RAKSHA MANTRALAYA
MINISTRY OF DEFENCE

JOINT SERVICES SPECIFICATION

ON

ENVIRONMENTAL TEST METHODS
FOR
SERVICE ELECTRONIC COMPONENTS
(GROUP CLASS 5999)

JSS 50101: 1996
Revision No. 1
Reaffirmed 2001

MANAKIKARAN NIDESHALAYA
RAKSHA UTPADAN TATHA POORTI VIBHAG
RAKSHA MANTRALAYA, 'H' BLOCK, DHQ PO
NEW DELHI - 110 011

DIRECTORATE OF STANDARDISATION
DEPARTMENT OF PRODUCTION & SUPPLIES
MINISTRY OF DEFENCE, 'H'- BLOCK, DHQ PO
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MINISTRY OF DEFENCE, 'II'- BLOCK, DHQ PO
NEW DELHI - 110 011
This reaffirmation of Joint Services Specification has been approved by Maj Gen AR Nambiar, Chairman, Electronic Standardisation Sub Committee in the meeting held on 24 Aug 2000/ by circulation.

2. The following members have been associated in approving the draft:

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Name and Designation</th>
<th>Organisation</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Shri PK Jain, Sc ‘G’</td>
<td>LCSO, Bangalore</td>
</tr>
<tr>
<td>2.</td>
<td>Shri MN Sen, Sc ‘G’</td>
<td>SSPL, new Delhi</td>
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<tr>
<td>3.</td>
<td>Brig ML Mathur</td>
<td>CQA (L), Bangalore</td>
</tr>
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<td>4.</td>
<td>Shri VN Ray, Sc ‘F’</td>
<td>DSC, Bangalore</td>
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<td>5.</td>
<td>Shri V Gopalkrishnan, Sc ‘F’</td>
<td>LRDE, Bangalore</td>
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<tr>
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<td>Shri S Krishnan, Sc ‘F’</td>
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<td>Shri S Mallikarjun, AGM</td>
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<tr>
<td>8.</td>
<td>Shri SK Kimothi, Addl Director</td>
<td>STQC, DOE, New Delhi</td>
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<td>9.</td>
<td>Shri Prakash Chand, Sc ‘E’</td>
<td>DEAL, Dehradun</td>
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<tr>
<td>10.</td>
<td>Cdr VKC Bakshi</td>
<td>JCES, New Delhi</td>
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<tr>
<td>11.</td>
<td>Lt Col J Nagarajun</td>
<td>CQA (AVL), Avadi</td>
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<tr>
<td>12.</td>
<td>Col Mahesh Chand</td>
<td>D of L&amp;I, DRDO</td>
</tr>
<tr>
<td>13.</td>
<td>Gp Capt K Ramachandran, JDGCA</td>
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</tr>
<tr>
<td>14.</td>
<td>Lt Col Ravi Mandla, JD</td>
<td>OS (L), AHQ</td>
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<tr>
<td>15.</td>
<td>Shri A Pratap Kumar</td>
<td>CRI, C/O BE (GAD)</td>
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<td>Shri M Arun Kumar, Chief Engineer</td>
<td>ITI, Bangalore</td>
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<td>21.</td>
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<td>DQA (N), New Delhi</td>
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<tr>
<td>22.</td>
<td>Shri JR Kamal, JDO</td>
<td>DOS (L), NHQ</td>
</tr>
<tr>
<td>23.</td>
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<td>HQ TGEME, Delhi Cantt</td>
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<td>25.</td>
<td>Lt Col Satwant Singh</td>
<td>Secretary, LSSC</td>
</tr>
<tr>
<td>26.</td>
<td>Lt Col CJ Singh</td>
<td>Dte of Signals, AHQ</td>
</tr>
<tr>
<td>27.</td>
<td>-</td>
<td>WE Dte (WE-7), AHQ</td>
</tr>
<tr>
<td>28.</td>
<td>-</td>
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</tr>
<tr>
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</tr>
<tr>
<td>30.</td>
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<td>Dte of Rocket and Missile</td>
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<tr>
<td>31.</td>
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## RECORD OF AMENDMENTS

<table>
<thead>
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<th>Amended by Name &amp; Appointment (IN BLOCK LETTERS)</th>
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</table>
## CONTENTS

<table>
<thead>
<tr>
<th>S.No.</th>
<th>Page No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td><strong>FOREWORD</strong></td>
</tr>
</tbody>
</table>

### SECTION-1

GENERAL INFORMATION

1. **SCOPE**  
2. **RELATED SPECIFICATIONS**  
3. **TERMINOLOGY**  
4. **INDEX OF TESTS**  
5. **DEGREES OF SEVERITY**  
6. **COMPONENT CLASSIFICATION**  
7. **STANDARD TEST SEQUENCE**  
8. **NUMBER OF COMPONENTS FOR TESTING**  
9. **MEASUREMENTS**  
10. **SEALING TEST**  
11. **DUST TEST**

### SECTION-2

STANDARD ATMOSPHERIC CONDITIONS

12. **REFERENCE CONDITIONS**  
13. **REFEREE CONDITIONS**  
14. **ATMOSPHERIC CONDITIONS FOR TESTING**  
15. **RECOVERY CONDITIONS**

### SECTION-3

NOTES FOR THE GUIDANCE OF TEST PERSONNEL

16. **POSITIONING OF COMPONENTS IN THE TEST CHAMBER**  
17. **INSULATION RESISTANCE MEASUREMENT**  
18. **VOLTAGE PROOF TEST**  
19. **WORKING TEST**
<table>
<thead>
<tr>
<th>TEST NUMBER</th>
<th>DESCRIPTION OF TESTS</th>
<th>PAGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>-1</td>
<td>ACCELERATION (STEADY STATE)</td>
<td>13</td>
</tr>
<tr>
<td>-2</td>
<td>AIR PRESSURE (LOW)</td>
<td>15</td>
</tr>
<tr>
<td>-3</td>
<td>CORROSIVE ATMOSPHERE (INDUSTRIAL)</td>
<td>17</td>
</tr>
<tr>
<td>-4</td>
<td>CORROSIVE ATMOSPHERE (SALT MIST)</td>
<td>18</td>
</tr>
<tr>
<td>-5</td>
<td>DAMP HEAT (CYCLIC)</td>
<td>22</td>
</tr>
<tr>
<td>-6</td>
<td>DAMP HEAT (MOISTURE RESISTANCE)</td>
<td>27</td>
</tr>
<tr>
<td>-7</td>
<td>DAMP HEAT (STEADY STATE)</td>
<td>33</td>
</tr>
<tr>
<td>-8</td>
<td>DUST</td>
<td>37</td>
</tr>
<tr>
<td>-9</td>
<td>EXPLOSION</td>
<td>42</td>
</tr>
<tr>
<td>10</td>
<td>FLAMMABILITY</td>
<td>43</td>
</tr>
<tr>
<td>11</td>
<td>IMPACT (BUMP)</td>
<td>46</td>
</tr>
<tr>
<td>11A</td>
<td>IMPACT (RANDOM DROP)</td>
<td>51</td>
</tr>
<tr>
<td>12</td>
<td>IMPACT (SHOCK)</td>
<td>58</td>
</tr>
<tr>
<td>13</td>
<td>LIFE (ELECTRICAL/MECHANICAL)</td>
<td>65</td>
</tr>
<tr>
<td>14</td>
<td>MOULD GROWTH</td>
<td>68</td>
</tr>
<tr>
<td>15</td>
<td>RESISTANCE TO SOLDERING HEAT</td>
<td>73</td>
</tr>
<tr>
<td>15A</td>
<td>RESISTANCE TO SOLVENTS</td>
<td>79</td>
</tr>
<tr>
<td>16</td>
<td>ROBUSTNESS OF TERMINATIONS</td>
<td>84</td>
</tr>
<tr>
<td>17</td>
<td>SEALING (STATIC AND OPERATIONAL SEALS)</td>
<td>91</td>
</tr>
<tr>
<td>18A</td>
<td>SEALING (GAS LEAKAGE)</td>
<td>93</td>
</tr>
<tr>
<td>18B</td>
<td>SEALING (SEEPAGE OF FILLING LIQUID)</td>
<td>96</td>
</tr>
<tr>
<td>18D</td>
<td>SEALING (TRACER GAS)</td>
<td>98</td>
</tr>
<tr>
<td>18E</td>
<td>SEALING (IMMERSION)</td>
<td>103</td>
</tr>
<tr>
<td>19</td>
<td>SOLDERABILITY</td>
<td>107</td>
</tr>
</tbody>
</table>
TEST NUMBER-20  TEMPERATURE CYCLING
TEST NUMBER-21  TEMPERATURE (COLD)
TEST NUMBER-22  TEMPERATURE (DRY HEAT)
TEST NUMBER-23  VIBRATION
TEST NUMBER-24  VIBRATION (RANDOM)

SECTION-5

1. SUGGESTIONS FOR IMPROVEMENT  134

APPENDIX-A  METHOD OF ACHIEVING CONSTANT RELATIVE HUMIDITY  135

APPENDIX-B  TEST SET UP FOR TESTING STATIC AND OPERATIONAL SEALS  136

APPENDIX-C  GROUPING AND SEQUENCE OF TESTS  139
0. FOREWORD

0.1 This specification has been prepared by the Electronic Components Standardisation Organisation (LCSO) on behalf of Electronic Standardisation Sub Committee (LSSC) on the authority of Standardisation Committee, Ministry of Defence.

0.2 This specification has been approved by the Ministry of Defence and is mandatory for use by the Defence Services.

0.3 This specification would be used to guide design, manufacture, quality assurance and procurement of Service electronic components.

0.4 Quality Assurance Authority for the item covered by this specification is CQA (L) for Army DQA (N) FOR NAVY AND DGAQA FOR AIR Force Enquiries regarding this specification relating to any contractual conditions, shall be addressed to the Quality Assurance Authority named in the tender or contract. Other technical enquiries shall be referred to:

   The Officer-in-Charge,
   Electronic Components Standardisation Organisation,
   Electronics and Radar Development Establishment,
   DRDO Complex,
   C V Raman -Nagar,
   Bangalore - 560 093.

0.5 Copies of this specification can be obtained on payment from:

   The Controller,
   Controllerate of Quality Assurance (Electronics),
   Jayachamrajendra Nagar PO.,
   Bangalore - 560 006.

0.6 This specification holds good only for the supply order for which it is issued.
SECTION-1

GENERAL INFORMATION

1. SCOPE

1.1 This specification describes standard procedures and conditions for environmental tests for Service electronic components. The tests specified herein are intended to serve the need for predetermining the potential causes of failure of components under Service environments. In some of the tests, the severity conditions are varied in order to enable the designers to select components to meet the requirements of the relevant equipment specification.

1.2 The acceptable performance limits of the components during environmental tests are not included in this specification. The relevant component specification shall define the acceptable performance limits during and after the specified environmental tests.

1.3 This specification shall always be invoked in the relevant component specification so that equipment designers shall have a common basis of comparison for the performance of components supplied to Joint Services Specifications.

1.4 The tests included in this specification do not cover all Service environments and additional tests, where necessary, may need to be specified in the relevant component specification.

1.5 The relevant component specification shall specify the deviations in test procedure which may be necessary when applying the test and also any special procedures which may be required.

2. RELATED SPECIFICATIONS

2.1 Joint Services Specifications

<table>
<thead>
<tr>
<th>Specification</th>
<th>Description</th>
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<tbody>
<tr>
<td>JSS 50102:1985 (Revision No. 1)</td>
<td>General specification and procedure for the qualification and approval and acceptance of electronic components</td>
</tr>
<tr>
<td>Reaffirmed 2000</td>
<td></td>
</tr>
<tr>
<td>JSS 51701:1975</td>
<td>Specification for metal clad base material (for printed wired boards of thickness 0.8 mm or greater)</td>
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<tr>
<td>Reaffirmed 1999</td>
<td></td>
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<tr>
<td>JSS 55555:2000</td>
<td>Environmental test methods for electronic and electrical equipment</td>
</tr>
<tr>
<td>Revision No. 2</td>
<td></td>
</tr>
</tbody>
</table>
2.2 **Other Specifications**

IS 193:1982 Soft solder (fourth revision)


IS 1921:1975 Rosin-cored solder wire (first revision) (Amendment No. 1) Reaffirmed 1991

IS 10005:1994 SI units and recommendations for the use of their multiples and of certain other unit (second revision)

2.3 **Source of supplies**

2.3.1 Copies of Joint Services Specifications are obtainable on payment from: -

The Controller, Controllerate of Quality Assurance (Electronics), Jayachamrajendra Nagar PO, Bangalore - 560 006

2.3.2 Copies of Indian Standards are obtainable on payment from: -

Bureau of Indian Standards
Manak Bhavan
9, Bahadur Shah Zafar Marg,
New Delhi - 110 002
or their regional/branch offices

3. **TERMINOLOGY**

The following, definitions shall apply: -

3.1 Ambient Temperature - The temperature of the medium surrounding the components.
3.2 Final Measurements - The measurements made at the conclusion of a test so that a comparison with the initial measurements will show what effect the whole test has had on the components.

3.3 Initial Measurements - The measurements made prior to a test to determine the characteristics of the components.

3.4 Intermediate Measurements - The measurements made during the test to determine the effects of the test conditions on the characteristics of the components.

3.5 Preconditioning - The treatment of a component with the object of removing or partly counteracting effects of its previous history. Where called for, it is the first process in the test procedure.

3.6 Recovery - The treatment given to a component after testing in order that it may return to a stable state before final measurements.

3.7 Recovery Conditions - These are defined in Section 2.

3.8 Temperature Stability - Temperature stability is considered to have been reached when the difference between the temperature at any specified point on the component and the ambient temperature is less than 3° C.

NOTE - This specification is applicable when the component is in non-heat generating state.

3.9 Test - A complete series of operations covered under a test heading.

3.10 Test Chamber - An enclosure having a working space in which the components are exposed to the specified environmental test conditions.

3.11 Working Space - The space inside a test chamber in which the specified environmental test conditions are maintained.
4. INDEX OF TESTS

4.1 The environmental tests described in this specification are shown in Table I.

**TABLE I: ENVIRONMENTAL TESTS**
(Clauses 4.1 and 5.1)

<table>
<thead>
<tr>
<th>TEST</th>
<th>TEST NUMBER OF SECTION 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acceleration (steady state)</td>
<td>1</td>
</tr>
<tr>
<td>Air pressure (low)</td>
<td>2</td>
</tr>
<tr>
<td>Corrosive atmosphere (industrial)</td>
<td>3</td>
</tr>
<tr>
<td>Corrosive atmosphere (salt mist)</td>
<td>4</td>
</tr>
<tr>
<td>Damp heat (cyclic)</td>
<td>5</td>
</tr>
<tr>
<td>Damp heat (moisture resistance)</td>
<td>6</td>
</tr>
<tr>
<td>Damp heat (steady state)</td>
<td>7</td>
</tr>
<tr>
<td>Dust</td>
<td>8</td>
</tr>
<tr>
<td>Explosion</td>
<td>9</td>
</tr>
<tr>
<td>Flammability</td>
<td>10</td>
</tr>
<tr>
<td>Impact (bump)</td>
<td>11</td>
</tr>
<tr>
<td>Impact (random drop)</td>
<td>11A</td>
</tr>
<tr>
<td>Impact (shock)</td>
<td>12</td>
</tr>
<tr>
<td>Life (electrical/mechanical)</td>
<td>13</td>
</tr>
<tr>
<td>Mould growth</td>
<td>14</td>
</tr>
<tr>
<td>Resistance to soldering heat</td>
<td>15</td>
</tr>
<tr>
<td>Resistance to solvents</td>
<td>16</td>
</tr>
<tr>
<td>Robustness of terminations</td>
<td>17</td>
</tr>
<tr>
<td>Sealing</td>
<td>18A, 18B, 18C, 18D, 18E</td>
</tr>
<tr>
<td>Solderability</td>
<td>19</td>
</tr>
<tr>
<td>Temperature cycling</td>
<td>20</td>
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<tr>
<td>Temperature (cold)</td>
<td>21</td>
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<tr>
<td>Temperature (dry heat)</td>
<td>22</td>
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<tr>
<td>Vibration</td>
<td>23</td>
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<tr>
<td>Vibration (random)</td>
<td>24</td>
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</table>
5. DEGREES OF SEVERITY

5.1 Some of tests given in Table I have degrees of severity as shown in Table 2.

**TABLE 2: DEGREES OF SEVERITY**
(Clause 5.1)

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<tr>
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<td><strong>Acceleration' (m/s²)</strong></td>
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<tr>
<td>A 10</td>
<td></td>
<td>170</td>
</tr>
<tr>
<td>A II</td>
<td></td>
<td>500</td>
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<td>A 12</td>
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<td>A 19</td>
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<td>200,000</td>
</tr>
<tr>
<td>Air pressure (low)</td>
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<td><strong>Pressure (kPa)</strong></td>
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<td>P 10</td>
<td></td>
<td>106-86</td>
</tr>
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<td>P II</td>
<td></td>
<td>70</td>
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<td>P 12</td>
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<td>60</td>
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TABLE 2 DEGREES OF SEVERITY (Continued)

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<td></td>
<td></td>
<td>No. of Cycles</td>
</tr>
<tr>
<td>H 12</td>
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<td>2</td>
</tr>
<tr>
<td>Damp heat</td>
<td>H 13</td>
<td>6</td>
</tr>
<tr>
<td>H 14</td>
<td></td>
<td>Test Number 6</td>
</tr>
<tr>
<td></td>
<td>Peak acceleration (m/s²)</td>
<td>Duration of pulse (ms)</td>
</tr>
<tr>
<td>S 10</td>
<td>300</td>
<td>18</td>
</tr>
<tr>
<td>S II</td>
<td>300</td>
<td>II</td>
</tr>
<tr>
<td>S 12</td>
<td>500</td>
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<td>S 13</td>
<td>750</td>
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<td>Impact</td>
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<td>(Shock)</td>
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<td>15,000</td>
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<td></td>
<td>S 18</td>
<td>30,000</td>
</tr>
<tr>
<td>Temperature (°C)</td>
<td>See Note 1</td>
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<tr>
<td>(cold)</td>
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<td>- 40</td>
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<td>- 65</td>
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<tr>
<td>Temperature (dry heat)</td>
<td>See Note 1 and Note 2</td>
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<td>125</td>
</tr>
<tr>
<td></td>
<td></td>
<td>150</td>
</tr>
<tr>
<td></td>
<td></td>
<td>200</td>
</tr>
<tr>
<td></td>
<td></td>
<td>350</td>
</tr>
<tr>
<td></td>
<td></td>
<td>500</td>
</tr>
</tbody>
</table>
### TABLE 2: DEGREES OF SEVERITY (Continued)

<table>
<thead>
<tr>
<th>TEST</th>
<th>SEVERITY</th>
<th>VALUE</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Frequency range (Hz)</td>
<td>Break value of vibration amplitude +/– 10%</td>
</tr>
<tr>
<td>V 10</td>
<td>10-55</td>
<td>0.75 mm</td>
</tr>
<tr>
<td>V 11</td>
<td>10-500</td>
<td>0.75 mm or 100 m/s whichever is less</td>
</tr>
<tr>
<td>V 12</td>
<td>10-2000</td>
<td>0.75 mm or 100 m/s whichever is less</td>
</tr>
<tr>
<td>V 13</td>
<td></td>
<td></td>
</tr>
<tr>
<td>V 14</td>
<td>10-2000</td>
<td>0.75 mm or 150 m/s whichever is less</td>
</tr>
<tr>
<td>V 15</td>
<td>10-2000</td>
<td>0.75 mm or 200 m/s whichever is less</td>
</tr>
<tr>
<td></td>
<td>10-2000</td>
<td>0.75 mm or 500 m/s whichever is less</td>
</tr>
</tbody>
</table>

NOTE-1 - Temperature severity is indicated as combined severity of temperature (cold) and temperature (dry heat). For instance, T55/125 would indicate – 55°C as the severity of temperature (cold) and 125°C as the severity of temperature (dry heat).

NOTE-2 - The surface temperature of heat generating components will exceed the ambient temperature. Therefore, a component when dissipating power in an ambient temperature of 100°C, will have a surf temperature of X deg C which will cause the surface temperature of the component to become 100°C + X deg C. The relevant component specification may limit the surface temperature for the purpose of rating, at any specified air pressure.

### 6. COMPONENT CLASSIFICATION

6.1 The relevant component specification shall specify the severities of the applicable environmental tests.

### 7. STANDARD TEST SEQUENCE

7.1 The tests shall normally be applied in a specified sequence conforming to specified test groups or components as shown in Appendix "C". Where deviations from the sequence are justified, these will be indicated in the relevant component specification.
7.2 When an interval between two tests become necessary, NOTE 3 in Appendix 'C' shall always apply.

8. **NUMBER OF COMPONENTS FOR TESTING**

8.1 The total number of components which shall be tested and the number of components in each group shall be detailed in the relevant component specification.

