56	1 915	3 419
	4 000	Large	55	56	2 553	4 559
D, E, F and H	600	Small	35	38	327	860
	2 000	Large	30	38	1 090	2 868
	3 000	Large	45	38	1 634	4 301
	4 000	Large	55	38	2 179	5 735
G	600	Small	35	44	349	792
	2 000	Large	30	44	1 162	2 640
	3 000	Large	45	44	1 743	3 961
	4 000	Large	55	44	2 324	5 281
J	600	Small	35	As recommended by the manufacturer		
	2 000	Large	30			
	3 000	Large	45			
	4 000	Large	55			

A-1.2.5 *Volume and Composition of Slurry in Mixer* — The volume of slurry in the small mixer shall be 600 ml. For the large size mixer, the volume of slurry shall be 2 000 ml, 3 000 ml or 4 000 ml. The composition of slurry for these volumes shall be as given in Table 4.

A-1.2.6 *Mixing of Cement and Water* — Mixing of the cement and the requisite percentage of water at the given temperature shall be done in accordance with the following procedure:

The required quantity of water shall be placed in the mixing container, the mixer turned on to operate at 'slow' speed, and the cement sample added in not more than 15 seconds. After all of the cement has been added to the water, the cover shall be replaced on the mixing container and stirring continued at 'high' speed in accordance with Table 4.

A-2. DETERMINATION OF FREE WATER CONTENT OF SLURRY

A-2.1 Apparatus

A-2.1.1 *Atmospheric Pressure Consistometer* — Furnished complete with motor, switches, thermoregulator, base board and carrying case (*see* Fig. 1).

A-2.1.2 *Interval Counter* — A stopwatch is suitable.

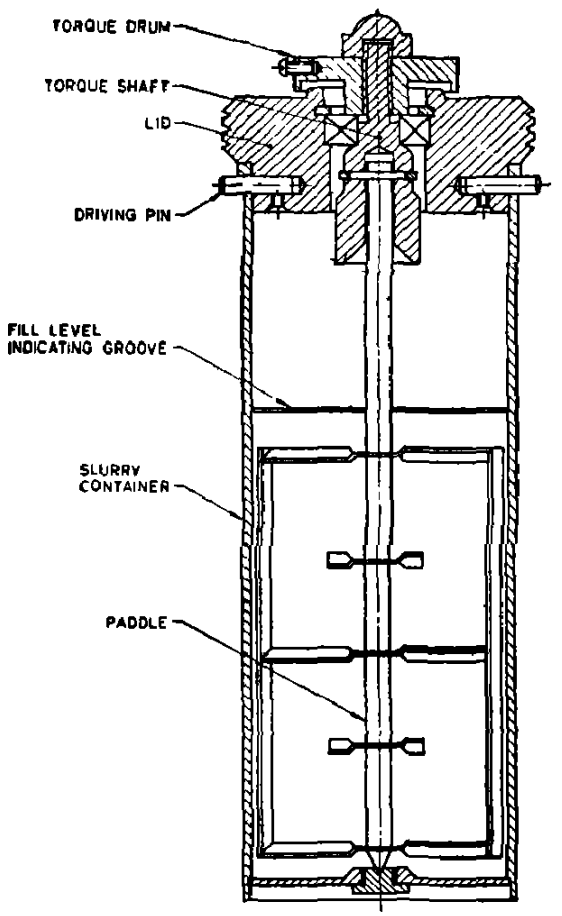

FIG. 1 TYPICAL ATMOSPHERIC PRESSURE CONSISTOMETER

A-2.2 Calibration — The apparatus shall be calibrated with Paratone calibration oil, the viscosity-temperature relationship of which is known over a range of 5 to 100 Bc. The apparatus shall be recalibrated at least once each year, also whenever wear of any metallic part in contact with cement slurry becomes noticeable or when such part is replaced. (Paratone shall be discarded after the use because of possible contamination during calibration.)

