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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.


“जान एक ऐसा खजाना है जो कभी चुराया नहीं जा सकता है”
Bhartrhari—Nitisatakam
“Knowledge is such a treasure which cannot be stolen”
Indian Standard

ROAD VEHICLES — LIQUEFIED PETROLEUM GAS (LPG) SPECIFIC EQUIPMENT — GENERAL DESIGN REQUIREMENTS, PERFORMANCE AND TEST METHODS

ICS 43.069.40; 75.160.30
FOREWORD

This Indian Standard was adopted by Bureau of Indian Standards, after the draft finalized by the Automotive Vehicles Running on Non-conventional Energy Sources Sectional Committee had been approved by the Transport Engineering Division Council.

In the formulation of this standard considerable assistance has been derived from UN ECE Regulation 67 (Revision 2 - Amendment 2: Supplement 8 to the 01 series of amendments: Date of entry into force: 3 February 2008): Uniform provisions concerning approval of specific equipment of motor vehicles using liquefied Petroleum Gases (LPG) in their propulsion system. However the tests specific to multifunction valve such as operational tests for excess flow valve, charging speed test, vibration test, endurance test, etc, are included in IS 15100 : 2001 ‘Multi-function valve assembly for permanently fixed LPG containers for automotive use’.

Following documents may be referred for latest update on statutory requirements related to use of LPG fuel system in internal combustion engine vehicles:

a) Central Motor Vehicle Rules, 1989 (CMVR) (As amended from time-to-time); and

The composition of the Committee responsible for the formulation of this standard is given in Annex D.

For the purpose of deciding whether a particular requirement of this standard is complied with, the final value, observed or calculated, expressing the result of a test or analysis, shall be rounded off in accordance with IS 2 : 1960 ‘Rules for rounding off numerical values (revised)’. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.
Indian Standard

ROAD VEHICLES — LIQUEFIED PETROLEUM GAS (LPG) SPECIFIC EQUIPMENT — GENERAL DESIGN REQUIREMENTS, PERFORMANCE AND TEST METHODS

1 SCOPE

1.1 This standard specifies general design requirements, performance and test methods for LPG specific equipment of motor vehicles of category L, M and N as defined in IS 14272 using LPG in their propulsion system.

1.2 This standard is applicable to LPG specific equipments intended for use on vehicles using liquefied petroleum gas in accordance with CMVR.

1.3 This standard is not applicable to the following:

a) Fuel containers;
b) Multi function valve assembly for permanently fixed liquefied petroleum gas (LPG) containers for automotive use; and
c) LPG specific equipment used in agricultural tractors and construction equipment vehicles.

2 REFERENCES

The following standards contain provisions, which through reference in this text, constitute provisions of this standard. At the time of publication the editions indicated were valid. All standards are subject to revision and parties to agreements based on this standard are encouraged to investigate the possibility of applying the most recent editions of the standards indicated below:

<table>
<thead>
<tr>
<th>IS No./Other Standard</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>ISO 14272 : 2011</td>
<td>Automotive vehicles — Types — Terminology (first revision)</td>
</tr>
<tr>
<td>ISO 1500 : 2001</td>
<td>Multi-function valve assembly for permanently fixed LPG containers for automotive use</td>
</tr>
<tr>
<td>ISO 15956 : 2010</td>
<td>Road vehicles — Liquefied petroleum gas (LPG) specific equipment — Definitions, classification and general requirements</td>
</tr>
<tr>
<td>ISO 1818 : 1998</td>
<td>Rubber, vulcanized or thermoplastic — Accelerated ageing and heat resistance test</td>
</tr>
<tr>
<td>ISO 1431-1 : 2004</td>
<td>Rubber, vulcanized or thermoplastic — Resistance to ozone cracking — Part 1: Static and dynamic strain testing</td>
</tr>
<tr>
<td>ISO 6957 : 1988</td>
<td>Copper alloys — Ammonia test for stress corrosion resistance</td>
</tr>
<tr>
<td>ISO 9227 : 1990</td>
<td>Corrosion tests in artificial atmospheres — Salt spray tests</td>
</tr>
<tr>
<td>IEC 60529 : 2001</td>
<td>Degrees of protection provided by enclosures (IP Code)</td>
</tr>
</tbody>
</table>

3 DEFINITIONS

For the purpose of this standard the definitions given in IS 15956 shall apply.

4 GENERAL DESIGN REQUIREMENTS

4.1 Electrical Operated Devices

In order to prevent in case of fracture of the component electric sparks on the surface of fracture, all electrical operated devices containing LPG shall,

a) be insulated in a manner that no current is lead through LPG containing parts,
b) have the electrical system of the device isolated,
   1) from the body; and
   2) from the container for the fuel pump,
c) insulation resistance shall be minimum 10 MOhms.

4.1.1 The electrical connections inside the boot and passengers compartment shall comply with insulation class IP 40 according to IEC 529.

4.1.2 All other electrical connections shall comply with insulation class IP 54 according to IEC 529.

4.1.3 The power supply bushing (fuel pump/actuator/fuel level sensor) to establish an isolated and tight electrical connection shall be hermetically sealed.

