IS : 4988 (Part IV) - 1968

(Reaffirmed 1997)

Indian Standard

GLOSSARY OF TERMS AND CLASSIFICATION OF EARTH-MOVING MACHINERY

PART IV EXCAVATORS

(First Reprint FEBRUARY 1981)

UDC 001.4 : 621.879

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

May 1970

Indian Standard

GLOSSARY OF TERMS AND CLASSIFICATION OF EARTH-MOVING MACHINERY

PART IV EXCAVATORS

Construction Plant and Machinery Sectional Committee, BDC 28

Chairman	*Representing*
LT-GEN R. A. LOOMBA	Engineer-in-Chief's Branch, Army Headquarters
Members	
SHRI B. D. AHUJA	National Buildings Organization, New Delhi
SHRI A. V. JAIN (*Alternate*)	
SHRI ARDAMAN SINGH	Beas Project
SHRI N. S. GILL (*Alternate*)	
SHRI R. S. BHALLA	Roads Wing (Ministry of Transport & Aviation)
SHRI G. V. CHELLAM (*Alternate*)	
SHRI CHANDRA MOHAN	Central Mechanical Engineering Research Institute (CSIR), Durgapur
SHRI R. K. MUKHERJEE (*Alternate*)	
SHRI A. B. CHAUDHURI	Jessop & Co Ltd, Calcutta
SHRI J. D. DAROGA	Italab Engineering Private Ltd, Bombay
SHRI J. DATT	The Concrete Association of India, Bombay
SHRI Y. K. MEHTA (*Alternate*)	
DIRECTOR, CIVIL ENGINEERING	Railway Board (Ministry of Railways)
JOINT DIRECTOR (WORKS) (*Alternate*)	
DIRECTOR (P & M)	Central Water & Power Commission, New Delhi
BRIG N. B. GRANT	Engineer-in-Chief's Branch, Army Headquarters
SHRI H. V. MIRCHANDANI (*Alternate*)	
SHRI P. N. GULATI	Tata Engineering & Locomotive Co Ltd, Bombay
SHRI K. G. K. RAO (*Alternate*)	
SHRI S. Y. KHAN	Killick, Nixon & Co Ltd, Bombay
SHRI A. T. KOTHAVALA (*Alternate*)	
SHRI K. M. KUMAR	Linkers Private Ltd, Patna
SHRI R. K. VARMA (*Alternate*)	
SHRI N. KUMAR	Heatly and Gresham Ltd, Calcutta
SHRI V. GULATI (*Alternate*)	
MAJ-GEN P. R. KUMAR	Bharat Earth Movers Ltd, Bangalore
SHRI M. M. PARTHASARATHY (*Alternate*)	
COL S. C. L. MALIK	Ministry of Defence (R & D)
LT-COL N. C. GUPTA (*Alternate*)	
SHRI M. R. MALYA	Burmah-Shell Oil Storage & Distributing Co of India Ltd, Bombay
DR B. S. BASSI (*Alternate*)	
SHRI S. C. MAZUMDAR	Gannon Dunkerley & Co Ltd, Bombay
SHRI N. H. PAI (*Alternate*)	

(*Continued on page* 2)

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

(*Continued from page* 1)

Members	*Representing*
Shri Y. G. Patel	Builders Association of India, Bombay
Shri H. J. Shah (*Alternate*)	
Shri D. M. Prasad	William Jacks & Co Ltd, Calcutta
Shri G. K. Sethi (*Alternate*)	
Shri Ramesh Khandelwal	Khandelwal Udyog Ltd, Bombay
Representative	Directorate General of Supplies & Disposals
Shri G. S. Rovshen	Armstrong Smith Private Ltd, Bombay
Shri U. G. Kalyanpur (*Alternate*)	
Senior Engineer	Hindustan Construction Co Ltd, Bombay
Shri S. K. Sinha	Directorate General of Technical Development
Shri B. C. Srivastava	Central Building Research Institute (CSIR), Roorkee
Shri J. P. Kaushik (*Alternate*)	
Superintending Engineer, Delhi Central Electrical Circle No. III	Central Public Works Department, New Delhi
Executive Engineer (Electrical), Mechanical & Workshop Division (*Alternate*)	
Prof C. G. Swaminathan	Central Road Research Institute (CSIR), New Delhi
Shri N. H. Taylor	Recondo Private Ltd, Bombay
Shri T. H. Peshori (*Alternate*)	
Shri N. S. Viswanathan	Marshall Sons & Co Mfg Ltd, Bombay
Shri R. Nagarajan, Director (Civ Engg)	Director General, ISI (*Ex-officio Member*)