A-2.3 Preparation of Apparatus

A-2.3.1 *Cleaning and Lubricating* — Care shall be taken to ensure that all surfaces which come in contact with the cement slurry are clean. After each test, such surfaces (particularly the outside edges of paddles) shall be cleaned and brushed with a brass cement mould brush. Surfaces which come in contact with the slurry shall be given a thin coating of waterproof grease or light oil before each test. The ball bearings in the top of the cylinder and those in the mechanism shall be kept clean by frequent washings in kerosene and shall be oiled with a light grade of lubricating oil.

A-2.3.2 *Water-Bath* — Water shall always be used as the bath liquid. For this reason, all exposed steel parts shall be kept clean and lightly oiled or greased. The water-bath shall always be filled with water before turning on the heater.

A-2.3.3 *Assembly* — The slurry-container mechanism shall be assembled and the paddle rotated by hand to ensure that none of the parts scrapes. The index of the torque-indicator mechanism shall point to zero when the pendulum hangs free. If it does not, the quadrant seals shall be adjusted. The slurry-container assembly shall rotate at a speed of 150 rev/min.

A-2.4 Procedure

A-2.4.1 *Filling of Apparatus* — The slurry prepared according to **A-1** shall be quickly poured into the slurry container to the proper fill level which is indicated by a groove around the inside of the container. The paddle shall be inserted and the lid placed in position by engaging the pin located in the torque shaft of the lid, with the slotted paddle shaft. The assembly shall then be placed in the bath, gears engaged, and the torque-indicator cord passed around the torque drum and looped over the pin. Care shall be taken to ensure that the cord is properly aligned on the 45-mm drums of both the torque-indicator ring and the torque drum in order to preserve a constant radius of pull. The motor shall be started.

A-2.4.2 The slurry shall be stirred at 27°C for a period of 20 minutes. It shall then be remixed for an additional 35 seconds at 'high' speed in a mixer of 1 000 ml capacity (*see* **A-1.1.4**), and used to fill a 250 ml graduated glass cylinder. The 0-250 ml graduated portion of the cylinder shall

neither be less than 232 mm nor more than 248 mm in length. The cylinder shall be sealed to prevent evaporation. The cylinder shall then be set on a 6-mm steel plate which is supported by a 25 mm foam-rubber pad. The steel plate and the pad shall be approximately 200 × 300 mm. The supernatant water developed after standing quiescent for 2 hours shall be removed by either pipetting or decanting and measured in a graduated glass cylinder of proper size. It shall be expressed in millilitres and designated as 'free water content'.

NOTE — The foam-rubber pad shall be upholsterer's medium density flatstock foam rubber, 25 mm thick.

A-3. TEST FOR COMPRESSIVE STRENGTH

A-3.1 Apparatus

A-3.1.1 *Sieve* — 850-micron IS sieve [*see* IS : 460 (Part 1)-1985*].

A-3.1.2 *Specimen Moulds* — Conforming to **9.3.2** of IS : 4031-1968†.

A-3.1.3 *Base and Cover Plates* — Plate glass or non-corroding metalplates having a minimum thickness of 6 mm.

A-3.1.4 *Water Curing Bath* — A curing bath or tank having dimensions suitable for the complete immersion of compressive strength moulds in water, operable within ± 2°C of the prescribed test temperatures, and having a suitable agitator or circulating system to ensure a uniform bath temperature. It may be either of the following two types:

a) A non-pressure vessel suitable for curing specimens at a temperature of 82°C or less.

b) A pressure vessel suitable for curing specimens at temperatures up to and including 193°C and at pressures that can be controlled between zero and 20 700 kPa. The vessel shall have sufficient heating capacity to raise the temperature uniformly from 27 to 174°C in 75 minutes.

A-3.1.5 *Cooling Bath* — Such that the specimen to be cooled from the curing temperature can be completely submerged in water maintained at 27 ± 2°C.

A-3.1.6 *Temperature Indicator*

A-3.1.6.1 *Thermometer (for non-pressure type vessel)* — range 0 to 104°C, with smallest scale divisions not exceeding 2°C.

*Specification for test sieves : Part 1 Wire cloth test sieves (*third revision*).
†Methods of physical tests for hydraulic cement.