NOTE — The requirements of 4.1 are deemed to be complied, if manufacturer certifies so.
4.2 Provisions on Valves Activated by an Electric/External (Hydraulic, Pneumatic) Power

4.2.1 In the case of valves activated by an electric/external power (for example shut-off valves, gas tube pressure relief valve, service coupling), those valves shall be in ‘closed’ position when power is switched off.

4.2.2 The power of the fuel pump shall be switched off when the electronic control unit becomes defective or non-operative.

4.3 Heat Exchange Medium (Compatibility and Pressure Requirements)

4.3.1 The materials constituting a device which are in contact with the heat exchange medium of a device when operating shall be compatible with that fluid and shall be designed to withstand a pressure of 200 kPa of the heat exchange medium. The material shall meet the requirements laid down in 20.

4.3.2 The compartment containing the heat exchange medium of the vapourizer/pressure regulator shall be leak proof at a pressure of 200 kPa.

4.4 A component consisting of both high pressure and low pressure parts shall be so designed to prevent a pressure build up in the low pressure part above 2.25 times the maximum working pressure for which it has been tested. Components connected directly to the tank pressure shall be designed for the classification pressure of 3 000 kPa for Class 1/2 000 kPa for Class 1A. Venting shall not be to the motor compartment or outside of the vehicle.

4.5 Provisions to Prevent Any Gas Flow

4.5.1 The pump shall be so designed that the outlet pressure shall not exceed 3 000 kPa/2 000 kPa, for example, when there is blocking of tubing or shut-off valve not opening. This can be realized by switching off the pump or by recirculating to the container.

4.5.2 The pressure regulator/vapourizer shall be so designed as to prevent any gas flow when the regulator/vapourizer unit is supplied with LPG at a pressure < 4 500 kPa for Class 1/< 3 000 kPa for Class 1A when the regulator is not operating.

5 APPLICABLE TEST PROCEDURES

The applicable test procedures dependent on the classification of specific equipment are shown in Table 1. Tests applicable to individual specific equipment, are specified in the respective part of this standard.

6 GENERAL REQUIREMENTS FOR TESTS

6.1 Leakage tests shall be conducted with pressurized gas like air or nitrogen.

6.2 Water or another fluid may be used to obtain the required pressure for the hydrostatic strength test.

6.3 All test values shall indicate the type of test medium used, if applicable.

6.4 The test period for leakage and hydrostatic strength tests shall be not less than 1 min.

6.5 All tests shall be performed at a room temperature of 27 ± 5°C unless otherwise stated.

NOTE — Components tested at 20 ± 5 °C shall be acceptable, as an alternate.

Table 1 Applicable Test Procedures for Various Classes of Specific Equipments

(Clause 5)

<table>
<thead>
<tr>
<th>Sl No.</th>
<th>Tests</th>
<th>Class 1</th>
<th>Class 1A</th>
<th>Class 2 and 2A</th>
<th>Class 3</th>
<th>Class 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1)</td>
<td></td>
<td>(2)</td>
<td>(3)</td>
<td>(4)</td>
<td>(5)</td>
<td>(6)</td>
</tr>
<tr>
<td>i)</td>
<td>Overpressure (see 7)</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>ii)</td>
<td>External leakage (see 8)</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>iii)</td>
<td>High temperature (see 9)</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>iv)</td>
<td>Low temperature (see 10)</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>v)</td>
<td>Seat leakage (see 11)</td>
<td>X</td>
<td>X</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>vi)</td>
<td>Endurance (see 12)</td>
<td>X</td>
<td>X</td>
<td>—</td>
<td>X</td>
<td>—</td>
</tr>
<tr>
<td>vii)</td>
<td>Operational test (see 13)</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>X</td>
<td>—</td>
</tr>
<tr>
<td>viii)</td>
<td>LPG compatibility (see 14)</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>ix)</td>
<td>Corrosion resistance (see 15)</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>x)</td>
<td>Resistance to dry heat (see 16)</td>
<td>X</td>
<td>X</td>
<td>—</td>
<td>X</td>
<td>—</td>
</tr>
<tr>
<td>xi)</td>
<td>Ozone ageing (see 17)</td>
<td>X</td>
<td>X</td>
<td>—</td>
<td>X</td>
<td>—</td>
</tr>
<tr>
<td>xii)</td>
<td>Creep (see 18)</td>
<td>X</td>
<td>X</td>
<td>—</td>
<td>X</td>
<td>—</td>
</tr>
<tr>
<td>xiii)</td>
<td>Temperature cycle (see 19)</td>
<td>X</td>
<td>X</td>
<td>—</td>
<td>X</td>
<td>—</td>
</tr>
<tr>
<td>xiv)</td>
<td>Compatibility with heat exchange fluid (see 20)</td>
<td>—</td>
<td>X</td>
<td>X</td>
<td>—</td>
<td>—</td>
</tr>
</tbody>
</table>

Note — ‘X’ stands for applicable.
7 OVERPRESSURE TEST UNDER HYDRAULIC CONDITIONS

7.1 A LPG containing component shall withstand hydraulic test pressure equal to 2.25 times the maximum classification pressure specified in Table 2 for minimum 1 min without any visible evidence of rupture or permanent distortion with the outlet of the high pressure part plugged.