9. **MEASUREMENTS**

9.1 Measurements relating to characteristics of a component are made initially, at specified intervals during the tests and at the conclusion of the tests. This is to establish any change in the characteristics due to the environmental condition applied during the tests.

9.2 Final measurements made at the end of one test may be taken as the initial measurements for the subsequent test.

9.3 Measurements on components may be made before the expiry of the full recovery period, in case of failure; the measurement shall be repeated after the specified recovery period (See 15.1).

10. **SEALING TEST**

10.1 Sealing test is not included in Appendix C' as it is regarded as an initial, intermediate or final measurement. The relevant component specification shall, therefore, specify in which test group and at what stage, this is to be performed.

11. **DUST TEST**

11.1 Dust test is not included in Appendix "C" as it is considered as a special test for components. Where its application is warranted, the relevant component specification shall include this test suitably in the sequence.
SECTION-2

STANDARD ATMOSPHERIC CONDITIONS

12. REFERENCE CONDITIONS

12.1 If the characteristics of the component to be measure depend on temperature and/or air pressure and the law of dependence is known, the values shall be measured under the atmospheric conditions for testing (See 14)' and if necessary corrected by calculation to the following reference values:

(a) Temperature  20 or 25°C  
(b) Air pressure 101.3 kPa

NOTE-1 -20°C shall be preferred.

NOTE-2 - No requirement for relative humidity in given as a correction by calculation is general not possible.

13. REFEREE CONDITIONS

13.1 If the characteristics of the component to be measure depend on temperature, air pressure and relative humidity and the law of dependence is unknown, the measurements shall be mad under one of the following conditions: -

a) Temperature:  between 19°C and 21°C  
Relative humidity: between 63 and 67 per cent  
Air pressure: between 86 k Pa and 106 k Pa

b) Temperature:  between 24 °C and 26°C  
Relative humidity: between 48 and 52 per cent  
Air pressure: between 86 k Pa and 106 k Pa

NOTE -1 - Suitable methods of achieving these relative Humidity’s are described in Appendix "A".

NOTE-2 - Referee condition (s) shall be preferred.

14. ATMOSPHERIC CONDITIONS FOR TESTING

14.1 Initial and final measurements shall be made under any combination of temperature, relative humidity and air pressure within the following limits:

a) Temperature : 15 to 35 °C  
b) Relative humidity : 4.5 to 75 per cent  
c) Air pressure : 86 to 106 kPa
14.2 Where it is impracticable or unnecessary to make measurements under the atmospheric conditions for testing stated above, a note to this effect, if required, stating the actual conditions, shall be added to the test report.

15. RECOVERY CONDITIONS

15.1 Recovery conditions shall be the atmospheric conditions for testing unless closer control of temperature and relative humidity is required, when the appropriate referee conditions shall be used. The period applicable shall be specified in the relevant component specification (See 9.3).
NOTES FOR THE GUIDANCE OF TEST PERSONNEL

16. POSITIONING OF COMPONENTS IN THE TEST CHAMBER

16.1 Unless otherwise specified, components shall be mounted in various orientations. The orientations adopted shall be recorded. Particular attention shall be paid, especially in the case of heat dissipating components, to the spacing between them. The total volume occupied by the components shall be small in relation to the effective volume of the working space of the chamber. Necessary connections to the test instruments and power supplies shall be made before commencing the test.

17. INSULATION RESISTANCE MEASUREMENT

17.1 Measurement of the insulation resistance of certain components may require the use of special techniques such as:

17.1.1 Guard Ring - A guard ring method shall preferably be used whenever it is necessary to discriminate between leakage through the insulation and leakage due to surface moisture.

17.1.2 Removal of Surface Moisture by an Air Blast - Where the test to be applied within 15 minutes after removal from a damp heat chamber involves measurement of insulation resistance, moisture on the external surfaces may make the measurement unstable. A blast of air of relative humidity not greater than 75 per cent at normal temperature may then be used if allowed in the relevant component specification, for the minimum time required to remove visible surface moisture.

18. VOLTAGE PROOF TEST

18.1 This test shall be carried out with a current limiter in the supply circuit, such that the current resulting from a short circuit of the component under test shall not exceed 2 mA or any other value specified in the relevant component specification.

19. WORKING TEST

19.1 The working test to be applied to a component shall be specified in the relevant component specification. This will normally take the form of the application of working voltage to the components from a low impedance source. Protection shall be provided by suitably rated low time-constant fuse or cutout.
SECTION-4
DESCRIPTION OF TESTS

TEST NUMBER -1
ACCELERATION (STEADY STATE)

1. OBJECT

1.1 The object of this test is to determine the structural suitability and satisfactory performance of components during and after subjection to a steady state acceleration.

2. TEST EQUIPMENT

2.1 The specified acceleration shall be applied by means of a suitable centrifuge.

3. TEST PROCEDURE

3.1 Mounting of Components

3.1.1 The components shall be secured to the centrifuge either directly or by means of a fixture as specified in 3.1.2 to 3.1.7.

3.1.2 Mounting fixtures shall be such as to subject the components to acceleration in each plane and sense as specified.

3.1.3 Components having a unique method of mounting shall be so mounted. For severities A16, A17, A18 and A19, suitable protection shall be provided for component terminations.

3.1.4 The mounting of components not provided with unique means of mounting shall be such that the test conditions applied should dynamically load the body and/or terminations. Either the body and the terminations or the terminations only, may be clamped, as specified by the relevant component specification.

3.1.5 Components with axial terminations weighing less than 15 grams shall be secured to rigid pillars leaving 5 to 8 mm between the point of emergence of the terminations and the pillars. Similar components weighing 15 grams and more shall be clamped so as to avoid any stress on the terminations.

3.1.6 Components with radial terminations and components having unusual mass distribution shall be mounted as specified in the relevant component specification.
3.1.7 External connections made to the components for power supply and measurements shall add a minimum of mass and place a minimum of restraint on the components.

3.2 **Testing**

3.2.1 The relevant component specification shall specify the applicable acceleration severity (see 5.1 of Section I Table 2).

3.2.2 The specified acceleration severity shall be applied to the components in both senses in each of the three mutually perpendicular planes, unless otherwise specified by the relevant component specification.

3.2.3 For A10, A11 and A12 severities, the duration of the acceleration in each sense shall be 5 minutes, so that the components are accelerated for a total period of 30 minutes.

3.2.4 For A13, A14 and A15 severities the duration of acceleration in each sense shall be as specified in the relevant component specification.

3.2.5 For A16, A17, A18 and A19 severities, the duration of the acceleration in each sense shall be 1 minute, so that, the components are accelerated for a total period of 6 minutes. For these four severities, the rise and decay times of the acceleration shall each be not less than 20 seconds.

3.2.6 The acceleration measured at any point on the component shall be within 15 per cent of the specified value unless otherwise specified.

3.2.7 During the test, components shall be loaded and/or operated and measured, if so specified by the relevant component specification.

4. **INFORMATION TO BE GIVEN IN THE RELEVANT COMPONENT SPECIFICATION**

(a) Preconditioning, if any.
(b) Initial measurements.
(c) Details of test equipment if other than a centrifuge (see 2.1)
(d) Any special mounting requirements (see 3.1)
(e) The applicable severity (see 3.2.1).
(f) Test duration for A13, A14 and A15 severities (see 3.2.4).
(g) Details of electrical loading (see 3.2.7).
(h) Intermediate measurements and time intervals.
(j) Final measurements.
(k) Acceptable performance limits.
(l) Any deviation from the normal test procedure.
1. **OBJECT**

1.1 The object of this test is to determine the ability of components to withstand exposure conditions of air pressure (low).

2. **TEST CHAMBER**

2.1 The chamber used for this test shall be capable of maintaining the required air pressure (low) to within ± 5 per cent of the appropriate severity over the period of the test.

3. **TEST PROCEDURE**

3.1 **Testing**

3.1.1 The components shall be placed in the chamber at the specified temperature, if other than that specified for atmospheric conditions for testing and the air pressure within the chamber shall be steadily reduced in 10 minutes or as specified in the relevant component specification to the appropriate severity. The specified air pressure (low) shall be maintained for the period specified.

3.1.2 While at the air pressure (low), the components shall be tested in accordance with the relevant component specification.

3.1.3 At the end of the test period, the air pressure in the chamber shall be returned steadily to normal using dry air in 10 minutes or as specified in the relevant component specification. Care shall be taken that no condensation shall occur on the components during their return to laboratory temperature in the testing chamber.

   **NOTE.** - When this test is performed at low or high temperatures, the chamber temperature shall be brought to the appropriate temperature severity before reducing the air pressure.

3.2 **Recovery**

3.2.1 The components shall be removed from the test chamber and allowed to remain under recovery conditions for a period of 1 to 2 hours or as specified by the relevant component specification (see Note 3 to Appendix 'C' for exception).
4. INFORMATION TO BE GIVEN IN THE RELEVANT COMPONENT SPECIFICATION

(a) Preconditioning, if any.

(b) Initial measurements.

(c) The appropriate severity (see 3.1.1).

(d) The temperature (s) at which the test should be conducted, if other than that specified for atmospheric conditions for testing (see 3.1.1).

(e) The duration of the test (see 3.1.1).

(f) Time duration for reduction of air pressure if oilier than 10 minutes (see 3.1.1) and time duration for restoration of air pressure to normal if other than 10 minutes (see 3.1.3).

(g) Appropriate electrical loading.

(h) Intermediate measurements and time intervals (see 3.1-.2).

(j) Final measurements.

(k) Acceptable performance limits.

(l) Any deviation from the normal tests procedure.
TEST NUMBER-3

CORROSIVE ATMOSPHERE (INDUSTRIAL)

UNDER CONSIDERATION
TEST NUMBER-4

CORROSIVE ATMOSPHERE (SALT MIST)

1. **OBJECT**

1.1 The object of this test is to determine the suitability of metals and protective coatings (metallic and non-metallic) of components when subjected to a salt laden atmosphere.

2. **TEST CHAMBER**

2.1 The chamber and all its accessories shall be made of such materials that are not themselves affected by the salt laden atmosphere or do not give rise to electrolytic corrosion, when in contact with each other or the components.

2.2 The chamber shall consist of a lower part and an upper part connected together. The components shall be placed in the upper part and the mist shall be produced, in the lower part so that the spray does not directly impinge on the components. Components shall be so arranged that no condensate can drip on them and the spray circulates freely about all components to the same degree. The liquid that comes in contact with the components during exposure shall not return to the salt solution reservoir. The chamber shall be vented.

2.3 The working space of the chamber shall be capable of maintaining the temperature of 35° C ± 2 degC. Satisfactory methods for controlling the temperature accurately shall be by housing the apparatus in a properly controlled constant temperature room, by thoroughly insulating the apparatus and preheating the air to the proper temperature prior to atomization, and by jacketing the apparatus and controlling the temperature of the water or the air used. The use of immersion heaters within the chamber shall be prohibited.

2.4 The conditions maintained at all part of working space shall be such that a suitable fog collecting receptacle placed at any point in the exposure zone shall collect from 0.5 to 3.0 ml of solution per hour for each 80 cm’ of horizontal collecting area (10 cm dia) based on an average run of at least 16 hours. At least two clean fog collecting receptacles shall be used, one placed near any nozzle and the other placed as far as possible from all nozzles. The receptacles shall be fastened to ensure that they are not shielded by the components and that no drops of solution from components or other sources are collected. With nozzle made of material non-reactive to the salt solution, suitable atomization has been obtained in chambers having a volume of less than 0.34 m3- with the following conditions:

(a) Nozzle pressure from 83 to 124 k Pa.
(b) Orifices from 0.51 to 0.76 mm dia.
(c) Atomization of approximately 2.9 liters of salt solution per 0.283 m$^3$ of chamber volume per 24 hours.

When using chambers considerably in excess of 0.34 m$^3$ the above conditions may have to be modified in order to meet the requirement for operating conditions.

2.5 The spray shall be produced by suitable atomizers employing compressed air. The compressed air shall be free from all impurities such as oil and dirt. Means shall be provided to humidify and warm the compressed air required to meet the operating conditions. The air pressure shall be suitable to produce a finely divided dense fog with the atomizer or atomizers used. To insure against clogging, of the atomizer by salt deposition, the air shall have a relative humidity of at least 85 per cent for the 20 per cent solution and between 95 and 98 per cent for the 5 per cent solution, at the point of release from the nozzle. A satisfactory method is to pass the air in very fine bubbles through a tower containing heated water. The temperature of the water should be 35° C, and often higher. The permissible temperature increases with increasing volume of air and with decreasing heat insulation of the chamber and temperature of its surroundings. It should not exceed a value above which an excess of moisture is introduced into the chamber (for example, 44° C at an air pressure of 85 kPa), or a value which makes it impossible to meet the requirements for operating temperature.

2.6 The salt solution used shall either be 5 or 20 per cent. The 5 per cent salt solution shall, however, be preferred, unless the relevant component specification specifies otherwise.

2.7 The distilled water used for making the salt solution shall not contain more than 200 parts per million of total solids.

2.8 The composition and characteristics of the salt solution shall be as stated in Table 4-1.

**TABLE 4-1 COMPOSITION OF SALT SOLUTION**

<table>
<thead>
<tr>
<th>Requirements</th>
<th>20 Per Cent Solution</th>
<th>5 Per Cent Solution</th>
</tr>
</thead>
<tbody>
<tr>
<td>Distilled water by mass</td>
<td>80 Parts</td>
<td>95 parts</td>
</tr>
<tr>
<td>Salt by mass 1/2/</td>
<td>20 parts</td>
<td>5 parts</td>
</tr>
<tr>
<td>Specific Gravity</td>
<td>1.126 to 1.157</td>
<td>1.0268 to 1.0413</td>
</tr>
<tr>
<td>pH (35° C ± 1 degO)</td>
<td>6.5 to 7.2</td>
<td>6.5 to 7.2</td>
</tr>
</tbody>
</table>
3. **TEST PROCEDURE**

3.1 **Preconditioning**

3.1.1 Components shall be given a minimum of handling, particularly on the significant surfaces, and shall be prepared for test immediately before exposure. Unless otherwise specified, uncoated metallic or metallic-coated components shall be thoroughly cleaned of oil, dirt and grease, as necessary until the surface is free from water break. The cleaning methods shall not include the use of corrosive solvents nor solvents which deposit either corrosive or protective films, nor the use of abrasives other than a paste of pure magnesium oxide. Components having an organic coating shall not be solvent cleaned. Those portions of components which come in contact with the support and, unless otherwise specified, in the case of coated components, cut edges and surfaces not required to be coated, shall be protected with a suitable coating of wax or similar substance impervious to moisture.

3.2 **Testing**

3.2.1 Unless otherwise specified, flat components and, where practicable, other components shall be supported in such a position that the significant surface is approximately 15° from the vertical and parallel to the principal direction of horizontal flow of the fog through the chamber. Other components shall be positioned so as to ensure most uniform exposure. Wherever practicable, the components shall be supported from the bottom or from the side. When the components are suspended from the top, the suspension shall be by means of hooks made of glass or plastic material, non-reactive to salt solution. The use of metal hooks is prohibited. The components shall not shield one another from freely settling of salt mist and corrosion products. Condensate of one component shall not fall upon any other.

3.2.2 The components shall be exposed to continuous salt-laden atmosphere in the chamber, maintained at 35° C ± 2 degC for 48 hours unless 96 hours testing is specified in the relevant component specification.

3.3 **Recovery**
3.3.1 To aid in examination, the components shall then be rinsed in running water not warmer than 38° C - with light brushing using a soft hair brush or plastic bristle brush to remove the salt deposits. The surplus water shall be removed by shaking or as specified by the relevant component specification.

3.3.2 The components shall then remain under recovery conditions for a period of 1 to 2 hours unless otherwise specified by the relevant component specification.

4. INFORMATION TO BE GIVEN IN THE RELEVANT COMPONENT SPECIFICATION

(a) Preconditioning (see 3.1).
(b) Initial measurements.
(c) Concentration of salt solution, if other than 5 per cent (see 2.6).
(d) Duration of test, if other than 48 hours (see 3.2.2)
(e) Method of removal of surplus water, if other than by shaking (see 3.3.1).
(f) Period of recovery if other than 1 to 2 hours.
(g) Final measurements, if any.
(h) Acceptable performance limits.
(j) Any deviation from the normal test procedure.
1. OBJECT

1.1 The object of this test is to determine the suitability of components for use and storage under condition of high relative humidity when combined with cyclic temperature changes.

2. TEST CHAMBER

2.1 The chamber shall be capable of controlling and varying cyclically the temperature of the working space between 25°C ± 2 deg C and 55°C ± 2 deg C.

2.2 The chamber shall be capable of achieving in its working space the rate of change of temperature as required in 3.1.4 to 3.1.8 and Fig 5-2.

2.3 The chamber shall be capable of maintaining 90 to 96 per cent relative humidity during the period of high temperature and not less than 95 per cent relative humidity during the rest of the cycle. To avoid the need for an instantaneous change in the relative humidity at the transition point of the cycle, it is permissible for the limits of relative humidity to be widened as stated in 3.1.4 to 3.1.8.

2.4 Condensed water shall be continuously drained from the chamber and shall not be used again until it has been purified.

2.5 When humidity conditions in the chamber are obtained by using dematerialized water, this should have a resistively of not less than 500 ohm meters.

2.6 The temperature and relative humidity of the chamber shall be monitored by sensing devices suitably located in the working space.

2.7 The conditions prevailing throughout the working space shall be uniform and shall be as similar as possible to those prevailing in the immediate vicinity of the sensing devices.

   NOTE - In case of damp heat chambers employing steam injection, the air velocity at the point accessible to the wet bulb thermometer shall be not less than 3 m/s.

2.8 The properties of the components or their loading shall not appreciably influence the conditions within the working space of the chamber.

2.9 Any condensed water from the walls and roof of the chamber shall not fall on the components.
3. TEST PROCEDURE

3.1 Testing

3.1.1 The components shall be introduced into the chamber while its working space is under atmospheric conditions for testing.

3.1.2 The components shall be exposed to 25° C ± 2 degC and shall remain under this condition till the temperature stability has been attained (see Fig 5-1). During this period, the relative humidity shall be between 45 and 75 per cent.

3.1.3 The relative humidity of the chamber shall then be adjusted to 95 per cent. The components shall remain exposed to 25° C ± 2 degC and a relative humidity of not less than 95 per cent for 1 hour (see Fig 5-1).

3.1.4 The temperature of the chamber shall then be gradually raised to 55° C ± 2 degC. This shall be achieved in a period of 3 hours ± 30 minutes and at a rate which is within the limits defined by the shaded area in Fig. 5-2. During this period, the relative humidity shall be not less than 95 per cent, except during the last 15 minutes when it shall be not less than 90 per cent (see Fig 5-2). Condensation shall occur on the surface of the components during this temperature rise period.

NOTE - The condition that condensation on the surface of the components shall occur implies that the surface temperature of the components is below the dew point of the working space of the chamber. This will necessitate that the construction and size of the chamber are adequately related to the size and thermal capacity of the components.

3.1.5 The temperature shall then be maintained at 55° C ± 2 deg C until completion of 16 hours ± 30 minutes after the start of the cycle (see Fig. 5-2).

3.1.6 During this period the relative humidity shall be between 90 and 96 per cent. For the first and the last 15 minute periods, it shall be not less than 90 per cent (see Fig. 5-2). Condensation must not occur during the last 15 minutes.

3.1.7 The temperature shall then fall to 25° C ± 2 deg C within 3 to 6 hours. The rate of fall for the first one and a half hours shall be such that if maintained as indicated in Fig. 5-2; it would result in a temperature of 25° C ± 2 deg C being attained in 3 hours ± 15 minutes. During this period the relative humidity shall be not less than 95 per cent, except for the first 15 minutes, when it shall be not less than 90 per cent (see Fig. 5-2).

3.1.8 The temperature shall then be maintained at 25° C ± 2 deg C with not less than 95 per cent relative humidity until the cycle of 24 hours is completed (see Fig. 5-2). - This shall constitute one damp heat cycle.
3.1.9 When more than one damp heat cycle are to be applied successively, these conditions as stated in 3.1.4 to 3.1.8 shall be repeated (see Appendix C).

3.2 Recovery

3.2.1 The components shall then be removed from the chamber. After removal from the chamber, surface condensation shall be removed from the components by shaking or as specified by the relevant component specification.

3.2.2 H12 and H13 severity components shall be subjected to a working test within 15 minutes of removal from the chamber.

3.2.3 The components shall remain under recovery conditions for a period of 1 to 2 hours for H13 severity and 20 to 24 hours for H12 severity, unless otherwise specified by the relevant component specification.

4. INFORMATION TO BE GIVEN IN THE RELEVANT COMPONENT SPECIFICATION

(a) Preconditioning, if any.
(b) Initial measurements.
(c) The applicable severity (see 3.1.9)
(d) Method of removal of surface condensation (see 3.2.1)
(e) Details of working test (see 3.2.2).
(f) Intermediate measurements and time intervals.
(g) Period of recovery, if other than 1 to 2 hours for H13 severity and 20 to 24 hours for H12 severity.
(h) Final measurements.
(i) Acceptable performance limits.
(j) Any deviation from the normal test procedure.
Fig. 5-1 STABILIZING PERIOD
TEST NUMBER-6

DAMP HEAT (MOISTURE RESISTANCE)

1. OBJECT

1.1. The object of this test is to determine in an accelerated manner, the resistance of components and constituent materials to the deteriorative effects of the high humidity and heat conditions typical of tropical environments.