A-3.1.6.2 *Pyrometer (for pressure type vessel)* — range 0 to 210°C, with smallest scale divisions not exceeding 3°C, calibrated to accuracy of ± 1 percent.

A 3.1.7 *Puddling Rod* — of glass or non-corroding metal, approximately 200 mm long and 6 mm in diameter.

A-3.1.8 *Grease to Seal Specimen Moulds* — Any grease which is non-corrosive in the temperature range of 27 to 210°C and which when subjected to test temperatures and pressures specified in Table 5 has : (a) a consistency to permit ease of application, (b) good adhesive properties to prevent leakage, and (c) water resistance.

TABLE 5 WELL-SIMULATION TEST SCHEDULES FOR CURING STRENGTH TEST SPECIMENS

(*Clauses* A-3.1.8, A-3.2.4.1, A-3.2.4.2 *and* A-3.2 4.4)

Schedule Number	Depth	Pressure	Temperature at Elapsed Time (from First Application of Heat and Pressure) of									
			30 min	45 min	60 min	75 min	90 min	120 min	150 min	180 min	210 min	240 min
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
	m	kPa	°C	°C	°C	°C	°C	°C	°C	°C	°C	°C
4S	1 830	20 700	47	49	51	53	55	59	64	68	72	77
6S	3 050	20 700	56	64	68	72	75	82	89	96	103	110
8S	4 270	20 700	67	87	99	103	106	113	121	128	136	143
9S	4 880	20 700	73	97	120	123	127	133	140	147	153	160
10S	5 490	20 700	82	108	136	150	153	157	162	167	172	177

Note 1 — The test pressure shall be applied as soon as the specimens are placed in the pressure vessel, and maintained within the following variations for the duration of the curing period.

Schedule 4S to 10S ± 3 400 kPa

Note 2 — The final temperature given in col 13 shall be maintained within ± 2°C throughout the remainder of the curing period

A-3.2 Procedure

A-3.2.1 *Preparation of Moulds* — The interior faces of the moulds and the contact surfaces of the plates shall be thinly covered with grease The contact surfaces of the halves of each mould shall also be coated with grease to make the joint watertight when assembled. Excess grease shall be removed

from the interior faces of the assembled moulds, giving particular attention to the corners. The moulds shall be placed on a thinly greased plate. It is necessary that grease be applied to the exterior contact line of the mould and the base plate.

A-3.2.2 *Placement of Slurry in Moulds* — The slurry prepared in accordance with **A-1** shall be placed in the prepared moulds in a layer of thickness equal to one-half of the mould depth and puddled 25 times per specimen with a puddling rod. The slurry shall be placed in all the specimen compartments before commencing the puddling operation After puddling the layer, the remaining slurry shall be stirred to eliminate segregation, the moulds filled to over-flowing, and puddled as for the first layer. After puddling, the excess slurry shall be struck off even with the top of the mould, using a straight edge. Specimens in moulds which show evidence of leaking shall be discarded A greased cover plate shall be placed on top of the mould. For one determination, not less than three specimens shall be employed.

A-3.2.3 *Curing Period* — The curing period is the elapsed time from subjecting the specimen to temperature in the curing vessel to testing the specimen for strength.

A-3.2.3.1 For specimens cured at atmospheric pressure, the curing period starts when specimens are initially placed in the curing bath, immediately after slurry has been placed in the moulds. The curing period ends when specimens are tested for strength.

A-3.2.3.2 For specimens cured at pressures above atmospheric, the curing period starts with the initial application of pressure and temperature, to be applied immediately after specimens are sealed in the curing vessel. The curing period ends when specimens are tested for strength.

A-3.2.3.3 The recommended curing periods for test specimens are 8 and 24 hours. However, in case of Class J cement the curing periods are 12 and 24 hours. Additional test at 7 days may be necessary for Class J cement. In some cases where waiting-on cement time data and other information are wanted, additional tests may be necessary.

A-3.2.4 *Curing Temperatures and Pressures*

A-3.2.4.1 *Curing at temperatures below 82°C* — For curing at atmospheric pressure and temperature of 82°C or less, one or more of the temperatures of 27, 38, 49, 60, 71 and 82°C are recommended. For curing at pressures above atmospheric and temperature of 77°C or less, Schedule 4S given in Table 5, is recommended.