7.2 The samples, shall be connected to a source of hydrostatic pressure. A positive shut-off valve and a pressure gauge, having a pressure range of not less than 1.5 times nor more than 2 times the test pressure, shall be installed in the hydrostatic pressure supply piping.

8 EXTERNAL LEAKAGE TEST

8.1 A component shall be free from leakage through stem or body seals or other joints and shall not show evidence of porosity in casting when tested as described in 8.3 at any aerostatic pressure up to the pressure shown in Table 3. The above prescriptions are deemed to be satisfied, if the provisions of 8.4 are met.

8.2 The test shall be performed at the following conditions:

a) At room temperature (see 6.5);

b) At the minimum operating temperature as per design temperature of respective component; and

c) At the maximum operating temperature as per design temperature of respective component.

The maximum and minimum operating temperature shall be as per relevant standard.

8.3 During this test the equipment under test shall be connected to a source of aerostatic pressure of 1.5 times the maximum pressure and in the case of a Class 3 component, 2.25 times the maximum classification pressure. A positive shut-off valve and a pressure gauge having a pressure range of not less than 1.5 times nor more than 2 times the test pressures shall be installed in the pressure supply line. The pressure gauge shall be installed between the positive shut-off valve and the sample under test. During the test the sample shall be submerged in water to detect leakage or any other equivalent test method (flow measurement or pressure drop).

8.4 The external leakage when subjected to a leakage test pressure shall be less than the requirements stated in the relevant standard or, if no requirements are mentioned, the external leakage shall be less than 15 cm$^3$/h with the outlet plugged.

9 HIGH TEMPERATURE TEST

A LPG containing component shall not leak more than 15 cm$^3$/h with the outlet plugged when subjected to test at gas pressure equal to the leakage test pressure (see Table 3) at maximum operating temperature, as indicated in the relevant standard. The component shall be conditioned for at least 8 h at this temperature before the test.

10 LOW TEMPERATURE TEST

A LPG containing component shall not leak more than 15 cm$^3$/h with the outlet plugged when subjected to test at gas pressure equal to the leakage test pressure (see Table 3) at the minimum operating temperature of –20 °C. The component shall be conditioned for at least 8 h at this temperature before the test.

Table 2 Hydraulic Test Pressure for Over-Pressure Test

<table>
<thead>
<tr>
<th>Sl No.</th>
<th>Classification of Component</th>
<th>Classification Pressure (kPa)</th>
<th>Hydraulic Test Pressure for Over-Pressure Test (kPa)</th>
</tr>
</thead>
<tbody>
<tr>
<td>i)</td>
<td>Class 1, 3</td>
<td>3 000</td>
<td>6 750</td>
</tr>
<tr>
<td>ii)</td>
<td>Class 1A</td>
<td>2 000</td>
<td>4 500</td>
</tr>
<tr>
<td>iii)</td>
<td>Class 2</td>
<td>450</td>
<td>1 015</td>
</tr>
<tr>
<td>iv)</td>
<td>Class 2 A</td>
<td>120</td>
<td>270</td>
</tr>
<tr>
<td>v)</td>
<td>Class 4</td>
<td>20</td>
<td>45</td>
</tr>
</tbody>
</table>

Table 3 Classification and Leakage Test Pressures

<table>
<thead>
<tr>
<th>Sl No.</th>
<th>Classification of Component</th>
<th>Classification Pressure (kPa)</th>
<th>Test Pressure for Leakage Test (kPa)</th>
</tr>
</thead>
<tbody>
<tr>
<td>i)</td>
<td>Class 1</td>
<td>3 000</td>
<td>4 500</td>
</tr>
<tr>
<td>ii)</td>
<td>Class 1A</td>
<td>2 000</td>
<td>3 000</td>
</tr>
<tr>
<td>iii)</td>
<td>Class 2</td>
<td>450</td>
<td>675</td>
</tr>
<tr>
<td>iv)</td>
<td>Class 2 A</td>
<td>120</td>
<td>180</td>
</tr>
<tr>
<td>v)</td>
<td>Class 3</td>
<td>3 000</td>
<td>6 750</td>
</tr>
<tr>
<td>vi)</td>
<td>Class 4</td>
<td>20</td>
<td>50</td>
</tr>
</tbody>
</table>

11 SEAT LEAKAGE TEST

11.1 The following tests for seat leakage shall be conducted on samples which have previously been subjected to the external leak test mentioned in 8.

11.1.1 Seat leakage tests are conducted with the inlet of the sample valve connected to a source of aerostatic pressure, the valve in the closed position, and with the outlet open. A positive shut-off valve
and a pressure gauge having a pressure range of not less than 1.5 times not more than 2 times the test pressure shall be installed in the pressure supply line. The pressure gauge shall be installed between the positive shut-off valve and the sample under test. During the test, observations for leakage shall be made with the open outlet submerged in water unless otherwise indicated.