Secretary

Shri Y. R. Taneja

Deputy Director (Civ Engg), ISI

Panel for Earth-Moving Machinery, BDC 28 : P6

Convener	
Brig N. B. Grant	Engineer-in-Chief's Branch, Army Headquarters
Members	
Shri S. P. Chugh	Central Water & Power Commission, New Delhi
Shri N. S. Gill	Beas Project
Lt-Col N. C. Gupta	Research & Development Organization, Poona
Maj Gurbux Singh	Vehicles Research & Development Establishment, Ahmednagar
Maj D. K. Pandit	College of Military Engineering, Poona

Indian Standard

GLOSSARY OF TERMS AND CLASSIFICATION OF EARTH-MOVING MACHINERY

PART IV EXCAVATORS

0. FOREWORD

0.1 This Indian Standard (Part IV) was adopted by the Indian Standards Institution on 30 December 1968, after the draft finalized by the Construction Plant and Machinery Sectional Committee had been approved by the Civil Engineering Division Council.

0.2 Earth-moving plant and machinery is being extensively used on all major irrigation projects, road construction, land reclamation and other tests involving removal and shifting of earth. Earth-moving machine has been in production in the country for over a number of years and the requirements have increased considerably in the last few years due to the overall increase in the development work and this has resulted in many manufacturers switching over their production to earth-moving plant and machinery. With the increasing use and manufacture of earth-moving machinery in the country it has been considered necessary by the Construction Plant and Machinery Sectional Committee to lay down the guide lines for present and future manufacture to ensure that there is standardization in the equipment under production or likely to be produced in future in the country.

0.2.1 As a first step towards this end, a glossary of terms relating to earth moving machinery has been prepared with a view to unifying the various technical terms and expressions in connection with the manufacture and use of such machinery. This standard does not cover the requirements relating to design, manufacture and testing of equipment, which will be covered subsequently in separate standards.

0.3 For convenience of reference, the standard has been divided into five parts. IS: 4988 (Part I)-1969* covers the definitions for the terms applicable in general to all types of earth moving machinery and not specifically to any one equipment.

*Glossary of terms and classification of earth-moving machinery: Part 1 General terms.

0.3.1 The terms applicable to a specific type of machinery are covered in separate parts as below:

IS : 4988 (Part II)-1968 Glossary of terms and classification of earth-moving machinery: Part II Dozers

IS : 4988 (Part III)-1968 Glossary of terms and classification of earth-moving machinery: Part III Motor and towed scrapers.

IS : 4988 (Part IV)-1968 Glossary of terms and classification of earth-moving machinery: Part IV Excavators

IS : 4988 (Part V)-1968 Glossary of terms and classification of earth-moving machinery: Part V Motor graders

0.4 In the formulation of this standard, due weightage has been given to international co-ordination among the standards and practices prevailing in different countries in addition to relating it to the practices in the field in this country.

0.4.1 While formulating this standard, due consideration has also been given to the type of equipment on the future plan of production by various manufacturers. In deciding the size and output of different types of machinery, for example, dozers, scrapers, motor graders and excavators, it has been kept in view that the power for prime mover required for different categories of equipment is similar. It has been endeavoured that a prime mover which is used for light dozer would also be suitable to provide power for light motor grader or a light excavator.

1. SCOPE

1.1 This standard (Part IV) gives definitions of terms applicable exclusively to excavators. This standard also lays down the classification and method to be adopted in calculating the output of excavators.

NOTE — The definitions of terms applicable in general to all types of earth-moving machinery are covered in IS : 4988 (Part I)-1969*.

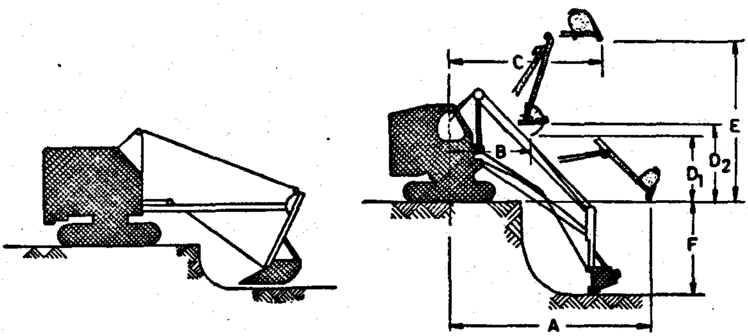
2. DEFINITIONS

2.1 Back Hoe — Equipment fitted to an excavator base machine that digs by pulling a boom handle mounted bucket towards itself (*see* Fig. 1).