A-3.2.4.2 *Curing at temperatures above 82°C* — For curing at temperatures above 82°C, one or more of the Schedules, 6S, 8S, 9S and 10S given in Table 5, are recommended.

A-3.2.4.3 *Curing at atmospheric pressure* — For curing at atmospheric pressure, the test specimens, immediately after being placed in moulds and covered, shall be immersed in a water-bath maintained at the curing temperature.

Where specimens are to be tested at ages of less than 24 hours, they shall be removed from the curing bath approximately 45 minutes before the age at which they are to be tested, immediately removed from their moulds, and placed in a water-bath maintained at 27 ± 2°C for approximately 35 minutes.

Where specimens are to be tested at ages of 24 hours or more, they shall be removed from the curing bath 20 to 23 hours after the cement slurry is initially mixed, immediately removed from their moulds, and returned to the curing bath. They shall remain in the curing bath till approximately 45 minutes prior to the age at which they are to be tested, at which time they shall be transferred to a water-bath and maintained at 27 ± 2°C for approximately 35 minutes.

A-3.2.4.4 *Curing at pressures above atmospheric* — For curing pressures greater than atmospheric, the test specimens, immediately after moulding and covering, shall be immersed in water at 27 ± 2°C in the pressure vessel. Heat and pressure shall be applied in accordance with the appropriate schedule as recommended in **A-3.2.4.1** and **A-3.2.4.2**. The maximum schedule temperature and pressure shall be maintained as given in Notes 1 and 2 in Table 5 till 105 minutes prior to the age at which the specimens are to be tested, at which time heating shall be discontinued. During the next 60 minutes, the temperature shall be decreased to 93°C or less without release of the pressure other than that caused by thermal contraction. At 45 minutes prior to the age at which specimens are to be tested, the pressure then remaining shall be released gradually (to avoid damage to the specimens) and the specimens removed from moulds, transferred to a water-bath and maintained at 27 ± 2°C for approximately 35 minutes.

A-3.2.4.5 *Testing of specimens* — Cube specimens shall be tested immediately after removal from the cooling-bath water.

A hydraulic testing machine shall be used and a rate of loading in the range of 6 900 to 27 600 kPa per minute shall be employed (*see* Note) When the ulimate strength is approached, no readjustment in the machine control shall be made to maintain the rate of loading selected.

NOTE — For normal strength specimens, a loading rate of 27 600 kPa per minute is recommended. For specimens of low strength (3 400 kPa or less), a rate of 6 900 to 13 800 kPa per minute is suggested.

A-3.3 Calculation and Reporting of Results — In the calculation of compressive strength, variations from the specified cross-sectional area (2 500 mm^2) shall be disregarded, provided deviations of 1·6 mm or more from the specified linear dimension of 50 mm (*see* IS : 4031-1968*) are reported. The compressive strength of all acceptable test specimens made from the same sample and tested for the same period shall be averaged and reported to the nearest 70 kPa.

A-4. TEST FOR THICKENING TIME

A-4.0 Thickening time test is designed to determine the length of time a given cement slurry remains in fluid state under given laboratory conditions, and thus serves as a method of comparing various cements.

A-4.1 Apparatus

A-4.1.1 *Thickening Time Tester Unit* — Pressurized consistometer (*see* Fig. 2). The apparatus consists essentially of a rotating cylindrical slurry container equipped with a stationary paddle assembly, all enclosed in a pressure chamber capable of withstanding the pressures and temperatures prescribed in Table 7. The space between the slurry container and the walls of the pressure container shall be completely filled with white mineral oil, Grade 95 NF (National Formulary) or equivalent. A heating element capable of raising the temperature of this oil-bath at the rate of at least 3°C per minute is provided Thermocouples are provided for determining the temperature of the oil-bath and also that of the cement slurry. The consistency of the cement slurry is indicated by the amount of deformation of a standardized coil-spring connecting the stirring paddle and a stationary head. The stirring paddle and all metal parts of the slurry container exposed to the slurry are made of corrosion-resistant alloys

A-4.1.2 *Stop Watch*

A-4.2 Calibration of Thickening Time Tester Unit — Calibration of the potentiometer mechanism of the pressurized consistometer shall be done as prescribed for atmospheric pressure consistometer in **A-2.2**. The thermocouples shall be calibrated at frequent intervals to ensure the accuracy of temperature measurements

A-4.3 Procedure

A-4.3.1 *Operating Instructions* — Operating instructions as furnished by the manufacturer shall be followed.