**11.1.2 Conformance with 11.2 to 11.4** shall be determined by connecting a length of tubing to the valve outlet. The open end of this outlet tube shall be located within an inverted graduated cylinder which is calibrated in cubic centimetre. The inverted cylinder shall be closed by a water seal. The apparatus shall be adjusted so that,

a) the end of the outlet tube is located approximately 13 mm above the water level within the inverted graduated cylinder; and

b) the water within and exterior to the graduated cylinder is at the same level. With these adjustments made, the water level within the graduated cylinder is to be recorded. With the valve in the closed position assumed as the result of normal operation, air or nitrogen at the specified test pressure is to be applied to the valve inlet for a test period of not less than 2 min. During this time, the vertical position of the graduated cylinder is to be adjusted, if necessary, to maintain the same water level within and exterior to it.

At the end of the test period and with the water within and exterior to the graduated cylinder at the same level, the level of water within the graduated cylinder is again recorded. From the change of volume within the graduated cylinder, the leakage rate shall be calculated according to the following formula:

\[
V_1 = V_i \times \frac{60}{T} \left( \frac{273 \cdot P}{T \cdot 101.6} \right)
\]

where

- \( V_1 \) = leakage rate, cubic centimetre of air or nitrogen/h;
- \( V_i \) = increase in volume within graduated cylinder during test, cm³;
- \( t \) = time of test, in min;
- \( P \) = barometric pressure during test, in kPa; and
- \( T \) = ambient temperature during test, in K.

**11.1.3** Instead of the method described above, leakage may be measured by a flow-meter installed on the inlet side of the valve under test. The flow-meter shall be capable of indicating accurately, for the test fluid employed, the maximum leakage flow rates permitted.

**11.2 The seat of a shut-off valve, when in the closed position, shall be free from leakage at any aerostatic pressure up to 3 000 kPa.**

**11.3 The seat of a service coupling, when in the closed position, shall be free from leakage at any aerostatic pressure up to 3 000 kPa.**

**11.4 The gas-tube pressure relief valve shall not show internal leakage up to 3 000 kPa.**

**12 ENDURANCE TEST**

**12.1 Endurance Test for Shut-off Valve**

**12.1.1** A shut-off valve shall be tested with the valve outlet plugged. The valve body filled with n-hexane and the valve inlet subjected to a pressure of 3 000 kPa.

**12.1.2** An endurance test shall be conducted at a rate not faster than 10 times/min. For a shut-off valve, the closing torque is to be consistent with the size of hand wheel, wrench, or other means employed to operate the valve.

**12.1.3** The appropriate tests for external and seat leakage, as described under external leakage test (see 8) and seat leakage test (see 11) shall be conducted immediately following the endurance test.

**12.2 Endurance Test for Pressure Regulator and Vapourizer**

The regulator shall be able to withstand 50 000 cycles without any failure when tested according to the following procedure:

a) Recycle the regulator for 95 per cent of the total number of cycles at room temperature (see 6.5) and at the classification pressure. Each cycle shall consist of flow until stable outlet pressure has been obtained, after which the gas flow shall be shut off by a downstream valve within 1s, until the downstream lock-up pressure has stabilized. Stabilized outlet pressures are defined as set pressure ± 15 percent for at least 5s.

b) Cycle the inlet pressure of the regulator for 1 percent of the total number of cycles at room temperature (see 6.5) from 100 percent to 50 percent of the classification pressure. The duration of each cycle shall be not less than 10s.

c) Repeat the cycling procedure listed in (a) at 120 °C at the classification pressure (see 6.5) from 100 percent to 50 percent of the classification pressure. The duration of each cycle shall be not less than 10s.

d) Repeat the cycling procedure listed in sub-paragraph (b) at 120 °C at the classification pressure for 1 percent of the total number of cycles.
13 OPERATIONAL TESTS

13.1 Operation Test of the Gas-Tube Pressure Relief Valve

13.1.1 In the case of pressure relief valves, three samples of each size, design, and setting shall be used for start-to-discharge and resealing pressure tests. This same set of three valves shall be used for flow capacity tests for other observations indicated in the following paragraphs.

Not less than two successive start-to-discharge and re-sealing pressure observations shall be made on each of the three test valves under test No. 1 and 3 of 13.1.2 and 13.1.4.

13.1.2 Start-to-Discharge and Resealing Pressures of Pressure Relief Valves — Test No. 1

13.1.2.1 Before being subjected to a flow capacity test, the start-to-discharge pressure of each of three samples of a pressure relief valve of a specific size, design, and setting shall be within +3 percent of the average of the pressures, but the start-to-discharge pressure of any one of the three valves shall be not less than 95 percent, not more than 105 percent, of the set pressure marked on the valve.

13.1.2.2 The re-sealing pressure of a pressure relief valve before being subjected to a flow capacity test shall be not less than 50 per cent of the initially observed start-to-discharge pressure.