2. TEST CHAMBER

2.1. A damp heat chamber capable of satisfying the requirements specified in 2.1.1 to 2.1.9 shall be used for this test.

2.1.1. The chamber shall be capable of maintaining at any point in its working space any temperature between 25°C ± 2 deg C and 65°C ± 2 deg C. The material used to fabricate the platform and stand offs, which support the components, shall be non reactive in high humidity. Wood or plywood shall not be used because they are resiniferous. Materials shall not be used if they contain formaldehyde or phenol in their composition.

2.1.1.1 Opening of the chamber door - During the periods when the humidity is ascending or descending, the chamber door shall not be opened. If the chamber door must be opened, it should be opened during the 16th hour of an individual cycle. When the chamber is at 25°C and the relative humidity tolerance must be maintained. The chamber door should only be allowed to be opened for a short period of time.

2.1.2. The chamber shall be capable of achieving in its working space a rate of change of temperature as specified in 3.2.1 to 3.2.8 and Fig. 6-1.

2.1.3. The chamber shall be capable of maintaining in its working space 90 to 100 per cent relative humidity at 25°C and 65°C as specified in 3.2.1, 3.2.2 and 3.2.6. It shall also be capable of maintaining a relative humidity of 80 to 100 per cent during the temperature cycling periods as specified in 3.2.4.

NOTE - Allowance of 100 per cent relative humidity is intended to avoid problems in reading values close to 100 per cent relative humidity, but actual chamber operation shall be such as to avoid condensation.

2.1.4. Air circulation within the working space of the chamber shall be at a minimum cubic rate per minute equivalent to 5 times the volume of working space of the chamber.
NOTE - In case of damp heat chambers employing steam injection, the air velocity at the point accessible to the wet bulb thermometer shall be not less than 3 m/s.

2.1.5 The temperature and relative humidity of the chamber shall be monitored by sensing device located suitably in its working space.

2.1.6 Condensed water shall be continuously drained from the chamber and shall not be used again until it has been purified.

2.1.7 When relative humidity conditions in the chamber are obtained by using dematerialized water, this should have a resistively of not less than 500 ohm meters.

2.1.8 The properties of the components or their loading shall not appreciably influence the conditions within the working space of the chamber.

2.1.9 Any condensed water from the walls and roof of the chamber shall not fall on the components.

2.1.10 For preconditioning the components, as specified in 3.1, a-dry heat chamber shall be used. This dry heat chamber shall be capable of satisfying the retirements specified for the test chamber for the temperature (dry heat) test (test number 22).

2.1.11 For achieving the conditions specified in 3.2.7, if necessary, a separate-cold chamber shall be used. This cold chamber shall be capable of satisfying the requirements specified for the test chamber for the temperature (cold) test (test number 21).

2.1.12 For achieving the conditions specified in 3.2.8, a vibration generator shall be used. This vibration generator shall be capable of satisfying the requirements specified for the test equipment for the vibration test (test number 23).

3. TEST PROCEDURE

3.1 Preconditioning

3.1.1 Unless otherwise specified in the relevant component specification, the component shall be dried in the dry heat chamber (2.1.10) at 50° C ±2 deg C for 24 hours.

3.1.2 The temperature of the components shall then be reduce to that specified for atmospheric conditions for testing or any oilier temperature specified by the relevant component specification and maintained at this temperature for such a period as to enable the components to attain temperature stability/prior to carrying out the initial measurements as required by the relevant component specification.
3.2  **Testing**

3.2.1  The components shall then be introduced into the damp heat chamber maintained at 25° C ±2 deg C and relative humidity of 90 to 100 per cent. Components shall be mounted by their normal mounting means, in their normal mounting position, but shall be positioned so that they do not contact each other and so that each specimen receives essentially the same degree of humidity.

3.2.2  The temperature of the chamber shall then be gradually raised to 45° C ±2 deg C. This shall be achieved in a period of two and half hours, the relative humidity being maintained between 90 and 100 per cent throughout this period.

3.2.3  The temperature and relative humidity conditions shall be maintained for five and half hours from the start of the cycle.

3.2.4  The temperature shall then be allowed to fall to 25° C + 10 deg C, -2 deg C within a period of two and a half hours, the relative humidity being maintained between 80 and 100 per cent.

3.2.5  The sequence of operation described in 3.2.2 to 3.2.4 shall then be repeated.

3.2.6  The relative humidity shall then be raised to a level of 90 to 100 per cent and the temperature shall be maintained at 25° C ±2 deg C for a period of 8 hours. This completes one cycle of the test. An additional sub-cycle as stated in 3.2.7 and 3.2.8 shall be performed during any 5 of the first 9 cycles during this 8 hours period.

3.2.7  At least 1 hour but not more than 4 hours after beginning of the conditions stated in 3.2.6, the components shall be subjected to one of the following conditions:

3.2.7.1  **Exposure to cold in the same chamber**

(a) The components shall be exposed to cold by lowering the temperature of the chamber. Beginning between 17 and 18 hours after the start of the cycle the temperature of the chamber shall be allowed to fall to -10° C ± 2 degC. This temperature shall be reached at eighteen and a half hours after the start of the cycle.

(b) Beginning at eighteen and a half hours after the start of the 'cycle the temperature shall be maintained at -10° C ± 2 deg C for a period of 3 hours.

(c) Beginning at twenty-one and a half hours after the start of the cycle the temperature shall be raised to 25° C ±2 deg C in a period of between half and one a half hours.
3.2.7.2 Exposure to cold in a separate chamber

(a) The components shall be transferred from the humidity chamber to the cold chamber within a period of 5 minutes.

(b) The components shall then be exposed to a temperature of -10° C ±2 deg C for a period of 3 hours.

3.2.8 Within 15 minutes after completion of the conditions stated in 3.2.7, the components shall be vibrated in the frequency range of 10 to 55 Hz for 15 minutes, at atmospheric conditions for testing, using simple harmonic motion, having an amplitude of 0.75 mm (1.5 mm total excursion). The entire frequency range from 10 to 55 Hz and return to 10 Hz shall be traversed in approximately 1 minute. The components shall then be maintained at 25° C ± 2 deg C and 90 to 100 per cent relative humidity for the remaining period of the cycle.

NOTE - Unless otherwise specified in the relevant component specification, sub-cycle 3.2.8 is not applicable to components which include test schedules with requirements of Test No. 23 (Vibration). Such components must routinely be subjected to, and pass the normal Vibration test in the specified test schedule.

3.2.9 If specified by the relevant component specification, the components shall be electrically loaded during the exposure to humidity conditions. When applicable, polarization voltage shall be 100 V dc or as specified.

3.2.10 The components shall be subjected to 10 continuous cycles as shown in Fig 6-1. In the event of no more than one unintentional test interruption (power interruption or equipment failure) prior to the completion of the specified number of cycles (except for the last cycle), the cycle shall be repeated and the test may continue. Unintentional interruptions occurring during the last cycle require a repeat of the cycle plus an additional uninterrupted cycle. Any intentional interruption, or any unintentional interruption of greater than 24 hours requires a complete retest.

3.2.11 On completion of the conditions stated in 3.2.4 of the final cycle, when measurements at high relative humidity are specified by the relevant component specification, the components shall be maintained at 25° C ± 2 deg C with 90 to 100 per cent relative humidity for a period of one and a half to three and a half hours, after which the specified measurements shall be made. Due to the difficulty in making measurements under high relative humidity conditions, the relevant component specification shall specify the necessary precautions to be observed while making such measurements. When measurements after high humidity are called for the components shall be removed from the humidity chamber at the end of the final cycle, and the final measurements shall be carried out within a period of 1 to 2 hours and the components shall not be subjected to any means of artificial drying.
3.3 **Recovery**

3.3.1 The components shall then be removed from the chamber. After removal from the chamber, surface condensation shall be removed from the components by shaking or as specified by the relevant component specification.

3.3.2 The components shall then remain under recovery conditions for a period of 24 hours or as specified by the relevant component specification.

3.3.3 Carrying of final measurements during the 24 hours of recovery period is permitted. However, failures shall be based on the performance after the 24 hours period only.

4. **INFORMATION TO BE GIVEN IN THE RELEVANT COMPONENT SPECIFICATION**

(a) Preconditioning (see 3.1).
(b) Temperature for initial measurements (see 3.1.2).
(c) Initial measurements.
(d) Details of electrical loading (see 3.2.9), and the polarization voltage if other than 100 V dc.
(e) Precautions while making measurements under high humidity conditions (see 3.2.11).
(f) Intermediate measurements and time intervals (see 3.2.11).
(g) Period of recovery, if other than 24 hours.
(h) Method of removal of surface condensation (see 3.3.1).
(j) Final measurements.
(k) Acceptable performance limits.
(l) Any deviation from the normal test procedure.
TEST NUMBER-7

DAMP HEAT (STEADY STATE)

1. OBJECT

1.1 The object of this test is to determine the suitability of components for use and storage under conditions of high relative humidity. This test is primarily intended to enable the observation of the effect of high relative humidity at constant temperature over a specified period.

2. TEST CHAMBER

2.1 The chamber shall be capable of maintaining at any point in its working space a temperature with a tolerance of ±0.5 degC of any value between 40° C ± 2 deg C with a relative humidity between 90 and 95 per cent.

NOTE - The temperature tolerance of ±2 deg C is introduced in order to take account of absolute errors in the measurements of slow changes of this temperature and of temperature variation in the working space. The temperature control shall keep the short term temperature fluctuation within ±0.5 deg C.

2.2 Condensed water shall be continuously drained from the chamber and shall not be used again until it has been purified.

2.3 When high relative humidity conditions in the chamber are obtained by using demineralised water, this should have a resistivity of not less than 500 ohm metres.

2.4 The temperature and relative humidity of the chamber shall be monitored by sensing devices suitably located in the working space.

2.5 The conditions prevailing throughout the working space shall be uniform and shall be as similar as possible to those prevailing in the immediate vicinity of the sensing devices.

NOTE - In case of damp heat chambers employing steam injection, the air velocity at the point accessible to the wet bulb thermometer shall be not less than 3 m/s.

2.6 The properties of the components or their loading shall not appreciably influence the conditions within the working space of the chamber.

2.7 Any condensed, water from the walls and roof of the chamber shall not fall on the components.

33
3. TEST PROCEDURE

3.1 Testing

3.1.1 At the time of introducing the components into the chamber, care shall be taken to avoid condensation on the components; this can be done by preheating the components above the dry bulb temperature. The components shall be introduced into the chamber which shall then be maintained at the temperature of 40°C ± 2 deg C with a relative humidity between 90 and 95 per cent.

3.1.2 The temperature and relative humidity as specified in 3.1.1 shall be maintained continuously for a period of 21 or 56 days, as appropriate to the damp heat severity of the components (see Appendix 'C').

3.1.3 If so specified by the relevant component specification, the components shall be electrically loaded during this exposure.

3.2 Recovery

3.2.1 The components shall then be removed from the chamber. After removal from the chamber, surface condensation shall be removed from the components by shaking or as specified by the relevant component specification.

3.2.2 H12 and H13 severity components shall be subjected to a working test within 15 minutes of removal from the chamber.

3.2.3 The components shall remain under recovery conditions for a period of 1 to 2 hours for H13 severity and 20 to 24 hours for H12 severity, unless otherwise specified by the relevant component specification.

4. INFORMATION TO BE GIVEN IN THE RELEVANT COMPONENT SPECIFICATION

(a) Precleaning, if any.
(b) Initial measurements
(c) The applicable severity (see 3.1.2).
(d) Initials of electrical loading (see 3.1.3).
(e) Details of working test. (See 3.2.2).
(f) Intermediate measurements and time intervals.
(g) Period of recovery, if other than 1 to 2 hours for H13 severity aim 20 to 24 hours for H12 severity.
(h) Method of removal of surface condensation (see 3.2.1)
(i) Final measurements.
(k) Acceptable performance limits.
(l) Any deviation from the normal test procedure.
2.6 The properties of the components or their loading shall not appreciably influence the conditions within the working space of the chamber.

2.7 Any condensed, water from the walls and roof of the chamber shall not fall on the components.

3. TEST PROCEDURE

3.1.1 At the time of introducing the components into the chamber, care shall be taken to avoid condensation on the components, this can be done by preheating the components above the dry bulb temperature. The components shall be introduced or into the chamber which shall then be maintained at the temperature of 40°C ± 2 deg C with a relative humidity between 90 and 95 per cent.

3.1.2 The temperature and relative humidity as specified in 3.1.1 shall be maintained continuously for a period of 21 or 56 days, as appropriate to the damp heat severity of the components (see Appendix 'C').

3.1.3 If so specified by the relevant component specification, the components shall be electrically loaded during this exposure.

3.2 Recovery

3.2.1 The components shall then be removed from the chamber. After removal from the chamber, surface condensation shall be removed from the components by shaking or as specified by the relevant component specification.

3.2.2 H12 and H13 severity components shall be subjected to a working test within 15 minutes of removal from the chamber.

3.2.3 The components shall remain under recovery conditions for a period of 1 to 2 hours for HIS severity and 20 to 24 hours for H12 severity, unless otherwise specified by the relevant Component specification.

4. INFORMATION TO BE GIVEN IN THE RELEVANT COMPONENT SPECIFICATION

(a) Preconditioning, if any.
(b) Initial measurements.
(c) The applicable severity (see 3.1.2).
(d) Details of electrical loading (see 3.1.3).
(e) Details of working test (see 3.2.2).
(f) Intermediate measurements and time intervals.
(g) Period of recovery, if other than 1 to 2 hours for H13 severity and 20 to 24 hours for HIS severity.
(h) Method of removal of surface condensation (see 3.2.1).
(j) Final measurements.
(k) Acceptable performance limits.
(l) Any deviation from the normal test procedure.
TEST NUMBER-8

DUST

1. **OBJECT**

1.1 The object of this test is to determine the ability of components to withstand conditions encountered in dust laden environments.

2. **TEST CHAMBER**

2.1 The chamber shall be capable of circulating dust in its working space in such a manner as to produce a dust concentration sufficient to deposit $25 \pm 5$ grams of dust in the dust measuring device specified under 2.5.

NOTE: Fig 8-1 indicates a suggested layout for this chamber.

2.2 This chamber shall also be capable of maintaining its working space at a temperature of $40^\circ C \pm 3$ deg C with a relative humidity not exceeding 50 per cent. In all other respects, this chamber shall satisfy the requirements specified for the test chamber for the temperature (dry heat). Test Number 22.

2.3 The dust used for this test shall be dry. It shall be heated to $40^\circ C \pm 3$ degC before the agitation of the dust in the chamber is commenced. A sufficient quantity of the dust shall be available in the chamber originally in order to give the specified dust concentration throughout the chamber when measured with the Dust Measuring Device specified under 2.5.

2.4 The dust shall conform to the following requirements:

2.4.1 Physical characteristics:

(a) 100 per cent dust shall pass through 150 micron IS Sieve.

(b) $98 \pm 2$ per cent dust shall pass through 106 micron IS Sieve.

(c) $90 \pm 2$ per cent dust shall pass through 75 micron IS Sieve.

(d) $75 \pm 2$ per cent dust shall pass through 45 micron IS Sieve.

NOTE: - Particulars of IS Sieves referred to in 2.4.1 shall conform to IS 460 (Part 1).

2.4.2 Chemical composition: The chemical composition of the dust shall be as indicated in Table 8-1.
TABLE 8-1: CHEMICAL COMPOSITION OF DUST
(Clause 2.4.2)

<table>
<thead>
<tr>
<th>SUBSTANCE</th>
<th>PER CENT BY MASS</th>
</tr>
</thead>
<tbody>
<tr>
<td>SiO₂</td>
<td>97 to 99</td>
</tr>
<tr>
<td>FeO</td>
<td>0 to 2</td>
</tr>
<tr>
<td>Al₂O₃</td>
<td>0 to 1</td>
</tr>
<tr>
<td>TiO₂</td>
<td>0 to 2</td>
</tr>
<tr>
<td>MgO</td>
<td>0 to 1</td>
</tr>
<tr>
<td>Ignition losses</td>
<td>0 to 1</td>
</tr>
</tbody>
</table>

The PERCENTAGE BY WEIGHT values shown against substances other than SiO₂ refers only to acceptable impurity levels.

2.5 A dust measuring device is shown in Fig. 8-2. The device shall be kept at any place within the dust chamber. The air shall be circulated for 5 minutes and the dust shall be allowed to settle down. The amount of dust collected in the device shall be 25 ± 5 grams.

3. TEST PROCEDURE

3.1 Testing

3.1.1 The components shall be introduced into the chamber under atmospheric conditions for testing. The temperature of the chamber shall then be raised to 40°C ±3 deg C. The relative humidity shall be maintained at a value not exceeding 50 per cent.

3.1.2 After temperature stability has been attained, the components shall be subjected to the stream of dust laden air for a period of 1 hour or any other period specified in the relevant component specification. During this period the dust concentration shall be maintained as in 2.1.

3.1.3 During the test, the components shall be electrically loaded and/or operated, if so specified by the relevant component specification.

3.2 Recovery

3.2.1 The components shall be removed from the chamber and allowed to remain under recovery conditions for a period of 1 to 2 hours or as specified by the relevant component specification.
3.2.2 The accumulated dust shall be removed before final measurements are made by brushing, wiping or shaking, care being taken to avoid introduction of additional dust into the component. Under no circumstances shall the dust be removed by an air blast or by vacuum cleaning.

4. INFORMATION TO BE GIVEN IN THE RELEVANT COMPONENT SPECIFICATION

(a) Preconditioning, if any".
(b) Initial measurements.
(c) Duration of testing if other than 1 hour (See 3.1.2).
(d) Details of electrical loading and mechanical operation (See 3.1.3).
(e) Intermediate measurements and time intervals.
(f) Period of recovery, if other than 1 to 2 hours.
(g) Final measurements.
(h) Acceptable performance limits.
(j) Any deviation from the normal test procedure.
TEST NUMBER-9

EXPLOSION

UNDER CONSIDERATION
TEST NUMBER-10

FLAMMABILITY

1. OBJECT

1.1.1 The object of this test is to determine whether components will support combustion.

2. TEST CHAMBER

2.1 The chamber shall consist of an enclosure protected from air currents, but provided with means of venting fumes and admitting an adequate supply of fresh air at the bottom.

NOTE -1: A metal box about 600 mm wide, 900 mm high and 600 mm deep, with a detachable front, a viewing window and suitable holes for intake of air and venting of fumes can be used.

NOTE-2: Adequate safety precautions shall be taken to protect personnel from possible explosion of the components.

2.2 A suitable stand or support for the components involving a minimum of heat retransfer shall be used 'inside the chamber.

2.3 A spirit burner of the pattern shown in Fig 10-1 shall be used. The fuel for-the burner shall be good quality 66 0.P.industrial methylated spirit containing nbfc more than 5 per cent of wood naptha. The burner and the flame are considered satisfactory if, a bare.copper wi.re 0.71 mm dia having a free length of not less than 100 mm in the flame in the position to be occupied by the components, melts in less than 6 seconds.

NOTE - The melting point of copper is 1083° C.

3. TEST PROCEDURE

3.1 Mounting of Components

3.1.1 The components shall be mounted on the stand, placed within the test chamber so that they are not shielded from the flame by the support. The precise orientation of the components relative to the flame, it not seated in the relevant component specification, shall be that judged to be the most unfavorable or which presents maximum surface to the test flame. The height of the components shall be so adjusted that the lowest part of the body of the component is 51 ± 1mm from the top of the burner as shown in Fig. 10-2.
3.2 **Testing**

3.2.1 After confirming that the flame is satisfactory as specified in 2.3, the burner shall be placed underneath the components in such a manner that they are enveloped by the flame. The components shall be exposed to the flame to either 1 minute or any lesser time necessary to cause ignition.

3.2.2 If ignition of the components has occurred, it shall not continue for more than 15 seconds or any other period specified in the relevant component specification after withdrawal of the flame.

3.2.3 The components shall be deemed to have failed if burning particles become detached from them.

4. **INFORMATION TO BE GIVEN IN THE RELEVANT COMPONENT SPECIFICATION**

   (a) Preconditioning, if any.
   (b) Initial measurements, if any.
   (c) Specific mounting (orientation) instructions (see 3.1.1).
   (d) Permissible period of burning after withdrawal of flame, if other than 15 seconds (see 3.2.2).
   (e) Final measurements, if any,
   (f) Acceptable performance limits, if other than those specified in 3.2.2 and 3.2.3.
   (g) Any deviation from the normal test procedure.
TEST NUMBER -11

IMPACT (BUMP)

1. OBJECT

1.1 The object of this test is to determine the ability of components to withstand repeated bumps without mechanical damage or malfunctioning.

