Disclosure to Promote the Right To Information

Whereas the Parliament of India has set out to provide a practical regime of right to information for citizens to secure access to information under the control of public authorities, in order to promote transparency and accountability in the working of every public authority, and whereas the attached publication of the Bureau of Indian Standards is of particular interest to the public, particularly disadvantaged communities and those engaged in the pursuit of education and knowledge, the attached public safety standard is made available to promote the timely dissemination of this information in an accurate manner to the public.

“जानने का अधिकार, जीने का अधिकार”
Mazdoor Kisan Shakti Sangathan
“The Right to Information, The Right to Live”

“पुराने को छोड़ नये के तरफ”
Jawaharlal Nehru
“Step Out From the Old to the New”

HYDRAULIC FLUID POWER — METHODS FOR CLEANING AND FOR ASSESSING THE CLEANLINESS LEVEL OF COMPONENTS

ics 23.100.60
NATIONAL FOREWORD

This Indian Standard which is identical to ISO/TR 10949:1996 ‘Hydraulic fluid power — Methods for cleaning and for assessing the cleanliness level of components’ issued by the International Organization for Standardization (ISO) was adopted by the Bureau of Indian Standards on the recommendation of Basic Fluid Power Sectional Committee and approval of the Basic and Production Engineering Division Council.

In hydraulic fluid power systems, power is transmitted and controlled through a liquid under pressure within an enclosed circuit. To ensure long life and satisfactory performance of hydraulic fluid power systems, the cleanliness of the system is of paramount importance. One factor affecting that cleanliness is the degree of contamination which is present in the system components after manufacture.

This standard has been prepared to give guidance to manufacturers for producing clean components and to select the most appropriate of three alternative procedures for assessing the level of cleanliness as delivered to the user.

As it is not always clear what level and type of cleanliness would be beneficial for improved performance and life on a cost-effective basis, the actual quantitative levels can only be set in relation to other parameters and should be agreed between the manufacturer, the supplier and the user.

The text of the ISO Standard has been approved as suitable for publication as Indian Standard without deviations. Certain conventions are, however, not identical to those used in Indian Standards. Attention is particularly drawn to the following:

a) Wherever the words ‘International Standard’ appear, referring to this standard, they should be read as ‘Indian Standard’.

b) Comma (,) has been used as a decimal marker in the International Standard while in Indian Standards, the current practice is to use a point (.) as the decimal marker.

In the adopted standard, reference appears to certain International Standards for which Indian Standards also exist. The corresponding Indian Standards which are to be substituted in their place are listed below along with their degree of equivalence for the editions indicated:

<table>
<thead>
<tr>
<th>International Standard</th>
<th>Corresponding Indian Standard</th>
<th>Degree of Equivalence</th>
</tr>
</thead>
<tbody>
<tr>
<td>ISO 4021:1992 Hydraulic fluid power — Particulate contamination analysis — Extraction of fluid samples from lines of an operating system</td>
<td>IS 13570:2000 Hydraulic fluid power — Particulate contamination analysis — Extraction of fluid samples from lines of an operating system</td>
<td>Identical</td>
</tr>
</tbody>
</table>


(Continued on third cover)
Indian Standard

HYDRAULIC FLUID POWER — METHODS FOR CLEANING AND FOR ASSESSING THE CLEANLINESS LEVEL OF COMPONENTS

1 Scope

This Technical Report recommends methods of cleaning hydraulic fluid power components and describes alternative procedures for assessing the cleanliness of the components as delivered by the manufacturer to a system constructor or user.

It is not intended to cover complete systems or procedures for cleaning and assessing solid pipework.

2 Normative references

The following standards contain provisions which, through reference in this text, constitute provisions of this Technical Report. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this Technical Report are encouraged to investigate the possibility of applying the most recent editions of the standards indicated below. Members of IEC and ISO maintain registers of currently valid International Standards.


ISO 4021:1992, Hydraulic fluid power — Particulate contamination analysis — Extraction of fluid samples from lines of an operating system.


ISO 4406:—1), Hydraulic fluid power — Fluids — Code for defining the level of contamination by solid particles.


ISO 5598:1985, Fluid power systems and components — Vocabulary.

ISO 6072:1986, Hydraulic fluid power — Compatibility between elastomeric materials and fluids.

3 Definitions

For the purposes of this Technical Report, the definitions given in ISO 5598 apply.

4 Contamination control

Creating and maintaining a clean component is primarily a manufacturing responsibility but the customer or user must also accept responsibilities.