2.2 Boom

2.2.1 *Boom Live* — A shovel boom which can be fitted and lowered without interrupting the digging cycle.

*Glossary of terms and classification of earth-moving machinery: Part I General terms.



A Maximum digging radius
B Radius at beginning of dump
C Radius at end of dump
D_1 Dumping height at beginning of dump (For bottom door bucket)
D_2 Dumping height at beginning of dump (For hoe Bucket)
E Dumping height at end of dump
F Maximum digging depth

FIG. 1 MACHINE CHARACTERISTICS OF EXCAVATORS WITH BACK HOE EQUIPMENT

2.2.2 *Boom Length* — It is the distance measured between the axis of the boom foot pivot and the axis of the top load block pivot pin.

2.3 Capacity

2.3.1 *Capacity Heaped* — Heaped capacity shall be based upon the physical dimensions of the bucket, with the soil at 2 : 1 angle of repose. If on measuring the heaped capacity of a bucket, it is found that the value falls below a given rating interval by more than 2 percent the next lower interval shall be deemed as the rating.

2.3.2 *Capacity Struck* — It is the quantity of material retained in the bucket after a heaped load is struck by drawing a straight edge along the width of the bucket.

NOTE — Teeth will not be taken into account when calculating the struck capacity.

2.4 Clamshell — Twin jawed bucket without teeth used with crane jib on excavator base machine for loading soft material (*see* Fig. 2).

2.5 Crane Equipment — A jib and crane hook fitted to an excavator base machine.

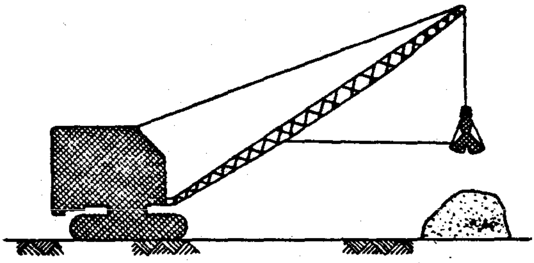


FIG. 2 CLAMSHELL

2.6 Crowd — The process of forcing the bucket to dig or the mechanism which does the forcing.

2.7 Digging

2.7.1 *Digging Depth Maximum* — It is the maximum depth below the ground on which the machine is standing, to which it can dig.

2.7.2 *Digging Height Maximum* — It is the height from the ground on which the machine is standing to the highest point to which the machine can dig.

2.7.3 *Digging Line* — On a shovel, the cable which forces the bucket into the soil called crowd in dipper shovel, drag in back hoe and dragline, and closing line in a clamshell.

2.7.4 *Digging Radius Maximum* — It is the distance from the axis of rotation of turn table to the farthest point the machine can dig.

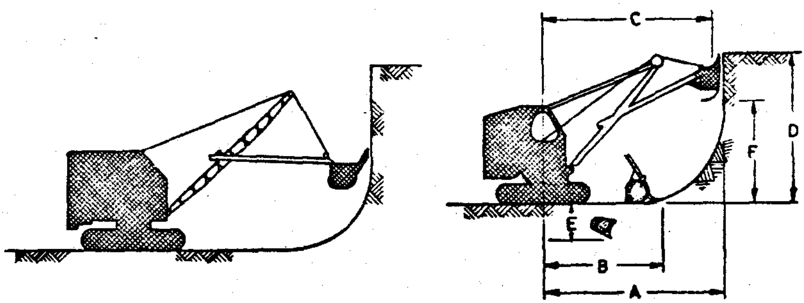
2.8 Dipper Shovel — Boom handle and bucket fitted to an excavator base machine for excavation from an exposed face above track level (*see* Fig. 3).

2.9 Drag — Pulling a bucket to dig or the mechanism by which the pulling is done or controlled.

2.9.1 *Dragline* — Equipment fitted to an excavator base machine with crane jib, ropes and a bucket, which digs, by pulling towards the base machine (*see* Fig. 4).