2. TEST EQUIPMENT

2.1 The bump test machine used for this test shall be capable of generating a pulse approximating to one half cycle of a sine wave as shown by dotted lines in Fig 11-1. The ideal pulse shall have a peak acceleration of 400 m/s² with a duration of 6 ms. The acceleration and time duration shall be achieved within the tolerance shown by thick lines in Fig. 11-1.

2.2 The bump repetition rate shall be such that, between impacts, the relative motion within the component shall be substantially zero and the values of the acceleration at the monitoring point shall be within the limits shown in Fig. 11-1.

NOTE - A bump repetition rate of 1 to 3 bumps per second is usually adequate to reduce secondary bumps to a minimum.

2.3 The actual velocity change shall be within ± 20 per cent of the value corresponding to the nominal pulse i.e., 1.50 m/s. To determine the velocity change, the actual pulse should be integrated from 0.4 D before the pulse to 0.1 D beyond the pulse, where, D is the duration of the nominal pulse (see Fig. 11-1).

2.4 The positive or negative peak acceleration at the monitoring point perpendicular to the intended direction of bumps shall not exceed at any time 30 per cent of the nominal value of the peak acceleration in the intended direction, when determined with a measuring system conforming to 2.6 to 2.8.

2.5 When the bump test machine and fixtures are loaded with the components and any other necessary load for the testing, the applied bumps shall, at the monitoring point, have the characteristics specified in 2.1 to 2.4.

2.6 The acceleration measuring device shall be an accelerometer placed at the monitoring point. This point shall be the component fixing point nearest to the centre of the table surface, unless, there is a fixing point having a more rigid connection to the table, in which case, the latter shall be chosen.

2.7 The accuracy of the measuring system shall be such that it can determine the true value within the given tolerances.
2.8 The frequency response of the overall measuring system including the accelerometer shall be within the limits shown in Fig. II-2.

NOTE - When it is necessary to employ filters to reduce the effect of any high frequency resonance inherent in the accelerometer, it may be necessary to examine the amplitude and phase characteristics of the measuring system in order to avoid distortion of the reproduced waveform.

3. TEST PROCEDURE

3.1 Mounting of Components

3.1.1 The components shall be mechanically secured to the bump test machine either directly or by means of fixture as specified in 3.1.2 to 3.1.7.

3.1.2 Mounting fixtures shall be such as to subject the components to bumps in each plane and sense as specified.

3.1.3 Components having unique means of mounting shall be so mounted.

3.1.4 The mounting of components not provided with unique means of mounting shall be such that the test conditions applied should dynamically load the body and/or terminations. Either the body and the terminations, or the terminatifs only, may be clamped, as specified by the relevant component specification.

3.1.5 Components with axial terminations weighing less than 15 grams shall be secured to rigid pillars leaving 5 to 8 between the point of emergence of the terminations and the pillars. Similar components weighing 15 grams and more shall be clamped so as to avoid any stress on the terminations.

3.1.6 Components with radial terminations and components having unusual mass distribution shall be mounted as specified in the relevant component specification.

3.1.7 External connections made to the components for power supply and measurements shall add a minimum of mass and place minimum of restraint on the components.

3.2 Testing

3.2.1 For the testing of components, the preferred number of bumps shall be 4000 ± 10.

3.2.2 The specified number of bumps shall be applied simultaneously in each sense of three mutually perpendicular planes to 6 components, one mounted in each of the six senses unless otherwise specified in the relevant component specification.
NQTE - When the number of components available is less than six, the specified number of bumps shall be applied to the reduced number of components in such a manner that a test is made in each of the six senses. According to the number of components, the test shall be applied as follows:

(a) Three to five components - Three components shall be tested, each of them in two of six possible senses.

(b) Two components - Each component shall be tested in three of the six possible senses.

(c) One component - The component shall be tested in each of the six possible senses.

The total number of bumps for each component shall, however, be limited to $4000 \pm 10$.

3.2.3 While being bumped, the components shall be electrically loaded and/or operated and measured, if so specified by the relevant Component specification.

4. INFORMATION TO BE GIVEN IN THE RELEVANT COMPONENT SPECIFICATION

(a) Preconditioning, if any.
(b) Initial measurements.
(c) Any special mounting requirements (see 3.1).
(d) Applicability of special procedure, if the number of components is less than 6 (see note under 3.2.2).
(e) The details of electrical loading and operation during the test (see 3.2.3).
(f) Intermediate measurements and time intervals.
(g) Final measurements.
(k) Acceptable performance limits.
(l) Any deviation from the normal test procedure.
TEST NUMBER-11 A

IMPACT (RANDOM DROP)

1. OBJECT

1.1 The object of this test is to determine the effect of random, repeated impacts due to handling, transportation and other field service conditions on components. The test is an accelerated test designed to indicate structural and mechanical weaknesses of types not necessarily detected in shock and vibration tests.

2. TEST EQUIPMENT

2.1 The random drop test machine consists of an assembly of either 2 or 4 steel cages as shown in Fig IIA-I with provisions for rotation about a common axis.

2.2 The interior of each cage shall be as shown in Fig. IIA-2.

2.3 Steel sleeves as shown in Fig IIA-3 shall be used to mount the component.

2.4 A typical 4 cage machine is shown in Fig IIA-4.

3. TEST PROCEDURE

3.1 Mounting of Components

3.1.1 The component shall be rigidly mounted by normal mounting means in- the steel sleeve so that no part of the component, including terminations or external hardware of the component, will extend beyond the sleeve.

3.1.2 When necessary, a suitable adapter may be used within the sleeve. End caps shall not be used on the sleeves. Through bolts may be employed as needed to mount the component in the sleeve.

3.1.3 Only one sleeve shall be placed in each cage during test. The number of components mounted in each sleeve shall be limited only by the available space.

3.2 Testing

3.2.1 Components shall be subjected to the random drop test for a period of 45 minutes at a' speed of approximately 5 revolutions per minute. The machine shall be rotated in the direction shown in Fig. IIA-2.

3.2.2 Upon completion of the test, measurements shall be made as specified.
4. INFORMATION TO BE GIVEN IN THE RELEVANT COMPONENT SPECIFICATION

(a) Initial measurements.
(b) Any special mounting requirements.
(c) Final measurements.
(d) Acceptable performance limits.
(e) Any deviation from the normal test procedure.
TEST NUMBER-12

IMPACT - (SHOCK)

1. OBJECT

1.1 The object of this test is to determine the structural integrity and performance of components when they are subjected to non-repetitive mechanical shocks.

2. TEST EQUIPMENT

2.1 When the shock test machine and the associated fixtures are loaded with the component, the applied shocks shall, at the monitoring point, have any of the characteristics specified in 2.2.

2.2 The shock test machine shall be capable of generating a I pulse approximating to one of the following nominal acceleration versus time curves:

(a) Final-peak saw tooth curve which is an asymmetrical triangle with a short fall time as shown by the dotted line in Fig. 12-2.

(b) Half-sine curve which is one half cycle of a sine wave as shown by the dotted line in Fig. 12-3.

(c) Trapezoidal curve with short rise and fall times as shown by the dotted line in Fig. 12-4.

2.3 The true value of the actual shock pulse shall be within the tolerances shown by the solid lines in Fig.12-2, 12-3, 12-4.

2.4 For all pulse shapes, the actual velocity change shall be within ± 10 per cent of the value corresponding to the nominal pulse. To determine the velocity change, the actual pulse should be integrated from 0.4 D before the pulse to 0.1 D beyond the pulse, where D is the duration of the nominal pulse (see Fig. 12-2, 12-3, 12-4).

2.5 The positive or negative peak acceleration at the monitoring point perpendicular to the intended shock direction, shall not exceed at any time 30 per cent of the value of peak nominal acceleration of nominal pulse in the intended direction, when determined with a measuring system conforming to 2.6 to 2.8.

2.6 The shock pulse shall be measured by an accelerometer placed at the monitoring point. This point shall be the component fixing point nearest to the centre of the table surface, unless there is a fixing point having a more rigid connection to the table, in which case, the latter point shall be chosen.
2.7 The accuracy of the measuring system shall be such that it can determine the true value of acceleration within the given tolerances.

2.8 The frequency response of the overall measuring system, including the accelerometer, shall be "within the limits shown in Fig. 12-1.

NOTE - When it is necessary to employ filters to reduce the effect of any high frequency resonances inherent in the accelerometer, it may be necessary to examine the amplitude and phase characteristics of the measuring system in order to avoid distortion of reproduced waveform.

3. TEST PROCEDURE

3.1 Mounting of Components

3.1.1 The component shall be secured to the shock test machine either directly or by means of fixture as specified in 3.1.2.

3.1.2 Mounting fixture shall be such as to subject the components to shocks in each plane and sense.

3.1.3 Components having a unique method of mounting shall be so mounted.

3.1.4 The mounting of components not provided with unique means of mounting shall be such that the test conditions applied should dynamically locate the body and/or terminations. Either the body and the termination, or the termination only, may be clamped, as specified by the relevant component specification.

3.1.5 Components with axial termination weighing less than 15 grams shall be secured to rigid pillars leaving 5 to 8mm between the point of emergence of terminations and the pillars. Similar components weighing 15 grams and more shall be clamped so as to avoid any stress on the terminations.

3.1.6 Components with radial termination and components having unusual mass distribution shall be mounted as specified in the relevant component specification.

3.1.7 External connections made to the components for power supply and measurements shall add a minimum of mass and place a minimum restraint on the components.

3.1.8 The relevant component specification shall state whether the gravitational force is important, in case it is important, the components shall be so mounted that the gravitational force acts in the same direction as it would be in Service vise. Where the effect of gravitational force is not important, the components may be mounted in any plane or sense.
3.2 **Testing**

3.2.1 A shock severity for a selected pulse shape (see 2.2) shall be given by the combination of the peak acceleration and the duration of the nominal pulse. The relevant component specification shall choose the appropriate severity from those listed in Table 12-1.

### TABLE 12-1: SHOCK SEVERITIES

(Clause 3.2.1)

<table>
<thead>
<tr>
<th>SEVERITY</th>
<th>PEAK ACCELERATION (A) m/s</th>
<th>DURATION OF THE PULSE ms</th>
<th>FINAL PEAK m/s</th>
<th>HALF SINE m/s</th>
<th>TRAPOZOIDAL m/s</th>
</tr>
</thead>
<tbody>
<tr>
<td>$10$</td>
<td>300</td>
<td>18</td>
<td>7.65</td>
<td>3.37</td>
<td>4.77</td>
</tr>
<tr>
<td>$11$</td>
<td>300</td>
<td>11</td>
<td>1.62</td>
<td>2.06</td>
<td>2.91</td>
</tr>
<tr>
<td>$12$</td>
<td>500</td>
<td>11</td>
<td>2.69</td>
<td>3.43</td>
<td>4.86</td>
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<tr>
<td>$13$</td>
<td>750</td>
<td>6</td>
<td>2.19</td>
<td>2.80</td>
<td>-</td>
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<tr>
<td>$14$</td>
<td>1000</td>
<td>6</td>
<td>2.94</td>
<td>3.74</td>
<td>5.40</td>
</tr>
<tr>
<td>$15$</td>
<td>5000</td>
<td>1</td>
<td>-</td>
<td>3.12</td>
<td>-</td>
</tr>
<tr>
<td>$16$</td>
<td>10000</td>
<td>0.5</td>
<td>-</td>
<td>3.12</td>
<td>-</td>
</tr>
<tr>
<td>$17$</td>
<td>15000</td>
<td>0.5</td>
<td>-</td>
<td>4.68</td>
<td>-</td>
</tr>
<tr>
<td>$18$</td>
<td>30000</td>
<td>0.2</td>
<td>-</td>
<td>3.74</td>
<td>-</td>
</tr>
</tbody>
</table>

3.2.2 The half-sine pulse shape shall be the preferred pulse shape unless otherwise specified in the relevant component specification.

3.2.3 The components mounted as described in 3.1 and electrically loaded if so required by the relevant component specification shall be subjected to 3 successive shocks of appropriate severity in both the senses in each of the 3 mutually perpendicular planes so chosen that the faults are most likely to be revealed (i.e. a total of 18 shocks).

4. **INFORMATION TO BE GIVEN IN THE RELEVANT COMPONENT SPECIFICATION**

(a) Preconditioning, if any.
(b) Initial measurements.
(c) The appropriate shock severity.
(d) The pulse shape, if other than half-sine.
(e) Whether gravitational force is important (see 3.1.8).
(f) Any special mounting requirements (see 3.1).
(g) The details of electrical loading (see 3.2.3)
(h) Intermediate measurements and time intervals.
(j) Final measurements.
(k) Acceptable performance limits.
(l) Any deviation from the normal test procedure.

Fig 12-1 FREQUENCY RESPONSE FOR MEASURING SYSTEM FOR IMPACT (SHOCK) TEST
REFERENCE LINE CORRESPONDING TO PRE-PULSE CONDITIONS

MIXIMUM TIME DURING WHICH THE PULSE SHOULD BE MONITORED

--- NOMINAL PULSE ---

TOLERANCE BOUNDARIES

\( D = \text{DURATION OF NOMINAL PULSE} \)

\( A = \text{PEAK ACCELERATION OF NOMINAL PULSE} \)

**NOTE:** THE REFERENCE LINE SHALL NOT DIFFER MORE THAN ±0.05A OR ±10 m/s² WHICHEVER IS THE GREATER FROM ZERO ACCELERATION.

Fig 12-3  HALF SINE PULSE
REFERENCE LINE CORRESPONDING TO PRE-PULSE CONDITIONS

MINIMUM TIME DURING WHICH THE PULSE SHOULD BE MONITORED

NOMINAL PULSE
TOLERANCE BOUNDARIES
D = DURATION OF NOMINAL PULSE
A = PEAK ACCELERATION OF NOMINAL PULSE

NOTE: THE REFERENCE LINE SHALL NOT DIFFER MORE THAN \( \pm 0.05 A \) OR \( \pm 10 \text{ m/s}^2 \) WHICHEVER IS THE GREATER FROM ZERO ACCELERATION.

Fig 12-4 TRAPEZOIDAL PULSE
1. **OBJECT**

1.1 The object of this test is to determine the effect on the components due to exposure for a specified duration of time and/or for a specified number of mechanical operations at elevated temperatures combined with or without specified electrical stress.

2. **TEST CHAMBER**

2.1 The test chamber shall be capable of maintaining its working space at a temperature of 70°C ± 3 deg C or any other selected temperature (s) in the range of severities of the temperature (dry heat) test within a tolerance of ± 3 deg C. In all other respects the chamber shall conform to the requirements specified for the test chamber for the temperature (dry heat) test (Test Number 22) -

2.2 While the components are maintained at the required temperature, it shall be possible to apply the required electrical stress and/or mechanical operations, in the manner specified by the relevant component specification.

3. **TEST PROCEDURE**

3.1 Mounting of Components 3.1.1 Components shall be mounted as specified by their normal mounting means. When group of components are to be subjected to test simultaneously, the mounting distance between components shall be as specified for the individual groups. When the distance is not specified, the mounting distance shall be sufficient to minimize the temperature of one component affecting the temperature of another. Components fabricated of different materials, which may have detrimental effect on each other and alter the results of this test shall not be tested simultaneously.

3.2 **Testing**

3.2.1 The components mounted as specified in 3.1 shall be placed in the chamber conforming to the requirements of 2.1 and shall be subjected to electrical and/or/mechanical stresses as specified by the relevant component specification. The temperature of the chamber shall be adjusted to the specified value and shall be maintained at this value throughout the test.

3.2.2 Unless otherwise specified by the relevant component specification, the duration of this test shall be one of the values specified in Table 13.1.
TABLE 13-1: TIME DURATION FOR LIFE TEST
(Clause 3.2.2)

<table>
<thead>
<tr>
<th>TIME HOURS</th>
</tr>
</thead>
<tbody>
<tr>
<td>100</td>
</tr>
<tr>
<td>250</td>
</tr>
<tr>
<td>500</td>
</tr>
<tr>
<td>1000</td>
</tr>
<tr>
<td>2000</td>
</tr>
<tr>
<td>3000</td>
</tr>
<tr>
<td>5000</td>
</tr>
<tr>
<td>10000</td>
</tr>
<tr>
<td>30000</td>
</tr>
<tr>
<td>50000</td>
</tr>
</tbody>
</table>

3.2.3 If the number of mechanical operations are to be carried out instead of time duration, unless otherwise specified by the relevant component specification, the number of operations for this test shall be one of the values specified in Table 13-2.

TABLE 13-2 NUMBER OF OPERATIONS FOR LIFE TEST
(Clause 3.2.3)

<table>
<thead>
<tr>
<th>NUMBER OF OPERATIONS</th>
</tr>
</thead>
<tbody>
<tr>
<td>100</td>
</tr>
<tr>
<td>200</td>
</tr>
<tr>
<td>500</td>
</tr>
<tr>
<td>1000</td>
</tr>
<tr>
<td>2000</td>
</tr>
<tr>
<td>3000</td>
</tr>
<tr>
<td>5000</td>
</tr>
<tr>
<td>10000</td>
</tr>
<tr>
<td>15000</td>
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<tr>
<td>25000</td>
</tr>
<tr>
<td>50000</td>
</tr>
<tr>
<td>100000</td>
</tr>
<tr>
<td>200000</td>
</tr>
<tr>
<td>300000</td>
</tr>
<tr>
<td>500000</td>
</tr>
</tbody>
</table>
3.2.4 Throughout the duration of this test, the required electrical and/or mechanical stresses shall be applied to the components in the manner specified by the relevant component specification which, if required, shall also specify monitoring or measuring of selected electrical characteristics during this period.

3.3 **Recovery**

3.3.1 The components shall be removed from the chamber. The components shall then be allowed to remain under recovery conditions for two hours, or such longer period as is required to attain temperature stability.

4. **INFORMATION TO BE GIVEN IN THE RELEVANT COMPONENT SPECIFICATION**

(a) Preconditioning, if any.
(b) Initial measurements.
(c) The temperature at which the test shall be carried out (see 3.2.1).
(d) Whether the test is to be repeated in part or whole at any other temperature.
(e) The period, manner and rate of application of the electrical and/or mechanical stresses (see 3.2.4)
(f) Duration of the test (see 3.2.2)
(g) The maximum permissible surface temperature of the components, if applicable.
(h) Intermediate measurements and time intervals.
(j) Final measurements.
(k) Acceptable performance limits.
(j) Any deviation from the normal test procedure.
TEST NUMBER-14

MOULD GROWTH

1. OBJECT

1.1 The object of this test is to determine whether the components will resist mould attack.

2. TEST CHAMBER

2.1 The test chamber used for small components shall conform to the requirements stated in 2.1.1 to 2.1.5.

2.1.1 The chamber shall be capable of maintaining its working space at a temperature between 28° C and 30° C.

2.1.2 Any periodic change of temperature inside the chamber shall not exceed a rate of 1° C per hour.

2.1.3 The components and the control strips specified in 3.3 shall be contained within glass containers with close fitting lids.

2.1.4 The containers shall have free water exposed at all times in the base to maintain a relative humidity greater than 90 per cent inside them. The components and control strips shall not rest in this water or be splashed by it.

2.1.5 The lids of containers shall be removed for a few seconds once in a week to ensure a regular supply of fresh oxygen to the growing moulds.

NOTE - If the chamber or the containers or both become contaminated, it is desirable to clean the same. The preferred method is to sterilize the same with the help of an autoclave. Where heating cannot be tolerated, an alternative method is to dry fumigate with propylene oxide, finally washing with water containing a detergent and ventilating to remove the oxide fumes.

2.2 When components are too large for the containers mentioned in 2.1.3 they shall be tested in a chamber conforming to the requirements stated in 2.2.1 to 2.2.5.

2.2.1 The chamber shall be capable of maintaining its working space at a temperature between 28° C and 30° C.

2.2.2 Any periodic change of temperature shall not exceed a rate of 1° C per hour.
2.2.3 The chamber shall have no aided circulation of air within it and the relative humidity shall be maintained at a value greater than 90 per cent by exposing a large area of water slurry of potassium sulphate (K2SO4).

2.2.4 The chamber shall have a well sealed door to prevent exchange of atmosphere between inside and outside.

2.2.5 The door of the chamber shall be opened for a few minutes, once a week to renew the oxygen-supply and to add further water to the slurry.

NOTE - If the chamber becomes contaminated so that it is desirable to clean it, the only cleaning procedure allowed shall be that described in the Note under 2.1.5.

3. TEST PROCEDURE

3.1 Cultures

3.1.1 The cultures used for this test shall be obtained from an official mould research station.

NOTE - Owing to a large number of generations in the genetic history of the standard cultures, it is possible for them to suffer variation in their ability to attack certain materials. The assessment of the ability requires a high degree of mycological skill and the research station supplying these cultures for test purposes should certify that they are as suitable for this test procedure as those previously supplied and considered acceptable.