Care with cleanliness is needed by the manufacturer at all stages of production.
The manufacturer is responsible for:

- cleaning component parts prior to assembly;
- assembly in a clean area;
- flushing, if this operation is needed;
- cleanliness during testing;
- preparation for packing, corrosion prevention, port sealing etc.;
- adequate packaging.

On receipt of the component, the customer or user is responsible for:

- care in unpacking;
- keeping the component clean after removing protective plugs, etc.;
- installing the component in the system in a clean condition.

5 Cleaning and assembly of components and parts

5.1 Cleaning

To ensure that an adequate standard of cleanliness of finished units is achieved, it is essential that all parts which make up a component are thoroughly cleaned before assembly.

An appropriate procedure shall be implemented, for each component or component element, to remove such residues as chips, sand, filings, rust, weld spatter and slag, elastomers, sealants, water, aqueous products, chlorine, oil, acid, detergent, etc.

This cleaning procedure is essential to ensure that no damage to the finished component will occur during flushing or testing.

The cleaning procedure can be carried out as follows:

- shot blast or chemically clean castings to remove casting sand and scale prior to machining, and then carefully deburr and wash them before assembly;
- remove manufacturing residues, burrs, etc. by mechanical, ultrasonic, vibratory, chemical means, etc.;
- remove cleaning residues using chemical means, solvents, dry filtered compressed air, etc.;
- wipe with lint-free cloths;
- oven-dry or dry with dry filtered compressed air.

When cleaning components, special care should be taken to ensure that cored passages and deep holes are cleaned, and it should be remembered that items with designed sharp edges, such as grooved spools, can collect quantities of "finger dirt". Assembler's hands and benches should be kept clean and cleaning materials should be lint-free.

Ultrasonic cleaning of components can be very effective, providing the manufacturer's instructions for the ultrasonic cleaner are carefully followed. This process relies mainly on the effect of vapour bubbles imploding on the surface of components; it is important that the bath and component temperature are correct for this action to be fully effective. Adequate time shall, therefore, be allowed for components to reach working temperature after immersion. The design of containers and spacing of components is also critical and adequate flow paths shall be allowed for the sonic waves to reach all parts of all components. Baskets made of perforated sheet may tend to attenuate the sound waves, as will tightly packed parts. Open wire mesh baskets are normally satisfactory.

A further important point is that if the bath fluid is even slightly contaminated with oil or dissolved preserving agent (grease for example), traces of this grease may be left on the components. Components which require subsequent treatment, such as plating or the use of some sealants, should be cleaned in a vapour bath. It should be noted that some vapours, particularly some chlorinated hydrocarbons, can promote very rapid corrosion even if the components are subsequently coated with oil soon after cleaning.

5.2 Assembly

Components should, ideally, be assembled immediately after cleaning as even short storage periods can allow corrosion to start or airborne dust to settle on them. Components which are not required for immediate assembly should be adequately protected.

Assembly should be done in a clean area, well away from contaminant-generating operations such as grinding, welding and machining. Air jets used for cleaning in the vicinity of the assembly should be avoided as these jets can project contaminant many metres.

If adhesives or PTFE tape are used during assembly, care should be taken to avoid entrapment within the unit. If grease is used, it is important that it be kept clean and it should be used sparingly as it may not be soluble in the system fluid and may block filters.
After assembly, all joint surfaces and ports should be covered unless the unit is to be tested immediately. Cover plates and other closures, such as plastic plugs, should be as clean as the unit. Closures which have been used for this purpose will probably be oily and should be cleaned before re-use.

A list of some of the means of protecting a component is given in table 1. If further cleansing of an assembled component is required, the component should be flushed on a specifically designed flushing rig prior to testing.

**WARNING** — Test plant should not be used as a primary cleaning station.

### Table 1

<table>
<thead>
<tr>
<th>Nature of protection</th>
<th>Cleared components</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pressed-on metallic plug or cap</td>
<td>T</td>
</tr>
<tr>
<td>Screwed cylindrical metallic plug with seal</td>
<td>R</td>
</tr>
<tr>
<td>Flanged plate with seal</td>
<td>R</td>
</tr>
<tr>
<td>Pressed-on plastic plug</td>
<td>T</td>
</tr>
<tr>
<td>Screwed male plastic plug</td>
<td>R</td>
</tr>
<tr>
<td>Self-cutting plastic plug</td>
<td>F</td>
</tr>
<tr>
<td>Anti-corrosive Kraft paper</td>
<td>F</td>
</tr>
<tr>
<td>Plastic packaging</td>
<td>R</td>
</tr>
<tr>
<td>Filling with clean compatible hydraulic fluid</td>
<td>R</td>
</tr>
<tr>
<td>Contact corrosion volatile inhibitor for spare parts</td>
<td>By agreement</td>
</tr>
<tr>
<td>Vacuum-tight envelope(^2)</td>
<td>R</td>
</tr>
<tr>
<td>Pressure-tight envelope(^2)</td>
<td>R</td>
</tr>
</tbody>
</table>

1) **R** = recommended; **T** = tolerated; **F** = forbidden.
2) In addition to port plugs.