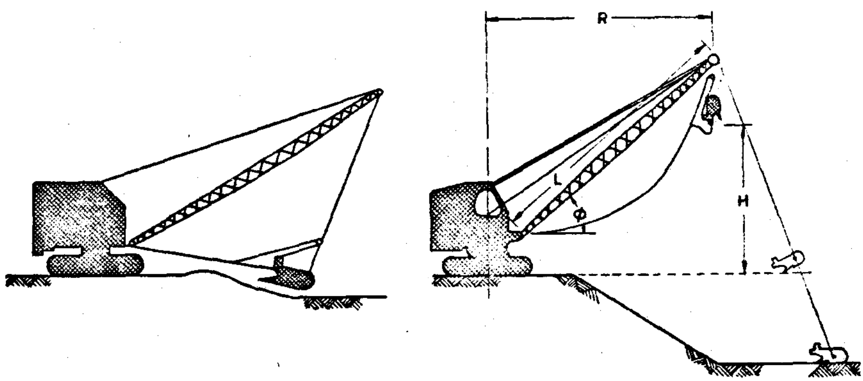
2.10 Dumping

2.10.1 *Dumping Height Maximum* — It is the height from the ground on which the machine is standing to the lower-most position of the bucket while discharging its lead, when the boom is at maximum elevation.



A Maximum cutting radius, overall
B Maximum cutting radius, at floor
C Maximum dumping radius
D Maximum cutting height, bank
E Maximum cutting height, ditch
F Maximum dumping height

FIG. 3 MACHINE CHARACTERISTICS OF EXCAVATOR WITH DIPPER-SHOVEL EQUIPMENT



ϕ Boom angle
H Maximum dumping height
L Length of boom
R Working radius

FIG. 4 MACHINE CHARACTERISTICS OF EXCAVATORS WITH DRAGLINE EQUIPMENT

2.10.2 *Dumping Radius* — The distance from the axis of rotation of the turn table to the edge of the teeth of the bucket in the discharge position.

2.11 Excavator — Tracked or wheeled prime mover consisting of a revolving superstructure mounted on the base to which a variety of front end excavating and lifting equipment can be fitted.

2.12 Hoist Line — The mechanism by which a bucket or blade is lifted or the process of lifting it.

2.13 Jack Boom — A boom which supports sheaves between hoist drum and main boom.

2.14 Jib Boom — An extension piece hinged to the upper end of crane boom.

2.15 Optimum Depth of Cut — It is the depth of cut at which the maximum output is obtained and at which the dipper shovel comes up with a full load without undue crowding, in a single cut, up the face.

2.16 Retract Line — A mechanism by which a dipper shovel bucket is pulled back out of the digging.

2.17 Side Casting — Piling spoil alongside the excavation from which the excavator takes its load.

2.18 Skimmer — A bucket, mounted with rollers on a boom fitted to an excavator base machine, which can excavate above, at the level of or slightly below tracks, by sliding the bucket forward on the boom (*see* Fig. 5).

2.19 Swing Angle — The angle in degrees which the shovel shall swing between digging and dumping points.

3. EXCAVATOR CAPACITY

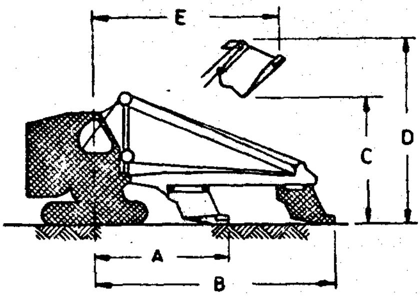
3.1 The capacity of excavator shall be expressed in terms of rated capacity of the bucket which will be the heaped capacity and shall be expressed in cubic metres.

NOTE — Actual capacity of an excavator to handle a particular load in the bucket would depend upon the cutting radius at a particular angle of the boom. This needs to be correlated with the capacity of the bucket.

4. CLASSIFICATION

4.1 The excavators shall be classified into the following classes on the bucket capacity of the attachments fitted:

Class	*Heaped Capacity of Bucket*
	m^3
Light	From 0·80 to 1·50
Medium	From 1·50 to 2·50
Heavy	Over 2·50



A Cutting radius minimum

B Cutting radius maximum

C Maximum dumping height

D Clearance over boom at maximum dumping height

E Dumping radius at maximum height

FIG. 5 MACHINE CHARACTERISTICS OF EXCAVATORS WITH SKIMMER EQUIPMENT

5. EXCAVATOR OUTPUT

5.1 To find out the output of an excavator it is essential to know what is cycle of operation of excavator.

5.1.1 *Cycle of Operation* — An excavator, with any front and equipment, works in a definite cycle of load — swing to discharge, discharge, and swing back to re-load.