3.1.2 The following cultures shall be used together for performing this test.

<table>
<thead>
<tr>
<th>Culture</th>
<th>Strain</th>
</tr>
</thead>
<tbody>
<tr>
<td>(a) Aspergillus niger</td>
<td>V. Tieghem</td>
</tr>
<tr>
<td>(b) Aspergillus terreus</td>
<td>Thorn.</td>
</tr>
<tr>
<td>(c) Aureobasiidiurn pullulans</td>
<td>(De Barry) Arnaud</td>
</tr>
<tr>
<td>(d) Paecilomyces varioti</td>
<td>Bainier</td>
</tr>
<tr>
<td>(e) Penicillum funiculosurn</td>
<td>Thorn</td>
</tr>
<tr>
<td>(f) Penicillium ochrocholoron</td>
<td>Biourge</td>
</tr>
<tr>
<td>(g) Seopulariopsis brevicaulis</td>
<td>(Sacc) Bain Var.</td>
</tr>
<tr>
<td>Glabra Thom.</td>
<td></td>
</tr>
<tr>
<td>(h) Trichoderma viride</td>
<td>Pers. Ex Fr.</td>
</tr>
</tbody>
</table>

3.1.3 The cultures shall be supplied, as spores on agar medium in glass containers with cotton plugs or as considered appropriate by the mycological institute supplying them.
3.1.4 The cultures shall be stored in a refrigerator at a temperature between 5° C and 10° C. The cultures shall be used for preparing the test suspension when they are between 14 and 21 days old. The stoppers shall not be removed until the mould suspension is about to be made and only one suspension shall be made from the opened container. A fresh unopened container shall be used for each batch of suspension. The suspension shall be used on the same day during which it is prepared and shall not be stored for future use.

3.2 Mould Suspensions

3.2.1 The mould suspension shall be prepared in distilled water to which has been added 0.05 per cent of a non-fungicidal wetting agent. An agent based on N-Methyl tauride (Igepon) or on dioctyl sodium sulphosuccinate is suitable.

3.2.2 Ten millilitres of the water and the required wetting agent shall be added gently to each phial or tube. A platinum or a nichrome wire shall be sterilized by heating to red heat in a flame and allowed to cool. This wire shall be used to scrape gently the surface of the culture to liberate the spores. The liquid shall be gently agitated to disperse the spores without detaching mycelial fragments and the mould suspension shall then be gently decanted into a flask.

3.2.3 All the eight dispersions shall be shaken vigorously together in a flask to mix thoroughly and to break up any clumps of spores.

3.3 Control Strips

3.3.1 The control strips shall consist of 3 strips of pure white filter paper soaked with nutrient salt solution described in 3.3.2.

3.3.2 The nutrient salt solution shall consist of a solution of the following materials in distilled water.

| (a) | Potassium dihydrogen orthophosphate (KH2PO4) | 0.7 g |
| (b) | Potassium monohydrogen orthophosphate (KHPO) | 0.3 g |
| (c) | Magnesium sulphate (MgSO4 7H2O) | 0.5 g |
| (d) | Sodium nitrate (NaNO3) | 2.0 g |
| (e) | Potassium Chloride (KCl) | 0.5 g |
| (f) | Ferrous sulphate (FeSO4 7H2O) | 0.01 g |
| (g) | Sucrose | 30.0 g |

3.3.3 The quantities specified in 3.3.2 are the amounts required for a litre of distilled water.
3.3.4 The control strips shall be placed in a small glass dish and covered with the nutrient salt solution. The strips shall be removed from this solution and allowed to drain free of drips immediately before use.

3.3.5 The control strips shall be freshly prepared on the same day during which they will be used for test.

3.3.6 A freshly prepared solution of nutrient salts shall be used for preparing each batch of control strips.

3.4 Pre-conditioning

3.4.1 The components shall be visually examined.

3.4.2 The components shall then be cleaned in ethanol or in water containing a detergent. Care shall be taken at all times to avoid touching the components with bare hands.

3.4.3 The components shall be sprayed with the mixed spore suspension in water. The spray shall be generated by a nozzle large enough not to be 'blocked by the fragments of mycelium. The spray shall impinge on all surfaces of the components.

3.5 Testing

3.5.1 The three control strips shall also be sprayed with the same spore suspension used for the components.

3.5.2 In case of small components, the components and 3 control strips are placed within individual containers which are then introduced into the chamber (see 2.1), maintained between 28° C and 30° C.

3.5.3 In case of large components, the components and 3 control strips shall together be introduced into the chamber (see 2.2), maintained between 28° C and 30° C.

3.5.4 The components and the control strips shall be placed in the container/chamber within 15 minutes of spraying and shall not be unduly disturbed, except for opening container lids and/or chamber door each week, until completion of the test.

3.5.5 If no mould growth is visible on any one of the control strips when first opened 7 days after spraying, the test shall be considered void and shall be recommenced.

3.5.6 Provided that the mould growth on the control strips indicates that the conditions are suitable, the components shall be exsposed continuously for 28 days.
3.5.7 The components shall be removed from the container/chamber after 28 days of exposure and examined immediately under 10 power magnification. There shall be no mould growth visible on the components.

NOTE - The mould growth if exposed to the drier atmosphere of the laboratory will begin to dry and hence any microscopic examination must be carried out quickly.
TEST NUMBER-15
RESISTANCE TO SOLDERING HEAT

1. OBJECT

1.1 The object of this test is to determine the ability of a component to withstand the heating effect associated with soldering.

2. TEST EQUIPMENT

2.1 Solder Bath

2.1.1 The solder bath used for this test shall have a volume sufficient to ensure that the temperature of the solder remains substantially uniform when the terminations are introduced. It shall also be ensured that the terminations shall not be closer than 10 mm to the walls and base of the bath. The bath shall be capable of maintaining the solder at the specified temperature.

   NOTE - The molten solder may be agitated to assure that the temperature is uniform. The surface of the solder shall be kept clean and bright.

2.1.2 The exposed area of the surface of the solder in the bath shall be reduced as far as possible (for example, by the use of a sheet of asbestos) in order that the component shall not be heated by direct radiation from the bath.

2.1.3 The solder bath shall be fitted with a mechanical dipping device capable of immersing and withdrawing the terminations at a rate of 20 to 30 mm per second and maintaining a dwell time as specified in Table 15-1.

2.2 Solder

2.2.1 The solder used shall be soft solder conforming to grade Sn 60 of IS 193.

2.2.2 The flux used shall be 25 per cent by mass of water white rosin and 75 per cent by mass of 99 per cent isopropyl alcohol.

2.3 Mounting Board

2.3.1 A mounting board in accordance with JSS 51701 (Type GF Un clad), 64 cm^2 minimum area (8x8, 4x16 etc.). 1.6 ± 0.18 mm thick shall be used. Component terminations holes shall be drilled from 0.05 to 0.5 mm diameter larger than the termination diameter. Metal eyelets or feed through shall not be used.
3. TEST PROCEDURE

3.1 General

3.1.1 The test shall be performed on all solder terminations attached to the component part not specifically exempted in the relevant component specification. Two separate solder dip procedures are covered in this test method (Procedure - I to accommodate the common practice of hot solder dipping (tinning) of leaded component parts, and Procedure - 2 to simulate a solder wave technique. One of the following procedures shall be made applicable:

(a) Procedure I - In this procedure the specified number of terminations (see 3.1.1) with any special preparation (see 3.1.4) shall be immersed in the solder bath (see 2.1) to the depth specified. Terminations shall be immersed simultaneously if the geometry of the component so permits. The applicable test condition, A, B or C, will be specified in the relevant component specification (see 3.1.2). Unless otherwise specified, Test Condition "B' shall apply.

(b) Procedure 2 - In this procedure, the terminations of the components as mounted on the board material (see 2.3) shall be immersed in the solder bath (see 3.1) so that the bottom of the board rests on the molten solder. The applicable test condition, D, E or F, shall be as specified in the relevant component specification (see 3.1.2). Unless otherwise specified Test Condition "D' shall apply.

3.1.2 The specific combination of solder dip method, solder bath temperature, and immersion duration shall be selected from Test Conditions listed in the Table 15-1.

<table>
<thead>
<tr>
<th>Test Condition</th>
<th>Applicable for</th>
<th>Temperature of Solder Bath</th>
<th>Immersion Duration (Dwell Time in seconds)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Procedure 1</td>
<td>340 to 360° C</td>
<td>3 + 1/2-0</td>
</tr>
<tr>
<td>B 1/</td>
<td>Procedure 1</td>
<td>255 to 265° C</td>
<td>10 ± 1</td>
</tr>
<tr>
<td>C</td>
<td>Procedure 1</td>
<td>255 to 265° C</td>
<td>20 ± 1</td>
</tr>
<tr>
<td>D 2/</td>
<td>Procedure 2</td>
<td>255 to 265° C</td>
<td>10 ± 2</td>
</tr>
<tr>
<td>E</td>
<td>Procedure 2</td>
<td>255 to 265° C</td>
<td>20 ± 2</td>
</tr>
<tr>
<td>F</td>
<td>Procedure 2</td>
<td>275 to 285° C</td>
<td>30 ± 2</td>
</tr>
</tbody>
</table>

NOTES - 1/ Preferred Test Condition under Procedure 1.

2/ Test Condition D under Procedure 2 is preferred for PCB through-hole mounted components.
3.1.3 The use of heat sinks or shielding, except for the mounting board of Procedure 2 (see 2.3) is prohibited except when it is a part of the component. When applicable, heat sinks or shielding shall be as specified in the relevant component specification, including all of the details, such as materials, dimensions, method of 'attachment and location of the necessary protection.

3.1.4 Any special preparation of components, prior to testing, shall be as specified in the relevant component specification. This shall include details of bending or any other reorientation of termination, cleaning, application of fluid, pertaining, and the attachment of heat sinks or protective shielding (see 3.1.3). Components mounted on a board shall not be in contact with each other, however, they shall be in contact with the board. Hole placement shall be such that the shortest possible termination length from the component body to the board shall be accommodated.

3.2 Testing

3.2.1 Procedure 1

3.2.1.1 Unless otherwise specified in the relevant component specification, the wire terminations of components shall be immersed in such a manner as to leave a clearance of 6 mm from the point, where the termination emerge from the body of cap of the component.

3.2.1.2 Unless otherwise specified in the relevant component specification, the tag terminations of components shall be immersed in a depth of 3 mm beyond the place intended for the connection of wires referred to the free end or one half of the tag length, whichever is less.

3.2.1.3 The terminations shall be immersed to the depth specified for the solder dip for a period of 5 to 10 seconds in the flux which is maintained between 15°C and 35°C.

3.2.1.4 The fluxed terminations shall then be mechanically immersed at a rate of 20 to 30 mm per second into the solder bath, which has just previously been skimmed of dross and burnt flux. The solder bath shall be maintained at the temperature as applicable for the specified Test Condition (see 3.1.1 (a) and 3.1.2).

3.2.1.5 The terminations shall be allowed to remain in the solder bath for the dwell time as applicable for the specified Test Condition (see 3.1.1 (a) and 3.1.2) at the end of which period, they shall be withdrawn mechanically from the solder bath at a rate of 20 to 30 mm per second.

3.2.1.6 After the dip, the components shall be allowed to cool and stabilize at laboratory ambient conditions and then visually examined. There shall be no evidence of damage due to heating on the surface of the components when examined under 10 power magnification.
3.2.1.7 Any additional examinations and measurements to be made before and after tests, shall be as per the relevant component specification. When specified, an internal examination of the component shall also be made after the test to check for solder reflow or heat damage.

3.2.2 Procedure 2

3.2.2.1 Mounting of Components on the Board Material – The following guidelines shall be applicable (See Fig. 15-1):

(a) Wire terminations - Wire terminations shall be brought through the board holes and bent at least 30° from a line perpendicular to the board. The terminations shall extend .27 mm to 2.54 mm from the bottom of the board. Axial terminations shall be bent at a 90° angle at a point between 1.52 mm and 2.05 mm from the body, eyelet fillet or weld unless otherwise specified (See Fig. 15-1).

(b) Pin terminations - Where the component is designed with rigid pin terminations, the full length of the termination shall be retained. Pin terminations shall not be cut or bent.

3.2.2.2 When flux is used, the conditions stipulated at 3.2.1.3 will be applicable.

3.2.2.3 The terminations mounted on the board material shall be immersed in the solder bath which has just previously been skimmed of dross and burnt flux, so that the bottom of the board rests on the molten solder. The solder bath shall be maintained at the temperature as applicable for the specified test condition (See 3.1.1 (b) and 3.1.2).

3.2.2.4 The terminations shall be allowed to remain immersed in the solder bath for the dwell time as applicable for specified Test Condition (See 3.1.1 (b) and 3.1.2), at the end of which period, the board shall be removed from the vicinity of the molten layer of solder.

3.2.2.5 After the dip, the components shall be allowed to cool and stabilize at laboratory ambient conditions and then visually examined. There shall be no damage due to heating on the surface of the components when examined under 10 power magnification.

3.2.2.6 When specified, an internal examination of the component shall also be made after the test to check for solder reflow or heat damage.

3.3 Recovery

3.3.1 The components shall remain under recovery conditions for a period of 1 to 2 hours or as specified in the relevant component specification.
4. INFORMATION TO BE GIVEN IN THE RELEVANT COMPONENT SPECIFICATION

(a) Preconditioning, if any.
(b) Initial measurements.
(c) Applicable procedure (see 3.1.2).
(d) Details of heat sinks or shielding (see 3.1.3).
(e) Special preparation of the components, if any (see 3.1.4).
(f) Period of recovery if other than 1 to 2 hours.
(g) Final measurements.
(h) Acceptable performance limits.
(j) Any deviation from the normal test procedure.
Fig 15-1 COMPONENT LEAD AND MOUNTING EXAMPLES
TEST NUMBER-16

RESISTANCE TO SOLVENTS

1. OBJECT

1.1 The object of this test is to determine the deleterious effects caused on components when subjected to solvents and processes (normally used to clean solder flux, finger prints and other contaminants from printed wiring and terminal board assemblies etc.) and to verify that the markings or colour codings remain legible, and without discolouration. This test can also be used to verify that component protective coatings and encapsulant materials are not degraded to the point where electrical or mechanical integrity is disturbed when subjected to such solvents and processes.

NOTE - When this test is referenced, care should be exercised to assure that conflicting requirements, as far as the properties of the specified finishes and markings are concerned, are not invoked.

2. TEST EQUIPMENT

2.1 A suitable container made of non reactive material and of a sufficient size to permit complete immersion of the components in the solvent solutions (See 2.2) shall be used.

2.2 The solvent solutions (See NOTE) used in this test shall consist of the following:

(a) SOLVENT SOLUTION - I (l/): A mixture of one part by volume of isopropyl alcohol, and three parts by volume of mineral spirits or three parts by volume of a mixture of 80 per cent by volume of kerosene and 20 per cent by volume of ethyl benzene.

(b) SOLVENT SOLUTION - 2 (2./) : A terpene defluxer consisting of a minimum of 90 per cent d-limonene and 10 per cent surfactant.

(c) SOLVENT SOLUTION - 3 (3./) : A mixture of 42 parts by volume of water (1 megohm - cm minimum resistivity), one part by volume of propylene glycol monomethyl ether (glycol ether PM, I - methoxy-2 - propanol), and one part by volume of monoethanolamine.

NOTE - The above three solvent formulations are considered typical and representative of the solvents used in printed wiring assembly processing of electronic components. Processing conditions are representative of processes used for printed wiring assembly.
HOWEVER, THE TWO SOLVENT SOLUTIONS (SOLVENT SOLUTION-2 AND SOLVENT SOLUTION-3) HAVE BEEN IDENTIFIED AND INCLUDED IN THIS TEST ON A TRIAL BASIS ONLY TILL SUCH TIME THEIR FREE AVAILABILITY IS ESTABLISHED, AND ADEQUATE DATA BASE ON THEIR CHARACTERISTICS IS AVAILABLE. ACCORDINGLY, FOR THE PRESENT, ONLY ONE SOLVENT SOLUTION (SOLVENT SOLUTION-1) SHALL BE MADE APPLICABLE FOR THE CONDUCT OF THIS TEST, UNTIL THE STATUS REVIEW PLANNED FOR 1996-97.

1. : Analytical Reagent (AR) Grade. equivalent to Grade "A' of TT-I-735.

1/: A commonly used terpene defluxer is BIOACT EC-7R 'BIOACT' is registered trade mark of Petroferm INC.

1/: Normal safety precautions for handling this solution are as applicable for diluted ammonium hydroxide.

2.2.1 The above solvent solutions exhibit some potential for health and safety hazards. The following safety precautions shall be strictly observed, apart from the safety precautions listed in the appropriate solvent manufacturers material safety data sheet.

(a) Avoid contact with eyes
(b) Avoid Prolonged contact with skin
(c) Avoid open flame
(d) Avoid contact with very hot surfaces
(e) Provide adequate ventilation.

2.3 A suitable brush (for example, tooth brush) with handle made of non reactive material shall be used. The brush shall have three or four long rows of hard bristles 25 to 30 mm long. Each row shall contain eight to twelve tufts, the free ends of which shall lie substantially in the same plane, A separate brush shall be used for each solvent solution and when there is any evidence of softening, bending, wear or loss of bristles, it shall be discarded.

3. TEST PROCEDURE

3.1 Testing (Normal Test Procedures)

3.1.1 The components to be subjected to this test shall be divided into 3 equal lots. Each lot shall be individually subjected to solvent action as specified below:

(a) The first lot shall be subjected to solvent solution as specified in 2.2 (a).

(b) The second lot shall be subjected to solvent solution as specified in 2.2 (b).
3.1.2 The solvent solution shall be maintained at a temperature of 25° C ±5 deg C in the case of test solvent solutions specified at 2.2 (a) and 2.2 (b), and at 65° C -2 deg C, +5 deg C in the case of test solvent solution specified at 2.2 (c). The component shall be completely immersed for 3 minutes +0.5 minute, -0 minute in the solvent solution in the container specified in 2.1.

3.1.3 Immediately following immersion, the bristle portion of the brush, specified in 2.3, shall be dipped in the solution until wetted and the component shall be brushed with normal hand pressure (approximately 60 to 90 g pressure applied normal to the surface) for ten strokes on the portion of the component where marking has been applied, unless otherwise specified in the relevant component specification, using the brush specified 2.3. The brush strokes shall be directed in a forward direction across the surface of the component under test.

3.1.4 Immediately after brushing, the above procedure shall be repeated two more times leading to a total of 3 immersions followed by brushing each time.

3.1.5 After completion of the third immersion and brushing, the components shall be rinsed in water at approximately 25° C (in the case of test solvent solutions specified at 2.2 (b) and 2.2 (c)) and all surfaces air blown dry. In the case of test solvent solution specified at 2.2 a) rinsing in water is not applicable and the components shall be air blown dry. The components shall then be inspected in accordance with 3.3.1 and 3.3.2 to determine the extent, if any, of deterioration that has occurred.

3.1.6 A summary of the above steps for Resistance to Solvents Test is given in the Table below:

**SUMMARY TABLE FOR RESISTANCE TO SOLVENTS**
(Clause 3.1.1 to 3.1.5 and 3.3)

<table>
<thead>
<tr>
<th>SOLVENT - 1</th>
<th>SOLVENT - 2</th>
<th>SOLVENT - 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>(a)</td>
<td>(b)</td>
<td>(c)</td>
</tr>
<tr>
<td>A mixture of one part by volume of isopropyl alcohol and three parts by volume of mineral spirits or a mixture of 80 per cent by volume of kerosene and 20 per cent by volume of ethyl benzene.</td>
<td>Terpene Defluxer</td>
<td>A mixture of 42 parts by volume of water, one part by volume of propylene glycol monomethyl ether, one-part by volume of monoethanolamine.</td>
</tr>
</tbody>
</table>
3.2 **Testing (Special Test Procedures)**

3.2.1 Optional spray exposure procedure for the third lot - The components shall be located on a test surface of known area which is located 15 ± 2.5 cm below a spray nozzle which discharges 0.62 ± 0.02 litres per min of solution per 6.5 square cm of surface area at a pressure of 138 ± 34 kPa. The solvent shall be held at a temperature range 63 to 70°C. The components shall be subjected to this spray for a period of 10 minutes. After the completion of the spray exposure, the specimens shall be thoroughly rinsed in water and all surfaces air blown dry and inspected in accordance with 3.3.1 and 3.3.2 to determine the extent, if any, of deterioration that has occurred. If this optional exposure procedure is specified, brushing of the samples in the third lot is not required. If conflict arises from the use of the spray lot is not required. If conflict arises from the use of the spray option, the brush method on the third lot shall be used as the referee procedure.

3.2.2 Immersion test for components with marking protected by sleeving Components with protective sleevings shall be divide into three lots and subjected to normal test procedures specified under 3.1, with the following deviations being applicable:

(a) The portion where the brush strokes are to be applied after immersion of the component will be the area on the sleeving directly above the area of marking.

(b) After the third immersion and brushing, the components shall be air blown dry, the step of "rinsing in water" being not applicable.
(c) The extent of deterioration, if any, on both the component and the sleeving shall be determined.