### 6 Flushing

#### 6.1 Principle

The principle of flushing is to apply sufficient energy to the contaminants in order to dislodge them and to wash them away from the component for subsequent collection in a filter.

#### 6.1.1 Fluid-conveying components

The preferred procedure involves circulating a fluid through the component under defined conditions of flow and temperature.

The fluid flow shall be turbulent \((Re > 4000)\) and calculated from the nominal diameter of the component supply ports:

\[
Re = \frac{Vd}{\nu} \times 10^3
\]

where

- \(Re\) is the Reynolds number;
- \(d\) is the nominal diameter of the ports, in millimetres;
- \(V\) is the linear velocity of the fluid, in metres per second;
- \(\nu\) is the kinematic viscosity of the fluid, in centi-stokes (cSt) \(^2\).

For the flowrate to achieve a Reynolds number of 4000, the flowrate, in litres per minute, must be greater than 0.189 \(vd\).

#### 6.1.2 Non fluid-conveying components

Flushing may be carried out by filling the components with a suitable fluid, and by flushing them completely several times until the fluid cleanliness, as measured at regular intervals, reaches the required level.

#### 6.2 Flushing installation

In order to achieve satisfactory conditions, it is recommended that an installation which meets the requirements given in 6.2.1 to 6.2.4 is used.

**CAUTION** — Special care shall be taken when mounting the component onto the flushing installation to check that the fluid sample taken for cleanliness determination is the same fluid as that conveyed by, or stored in, the component during the flushing operation.
6.2.1 The flushing fluids shall have the following properties:

- they shall be compatible with the components, the seals and the fluid for final use;
- they shall have a viscosity which minimizes wall effects. Empirically, such effects are acceptable as long as viscosity does not exceed 40 cSt.

6.2.2 The tank shall be sealed to prevent ingress of external contamination and shall include a breather with a filtration efficiency compatible with the required cleanliness class.

6.2.3 The filter shall:

- allow the maximum flowrate, as defined in 6.1.1, to pass through it;
- have a filtration efficiency which easily allows the required cleanliness class to be reached;
- include a blocking indicator.

6.2.4 A sampling valve or contamination monitoring port shall be fitted downstream of the component to be flushed.

6.3 Flushing procedure

The time required for flushing is dependent on the component complexity, on the required cleanliness and on the equipment performance.

Flushing should be continued until

- either the contamination level reaches the required value, or
- a specified time is reached, determined experimentally for a given installation and a given component when developing the method.

The moving parts of the component shall be operated for the whole duration of the flushing process. In addition, pumps, motors and cylinders shall be operated at their maximum permissible continuous speed or stroke.

7 Measurement methods

7.1 General

As appropriate, the following three methods should be used to assess the level of contaminant remaining in components or sub-assemblies:

a) monitoring the contamination level of fluid in a production test rig (see 7.2);

b) the flush test method to determine contaminant level flushed out (see 7.3);

c) the strip-wash test method to determine contaminant removed (see 7.4).

One or more of these methods should be used by component manufacturers as part of their quality assurance programme.

It is not recommended that these tests be performed by customers. If a customer considered it essential to conduct either the flush or strip-wash test, he should only do so by prior agreement with the manufacturer, as tests of this nature will certainly invalidate the warranty on the units concerned.

Monitoring the component test fluid will give a very good average indication of the level of fine particulate remaining in all components, but the flush and strip-wash tests will demonstrate the quantity and nature of larger particles present in a component.

7.2 Production test rig method

7.2.1 Commentary

This method is suitable for most components and sub-assemblies, such as gasket-mounted modules and multiple valves, provided adequate fluid flow is directed through all active flow paths, if possible in both directions during test, and that sufficient time is allowed for thorough flushing.

There are limitations to this method as some units contain blind passages which will not be cleaned out by this process, e.g. passages between a pilot valve and the ends of a second stage spool. The housings of piston pumps and motors may also contain additional contaminant which may not be removed due to the flows into these cavities.