5.1.2 *Cycle Time* — The time taken to complete this cycle depends not only on type of soil and angle of swing but also on the mechanism of controls on the machine concerned. Tabulated values of cycle time can only therefore be taken as an average. Average cycle times for an excavator are shown in Table 1 for different types of soil. These timings are based on 90° angle of swing. Cycle times for grabs and clamshells vary so greatly with the type of work being done that no reliable figures can be given.

TABLE 1 CYCLE TIMES FOR DIPPER SHOVELS, DRAGLINES, BACK HOES AND SKIMMERS

(*Clauses* 5.1.2 *and* 5.2.1)

Sl No.	Equipment	Capacity (m^3)	Cycle Time (in Seconds)*		
			Easy Digging (Light Moist Clay or Loam)	Medium Digging (Loam)	Hard Digging (Hard Tough Clay)
(1)	(2)	(3)	(4)	(5)	(6)
		0·29	15	18	24
		0·38	15	18	24
		0·57	18	20	26
i)	Dipper shovel (90° swing)	0·77	18	20	26
		0·96	18	20	26
		1·15	18	20	26
		1·53	18	20	26
		0·29	20	24	30
		0·38	20	24	30
		0·57	22	26	32
ii)	Dragline (90° swing)	0·77	24	28	35
		0·96	24	28	35
		1·15	24	28	35
		1·53	28	33	40
		0·29	16	20	26
		0·38	17	20	26
		0·57	20	22	28
iii)	Back hoe (90° swing)	0·77	20	22	28
		0·96	20	22	29
		1·15	20	22	29
		1·53	20	22	29
		0·29	19	22	30
		0·38	19	23	30
		0·57	22	25	32
iv)	Skimmer	0·77	22	25	32
		0·96	23	25	33
		1·15	23	25	33
		1·53	23	25	33

*For each increase of 10° in swing add 2 seconds to cycle time, for each decrease of 10° in swing subtract 2 seconds from cycle time.

5.2 Calculation of Output

5.2.1 The output of excavator shall be calculated from the following formula:

$$\text{Output} = \frac{3\,600 \times Q \times f \times E \times k}{C} \ \text{m}^3/\text{hour}$$

where

Q = rated capacity of buckets (m^3) in loose measure;

f = soil factor. The bucket will handle earth in loose measures. To obtain equivalent bank measure apply a soil conversion factor (*see* Table 2);

E = a factor combining operator efficiency and task efficiency. Average operator efficiency is 75 percent. Task efficiency for excavators shall be obtained from Table 3;

k = this factor makes allowance for the effect, on the rated bucket capacity, of different types and conditions of soil (*see* Table 4); and

C = cycle time in seconds (*see* Table 1).

TABLE 2 SOIL CONVERSION FACTORS

SL No.	MATERIAL	STATE	CONVERT TO		
			Bank	Loose	Compacted
(1)	(2)	(3)	(4)	(5)	(6)
i)	Sand	Bank	1·00	1·00	0·92
		Loose	1·00	1·00	0·92
		Compacted	1·09	1·09	1·00
ii)	Common earth	Bank	1·00	1·05	0·88
		Loose	0·95	1·00	0·84
		Compacted	1·14	1·19	1·00
iii)	Clay	Bank	1·00	1·20	0·80
		Loose	0·83	1·00	0·75
		Compacted	1·11	1·33	1·00
iv)	Rock	Bank	1·00	1·50	1·40
		Loose	0·67	1·00	0·93
		Compacted	1·11	1·07	1·00

TABLE 3 TASK EFFICIENCY FACTOR FOR EXCAVATORS

(*Clause* 5.2.1)

Sl No.	Front End Equipment in Use	Task	Task Efficiency Factor	
			When Loading into Haulage Vehicle	When Side-Casting
(1)	(2)	(3)	(4)	(5)
i)	Dipper shovel	*Excavation above track level:*		
		Little movement	0·65	0·8
		Much movement	0·45	0·6
		When using timber mats	0·45	0·6
		Working in shattered rock at quarry face (delays due to blasting)	0·4	0·6
ii)	Back hoe	*Trenching*:		
		Trench of bucket width	0·8	1·0
		Trench wider than bucket	0·6	0·7
iii)	Dragline	*Excavation below track level:*		
		Bulk excavation	0·8	1·0
		Excavating wide, open ditches	0·7	0·9
iv)	Skimmer	Excavation of shallow surface cut above track level	0·7	1·0

5.3 Optimum Depth of Cut — The above calculation assumes a 90° swing of the boom from load to discharge and an optimum depth of cut. The optimum depth of cut is the distance the bucket travels excavating in each sweep. If the cut is shorter or longer than the optimum, output is reduced.