A-4.3.2 *Filling of Apparatus* — The slurry prepared in accordance with **A-1** shall be quickly poured into the inverted slurry container. During this filling operation, the slurry shall be lightly stirred to prevent segregation.

*Methods of physical tests for hydraulic cement.

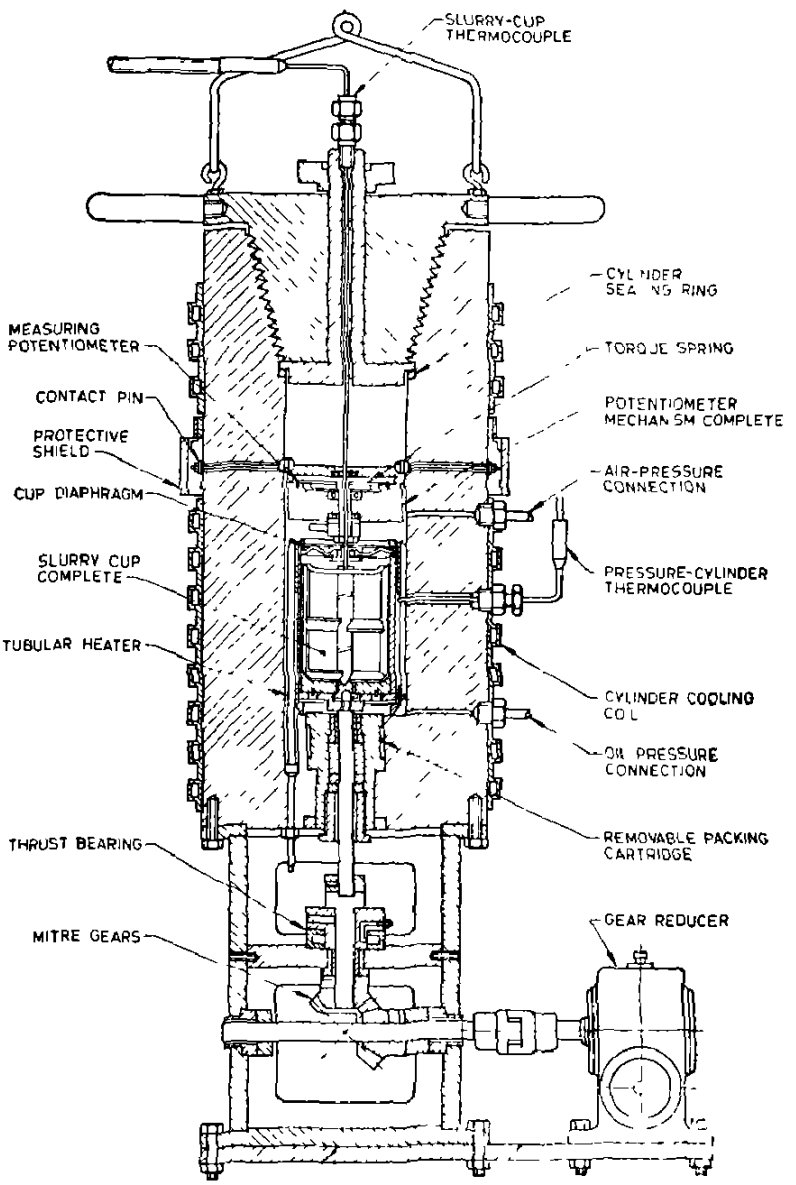

FIG 2 TYPICAL PRESSURIZED CURRENT CONSISTOMETER

When the slurry container is completely filled, the bottom shall be screwed in, care being taken to ensure that all air is excluded. The centre plug shall then be screwed tightly, the container placed in the pressure chamber and the chamber filled with the bath oil. The head assembly of the pressure chamber shall then be screwed in place, the slurry container set rotating and the oil-pressure pump started. With the pump in operation, any air in the top of the chamber shall be vented through the top vent. The operation of filling and sealing the slurry container, placing the container in the pressure chamber, sealing and venting the pressure chamber and placing the apparatus in operation shall be completed within 5 minutes after completion of the mixing period.