13.1.2.3 A pressure relief valve shall be connected to an air or other aerostatic supply source capable of being maintained at a pressure of at least 500 kPa effective pressure above the marked set pressure of the valve being tested. A positive shut-off valve and a pressure gauge having a pressure range of not less than 1.5 times nor more than 2 times the test pressure shall be installed in the pressure supply piping. The pressure gauge shall be installed in the piping between the valve being tested and the positive shut-off valve. Start-to-discharge and resealing pressure shall be observed through a water seal not more than 100 mm in depth.

13.1.2.4 After recording the start-to-discharge pressure of the valve, the pressure shall be increased above the start-to-discharge pressure to ensure unseating of the valve. The shut-off valve is then to be closed tightly and the water seal, as well as the pressure gauge, shall be observed closely. The pressure at which bubbles through the water seal cease shall be recorded as the resealing pressure of the valve.

13.1.3 Flow Capacity of Pressure Relief Valves — Test No. 2

13.1.3.1 The flow capacity of each of three samples of a pressure relief valve of a specific size, design, and setting shall fall within a range of 10 percent of the highest observed capacity.

13.1.3.2 During flow capacity tests on each valve, there shall be no evidence of chattering or other abnormal operating condition.

13.1.3.3 The blow-down pressure of each valve shall be not less than 65 percent of the initially recorded start-to-discharge pressure.

13.1.3.4 A flow capacity test on a pressure relief valve shall be conducted at a flow rating pressure of 120 percent of the maximum set pressure.

13.1.3.5 A flow capacity test on a pressure relief valve shall be conducted by utilizing a properly designed and calibrated orifice flowmeter of the flange type connected to a source of air supply of adequate capacity and pressure. Modifications of the flowmeter from that described herein, and an aerostatic flow medium other than air, may be used provided the end results are the same.

13.1.3.6 The flowmeter shall be arranged with sufficiently long lengths of pipe both preceding and following the orifice, or other arrangements including straightening vanes, to assure no disturbance at the orifice place for the ratios of orifice to pipe diameters to be employed. Flanges between which the orifice plate is located and clamped shall be provided with pressure take-off lines connected to a manometer. This instrument indicates the pressure differential across the orifice plate and the reading shall be used in the flow calculation. A calibrated pressure gauge shall be installed in that portion of the meter pipe downstream of the orifice plate. This gauge indicates the flow pressure and the reading is also used in the flow calculation.

13.1.3.7 A temperature-indicating instrument shall be connected to the meter pipe downstream of the orifice plate to indicate the temperature of the air flowing to the safety valve. The reading of this instrument shall be integrated in the calculation to correct the temperature of the air flow to a 15 °C base
temperature. A barometer shall be available for indicating the prevailing atmospheric pressure. The reading of the barometer shall be added to the indicated air-flow gauge pressure. This absolute pressure is similarly to be integrated in the flow calculation. The air pressure to the flowmeter shall be controlled by a suitable valve installed in the air-supply piping ahead of the flowmeter. The pressure relief valve under test shall be connected either to the discharge end of the flowmeter or upstream side of the flowmeter.

13.1.3.8 After all preparations for flow capacity tests have been made, the valve in the air supply line is to be opened slowly and the pressure to the valve under test shall be increased to the appropriate flow rating pressure. During this interval, the pressure at which the valve ‘pops’ open shall be recorded as the popping pressure.

13.1.3.9 The pre-determined flow rating pressure shall be maintained constant for a brief interval until the readings of the instruments become stabilized. Readings of the flow pressure gauge, pressure differential manometer, and the flowing air temperature indicator shall be recorded simultaneously. The pressure is then to be decreased until there is no further discharge from the valve. The pressure at which this occurs shall be recorded as the blow-down pressure of the valve.

13.1.3.10 From the recorded data and the known orifice coefficient of the flowmeter, the airflow capacity of the pressure relief valve tested shall be calculated using the following formula:

\[ Q = \frac{F_b \cdot F_t \cdot \sqrt{0.1 \cdot h \cdot p}}{60} \]

where

- \( Q \) = flow capacity of pressure relief valve of air at 100 kPa absolute and at 15 °C, in m³/min;
- \( F_b \) = basic orifice factor of flowmeter at 100 kPa absolute and at 15 °C;
- \( F_t \) = flowing air temperature factor to convert recorded temperature to base of 15°C;
- \( h \) = differential pressure across orifice of meter, in kPa;
- \( p \) = flowing air pressure to pressure relief valve absolute (recorded gauge pressure plus recorded barometric pressure), in kPa; and
- 60 = denominator to convert equation from m³/h to m³/min.

13.1.3.11 The average flow capacity of the three pressure relief valves rounded off to the nearest five units is to be taken as the flow capacity of the valve of that specific size, design, and setting.

13.1.4 Re-check Start-to-Discharge and Resealing Pressures of Pressure-Relief-Valves — Test No. 3

13.1.4.1 Subsequent to flow capacity tests, the start-to-discharge pressure of a pressure relief valve shall be not less than 85 percent and the resealing pressure shall be not less than 80 percent of the initial start-to-discharge and resealing pressures recorded under Test No. 1 of 13.1.2.

13.1.4.2 These tests shall be conducted approximately 1 h after the flow capacity test and the test procedure shall be the same as described under Test No. 1 of 13.1.2.