This test gives an indication of the level of cleanliness of the flow passageways of components in production.

Units that use the test rig to cut themselves in, for example gear pumps, can be checked by this method.

NOTE 1 It is recommended that the specified level of cleanliness be established after consultation between the customer and the manufacturer due to the special conditions that exist.
7.2.2 Procedure

a) By this method, the oil in a suitable final rig is used to quantify the cleanliness level of the complete unit by using oil which is cleaner than the contaminant level stated in the catalogue or the "as-shipped" specification of the unit. The contaminant level should be stated in accordance with ISO 3938 and ISO 4406.

b) The test rig should not be used as a means of cleaning the parts that make up the final assembly.

c) Monitoring of the fluid condition should be recorded in order to optimize the frequency of checking and predict the probable deterioration of cleanliness levels to a point where other actions may be needed in the rig.

d) Oil samples should be taken from sampling valves positioned in an active part of the circuit to give a realistic contaminant count and in a manner that does not introduce outside contaminants to the sample, or the sample containers; i.e. in accordance with ISO 4021.

e) Satisfactory methods of monitoring the levels of contamination include automatic particle counters, gravimetric analysis, comparison membranes and several other proprietary methods. Related standards are ISO 3722, ISO 4402, ISO 4405 and ISO 4407.

7.3 Flush test method

7.3.1 Commentary

In this method, the outside of the component is first thoroughly cleaned, then the internal surfaces are carefully flushed with a suitable solvent whilst being agitated as strongly as possible. The solvent is subsequently filtered to separate out the contaminant for inspection.

It is a simple and easy-to-perform quality control test and will give a good indication of the quantity and nature of the larger particles remaining in the component. However, it is unsuitable for very large components and suffers from the disadvantage that some components have cavities which cannot be adequately flushed.

It is, however, essential to take extreme care to prevent external contamination being added to the sample. After flushing, all surfaces should be re-wetted with clean hydraulic oil or preservative to prevent corrosion or damage during initial use.

7.3.2 Procedure

a) Clean all external surfaces with solvent to remove extraneous contaminant from the sample.

b) Remove shipping plugs carefully to prevent adding contaminant such as plastic plug shavings. Clean each port, if necessary, with a bottle brush. Do not remove permanent plugs which remain in the component during service.

c) Place the component in a clean collecting tray. This tray, and all other apparatus used, should be pre-cleaned to a level such that any contamination released from it should have no significant effect on the final test result.

d) Select a solvent which is compatible with all the materials used in the components, including seals and the working fluid (see ISO 6072) and filter to better than the required cleanliness level of the component. The required level should be stated in accordance with ISO 4406 and ISO 3938.

e) Valves, hoses and similar components should have their lower ports plugged, half filled with solvent and the remaining plugs refitted. Thoroughly agitate the half-filled component. Valves with manually operated spools should, where practicable, be agitated with the spool in each position. Hoses should be flexed 10 times during agitation.

Remove shipping plugs and drain solvent into the collecting tray. Ideally, this entire procedure should be repeated two or three times.

f) Pumps and motors should have all shipping plugs removed, and the inlet port filled with solvent. The drive shaft should then be rotated 1.5 times in the correct direction. Repeat this three times. After the fourth filling, rotate the shaft three times.

Pumps and motors with a separate case cavity should have this cavity rinsed as for valves.

Remove any remaining shipping plugs and drain all remaining solvent into the collecting tray.

g) Pour the contents of the collecting tray into a funnel containing a suitable filter paper or membrane. Wash the tray with solvent and pour the contents into the funnel.

h) Dry the filter paper or membrane and remove it for inspection, either visually, gravimetrically (ISO 4405) by electronic particle counting, or by microscope.
Re-lubricate the inside of the component to protect it from corrosion in transit and storage. Lubricate and cover, or plug the joint surfaces and ports.

7.4 Strip and wash test method

7.4.1 Commentary

In this method, the outside of the component is first thoroughly cleaned. It is then completely disassembled and all internal surfaces carefully washed in a suitable solvent.

It is essentially a quality control test and will give an accurate measure of the total quantity and nature of contaminant particles remaining in the component.

The solvent is subsequently filtered to remove the contaminant for inspection.

Extreme care is essential to prevent external contamination being added to the sample and care should also be taken to prevent the addition of contaminant from blind cavities, such as the bottom of screw holes which would normally be excluded from the hydraulic fluid flow.