3.3 Examination after Testing

3.3.1 Marking resistance to solvents - After subjection to the test, any evidence of the damage to specified markings which are observed to be missing in whole or in part, faded, smeared, blurred or shifted (dislodged) to the extent they cannot be readily identified from a distance or atleast 15 cm with normal laboratory illumination and without the aid of magnification or with a viewer having a magnification no greater than 3X shall constitute a failure.

3.3.2 Component protective coating, encapsulation material and sleeving resistance - After subjection to the test, the components shall be examined for cracks, separations, crazing, swelling, softening and degradation of body material and caps and seals, if present, or any other damage or degradation that has occurred due to solvent exposure and which effects the mechanical integrity or reliability shall constitute a failure. The examination shall be made with a viewer having a magnification of I OX maximum.

4. INFORMATION TO BE GIVEN IN THE RELEVANT COMPONENT SPECIFICATION

(a) Preconditioning, if any
(b) Initial measurements
(c) The portion of the specimen to be brushed (See 3.1.3)
(d) Final measurements
(e) Acceptable performance limits
(f) Any deviation from the normal test procedure
TEST NUMBER -17

ROBUSTNESS OF TERMINATIONS

1. OBJECT

1.1 The object of this test is to determine the ability of terminations of components to withstand mechanical stresses likely to be applied during normal assembly or mounting operations.

2. TEST PROCEDURE

2.1 General

2.1.1 One or more of the following procedures shall be made applicable.

(a) **Procedure 1**: Tensile - In this procedure, a tensile test shall be applied on terminations of components.

(b) **Procedure 2**: Bending (wire terminations) – In this procedure, a bending test shall be applied on terminations of components.

(c) **Procedure 3**: Bending (tag and strip terminations) - in this procedure, a bending test shall be applied on tag and strip terminations of components.

(d) **Procedure 4**: Torsion (axial wire terminations) - In this procedure, a torsion test shall be applied on axial wire terminations of components.

(e) **Procedures 5**: Torque (screw terminations) – In this procedure, a torque test shall be applied on screw terminations of components.

(f) **Procedure 6**: Torque (non-wire rigid terminations) - in this procedure, a torque test shall be applied on non-wire rigid terminations of components.

2.2 TESTING

2.2.1 **Procedure 1: Tensile**

2.2.1.1 The body of the components shall be clamped and the terminations shall be loaded in turn in their normal position relative to the body in the direction of the axes of the terminations (See Fig 17-1).
2.2.1.2 Unless otherwise specified in the relevant component specification, one of the following loadings shall be applied gradually to the terminations and maintained for a period of 10 seconds:

(a) 2.5 N
(b) 5 N
(c) 10 N
(d) 20 N
(e) 40 N

2.2.2 Procedure 2: Bending (Wire Terminations)

2.2.2.1 The components shall have a load applied to their terminations equal to half of that specified for procedure 1 or any other value specified by the relevant component specification. The load shall be freely suspended from each termination in turn at a point within 6 mm from the free end of the termination, the body of the component being held so that the terminations are in their normal position relative to the components.

2.2.2.2 The body of the components shall then be inclined slowly so as to bend the termination through 90° from normal and back to normal, the entire action taking place in one quadrant (see Fig. 17-2). This operation is defined as one bend. The rate of bending shall be 3 seconds per bend in each direction. The number of bending operations shall be 3 unless otherwise specified in the relevant component specification.

2.2.2.3 Where the terminations are weaker in one plane than in the others they shall be tested in the direction most likely to damage the components or several tests, each on a separate component shall be made.

2.2.2.4 Consecutive bends shall be in the same direction.

2.2.3 Procedure 3: Bending (Tacr and Strip terminations)

2.2.3.1 The tag terminations of the components, capable of being bent with fingers shall be so bent either 2 or 5 times, as specified in the relevant component specification in alternate directions (see Fig. 17-3). The rate of bending shall be approximately 3 seconds per bend in each direction.

2.2.3.2 Those terminations which are not capable of being bent with the fingers shall be tested in accordance with the relevant component specification.

2.2.4 Procedure 4: Torsion (axial Wire Terminations)

2.2.4.1 Each termination of the components shall be bent through 90° at a point 6 mm from the point of emergence of the termination. The radius of curvature of the bend shall be approximately 0.75 mm (see Fig. 17-4).
2.2.4.2 The free end of the termination shall then be clamped at a point 1.2 ± 0.4 mm from the bend (see Fig. 17-5).

2.2.4.3 The body of the components or the clamping device shall then be rotated about the original axis of the termination at the rate of 1 rotation per 5 seconds.

2.2.4.4 Successive rotations shall be in alternate directions.

2.2.4.5 The termination shall be subjected to one of the following conditions as specified by the relevant component specification:

(a) 3 rotations of 360° each.
(b) 2 rotations of 180° each.

Unless otherwise specified by the relevant component specification, 3 rotations of 360° each shall apply.

2.2.5 **Procedure 5 : Torque (screw Terminations)**

2.2.5.1 The relevant component specification shall specify the value of torque from Table 17.1 based on the thread diameter of the nut or screw.

<table>
<thead>
<tr>
<th>THREAD DIAMETER (mm)</th>
<th>TORQUE (Nm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.6</td>
<td>0.39</td>
</tr>
<tr>
<td>3.0</td>
<td>0.49</td>
</tr>
<tr>
<td>3.5</td>
<td>0.78</td>
</tr>
<tr>
<td>4.0</td>
<td>1.17</td>
</tr>
<tr>
<td>5.0</td>
<td>1.76</td>
</tr>
<tr>
<td>5.5</td>
<td>2.156</td>
</tr>
<tr>
<td>6.0</td>
<td>2.45</td>
</tr>
</tbody>
</table>

2.2.5.2 The nuts or screws of the terminations of the components shall be gradually tightened till the specified torque is reached.

2.2.5.3 The torque shall be applied in a plane perpendicular to the axis of the termination (see Fig. 17.6).

2.2.5.4 The specified torque shall be maintained for 5 to 15 seconds.

2.2.5.5 The nuts or screws shall then be loosened.

2.2.5.6 **Procedure 6: Torque (Non-Wire Rigid Terminations)**
2.2.6.1 The relevant component specification shall specify the value of the torque from Table 17.2 based on the equivalent diameter of the external portion of the termination assembly. The equivalent diameter is defined as equal to twice the distance from the termination axis to the point of normal wire connection, as shown in Fig. 17-7.

**TABLE 17.2 VALUES OF TORQUE**

(Clause 2.2.6.1)

<table>
<thead>
<tr>
<th>EQUIVALENT DIAMETER</th>
<th>TORQUE (mNm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>up to 1.6</td>
<td>0</td>
</tr>
<tr>
<td>1.7 to 3.2</td>
<td>56.5</td>
</tr>
<tr>
<td>3.3 to 4.8</td>
<td>127.1</td>
</tr>
<tr>
<td>4.9 to 7.9</td>
<td>282.5</td>
</tr>
<tr>
<td>8.0 to 12.7</td>
<td>565.0</td>
</tr>
<tr>
<td>greater than 12.7</td>
<td>as specified in the relevant component specification</td>
</tr>
</tbody>
</table>

2.2.6.2 The method of application and duration of the torque shall be as in procedure 5 unless otherwise specified in the relevant component specification.

3. **INFORMATION TO BE GIVEN IN THE RELEVANT COMPONENT**

(a) Preconditioning, if any.
(b) Initial measurements.
(c) Applicable procedure(s)
(d) For procedure 1, the load to be applied (see 2.2.1.2) and acceptable performance limits.
(e) For procedure 2, the load to be applied (see 2.2.2.1), the number of bends if other than 3 bends (see 2.2.2.2) and the direction of bend.
(f) For procedure 3, the details of bending (see 2.2.3.1 and 2.2.3.2) and the number of bends.
(g) For procedure 4, the details of rotation (see 2.2.4.5) if other than 3 rotations of 360°.
(h) For procedure 5, the torque to be applied (see 2.2.5.1).
(i) For procedure 6, the torque to be applied (see 2.2.6.1) details of torque application if other than those specified (see 2.2.6.2).
(k) Final measurements.
(l) Acceptable performance limits.
(m) Any deviation from the normal test procedure.
Fig 17-1 LOADING FOR TENSILE TEST

Fig 17-2 BENDING (WIRE TERMINATIONS) TEST

Fig 17-3 BENDING (TAG AND STRIP TERMINATIONS) TEST
5.4 Method of Bending Wire Terminations for Torsion (Axial Wire Terminations) Test

NOTE - All dimensions in millimetres.

5.5 Method of Twisting Wire Terminations for Torsion (Axial Wire Terminations) Test

NOTE - All dimensions in millimetres.
Fig 17-6 TORQUE TEST

NOTE. Equivalent diameter is twice the distance between the lines indicated by the arrows.

Fig 17-7 METHOD OF DETERMINING EQUIVALENT DIAMETER FOR TORQUE (NON-WIRE RIGID) TERMINATIONS TEST
TEST NUMBER - 18A

SEALING (STATIC AND OPERATIONAL SEALS)

1. **OBJECT**

   1.1 The object of this test is to determine the air tightness of sealing features of electronic components.

2. **TEST CHAMBER**

   2.1 A sealed chamber capable of withstanding and maintaining pressure differentials as specified shall be used.

   2.2 The chamber shall be fitted with an air inlet nozzle, air line and a suitable valve (see Fig Bl at Appendix B).

   2.3 The components shall be mounted on the lid of the chamber.

   2.4 The components shall be connected to a suitable operating mechanism for mechanical operation.

   NOTE - A test set up suitable for pressure differentials of upto 108 kPa is described in Appendix B.

3. **TEST PROCEDURE**

   3.1 **GENERAL**

   3.1.1 For the purpose of this test, seals shall be classified as follows:

   (a) Type A seals - Type A seals are static seals (for example, mounting bushes having seals under permanent Compression such as rubber gaskets or seals of connectors and adapters).

   (b) Type B seals - Type B seals are operational seals (for example, spindle and switch lever seals)

   3.2 **Testing**

   3.2.1 Unless otherwise specified, a differential air pressure as specified below shall be applied across each seal or simultaneously across a group of seals forming an assembly.
(a) 98 to 108 k Pa for type A seals in the direction specified by the relevant component specification.

(b) 98 to 108 k Pa for Type B seals, in each direction.

3.2.2 Type B seals shall be tested in the static condition and also while being mechanically operated, if so required by the relevant component specification.

3.2.3 The leakage rate of the components shall be measured while they are under the specified pressure differential.

4. INFORMATION TO BE GIVEN IN THE RELEVANT COMPONENT SPECIFICATION

a) Classification of seal.
b) Preconditioning, if any.
c) Differential air pressure to be applied (see 3.2.1)
d) Whether Type B seals should be tested in the static condition or while being operated or both, and details of mechanical operation, if applicable.
e) Direction of pressure differential for Type A seals (see 3.2.1(a).
f) Acceptable leakage rate limits.
g) Any deviation from the normal test procedure.
1. **OBJECT**

1.1 The object of this test is to determine the effectiveness or component seals having an included gas filled space (for example components not completely filled with impregnant)

2. **TEST CHAMBER**

2.1 The chamber used for procedure I (see 3.1.1 (a)) shall conform to the requirements stated in 2.1.1 to 2.1.3.

2.1.1 The chamber shall be capable of being evacuated to the required low pressure.

2.1.2 The chamber shall contain a bath with sufficient liquid to enable the components to be completely immersed to a depth of not less than 10 mm above the uppermost part of the enclosure or seal of the components to be tested.

2.1.3 The liquid used in the bath shall be maintained between 15° C and 30° C and shall have the following characteristics:

   (a) Specific gravity at 20° C - 0.890
   (b) Kinematic viscosity at 20° C - 25 X 10^-4 m2/s
   (c) Kinematic viscosity at 50° C - 9X10^-4 m2/s

   NOTE - A suitable liquid is degassed transformer oil.

2.2 The chamber used for Procedure 2 (see 3.1.1 (b)) shall conform to the requirements stated in 2.2.1 and 2.2.2.

2.2.1 The chamber shall contain a bath with sufficient liquid to enable the components to be completely immersed to a depth of not less than 10 mm above the uppermost part of the enclosure or seal of the components to be tested.

2.2.2 The liquid used in the bath shall be maintained at a temperature of 1 to 5° C above the temperature (dry heat) severity of the components.

   NOTE - Water with a wetting agent or any other suitable liquid having a kinematic, viscosity of not more than 22 X 10^-5 m/s at 38° C may used.
3. TEST PROCEDURE

3.1 General

3.1.1 One of the following procedures shall be made applicable:

(a) Procedure 1 - This shall consist of immersion of the components in a suitable liquid, and evacuating the chamber to the specified low air pressure.

(b) Procedure 2 - This shall consist of immersing the components in a liquid maintained at a high temperature.

3.2 Testing

3.2.1 Procedure 1

3.2.1.1 The components shall be immersed in- the liquid bath with their seals uppermost.

3.2.1.2 The air pressure inside the chamber containing the liquid bath shall then be reduced to a value of 1.33 kPa within one minute and shall be maintained at this pressure for 1 minute, unless repetitive bubbling has been observed at any intermediate pressure.

3.2.1.3 Components having seals on more than one face shall be tested in accordance with 3.2.1.1 and 3.2.1.2 with each face in the uppermost position.

3.2.1.4 There shall be no leakage as determined by repetitive bubbles emerging from the components.

NOTE - It is essential that the low air pressure be attained promptly so that initial frothing may clear rapidly and not mask the bubbles due to leak from the components. Holes as small as 2 µm in diameter will be indicated by this method. However, when the air space within the component is small or the leakage large, the bubbles may disappear in the first frothing.

3.2.2 Procedure 2

3.2.2.1 The components which shall be at a temperature between 15° C and 35° C shall be immersed in the liquid bath maintained at the specified high temperature for 1 minute with their seals uppermost.

3.2.2.2 Components having seals on more than one face shall be tested in accordance with 3.2.2.1 with each face in the uppermost position.
3.2.2.3 There shall be no leakage as determined by repetitive bubbles emerging from the components -

4. INFORMATION TO BE GIVEN IN THE RELEVANT COMPONENT SPECIFICATION

(a) Pre-conditioning, if any.

(b) The applicable procedure

(c) Temperature for procedure 2 (see 2.2.2).

(d) Any special details of liquid for the bath.

(e) Any deviation from the normal test procedure.
1. **OBJECT**

1.1 The object of this test is to determine the effectiveness of seals of components filled with liquid.

NOTE - This test may also be used for components having filling which is solid at the laboratory ambient temperature but which liquefies at the specified test temperature.

2. **TEST CHAMBER**

2.1 A dry heat chamber capable of maintaining its working space at the temperature specified (see 3.1.1) shall be used. In all other respects, the dry heat chamber shall conform to the requirements specified for the chamber for the temperature (dry heat) test (Test Number 22).

3. **TEST PROCEDURE**

3.1 **Testing**

3.1.1 Components, with their seals downwards, shall be placed in the chamber whose temperature shall then be raised until the surface temperature of the components is 1 to 5°C above the appropriate temperature (dry heat) severity and shall be maintained at this temperature for 10 minutes. The components shall then be removed from the chamber and allowed to stand for 10 minutes under atmospheric conditions for testing.

3.1.2 Components having seals on more than one face shall be tested in accordance with the above procedure, with each sealed face in the downward position.

3.1.3 The components shall be visually examined for seepage of liquid. Unless otherwise specified by the relevant component specification, there shall be no seepage. The relevant component specification, may however, specify a permissible seepage and its method of detection.

4. **INFORMATION TO BE GIVEN IN THE RELEVANT COMPONENT SPECIFICATION**

   (a) Preconditioning, if any.
   (b) The temperature (dry heat) severity (see 3.1.1)
(c) The method of detecting seepage and permissible seepage (see 3.1.3)
(d) Acceptable performance limits.
(e) Any deviation from the normal test procedure.
TEST NUMBER -18D

SEALING (TRACER GAS)

1. OBJECT

1.1 The object of this test is to detect leakage rates between the values of 10^{-4} and 10^{-9} Pa.dm^{-3} per second in components.

NOTE - For rapid testing, as in batch acceptance tests, the usable sensitivity is approximately 10^{-4} Pa.dm^{-3} per second.

2. TEST EQUIPMENT

2.1 When performing this test in accordance with procedures 1, 2, 3A and 4 (see 3.1.1) a tracer gas such as helium, argon or any other rare gas or a mixture of such a gas with nitrogen (such as 90 per cent nitrogen and 10 per cent helium) shall be used. The tracer gas used in procedure 3B (see 3.2.4) shall be radioactive gas krypton 85.

2.2 A commercially available mass spectrometer type leak detector, preset to read a tracer gas content, shall be used to measure the leakage rate of the tracer gas through a faulty seal for procedure 1, 2, 3A and 4 of this test. Any other suitable instrument calibrated to read a tracer gas content properly with a suitable leakage-detection sensitivity, can also be used.

2.3 Any commercially available equipment, using the principle of radioactive gas detection to measure leaks, shall be used for procedure 33 of this test.

3. TEST PROCEDURE

3.1 General

3.1.1 One of the following procedures shall be made applicable:

(a) Procedure I - This procedure shall be made applicable for components which have an unsealed evacuation tube that can be connected to the leak detector for test purposes and in which leaks occur from outside to inside.

(b) Procedure 2- This procedure shall be made applicable for components which have an unsealed evacuation tube that will permit pressurising with a tracer gas and in which leaks occur from inside to outside.
(c) Procedure 3A - This procedure shall be made applicable for components which are not filled with a tracer gas and which can be tested without breaking their seals by forcing the tracer gas into the leaks and determining its escape by a suitable method.

(d) Procedure 3B - This procedure shall be made applicable for components which are not filled with a tracer gas and which can be tested without breaking their seals by forcing radioactive gas into the leaks and determining the quantity of the radioactive gas that has entered.

(e) Procedure 4 - This procedure shall be made applicable for components which are normally supplied backfilled with a tracer gas and which are to be tested without breaking their seals for leaks from inside to outside.

3.2 Testing

3.2.1 Procedure I

3.2.1.1 The mass spectrometer type leak detector shall be coupled to the unsealed evacuation tube of the components and a vacuum created within the components.

3.2.1.2 The coupling connections between the components and the leak detector shall be perfectly sealed.

3.2.1.3 The components shall then be subjected to the tracer gas atmosphere either by 'surrounding them with the tracer gas or by spraying them thoroughly with a jet of the tracer gas.

3.2.1.4 If a leak exists in the specimen, an amount of gas will be drawn through it and passed into the leak detector, which will indicate the leakage rate. This shall be recorded.

3.2.1.5 The components shall then be filled with air or gas at a specified pressure and the evacuation tubes shall be pinched off and sealed.

3.2.1.6 The seal of the evacuation tubes shall be verified by either procedure 3A or procedure 4.

3.2.2 Procedure 2

3.2.2.1 The mass spectrometer type leak detector shall be coupled to a suitable vacuum chamber. The components shall be placed in the chamber and a tube leading from the gas source shall be connected to the unsealed evacuation tubes of the components.
3.2.2.2 The coupling connections between the components and the gas source shall be perfectly sealed.

3.2.2.3 The chamber shall then be evacuated and the gas shall be forced into the components under pressure.

3.2.2.4 If a leak exists an amount of gas will pass through the specimen into the chamber and then into the leak detector, which will indicate the leakage rate. This shall be recorded. If pressure cycling is required, the relevant component specification shall state the number of times the pressure cycling is to be applied. The leakage rate shall be read at the end of each cycle.

3.2.2.5 The component shall be filled with air or gas at a specified pressure and the evacuation tubes shall then be pinched off and sealed.

3.2.2.6 The seal of the evacuation tubes shall be verified by either procedure 3A or procedure 4.

3.2.3 Procedure 3A

3.2.3.1 The components shall be placed in sealed chamber which is then pressurised with a tracer gas. Unless otherwise specified in the relevant component specification, the pressure shall be 413 kPa and the duration shall be a minimum of 4 hours. The conditions stated in the 3.2.3.2 and 3.2.3.3 shall be completed within 30 minutes after pressurisation.

3.2.3.2 The pressure shall then be relieved. The components shall then be transferred preferably to another chamber which is connected to the evacuating system and the mass spectrometer type leak detector.

3.2.3.3 Any gas that was previously forced into the specimen (see 3.2.3.1) will thus be drawn out and indicated by the leak detector. The leakage rate shall then be read and recorded.

3.2.3.4 The components shall be checked for gross leak by procedure specified by the relevant component specification.

NOTE - This procedure shall not be applied to components crated with organic materials. Further in order to avoid spurious indications, contaminants or surface coatings that may conceal existing leaks and tracer gas which may be absorbed or adsorbed on the surface of the component shall be removed.

3.2.4 Procedure 3B

3.2.4.1 The components shall be placed in a sealed chamber which is then pressurised with gas Krypton 85. The pressure and the duration of pressurisation shall
be as specified in the relevant component specification. Unless otherwise specified in the relevant component specification, the conditions stated in 3.2.4.2 shall be completed within 30 minutes after the pressurisation.

3.2.4.2 The components shall then be removed from the chamber and the internal content of radioactive gas shall be determined by the counter. The quantity of radioactive gas is then expressed in terms of leakage rate.