A-4.3.3 *Temperature and Pressure Control* — During the test period, the temperature of the cement slurry, determined with the thermocouple in position in the centre of slurry container, and the pressure in the slurry container shall be increased in accordance with the relevant schedule (*see* **A-4.3.4**).

A-4.3.4 *Test Schedules* — Thickening time test schedules representing casing cementing conditions assumed as in Table 6, are given in Table 7. The thickening time for different classes of oil-well cement shall be determined in accordance with the following schedules:

	Test Schedule(s)
Classes A, B and C	1S and 4S
Class D	4S and 6S
Class E	6S and 8S
Class F	6S and 9S
Classes G and H	5S
Class J	6S and 9S

A-4.3.4.1 If only limited data are required, it is not necessary to conduct tests in accordance with all of the specified schedules for Classes A, B, C, D, E, F and J.

A-4.3.4.2 The desired thickening time for any particular well will depend on the history and conditions of the well and it is possible to effect certain suitable modifications in the thickening times for Schedules 5S, 6S, 8S and 9S if the local conditions so demand but this will not have any bearing on the acceptance of a particular type of consignment.

A-4.4 Record of Results — The elapsed time between the starting of the apparatus and the occurrence of a consistency of 100 Bc shall be reported as the thickening time for the cement under test for the particular schedule followed in the test. For the schedules involving higher temperatures, it is permissible to stop the test at a consistency of approximately 70 Bc and to extrapolate the 100 Bc value by plotting the results.

TABLE 6 BASIS FOR THICKENING TIME TEST SCHEDULE

(*Clause* A-4 3 4)

Schedule Number	Depth	Mud Density	Surface Temperature	Surface Pressure	Bottom-Hole Circulating Temperature	Bottom-Hole Pressure	Time to Reach Bottom
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
		kg/L(kPa/m)	°C	kPa	°C	kPa	min
1S	305	1·2 (0·120)	27	3 400	27	7 000	7
4S	1 830	1·2 (0·120)	27	5 200	45	26 700	20
5S	2 440	1·2 (0 120)	27	6 900	52	35 600	28
6S	3 050	1 4 (0 144)	27	8 600	62	51 600	36
8S	4 270	1·9 (0·192)	27	12 100	97	92 300	52
9S	4 880	2 0 (0·204)	27	13 800	120	111 300	60

Note 1 — Mud densities have been obtained from a review of field data.

Note 2 — Surface pressures have been obtained from a review of field data.

Note 3 — Bottom-hole circulating temperatures have been averaged from actual field tests run at various depths

Note 4 — Bottom hole pressures have been calculated from the corresponding surface pressures, mud densities and depths shown in the table.

Note 5 — Time to reach bottom is based on a survey of field operations and reflects conditions as severe as 75 percent of the jobs surveyed.

TABLE 7 THICKENING TIME TEST SCHEDULE

(*Clauses* A-4 1.1 *and* A-4.3.4)