14 LPG COMPATIBILITY TESTS FOR SYNTHETIC MATERIALS

14.1 A synthetic part in contact with liquid or vapour LPG when tested for resistance to \( n \)-pentane according to Annex A with the following conditions shall meet the requirements of change in volume and mass as specified in 14.2:

a) Medium : \( n \)-pentane  
b) Temperature : 23°C  
c) Immersion period : 72 h

14.2 Requirements

a) Maximum change in volume, 20 percent; and
b) After storage in air with a temperature of 40°C for a period of 48 h the change in mass compared to the original value shall not be more than 5 percent.

15 CORROSION RESISTANCE

15.1 A metal LPG containing component shall comply with the leakage tests mentioned in 7, 8, 9 and 10 after having been subjected to 144 h salt spray test according to ISO 9227, with all connections closed or an alternative test specified in 15.2.

15.2 A metal LPG containing component shall comply with the leakage tests mentioned in 7, 8, 9 and 10 and after having been subjected to a salt spray test according to Annex B.

15.3 A copper or copper alloy LPG containing component shall comply with the leakage tests mentioned in 7, 8, 9 and 10 and after having been subjected to 24 h immersion in ammonia according to Annex C (see ISO 6957) with all connections closed.

16 RESISTANCE TO DRY HEAT

The test has to be done in compliance with ISO 188. The test piece has to be exposed to air at a temperature equal to the maximum operating temperature for 168 h. After the ageing the maximum change in tensile strength and ultimate elongation
from the original values shall be as given below:

- Tensile strength: +25 percent
- Ultimate elongation: +10 percent
  -30 percent

17 OZONE AGEING

17.1 The test shall be conducted in accordance with ISO 1431-1/Amendment 1.

The test piece, stressed to 20 percent elongation, shall be exposed to air at 40°C with an ozone concentration of 50 parts per hundred million for 72 h.

17.2 There shall be no crack of the test piece.

18 CREEP

A non-metallic part containing liquid or vapour LPG shall comply with the leakage tests mentioned in 8, 9 and 10 after having been subjected to a hydraulic pressure of 2.25 times the maximum operating pressure at a temperature of 120 °C for minimum 96 h. Water or any other equivalent hydraulic fluid may be used as a test medium.

NOTE — The test may be conducted on the assembly of the component.

19 TEMPERATURE CYCLIC TEST

A non-metallic part containing liquid or vapour LPG shall comply with the leakage tests mentioned in 8, 9 and 10 after having been subjected to a 96 h temperature cycle from the minimum operating temperature up to the maximum operating temperature with a cycle time of 120 min, under maximum working pressure.

NOTE — The test may be conducted on the assembly of the component.

20 COMPATIBILITY WITH HEAT EXCHANGE FLUIDS OF NON-METALLIC PARTS

20.1 Test samples shall be submerged in heat exchange medium for 168 h at 90 °C; then they shall be dried for 48 h at a temperature of 40 °C. The composition of the heat exchange medium used for the test is water/ethylene-glycol fluid of 50 percent/50 percent respectively.

20.2 The test is deemed to be satisfactory, if the change in volume is less than 20 percent, the change in mass is less than 5 percent, the change in tensile strength is less than –25 percent and the change in elongation at break is within –30 percent and +10 percent.

ANNEX A

(Clause 14.1)

DETERMINATION OF THE EFFECT OF \( n \)-PENTANE ON VULCANIZED RUBBER

A-1 PROCEDURE

A-1.1 General

Test pieces shall be prepared in accordance with IS 3400 (Part 6). Alternatively the actual component may be used as test specimen.

Use 3 test pieces for each set of measurements and make any identification marks, if required before immersion.

Immerse the test pieces in the appropriate container using \( n \)-pentane at room temperature (see 6.5).

For total immersion, place the specimens at a distance of at least 5 mm from each other as well as from the sides of the container. Also specimen should be at least 10 mm above the bottom of container and 10 mm below the level of \( n \)-pentane.

The test container should be closed with a cover, and should be shielded from light during the test to avoid evaporation of \( n \)-pentane.

Immerse the test piece for \( 72 \pm 2 \) h in \( n \)-pentane.

At the end of immersion period remove the sample from \( n \)-pentane and gently wipe off any liquid sticking on the surface.

Following removal of test pieces from \( n \)-pentane, it is important that each subsequent manipulation takes place as soon as possible. Carry out the tests immediately after removal of surplus liquid or, for change in mass or volume, by placing the test piece immediately in a weighing bottle.

A-1.2 Change in Mass

Weigh each test piece to the nearest milligram at room temperature (see 6.5) before and after immersion.

Calculate the percentage change in mass \( m_{100} \) as follows:

\[
m_{100} = \frac{m_i - m_o}{m_o} \times 100
\]

where

- \( m_o \) = initial mass of the test piece; and
- \( m_i \) = mass of the test piece after immersion.
Report the result as the average value for the 3 test pieces.

**A-1.3 Change in Volume**

The water displacement method is used for change in volume.