3.2.4.3 The components shall be checked for gross leak by a suitable procedure as specified by the relevant component specification.

NOTE - This procedure shall not be applied to components coated with organic materials. Further, in order to avoid spurious indications, contaminants or surface coatings that may conceal existing leaks and tracer gas which may be absorbed or adsorbed on the surface of the components shall be removed.

3.2.5 Procedure 4

3.2.5.1 The components which are backfilled and sealed with a tracer gas during production shall be placed in a chamber connected to the mass spectrometer type leak detector and the chamber shall then be evacuated. The low pressure value and the time duration required for achieving it shall be specified by the relevant component specification.

3.2.5.2 The internal pressure of the specimen is one atmosphere or greater depending on the backfilling pressure, so that the tracer gas is forced through any defect or poor seal into the chamber and then to the leak detector, which will indicate the leakage rate. This shall be recorded.

3.2.5.3 If specified in the relevant, component specification, the components shall be perforated in order to determine if gas is actually present.

3.2.5.4 The components shall be checked for gross leak by a suitable procedure specified by the relevant component specification.

4. INFORMATION TO BE GIVEN IN THE COMPONENT

(a) Preconditioning, if any.

(b) Applicable procedure

(c) Acceptable leakage rate.

(d) For procedure I, details of pressure (See 3.2.1.5) and the procedure for leakage rate verification (see 3.2.1.3)
(e) For procedure 2, the number of pressure cycles to be given (See 3.2.2.4), pressure of gas (see 3.2.2.5) and the procedure for leakage rate verification (see 3.2.2.6)

(f) For procedure- 3A, the pressure, the duration of pressurisation, and the interval permitted between the pressurisation and the testing, if other than those specified (See 3.2.3.1) and the gross leak verification procedure (see 3.2.3.4)

(g) For procedure 3B, the pressure, the duration of pressurisation, and the interval permitted between the pressurisation and the testing, if other than that specified (See 3.2.4.1) and the gross leak verification procedure (see 3.2.4.3)

(h) For procedure 4, the low pressure value and time duration (See' 3.2.5.1) and details of gross leak verification procedure (see 3.2.5.4)

(j) Any deviation from the normal test procedure.
1. **OBJECT**

1.1 The object of this test is to determine the effectiveness of seals of components when subjected to specified immersion conditions.

2. **TEST EQUIPMENT**

2.1 A suitable water tank or a high pressure water chamber capable of providing the conditions stated in Table 18E-1 shall be used for procedure I" (see 3.1.1(a)),.

2.2 Suitable hot -and cold baths of salt or tap water capable of providing the conditions stated in Table 18E-2 shall be used for procedure 2' (see 3.1.1(b)).

3. **TEST PROCEDURE**

3.1 **General**

3.1.1 One of the following procedures shall be made applicable: -

(a) Procedure I - The components shall be subjected to the specified depth of immersion in a water tank or to an equivalent pressure in a high pressure water chamber.

NOTE - This procedure may be used for components whose water tightness under specified conditions of pressure and time is to be determined.

(b) Procedure 2 - The components shall be subjected to successive cycles of immersion in hot and cold baths.

NOTE - This procedure may be used to detect a defective terminal assembly or a partially closed seam or moulded enclosure of a component by subjecting it to alternate thermal stresses.

3.2 **Preconditioning**

3.2.1 The relevant component specification shall indicate, if required, whether aging of gaskets is necessary before subjecting the components to this test.

3.3 **Testing**
3.3.1 **Procedure - I**

3.3.1.1 The components shall be oriented in the position as specified in the relevant component specification while immersing in a water tank or a high pressure water chamber.

3.3.1.2 The components shall then be subjected to immersion at the appropriate severity (see Table 18E-1) as required by the relevant component specification.

**TABLE 18E-1 : SEVERITIES FOR PROCEDURE I**

(Clause 3.3.1.2)

<table>
<thead>
<tr>
<th>SEVERITY</th>
<th>HEAD OF WATER m</th>
<th>CORRESPONDING EXCESS PRESSURE at 25° C k Pa</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.15</td>
<td>1.47</td>
</tr>
<tr>
<td>2</td>
<td>0.40</td>
<td>3.91</td>
</tr>
<tr>
<td>3</td>
<td>1.00</td>
<td>9.70</td>
</tr>
<tr>
<td>4</td>
<td>1.50</td>
<td>14.7</td>
</tr>
<tr>
<td>5</td>
<td>4</td>
<td>39.1</td>
</tr>
<tr>
<td>6</td>
<td>6</td>
<td>58.7</td>
</tr>
<tr>
<td>7</td>
<td>10</td>
<td>97.8</td>
</tr>
<tr>
<td>8</td>
<td>15</td>
<td>147.0</td>
</tr>
</tbody>
</table>

3.3.1.3 When a tank is used, the specified head of water shall be measured above the highest point of the component.

3.3.1.4 When a high pressure water chamber is used, the excess pressure shall be adjusted to one of the values given in Table 18E-1.

3.3.1.5 The components shall remain immersed for a duration as required by the relevant component specification. The preferred duration shall be either 30 minutes, 2 hours or 24 hours.

3.3.1.6 The temperature of the components shall be not less than the temperature of the water, and not more than 10° C above the temperature of water, which shall not exceed 35° C.

3.3.2 **Procedure 2**

3.3.2.1 The components shall be subjected to successive cycles of immersion, each cycle consisting of immersion in a hot bath of tap water at a temperature of 65° C ±5 deg C, -0 deg C followed by an immersion in a cold bath. The number of cycles, the duration of each immersion and the nature and temperature of cold bath shall be as indicated in Table 18E-2.
TABLE 18E-2: SEVERITIES FOR PROCEDURE 2
(Clauses 3.3.2.1)

<table>
<thead>
<tr>
<th>SEVERITY</th>
<th>NUMBER OF CYCLES</th>
<th>DURATION OF EACH IMMERSION min</th>
<th>NATURE OF COLD BATH</th>
<th>TEMPERATURE OF COLD BATH</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2</td>
<td>15</td>
<td>Tap water</td>
<td>25°C +10 deg C - 5 deg C</td>
</tr>
<tr>
<td>2</td>
<td>2</td>
<td>15</td>
<td>Saturated solution of sodium chloride and water</td>
<td>25°C +10 deg C - 5 deg C</td>
</tr>
<tr>
<td>3</td>
<td>5</td>
<td>60</td>
<td>Saturated solution of sodium chloride and water</td>
<td></td>
</tr>
</tbody>
</table>

3.3.2.2 The transfer of the components from one bath to the other shall be accomplished as rapidly as practicable.

NOTE - When electrical measurements are made after immersion cycling to obtain evidence of leakage, the use of salt solution instead of tap water will facilitate detection of water penetration.

3.4 Recovery

3.4.1 In case of procedure 2, the components shall be thoroughly and quickly rinsed in tap water.

3.4.2 The components shall be thoroughly dried externally by wiping or by applying a blast of air at atmospheric conditions for testing as required by the relevant component specification.

3.4.3 The components shall then remain under recovery conditions for 1 to 2 hours for procedure 1 and 4 to 24 hours for procedure 2 or as required by the relevant component specification.

4. INFORMATION TO BE GIVEN IN THE RELEVANT COMPONENT SPECIFICATION.

(a) Preconditioning, if any (see 3.2.1)

(b) Applicable procedure and severity.

(c) Duration of test for procedure 1.
(d) Method of drying the components (see 3.4.2)

(e) Duration of recovery, if other than 1 to 2 hours for procedure 1, and if other than 4 to 24 hours for procedure 2.

(f) Final measurements, if required.

(g) Acceptable performance limits.

(h) Any deviation from the normal best procedure.
TEST NUMBER-19

SOLDER ABILITY

1. OBJECT

1.1 The object of this test is to determine the ability of component terminations to wet easily by a new coating of solder. An accelerated aging test is included in this test method which simulates a combination of various storage conditions.

2. TEST EQUIPMENT

2.1 Solder Bath

2.1.1 The solder bath used for this test shall have a volume sufficient to ensure that the temperature of the solder remains substantially uniform when terminations are introduced. The bath shall be capable of maintaining the solder at the specified temperature.

2.1.2 The exposed area of the surface of the solder in the bath shall be reduced as far as possible (for example, by the use of a sheet of asbestos) in order that the component shall not be heated by direct radiation from the bath.

2.1.3 The solder bath shall be fitted with a mechanical dipping device capable of immersing and withdrawing the terminations at a rate of 20 to 30 mm per second and maintaining a dwell time of 4.5 to 5.5 seconds.

2.1.4 The solder used shall be soft solder conforming to grade Sn 60 of IS: 193.

2.1.5 The flux used shall be 25 per cent by mass of Water White Resin and 75 per cent by mass of 99 per cent Isopropyl Alcohol.

2.2 Soldering Iron

2.2.1 The soldering iron used for this test shall be temperature controlled type with three wire cord and tip grounding, and shall have one of the following bit sizes:

(a) 8 mm diameter with 32 mm exposed length reduced to a wedge shape over a length of approximately 10 mm, which is designated as Size A.

(b) 3 mm diameter with 12 mm exposed length reduced to a wedge shape over a length of approximately 5 mm, which is designated as Size B.

2.2.2 The surface of the bit shall be smooth and properly tinned.
2.2.3 The temperature of the bit shall be 350° C ±5 deg C.

2.2.4 The solder used shall be 60/40 tin-lead alloy with a non-activated wood rosin core conforming to IS: 1921.

2.3 **Steam Arcing Apparatus**

2.3.1 The steam aging apparatus used for this test shall be a non-corrodible container of sufficient size to allow the support of the component above the boiling distilled or deionizer water used for steam generation. The non-corrodible cover of the container shall be such that its open area allows for a constant temperature of all terminations within the container. A suitable non-corrodible method of supporting the components shall be used. Perforations or slots as a means of support are permitted for this purpose. All material in contact with steam, water or units shall be non-corrosive and non-reactive to the contents. The steam aging apparatus shall be capable of maintaining the steam temperature, as indicated in Table 19-1.

**TABLE 19-1 : STEAM TEMPERATURE REQUIREMENTS**

<table>
<thead>
<tr>
<th>Altitude</th>
<th>Average local boiling point (°C)</th>
<th>Steam temperature limits (°C)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 to 305 m</td>
<td>100</td>
<td>93 ± 3</td>
</tr>
<tr>
<td>&gt; 305 to 610 m</td>
<td>99</td>
<td>92 ± 3</td>
</tr>
<tr>
<td>&gt; 610 to 915 m</td>
<td>98</td>
<td>91 ± 3</td>
</tr>
<tr>
<td>&gt; 915 to 1220 m</td>
<td>97</td>
<td>90 ± 3</td>
</tr>
<tr>
<td>&gt;1220 to 1525 m</td>
<td>96</td>
<td>89 ± 3</td>
</tr>
<tr>
<td>&gt;1525 to 1830 m</td>
<td>95</td>
<td>88 ± 3</td>
</tr>
</tbody>
</table>

The steam aging apparatus shall be periodically cleaned in a suitable manner and rinsed with deionized or distilled water. The cleaning frequency shall be a minimum of once a week (production usage) or prior to each use.

2.4 **Standard Copper Wrapping Wire**

2.4.1 The standard wrapping wire specified in 3.1.6 shall be a copper wire fabricated from soft or drawn and annealed copper with a diameter of 0.635 ± 0.127 mm. The wrapping wire shall be prepared, as follows:

(a) Straighten and cut wire into convenient lengths (50 mm minimum).
(b) Degrease by immersion in appropriate cleaner for two minutes.

(c) Clean in 10 per cent solution by mass of fluoboric acid (HBF\(^{3}\)) in water for 5 minutes with agitation.

(d) Rinse acid off as follows:
   i) Two cold water rinses.
   ii) Two Isopropyl Alcohol rinses.

(e) Immersion in flux (see 2.1.5).

(f) Dip in molten solder for 5 seconds at 245\(^\circ\) C ±5 deg C.

(g) To remove or dissolve the residual flux, wash or rinse in Isopropyl Alcohol.

(h) Standard wrapping wire shall be stored in a clean, covered container if not used immediately.

(j) The usable life of the standard wrapping wire shall not exceed 48 hours. If not used within 48 hours after preparation, it shall be reprocessed as specified in 2.4.1 (a) through 2.4.1 (d).

NOTE - All chemicals shall be of commercial grade or better. Fresh solvents shall be used as often as is necessary to preclude contamination.

CAUTION - The above steps may involve substances that are flammable, toxic to eyes, skin and respiratory tract, or present serious burn potential. Eye and skin protection are required, including heat resistant gloves when handling hot objects.

3. **TEST PROCEDURE**

3.1 **General**

3.1.1 This test shall be performed on the number of units (components) as specified in the relevant, component specification. During handling, care shall be exercised to prevent the surfaces of the terminations to be tested from being abraded or contaminated. Testing shall consist of the following operations:

(a) Proper preparation of the terminations (see 3.1.4), if applicable.

(b) Aging of all terminations (see 3.1.5).
(c) Application of Flux and immersion of terminations into colder (see 3.2.1.3 and 3.2.1.4) for Procedure I - Solder Bath Method (see 3.1.2 (a)) or application of solder to terminations for Procedure 2 - Soldering Iron Method (see 3.1.2 (b)).

(d) Examination and evaluation of the tested portions of the terminations upon completion of the solder application (see 3.2.1.7 and 3.2.2.4).

3.1.2 One of the following two procedures shall be made applicable:

a) Procedure I - Solder Bath Method - This procedure shall consist of dipping the terminations of components for a period of 4.5 to 5.5 seconds in a solder bath (see 2.1) maintained between 240° C and 250° C.

NOTE - This procedure applies to wire as well as tag terminations.

b) Procedure 2 - Soldering Iron Method – This procedure shall consist of applying the solder (see 2.2.4) to the terminations of components for a period of 10 seconds' by means of a soldering -iron (see 2.2.1).

3.1.3 Unless otherwise specified in the relevant component specification Procedure I shall be preferred.

3.1.4 No wiping, cleaning, scraping or abrasive cleaning of the terminations shall be performed. Any special preparation of the terminations, such as bending or reorientation prior to the test, shall be specified in the relevant component specification. If the insulation on stranded wires has to be removed, it shall be done in a manner not to loosen the strands in the wire.

3.1.5 Aging - Prior to the application of flux and solder all terminations shall be subjected to aging by exposure of the surfaces to be tested to steam in the container specified in 2.3. The components shall be suspended so that no portion of the terminations is more than 60 mm or less than 40 mm above the distilled or deionized water for 8 hours ± 30 minutes with a maximum of 10 minutes interruption. The cover specified in 2.3.1 shall be in place during aging. If necessary, additional distilled or deionized water shall be gradually added in small quantities so that the steam temperature, measured at the component level, remains essentially constant as specified in Table under 2.3.1. Precautions shall be taken to prevent terminations touching each other and also to prevent condensation forming on the body of the component from draining into the terminations. Standard wire shall be subjected to only I hour of steam aging (with insulation removed) with no interruption allowed.

3.1.6 Post Aging - Upon completion of aging (see 3.1.5) the components shall be immediately removed from the steam aging container and dried in ambient air. The terminations so dried shall be subjected to the solderability testing procedures as specified (see 3.2) within 72 hours of completion of aging.
3.1.7 Application of Standard Copper Wrapping Wire - All aged specimens of lugs, tabs, stranded wire greater than 1 mm dia and solid wire greater than 1.14 mm dia shall have a wrap of 11/2 turns of the standard wire around the portion of the wire to be tested. The standard wrapping wire as described in 2.4.1 shall be wrapped in such manner that it will not move during the solder dip. Special instructions concerning the portion of the terminations to be wrapped shall be specified in the relevant component specification. For lugs and tabs designed to accept wire smaller than 0.635 mm diameter, the standard wrapping wire specified in 2.4.1 shall be the size for which the lugs and tabs are designed.

3.2 Testing

3.2.1 Procedure I - Solder Bath Method

3.2.1.1 The wire terminations of components shall be immersed in such a manner as to leave a clearance of 6 mm from the point where the termination emerges from the body or cap of the component.

3.2.1.2 The tag terminations of components shall be immersed to a depth of 3 mm beyond the place intended for the connection of wires referred to the free end or one half of the tag length, whichever islets.

3.2.1.3 The terminations shall be immersed for a period of 5 to 10 seconds in the flux which is maintained between 15° C and 35° C and drained for 5 to 20 seconds before solder dip.

3.2.1.4 The dross and burnt flux shall be skimmed from the surface of the molten solder. The molten solder shall then be stirred with a clean, stainless steel paddle to assure that the solder bath is at uniform temperature between 240° C and 250° C. The surface of the molten solder shall be skimmed again just prior to the immersion of the terminations. The fluxed terminations shall then be mechanically immersed at a rate of 20 to 30 mm per second into the solder bath.

3.2.1.5 The terminations shall be allowed to remain in the solder bath for 4.5 to 5.5 seconds at the end of which period they shall be withdrawn mechanically from the solder bath at a rate of 20 to 30 mm per second.

3.2.1.6 After the dipping process, the terminations shall be allowed to air cool at ambient to 38°C or lower prior to exposure to the cleaning solvent. The residual flux shall be removed by dipping the terminations in clean Isopropyl Alcohol if necessary, a soft cloth moistened with clean 91 per cent isopropyl Alcohol shall be used to remove all remaining flux.

3.2.1.7 The terminations shall then be examined under 10 power magnification. It shall be seen that a minimum of 95 per cent of the solderable surface of the terminations is covered by
continuous coating of solder and the pinholes and voids are not concentrated in one area. In the case of wrapped lugs, tabs or wire (see 3.1.6), the criteria for acceptable solderability is, as follows:

(a) Ninety-five per cent of the total length of fillet, between the standard wrap wire and the termination is tangent to the surface of the termination being tested and free from pinholes, non wetting or dewetting.

(b) There is no ragged or interrupted line at the point of tangency between the fillet and the termination under test. In case of dispute the per cent fillet length with defects shall be determined by actual measurement.

3.2.2 Procedure 2 - Soldering Iron Method

3.2.2.1 The solder shall be applied to the terminations of the components by means of the soldering iron to the extent specified under 3.2.1.1 to 3.2.1.2 for a period of 10 seconds.

3.2.2.2 Tinning, as evidenced by free flowing of solder, with proper wetting of termination, shall be completed within the first 2 seconds, unless otherwise specified in the relevant component specification.

3.2.2.3 The terminations shall be wiped with a lint-free cloth whilst the solder is still molten.

3.2.2.4 The terminations shall then be examined under 10 power magnification. It shall be seen that a minimum of 95 per cent of the solderable surface is covered by a continuous coating of solder and the pinholes and voids are not concentrated in one area.

3.3 Recovery

3.3.1 The components shall remain under recovery conditions for 1 to 2 hours or as specified in the relevant component specification.

4. INFORMATION TO BE GIVEN IN THE RELEVANT COMPONENT SPECIFICATION

(a) Preconditioning, if any.
(b) Applicable procedure (see 3.1.2).
(c) Size of soldering bit for Procedure 2.
(d) Special preparation of terminations, if any (see 3.1.4).
(e) Period of recovery, if other than 1 to 2 hours.
(f) Acceptable performance limits (see 3.2.1.7 and 3.2.2.4).
(g) Any deviation from the normal test procedure.
TEST NUMBER 20

TEMPERATURE CYCLING

1. OBJECT

1.1 The object of this test is to determine the resistance of components when subjected to alternate exposures of specified extremes of high and low temperatures.

2. TEST EQUIPMENT

2.1 A cold chamber and a dry heat chamber which shall be capable of maintaining the temperatures of their working space within ±3 deg C of the specified value as required for procedure I (see 3.2.1) and procedure 2 (see 3.2.2) shall be used. For this test, in all other respects, these chambers shall conform to the requirements of those specified for the temperature (cold) test (Test Number 21) and temperature (dry heat) test (Test Number 22) respectively. The location of chamber shall be such as to allow a rapid transfer of components from one chamber to other.

2.2 For procedure 3 (see 3.2.3) and procedure 4 (see 3.2.4) suitable hot and cold liquid baths, which shall, if necessary, incorporate suitable facilities for rapid transfer of the components from one bath to other, shall be used. The baths shall be so constructed that at no moment, during the test, shall the temperature of the cold bath rise 2° C above and the temperature of the hot-bath fall 2° C below the specified temperatures of the cold and hot baths respectively.

Note - The following are considered as suitable liquids for the baths:

(a) Ethyl alcohol (C2H5OH) for the temperature range of -65 to +35° C (This liquid is known as Ethanol but industrial methylated spirit may be used as a substitute).

(b) Phenyl methyl silicone for the temperature range of -50 to +200°C.

3. TEST PROCEDURE

3.1 General

3.1.1 One of the following procedures shall be used:

(a) Procedure I - in this procedure, a dry heat chamber and a cold chamber shall be used. The components shall be transferred from one chamber to the other after exposure in each chamber for a period of 30 minutes. The transfer time from one chamber to the other shall be between 10 and 15 minutes.
(b) Procedure 2 - In this procedure, a dry heat chamber and a cold chamber shall be used. The components shall be transferred from one chamber to the other after exposure in each chamber for a period of 1 hour or any other period specified in the relevant component specification. The transfer time from one chamber to the other shall be not more than 3 minutes.