5.3.1 If the swing of the boom is greater than 90°, the output is reduced as the cycle time lengthens by 2 seconds for each 10° of increase. Reduction of swing increases output, the cycle time being shortened by 2 seconds by each 10° swing below 90°.

TABLE 4 EXCAVATOR BUCKET EFFICIENCY FACTORS

(*Clause* 5.2.1)

SL No.	MATERIAL	BUCKET EFFICIENCY FACTOR	
		Dipper Shovel	Dragline
(1)	(2)	(3)	(4)
i)	*Easy digging*:		
	a) Loose, soft, free-running material	0·95 to 1·00	0·95 to 1·00
	b) Close-lying material which fills bucket and often provides heaped loads		
	c) Overloads compensate for swell of material		
	d) Dry or moist sand, small gravel, loose earth, sandy clay cinders of ashes, well blasted material		
ii)	*Medium digging*:		
	a) Harder material that does not require blasting, but breaks up with bulkiness causing voids in bucket	0·85 to 0·90	0·80 to 0·90
	b) Dry or wet clay, coarse gravel, packed earth		
iii)	*Medium-hard digging*:		
	a) Material that requires some breaking up by blasting or shaking, but which is bulky and somewhat hard to penetrate causing voids in bucket	0·75 to 0·80	0·65 to 0·75
	b) Well broken limestone, sand rock and other blasted rocks, blasted shale, heavy wet sticky clay, gravel with large boulders, cemented gravel		
iv)	*Hard digging*:		
	a) Blasted rock, hard pan, and other bulky material which is difficult to penetrate and leaves large voids in the bucket	0·50 to 0·70	0·40 to 0·65
	b) Hard tough shale, limestone, granite, sandstone, conglomerate (all these blasted to large pieces and mixed with fines and dirt)		
	c) Tough rubbery clay that shaves from the bank		

INTERNATIONAL SYSTEM OF UNITS (SI UNITS)

Base Units

Quantity	*Unit*	*Symbol*
Length	metre	m
Mass	kilogram	kg
Time	second	s
Electric current	ampere	A
Thermodynamic temperature	kelvin	K
Luminous intensity	candela	cd
Amount of substance	mole	mol

Supplementary Units

Quantity	*Unit*	*Symbol*
Plane angle	radian	rad
Solid angle	steradian	sr

Derived Units

Quantity	*Unit*	*Symbol*	*Conversion*
Force	newton	N	1 N = 1 kg.1 m/s^2
Energy	joule	J	1 J = 1 N.m
Power	watt	W	1 W = 1 J/s
Flux	weber	Wb	1 Wb = 1 V.s
Flux density	tesla	T	1 T = 1 Wb/m^2
Frequency	hertz	Hz	1 Hz = 1 c/s (s^{-1})
Electric conductance	siemens	S	1 S = 1 A/V
Pressure, stress	pascal	Pa	1 Pa = 1 N/m^2

INDIAN STANDARDS INSTITUTION

Manak Bhavan, 9 Bahadur Shah Zafar Marg, NEW DELHI 110002

Telephones : 26 60 21, 27 01 31 **Telegrams : Manaksanstha**

Regional Offices:		Telephone
Western : Novelty Chambers, Grant Road	BOMBAY 400007	37 97 29
Eastern : 5 Chowringhee Approach	CALCUTTA 700072	23-08 02
Southern : C. I. T. Campus, Adyar	MADRAS 600020	41 24 42
Branch Offices:		
'Pushpak', Nurmohamed Shaikh Marg, Khanpur	AHMADABAD 380001	2 03 91
'F' Block, Unity Bldg, Narasimharaja Square	BANGALORE 560002	2 76 49
Gangotri Complex, Bhadbhada Road, T.T. Nagar	BHOPAL 462003	6 27 16
22E Kalpana Area	BHUBANESHWAR 751014	5 36 27
Ahimsa Bldg, SCO 82-83, Sector 17C	CHANDIGARH 160017	2 83 20
5-8-56C L. N. Gupta Marg	HYDERABAD 500001	22 10 83
D-277 Todarmal Marg, Banipark	JAIPUR 302006	6 98 32
117/418 B Sarvodaya Nagar	KANPUR 208005	8 12 72
Patliputra Industrial Estate	PATNA 800013	6 28 08
Hantex Bldg (2nd Floor), Rly Station Road	TRIVANDRUM 695001	32 27

Reproduced by Reprography Unit, ISI, New Delhi