Time	Pressure						Temperature					
	Schedule 1S	Schedule 4S	Schedule 5S	Schedule 6S	Schedule 8S	Schedule 9S	Schedule 1S	Schedule 4S	Schedule 5S	Schedule 6S	Schedule 8S	Schedule 9S
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
min	kPa	kPa	kPa	kPa	kPa	kPa	°C	°C	°C	°C	°C	°C
0	3 400	5 200	6 900	8 600	12 100	13 800	27	27	27	27	27	27
2	4 100	7 600	9 000	11 000	15 200	17 200	27	28	28	29	29	30
4	5 500	9 700	11 000	13 100	18 000	20 000	27	31	30	31	32	33
6	6 200	11 700	13 100	15 900	21 400	23 400	27	32	32	33	35	36
8	7 000	13 800	15 200	17 900	24 100	26 900	27	34	34	34	37	39
10	—	15 900	17 300	20 700	27 600	30 300	—	36	36	37	40	42
12	—	17 900	19 300	22 800	30 300	33 100	—	38	37	38	43	46
14	—	20 000	21 400	25 500	33 800	36 500	—	39	39	41	46	48
16	—	22 100	23 400	27 600	36 500	40 000	—	41	41	42	48	52
18	—	24 800	25 500	30 300	40 000	42 700	—	43	43	44	51	54
20	—	26 700	27 600	32 400	42 700	46 200	—	45	44	47	53	58
22	—	—	29 600	35 200	46 200	49 600	—	—	46	48	56	61
24	—	—	31 700	37 200	49 000	53 100	—	—	48	51	59	64
26	—	—	33 800	39 300	52 400	55 800	—	—	50	52	62	67
28	—	—	35 600	42 100	55 200	59 300	—	—	52	54	64	70
30	—	—	—	44 100	58 600	62 700	—	—	—	56	67	73

32	—	—	—	46 900	61 400	65 500	—	—	—	58	70	77
34	—	—	—	49 000	64 800	68 900	—	—	—	60	72	79
36	—	—	—	51 600	67 600	72 400	—	—	—	62	75	83
38	—	—	—	—	71 000	75 800	—	—	—	—	78	86
40	—	—	—	—	73 800	78 600	—	—	—	—	81	89
42	—	—	—	—	77 200	82 000	—	—	—	—	83	92
44	—	—	—	—	80 000	85 500	—	—	—	—	86	95
46	—	—	—	—	82 700	88 300	—	—	—	—	88	98
48	—	—	—	—	86 200	91 700	—	—	—	—	91	101
50	—	—	—	—	88 900	95 100	—	—	—	—	94	104
52	—	—	—	—	92 300	98 600	—	—	—	—	97	108
54	—	—	—	—	—	101 400	—	—	—	—	—	111
56	—	—	—	—	—	104 800	—	—	—	—	—	114
58	—	—	—	—	—	108 200	—	—	—	—	—	117
60	—	—	—	—	—	111 300	—	—	—	—	—	120

NOTE — The final temperature and pressure should be held constant within ± 1°C and ± 700 kPa respectively till completion of the test.

APPENDIX B

(*Clauses* 0.4 *and* 9.2)

TOLERANCE REQUIREMENTS FOR THE MASS OF CEMENT PACKED IN BAGS

B-1. The average net mass of cement packed in bags at the plant in a sample shall be equal to or more than 50 kg. The number of bags in a sample shall be as given below:

Batch Size	*Sample Size*
100 to 150	20
151 to 280	32
281 to 500	50
501 to 1 200	80
1 201 to 3 200	125
3 201 and over	200

The bags in a sample shall be selected at random (*see* IS : 4905-1968*).

B-1.1 The number of bags in a sample showing a minus error greater than 2 percent of the specified net mass (50 kg) shall be not more than 5 percent of the bags in the sample and the minus error in none of such bags in the sample shall exceed 4 percent of the specified net mass of the bag.

NOTE — The matter given in **B-1** and **B-1.1** are extracts based on the Standard of Weights and Measures (Packaged Commodities) Rules, 1977 to which reference shall be made for full details Any modification made in these Rules and other related Acts and Rules would apply automatically.

B-1.2 In case of a wagon-truck load of 20 to 25 tonnes, the overall tolerance on net mass of cement shall be 0 to +0·5 percent.

NOTE — The mass of a jute sacking bags conforming to IS : 2580-1982† to hold 50 kg of cement is 531 g, the mass of a double hessian bituminized (CRI type) bag to hold 50 kg of cement is 630 g, the mass of a 6-ply paper bag to hold 50 kg of cement is approximately 400 g and the mass of a polyethylene lined (CRI type) jute bag to hold 50 kg of cement is approximately 480 g

*Methods for random sampling.

†Specification for jute sacking bags for packing cement (*second revision*).

(*Continued from page* 2)

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