After a component has been checked by this method, it is essential that it is retested after re-assembly. Most pumps and motors will need to be "bedded in" as it is unlikely that all parts, such as pistons or vanes, will be replaced in exactly their original positions.

7.4.2 Procedure

a) Clean all external surfaces with solvent to remove extraneous contamination from the sample.

b) Remove all external parts such as solenoids, manual levers, etc. which are not part of the wetted volume of the component.

c) Place the component in a clean collecting tray. This tray, and all other apparatus used, should be precleaned to a level such that any contamination released from it should have no significant effect on the final test result.

d) Select a solvent which is compatible with all the materials used in the component, including seals and the working fluid, and which has been filtered to better than the required cleanliness level of the component.

e) Disassemble the component taking care not to damage the seals, all of which should be removed. It is preferable to replace the cover-retaining screws into their respective holes after removing the covers. This will reduce the risk of adding contaminant to the sample from blind tapped holes. Such contaminant, if present, would not affect the operation of the component.

f) If practical, demagnetize hardened components to 100 μT (microtesla) to facilitate the removal of particles which are adhering due to magnetism.

g) Carefully wash those parts of all components which are normally in contact with the hydraulic fluid. If practical, use a pressure jet of solvent to clean out cored passages, hollow spools, pistons, etc.

h) Place washed parts in a second clean tray for later re-assembly.

i) Pour the contents of the collecting tray into a funnel containing a suitable filter paper or membrane, wash the tray and pour the washings into the funnel.

j) Dry the filter paper or membrane and remove it for inspection, either visually, gravimetrically (ISO 4405) or by microscope.

k) Re-assemble the component.

l) Subject the component to a full normal test.

8 Post-test precautions

8.1 General

The standard of cleanliness maintained during the assembly of the unit by the manufacturer can easily be compromised if care is not also exercised during finishing operations, such as during painting and packing.

NOTE 2 Once the product has been shipped from the manufacturer's works, the responsibility for maintaining cleanliness is transferred to the distributor, installer and end-user.

Precautions are still essential at these points to ensure that the service performance of the unit does not fail to meet the customer's expectations because of contamination.

8.2 Finishing, packing and despatch

The following recommendations reflect good practice for maintaining product cleanliness after assembly and test.
8.2.1 Drain the unit after test in a clean area. If required, inhibit corrosion in the inside of the unit during transit and storage by adding a clean preservative fluid according to the manufacturer's instructions. Re-seal all ports, carefully avoiding the ingress of contamination whilst doing so. Protect breather filters with clean plastic film.

8.2.2 If the product is to be painted after testing, check that all ports are still sealed. Breathers should be protected from becoming blocked with paint. Moving parts, such as cylinder rods, which may provide a route for paint particles to enter the components, should also be shielded from paint.

8.2.3 It is prudent for manufacturers to warn their customers about the harm which can result from allowing contaminants to be introduced into a unit after receipt. This may be done by methods such as:

a) information in the product literature (e.g. application, installation, start-up and maintenance instructions);

b) information supplied with the product, such as a warning notice on the box or on a label tied to the unit.

Such information might usefully refer to the standard or product cleanliness claimed by the manufacturer. For example, "During assembly the parts in this unit were carefully cleaned and the unit was tested using a fluid with a contamination code of x/y/z in accordance with ISO 4406. Do not remove any protection until immediately before the unit is ready for installation. Clean and careful handling will help to prolong its working life".

9 Customer handling precautions

9.1 General

It is possible to identify five common stages at which contamination can be inadvertently introduced into a fluid power component after it has left the manufacturer's care. These are mentioned in 9.2 to 9.6.

9.2 Storage

The manufacturer's recommendations regarding the storage of any components should always be followed, including maximum duration of storage.

9.3 Customizing

Customizing is often necessary to adapt a standard unit to a particular system. Perhaps the most common example is the altering of relief valve ranges. This will entail opening the unit, for example, when springs have to be changed, or a complete cartridge exchanged. All such work should be carried out in clean conditions, and common sense precautions observed to deny entry of contamination. The unit should not be left open any longer than necessary.

9.4 Inspection

Customers should not internally examine units as part of their quality assurance programme, even on a percentage sample basis. If they insist on doing this, they should be advised of all the procedures for correct re-assembly, corrosion-inhibition, packaging, and how to avoid introduction of contaminant. They should also be advised on any reduction in warranty conditions which will be the result of their actions.

It may be in the interest of both parties for the customer to permanently mark inspected units in a suitable manner.