Weigh each test piece in air to the nearest milligram \(m_o\), and then reweigh each test piece in distilled water at the room temperature \(m_{o,w}\) taking care to ensure that all air bubbles are removed.

Immerse each test piece in the \(n\)-pentane. At the end of period of immersion, weigh each test piece in air \(m_i\) to the nearest milligram, and then reweigh each test piece in distilled water \(m_{i,w}\) at room temperature \(\text{see 6.5}\).

Calculate the percentage change in volume \(V_{100}\) using the following equation:

\[
V_{100} = \left[ \frac{m_{i} - m_{i,w}}{m_{o} - m_{o,w}} - 1 \right] \times 100
\]

where

- \(m_o\) = initial mass of the test piece in air;
- \(m_i\) = mass of the test piece in air after immersion;
- \(m_{o,w}\) = initial mass of the test piece in water; and
- \(m_{i,w}\) = mass of the test piece in water after immersion.

Report the result as the average value for the 3 test pieces.

**ANNEX B**

*(Clause 15.2)*

**CORROSION RESISTANCE TEST**

**B-1 TEST APPARATUS**

**B-1.1 Salt Mist Chamber**

The chamber for this test shall be constructed of such material that will not influence the corrosive effects of the salt mist.

The detailed construction of the chamber, including the method of producing the salt mist is optional, provided that,

a) the conditions in the chamber are within the limits specified;

b) a sufficiently large volume with constant, homogeneous conditions (not affected by turbulence) are available; these conditions should not be influenced by the specimen under test;

c) no direct spray impinges upon the specimen under test;

d) drop of liquid accumulating on the ceiling, the walls, or other parts cannot drip on the specimen; and

e) the chamber shall be properly vented to prevent pressure built-up and allow uniform distribution of the salt mist. The discharge end of the vent shall be protected from strong draughts, which can cause strong air currents in the chamber.

**NOTE —** The sprayed solution shall not be re-used.

**B-1.1.1 Atomizer(s)**

The atomizer(s) shall be of such a design and construction as to produce a finely divided, wet, dense mist. The atomizer(s) shall be made of material that is non-reactive to the salt solution.

**B-1.1.2 Air Supply**

If use is made of compressed air, that air shall, when entering the atomizer(s), be essentially free from all impurities, such as oil, dust.

Means shall be provided to humidify the compressed air as required to meet the operating conditions. The air pressure shall be suitable to produce a finely divided dense mist with the atomizer(s) used.

To ensure against clogging of the atomizer(s) by salt deposition, the air is recommended to have a relative humidity of at least 85 percent at the point of release from the nozzle. A satisfactory method is to pass the air in very fine bubbles through a tower containing water, which should be automatically maintained at a constant level. The temperature of this water shall be not less than that of the chamber.

The air pressure shall be capable of adjustment so that the collection rate as specified in **B-3.2** is maintained.

**B-1.2 Humidity Chamber**

The chamber shall maintain a humidity of \(93^{\circ}2\) percent at a temperature of \(40 \pm 2^{\circ}C\).
B-2 SALT SOLUTION

B-2.1 5 percent sodium chloride (NaCl) solution.

B-2.1.1 The salt used for the test shall be high-quality sodium chloride (NaCl) containing, when dry, not more than 0.1 percent sodium iodide and not more than 0.3 percent of total impurities. The salt solution concentration shall be 5 ± 1 percent by weight.

The solution shall be prepared by dissolving 5 ± 1 parts by weight of salt in 95 parts by weight of distilled or demineralized water.

B-2.1.2 The pH value of solution shall be between 6.5 and 7.2 at a temperature of 20 ± 5 °C. The pH value shall be maintained within this range during conditioning; for this purpose, diluted hydrochloric acid or sodium hydroxide may be used to adjust the pH value, provided that the concentration of NaCl remains within the prescribed limits. The pH value shall be measured when preparing each new batch of solution.

B-3 TESTING

B-3.1 Before the test the component shall be cleaned according to the instructions of the manufacturer. All the connections shall be closed off. The component shall not be operated during the test.

B-3.2 The specimen shall be placed in the salt mist chamber, and sprayed with the salt solution, for a period of 2 h at room temperature (see 6.5).

B-3.3 A minimum of two receptacles shall be used to ensure that the salt mist condition is maintained in all parts of the exposure zone. Each clean collecting receptacle with a horizontal collecting area of 80 cm², placed at any point in the exposure zone, shall collect between 1.0 ml to 2.0 ml of solution per hour, averaged over the collecting period. The receptacles shall be placed such that the specimen does not shield them and so that no condensate from any source shall be collected.

NOTE — When calibrating the spray rate of the chamber, a minimum spray period of 8 h should be used for accurate measurement purposes.

B-3.4 After the spraying the component is stored at temperature of 40 ± 2°C and 90 to 95 percent relative humidity for 168 h. This sequence shall be repeated 4 times.

B-3.5 At the end of testing the specimen shall be washed in running tap water for 5 min rinsed in distilled or demineralized water, shaken by hand or subjected to air blast to remove droplets of water, then dried for 1 h at 55 ± 2°C and allowed to cool under controlled recovery conditions for not less than 1 h and not more than 2 h.

ANNEX C
(Clause 15.3)
COPPER AND COPPER ALLOYS—AMMONIA TEST FOR STRESS CORROSION RESISTANCE

C-1 PRINCIPLE
Exposure of test pieces to an ammoniacal atmosphere for 24 h followed by examination for cracks at a magnification of 10X to 15X.

C-2 TERMINOLOGY

C-2.1 Stress Corrosion — A process involving conjoint corrosion and straining of the metal due to residual or applied stress.

C-2.2 Applied Stress — Stress in a body due to application of an external load.

C-2.3 Residual Stress — Stress remaining within a body as the result of plastic deformation.

C-3 REAGENTS AND MATERIALS

C-3.1 Ammonium Chloride 4 mol/l Solution for the Preparation of the Test Solution
Dissolve 107 ± 0.1 g of ammonium chloride (NH₄Cl) in distilled water, make up the volume to 500 ml and keep the solution in a closed vessel.

C-3.2 Sodium Hydroxide, 30 to 50 percent (m/m) solution, for adjusting the pH value.

C-3.3 Clean organic solvent (for example, trichloro ethylene) or hot alkaline solution, for degreasing the test pieces.

C-3.4 Sulphuric Acid, 5 percent (m/m) solution, for cleaning the test pieces.

C-3.5 Hydrogen Peroxide 30 Percent (m/m) Solution, for addition to the pickling solution.

C-4 TEST APPARATUS

C-4.1 Ordinary Laboratory Apparatus

C-4.2 pH Meter

C-4.3 Closed Vessel Such as Desiccator
C-5.1 Slowly add sodium hydroxide solution to ammonium chloride solution to give a test solution with the specified pH value of ± 0.05. Maintain the solution at ambient temperature and dilute with water up to a volume of 1 000 ml. Check the pH value with the pH meter after dilution. Prepare the solution preferably in a fume cupboard in a laboratory and store it in a closed vessel. Before use, check the pH value again, and adjust it, if necessary.

C-5.1.1 On the basis of the known correlation between the behaviour of test pieces in the ammonia test and the behaviour of copper alloy products under service conditions, the following pH values are recommended on being representative of atmospheres of different corrosiveness and corresponding to different safety requirement:

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<th>Corrosiveness of Atmosphere</th>
<th>pH Value</th>
<th>Safety Requirement</th>
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<tr>
<td>Low: Indoor atmosphere under dry conditions</td>
<td>9.3</td>
<td>Low</td>
</tr>
<tr>
<td>Moderate: d) Indoor atmosphere with risk of formation of condensation</td>
<td>9.5</td>
<td>10.0</td>
</tr>
<tr>
<td>Moderate: b) Outdoor atmosphere, temperate climate</td>
<td>9.5</td>
<td>10.0</td>
</tr>
<tr>
<td>High: Atmosphere with ammoniacal pollution, for example in stables</td>
<td>10.0</td>
<td>10.5</td>
</tr>
</tbody>
</table>

C-5.2 The pickling solution for cleaning test pieces before and after testing shall be 5 percent (m/m) sulphuric acid. If necessary, for cleaning test pieces after testing, a small amount of hydrogen peroxide solution may be added to the pickling solution (for example, 20 to 50 ml of hydrogen peroxide solution per litre of pickling solution).

C-6.1 Degrease the test piece using the clean organic solvent or the hot alkaline solution.

C-6.2 After degreasing, clean the test piece in the pickling solution and immediately thereafter thoroughly rinse it, first in cold running water, then in hot water, and finally completely dry it in a stream of warm air.

C-6.3 Allow the dry test piece to reach the exposure temperature between 20 °C and 30 °C, and transfer it to the closed vessel at the same temperature, and containing the freshly prepared test solution at the specified pH value. Place the test piece in the vessel in such a way that the ammonia vapour has free access to all surfaces.

The volume of test solution shall be at least 200 ml per litre of total vessel volume and at least 100 ml/dm² of test piece surface. The exposure temperature shall be between 20 °C and 30 °C.

C-6.4 After exposure, remove the test piece from the closed vessel and immediately clean it in the pickling solution for a few minutes at ambient temperature (below 40°C), that is until the surfaces of the test piece are sufficiently clean from corrosion products to allow observation of possible cracks. After rinsing in water and drying in warm air, as specified in C-6.2 examine the surfaces of the test piece for cracks at a magnification of 10X to 15X. Before inspection, it may be necessary to deform the test piece slightly so that the fine cracks are opened up and more readily seen. For heavy sections, a slice may be cut to facilitate bending. Cracks within a 5 mm wide zone along cut or sawn edges, or around punched markings, originating from the test piece preparation shall be disregarded. For thin sections (below 0.2 mm), check by metallographic examination whether observed cracks represent stress corrosion cracking or intergranular corrosion.
## ANNEX D

(Foreword)

### COMMITTEE COMPOSITION

**Automotive Vehicles Running on Non-conventional Energy Sources Sectional Committee, TED 26**

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<thead>
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<th>Representative(s)</th>
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<td>Automotive Research Association of India, Pune</td>
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