9.5 Installation

Common sense measures to prevent contamination should be observed during system building, etc. are as follows:

a) ports, joint faces, etc. should be examined and carefully wiped clean with a lint-free cloth;

b) hoses and pipes are also components which should be carefully cleaned as they can introduce contamination into a system;

c) plugs should be removed just before use and steel pipes cleaned free of rust, weld spatter, etc.

9.6 Servicing

It is frequently overlooked that contamination introduced into fluid power systems during servicing operations (whether preventative or fault finding) can seriously impair continuing satisfactory performance. Of course, the benefits of regular preventive maintenance, conscientiously carried out, far outweigh such risks. However, it is important that appropriate measures be observed during maintenance and servicing.
<table>
<thead>
<tr>
<th>International Standard</th>
<th>Corresponding Indian Standard</th>
<th>Degree of Equivalence</th>
</tr>
</thead>
<tbody>
<tr>
<td>ISO 5598:1985 Fluid power systems and components —</td>
<td>IS 10416:1992 Fluid power systems and components —</td>
<td>Identical</td>
</tr>
<tr>
<td>Vocabulary</td>
<td>Vocabulary (first revision)</td>
<td></td>
</tr>
<tr>
<td>between elastomeric materials and fluids</td>
<td>elastomeric materials and fluids (under preparation)</td>
<td></td>
</tr>
</tbody>
</table>

The technical committee responsible for the preparation of this standard has reviewed the provisions of the following ISO Standards and has decided that they are acceptable for use in conjunction with this standard:

ISO 4405:1991 Hydraulic fluid power — Fluid contamination — Determination of particle contamination by the gravimetric method

ISO 4406:1999 Hydraulic fluid power — Fluids — Method for coding the level of contamination by solid particles

ISO 4407:1991 Hydraulic fluid power — Fluid contamination — Determination of particulate contamination by the counting method using a microscope
Bureau of Indian Standards

BIS is a statutory institution established under the Bureau of Indian Standards Act, 1986 to promote harmonious development of the activities of standardization, marking and quality certification of goods and attending to connected matters in the country.

Copyright

BIS has the copyright of all its publications. No part of these publications may be reproduced in any form without the prior permission in writing of BIS. This does not preclude the free use, in the course of implementing the standard, of necessary details, such as symbols and sizes, type or grade designations. Enquiries relating to copyright be addressed to the Director (Publication), BIS.

Review of Indian Standards

Amendments are issued to standards as the need arises on the basis of comments. Standards are also reviewed periodically; a standard along with amendments is reaffirmed when such review indicates that no changes are needed; if the review indicates that changes are needed, it is taken up for revision. Users of Indian Standards should ascertain that they are in possession of the latest amendments or edition by referring to the latest issue of ‘BIS Handbook’ and ‘Standards: Monthly Additions’.

This Indian Standard has been developed from Doc: No. BP 14 (0173).

Amendments Issued Since Publication

<table>
<thead>
<tr>
<th>Amend No.</th>
<th>Date of Issue</th>
<th>Text Affected</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

BUREAU OF INDIAN STANDARDS

Headquarters:
Manak Bhavan, 9 Bahadur Shah Zafar Marg, New Delhi 110002
Telephones: 323 01 31, 323 3375, 323 94 02

Regional Offices:
Central : Manak Bhavan, 9 Bahadur Shah Zafar Marg
          NEW DELHI 110002
          323 76 17, 323 38 41

Eastern : 1/14 C.I.T. Scheme VII M, V.I.P. Road, Kankurgachi
          KOLKATA 700054
          { 337 84 99, 337 85 61
             337 86 26, 337 91 20

Northern : SCO 335-336, Sector 34-A, CHANDIGARH 160022
          60 38 43
          60 20 25

Southern : C.I.T. Campus, IV Cross Road, CHENNAI 600113
          254 12 16, 254 14 42
          254 25 19, 254 13 15

Western : Manakalaya, E9 MIDC, Marol, Andheri (East)
          MUMBAI 400093
          832 92 95, 832 78 58
          832 78 91, 832 78 92

Branches : AHMEDABAD. BANGALORE. BHOPAL. BHUBANESHWAR. COIMBATORE. FARIDABAD.
          GHAZIABAD. GUWAHATI. HYDERABAD. JAIPUR. KANPUR. LUCKNOW. NAGPUR.
          NALAGARH. PATNA. PUNE. RAJKOT. THIRUVANANTHAPURAM. VISAKHAPATNAM.

Printed at Simco Printing Press, Delhi