(c) Procedure 3 - In this procedure, a hot bath and a cold bath shall be used. The components shall be transferred from one bath to the other after exposure in the hot bath for a minimum of 15 seconds and in the cold bath for a minimum of 5 seconds. The transfer time from one bath to the other shall be not more than 3 seconds.

(d) Procedure 4 - This is same as procedure 3, except that the time at the high temperature shall be a minimum of 5 minutes, the time at the low temperature shall be a minimum of 5 minutes, and the transfer time shall be less 10 seconds.

3.2 Testing

3.2.1 Procedure 1

3.2.1.1 The components shall be introduced into the cold chamber while it is maintained at the appropriate temperature (cold) severity.

3.2.1.2 The components shall be exposed to these conditions for a period of 30 minutes.

3.2.1.3 The components shall then be removed from the cold chamber and exposed to atmospheric conditions for testing for a period of 10 to 15 minutes.

3.2.1.4 The components shall then be introduced into the dry heat chamber which is maintained at the appropriate temperature (dry heat) severity.

3.2.1.5 The components shall be exposed to these conditions for a period of 30 minutes.

3.2.1.6 The components shall then be removed from the dry heat chamber and exposed to atmospheric conditions for testing for a period of 10 to 15 minutes.

3.2.1.7 The above procedure under 3.2.1.1 to 3.2.1.6 shall constitute one cycle. The components shall be subjected to a total of 5 such cycles.

3.2.2 Procedure 2

3.2.2.1 This procedure shall be the same as that specified under 3.2.1.1 to 3.2.1.6 but with an exposure period of 1 hour or any other period as specified by the relevant component specification in each of the cold and dry heat chambers and a transfer time
from one chamber to the other of not exceeding 3 minutes. This procedure constitutes one cycle.

3.2.2.2 The total number of cycles as specified in 3.2.2.1 to which the components shall be subjected shall be 10 cycles or as specified by the relevant component specification.

3.2.3 **Procedure 3**

3.2.3.1 The components shall be preconditioned by immersing them in a hot bath which is maintained at the specified temperature for a minimum of 15 seconds.

3.2.3.2 Immediately at the conclusion of the preconditioning period, the components shall be transferred to the cold bath which is maintained at the specified temperature and shall remain immersed in the cold bath for a minimum of 5 seconds.

3.2.3.3 The components shall then be transferred to the hot bath which is maintained at the specified temperature and shall remain immersed in the hot bath for a minimum of 15 seconds.

3.2.3.4 The transfer time from one bath to other shall be not more than 3 seconds.

3.2.3.5 The above procedure under 3.2.3.2 to 3.2.3.4 shall constitute one cycle. The components shall be subjected to a total of 5 such cycles.

3.2.4 **Procedure 4**

3.2.4.1 The testing shall be done as described in clauses 3.2.3.1 to 3.2.3.5. However, the time durations shall be as specified in 3.1.1(d).

3.3 **Recovery**

3.3.1 The components shall be allowed to remain under recovery conditions for a period adequate for attaining temperature stability.

4. **INFORMATION TO BE GIVEN IN THE RELEVANT COMPONENT SPECIFICATION**

(a) The applicable procedure (see 3.1)

(b) Preconditioning, if any

(c) Initial measurements.

(d) Severities of high and low temperatures.
(e) Period of exposure; if other than 30 minutes for procedure 1.

(f) Period of exposure if other than 1 hour and total number of cycles if other than 10 for procedure 2.

(g) Period of recovery.

(h) Final measurements.

(j) Acceptable performance limits.

(k) Any deviation from the normal test procedure.
TEST NUMBER - 21

TEMPERATURE (COLD)

1. OBJECT

1.1 The object of this test is to determine the suitability of components for use and storage at specified low ambient temperature conditions.

2. TEST CHAMBER

2.1 The chamber shall be capable of maintaining its working space within ±3 degC of the appropriate temperature (cold) severity.

2.2 The low temperature conditions in the chamber shall be achieved by circulating cold air and these conditions shall be maintained uniformly throughout the working space of the chamber.

2.3 Temperature within the chamber shall be monitored by a temperature sensing device suitably located in its working space.

2.4 The design and construction of the chamber shall be such that any heat dissipated by the components during testing, shall not appreciably influence the conditions within the chamber.

3. TEST PROCEDURE

3.1 Testing

3.1.1 Unless otherwise specified, the components shall be introduced into the chamber which is maintained at the appropriate temperature (cold) severity.

NOTE - The relevant component specification, if necessary, may specify the introduction of the components into the chamber under atmospheric conditions for testing. In this case, the temperature of the chamber shall be gradually lowered to the appropriate temperature (cold) severity. The rate of change of temperature shall not exceed 1°/h C per minute, averaged over a period of not more than 5 minutes.

3.1.2 The components shall then be exposed to the appropriate temperature (cold) severity for a period of 2 hours or as specified in the relevant component specification.

3.1.3 If so required by the relevant component specification, the components shall be electrically loaded during this period.
3.1.4 While still at the low temperature, the components shall be tested if so
specified by the relevant component specification.

3.1.5 In case the procedure shown in the note under 3.1.1 has been invoked in
the relevant component specification, at the end of the exposure period, the
components shall remain in the chamber and the temperature shall be gradually raised
to a value within the atmospheric conditions for testing. The rate of change of
temperature shall not exceed 1 degC per minute, averaged over a period of not more
than 5 minutes.

3.2 RECOVERY

3.2.1 The components shall be removed from the chamber and shall remain
under recovery conditions for a period of 1 to 2 hours or as specified by the relevant
component specification.

3.2.2 Condensed moisture shall be removed from the component by shaking or
by such other methods as may be specified in the relevant component specification.

3.2.3 The components shall then remain under recovery conditions for a period
of 1 to 2 hours or as specified by the relevant component specification.

4. INFORMATION TO BE GIVEN IN THE RELEVANT
COMPONENT SPECIFICATION

(a) Preconditioning, if any.
(b) Initial measurements.
(c) The appropriate temperature (cold), severity.
(d) Details of electrical loading (see 3.1.3)
(e) Period of testing if other than 2 hours (see 3.1.2)
(f) Intermediate measurements and time intervals (see 3.1.4)
(g) Periods of recovery, if other than 1 to 2 hours, (see 3.2.1 and 3.2.3).
(h) Final measurements.
(j) Acceptable performance limits.
(k) Any deviation from the normal test procedure.
TEST NUMBER - 22

TEMPERATURE (DRY HEAT)

1. OBJECT

1.1 The object of this test is to determine the suitability of components for use and storage at specified high ambient temperature conditions.

2. TEST CHAMBER

2.1 The chamber shall be capable of maintaining its working space within ±3 degC of the appropriate temperature (dry heat) severity and a relative humidity not exceeding 50 per cent.

2.2 The high temperature conditions in the chamber shall be achieved by circulating hot air and these conditions shall be maintained uniformly throughout the working space of the chamber.

2.3 The heating elements of the chamber shall be baffled to prevent direct radiation on the components under test.

2.4 The temperature within the chamber shall be monitored by a temperature sensing device suitably located in its working space.

2.5 The design and construction of the chamber shall be such that any heat dissipated by the components during testing shall not appreciably influence the conditions within the chamber.

3. TEST PROCEDURE

3.1 Testing

3.1.1 Unless otherwise specified by the relevant component specification, the components shall be introduced into the chamber which is maintained at the appropriate, temperature (dry heat) severity.

NOTE - The relevant component specification, if necessary, may specify the introduction of the components into the chamber under atmospheric conditions for testing. In this case, the temperature of the chamber shall be gradually raised to the appropriate temperature (dry heat) severity. The rate of change of temperature shall not exceed 1° C per minute, averaged over a period of not more than 5 minutes.
3.1.2 The components shall be exposed to the appropriate temperature (dry heat) severity for a period of 16 hours.

3.1.3 If so required by the relevant component specification, the components shall be electrically loaded during this period. The spacing of the components must be adequate to minimize inter-radiations and local gradients, in case they are loaded.

3.1.4 While still at the high temperature, the components shall be tested if so specified by the relevant component specification.

3.1.5 In case the procedure shown in the note under 3.1.1 has been invoked in the relevant component specification, at the end of the exposure period, the components shall remain in the chamber and the temperature shall be gradually lowered to a value within the atmospheric conditions for testing. The rate of change of temperature shall not exceed 1°C per minute, averaged over a period of not more than 5 minutes.

3.2 Recovery

3.2.1 The components shall be removed from the chamber and shall remain under recovery conditions for a period of 1 to 2 hours or as specified in the relevant component specification.

4. INFORMATION TO BE GIVEN IN THE RELEVANT COMPONENT SPECIFICATION

(a) Preconditioning, if any.
(b) Initial measurements.
(c) The appropriate temperature (dry heat) severity.
(d) Details of electrical loading (see 3.1.3).
(e) Intermediate measurements and time intervals (see 3.1.4)
(f) Period of recovery, if other than 1 to 2 hours.
(g) Final measurements.
(h) Acceptable performance limits
(j) Any deviation from the normal test procedure.
TEST NUMBER-23

VIBRATION

1. OBJECT

1.1 The object of this test is to determine the ability of components to withstand specified vibration conditions.

2. TEST EQUIPMENT

2.1 The vibration generator shall be capable of imparting to the components sinusoidal motions as specified in Table 23-1 below (see also Fig 23-1). This motion shall be substantially in phase and in straight parallel lines at the fixing points of the components. Transverse motion shall not exceed 20 per cent of the motion in the intended direction.

**TABLE 23-1 SINUSOIDAL VIBRATION SEVERITIES**
(Clause 2.1 and 3.3.8)

<table>
<thead>
<tr>
<th>SEVERITY</th>
<th>FREQUENCY RANGE Hz</th>
<th>PEAK VALUE OF VIBRATION AMPLITUDE ± 10 PER CENT</th>
<th>TOTAL ENDURANCE TEST DURATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>V10</td>
<td>10-55</td>
<td>0.75mm</td>
<td>6h</td>
</tr>
<tr>
<td>V11</td>
<td>10-500</td>
<td>0.75 mm or 100 m/s-2 whichever is less</td>
<td>9h</td>
</tr>
<tr>
<td>V12</td>
<td>10-2000</td>
<td>0.75 mm or 100 m/s-2 whichever is less</td>
<td>9h</td>
</tr>
<tr>
<td>V13</td>
<td>10-2000</td>
<td>0.75 mm or 150 m/s-2 whichever is less</td>
<td>12h</td>
</tr>
<tr>
<td>V14</td>
<td>10-2000</td>
<td>0.75 mm or 200 m/s-2 whichever is less</td>
<td>12h</td>
</tr>
<tr>
<td>V15</td>
<td>10-2000</td>
<td>0.75 mm or 500 m/s-2 whichever is less</td>
<td>12h</td>
</tr>
</tbody>
</table>

3. TEST PROCEDURE

3.1 General

3.1.1 A vibration severity is given by the combination of frequency range, vibration amplitude and endurance duration. The relevant component specification shall choose the appropriate severity from those listed in the table under 2.1 and Fig. 23-1.
3.1.2 A sweep which is the traverse of the specific frequency range once in each direction shall be continuous and logarithmic and the sweep rate shall be approximately one octave per minute. Whilst searching for resonances, the sweep rate may be decreased or the sweeping stopped temporarily, if necessary. Undue dwell time shall be avoided.

3.1.3 Measurements of frequency for resonance determination shall be made with a tolerance of ± 0.5 per cent or ±0.5 Hz whichever is greater. Frequency tolerance in other cases shall be ± 1 Hz for values up to 50 Hz and ± 2 per cent for values above 50 Hz.

3.1.4 This test shall be divided into the following three distinct stages for the all the procedures specified under 3.1.7 except for procedure 5.

3.1.4.1 **Initial Resonance Search** - The component shall be vibrated over the whole range of specified frequencies at the specified amplitude. It is checked functionally and examined for any frequency dependent effects such as mechanical resonances and malfunctioning. These vibration characteristics as well as the frequencies and amplitudes at which they occur are noted. The initial resonance search is carried out for information only for procedures I and 3 and is always required for procedures 2 and 4.

3.1.4.2 **Endurance testing** - One or more of the following procedure shall be used.

   (a) **Endurance testing by sweeping** - Endurance testing by sweeping is carried out at specified amplitude, frequency range and duration.

   (b) **Endurance testing at resonance frequencies** - Endurance testing at resonance frequencies is carried out at resonance frequencies of specified amplitude for a specified duration.

   (c) **Endurance testing at predetermined frequencies** - Endurance testing at one or more specified frequencies (or narrow band of frequencies) is carried out at specified amplitude for specified duration.

3.1.4.3 Final resonance search - After the endurance testing, the component is retested functionally and re-examined for vibration characteristics as in the initial resonance search. The frequencies for each effect, determined in the initial and later in the final resonance searches are compared. The final resonance search is carried out for information only.

3.1.5 The component shall be vibrated in three mutually perpendicular axes in turn, which should be so chosen that faults are most likely to be revealed.

3.1.6 The three test stages (see 3.1.4) shall be performed in sequence in the same direction and repeated for the other directions. The relevant component specification
may, however, vary this sequence so as to allow the initial -resonance search to be carried out in more than one direction before starting the endurance testing.

3.1.7 One of the following procedures shall be used.

3.1.7.1 Procedure I - This is the preferred procedure and shall consist of the following sequence of testing:

(a) Initial resonance search.
(b) Endurance testing by sweeping.
(c) Final resonance search.

3.1.7.2 Procedure 2. - This procedure shall consist of the following sequence of testing:

(a) Initial resonance search.
(b) Endurance testing at resonance frequencies.
(c) Final resonance search.

NOTE - This procedure is suitable for components with a very small number of resonance frequencies. The existence of these resonance frequencies will be found during the initial resonance search.

3.1.7.3 Procedure 3 - This procedure shall consist of the following sequence of testing:

(a) Initial resonance search.
(b) Endurance testing by predetermined frequencies.
(c) Final resonance search.

NOTE - Endurance testing by this procedure is needed for components when the vibration environment encountered in Service is known to impose significant stresses at dominant frequencies only.

3.1.7.4 Procedure 4. This procedure shall consist of the following sequence of testing:

(a) Initial resonance search.
(b) Endurance testing by sweeping.
(c) Endurance testing at resonance frequencies.
(d) Final resonance search.

NOTE - This procedure is applicable when a component has a few very dominant resonance frequencies in addition to many less dominant ones. In such circumstances there may be a need for endurance conditioning by
sweeping to be supplemented by endurance conditioning at the dominant resonance frequencies.

3.1.7.5 Procedure 5 - This procedure shall consist of endurance testing by sweeping.

NOTE - This procedure is specifically applicable to very small components where it is known that there are no resonances within the specified frequency range.

3.2 Mounting of Components

3.2.1 The component shall be secured to the vibration generator either directly or by means of a fixture as specified in 3.2.2 to 3.2.6.

3.2.2 Mounting fixtures shall be such as to enable the component to be vibrated along the specified axes for testing (see 3.1.5). The relevant component specification should state, if significant, the maximum level of magnetic interference to which the component may be subjected.

3.2.3 Components having a unique method of mounting shall be so mounted.

3.2.4 The mounting of components not provided with unique means of mounting shall be such that the test conditions applied should dynamically load the body and/or terminations. Either the body and the terminations, or the terminations only, may be clamped, as specified by the relevant component specification.

3.2.5 Components with axial terminations weighing less than 15 grams shall be secured to rigid pillars leaving 5 to 8 mm between the points of emergence of the terminations and the pillars. Similar components weighing 15 grams 'and more shall be clamped so as to avoid any stress on the terminations.

3.2.6 Components with radial terminations and components having unusual mass distribution shall be mounted as specified in the relevant component specification.

3.2.7 External connections made to the components for power supply and measurements shall add a minimum of mass and place a minimum of restraint on the components.

3.3 Testing

3.3.1 The relevant component specification shall choose the required procedure (see 3.1.7) for testing.

3.3.2 Initial resonance search (see 3.1.4.1) shall be carried out at the appropriate vibration severity (see 3.1.1). If found necessary, for a more precise determination of
the resonance characteristics, the vibration amplitude may, however, be decreased to any convenient value.

3.3.3 During the initial resonance search, the frequencies at which either deterioration in performance or mechanical resonances occur shall be noted.

3.3.4 The components shall be functioning during the initial resonance search if so required by the relevant component specification.

3.3.5 Where the mechanical vibration characteristics can not be assessed satisfactorily because of the loading of the component an additional initial resonance search may be carried out with the components not loaded.

3.3.6 The endurance testing (see 3.1.4.2) shall then be carried out as appropriate to the procedure selected (see 3.3.1)

3.3.7 Where components are mounted on vibration isolators, the relevant component specification shall state whether or not the fundamental resonance frequencies of the components on vibration isolators should be chosen for the endurance testing.

3.3.8 The endurance testing time (see Table 23-1) shall be equally divided amongst the resonance/predetermined frequencies and/or axes unless otherwise specified in the relevant component specification.

3.3.9 The components shall be loaded and their performance checked during the endurance testing, if so required by the relevant component specification.

3.3.10 Final resonance search (see 3.1.4.3) shall then be carried out at the same amplitude and in the same manner as the initial resonance search.

3.3.11 The relevant component specification shall state the action to be taken if any shift in resonance frequency or frequencies has been noticed in the final resonance search.

4. INFORMATION TO BE GIVEN IN THE RELEVANT COMPONENT SPECIFICATION

(a) Intial measurements.

(b) Any Special mounting requirements (see 3.2)

(c) The order of the three mutually perpendicular axes (see 3.1.5)

(d) If the sequence of the three test stages is to be varied, the details of this variation (see 3.1.6)
(e) Applicable procedure (see 3.3.1) if other than procedure I

(f) Details of electrical loading and mechanical functioning of the components for initial and final resonance searches and also for endurance testing

(g) Intermediate measurements and time intervals

(h) Maximum level of magnetic interference allowed, if necessary (see 3.2.2)

(j) Details of predetermined frequencies for procedure 3

(k) The appropriate severity (see 3.3.2)

(l) If there is a necessity to repeat resonance search without load (see 3.3.5)

(m) Whether the fundamental resonance frequency of the component on vibration isolators shall be chosen for endurance testing (see 3.3.7), if applicable.

(n) How the total endurance testing duration shall be divided, if not equally (see 3.3.8)

(p) Action to be taken if there is shift in resonance frequencies (see 3.3.11)

(q) Final measurements.

(r) Acceptable performance limits.

(s) Any deviation from the normal test procedure.
Fig. 23-1 VIBRATION TEST CURVES.
TEST NUMBER-24

VIBRATION (RANDOM)

1. OBJECT

1.1 The object of this test is to determine the ability of components to withstand the dynamic stress exerted by random vibration applied between the upper and lower frequency limits for simulating the vibration that is experienced in various modern Service field environments like missiles, high thrust jets and rocket engines.

2. TEST EQUIPMENT

2.1 Vibration System - The Vibration System shall consist of a vibration machine and auxiliary equipment having the features given below:

2.1.1 The vibration machine together with its auxiliary equipment shall be capable of generating a random vibration, for which the magnitude has a gaussian (normal) amplitude distribution, except that the acceleration magnitude of the peak values can be limited to a minimum three times the rms (three sigma (a) limits).

2.1.2 The machine shall be capable of being equalized so that the magnitude of its spectral density curve will be between the specified limits (for example. See Fig. 24-1 and Fig. 24-2), when the test item or a substitute equivalent mass, is appropriately secured to vibration machine.

NOTE: The equalization of an electro dynamic vibration machine system is the adjustment of the gain of the electrical amplifier and control system so that ratio of the output vibration amplitude to the input signal amplitude is a constant value (or given values) throughout the required frequency spectrum.

2.1.3 Control and analysis of vibration

2.1.3.1 Spectral density curves - The output of the vibration machine shall be graphically presented as power spectral density versus frequency. The spectral density values shall be within +40 and -30 per cent (± 1.5 dB) of the specified values between a lower specified frequency and 1000 Hz, and within +100 and -50 per cent (± 3 dB) of the specified values between 1000 and 2000 Hz. A filter bandwidth will be a maximum of 1/3 octave or a frequency of 25 Hz, whichever is greater.

NOTE - Power 'spectral density is the mean square value of an oscillation passed by a narrow band filter per unit filter bandwidth. For this application it is expressed as G^2/f where G^2/f is the mean square value of acceleration expressed in gravitational units per number of cycles of filter bandwidth. The spectral density curves are usually plotted either on a
logarithmic scale or in units of decibels (dB). The number of decibels is defined by the equation:

$$\text{dB} = 10 \log \frac{G^2/f}{G^2/\sqrt{f}} = 20 \log \frac{G^2/r/f}{Gr/\sqrt{f}}$$

The rms value of acceleration within a frequency band between $f_1$ and $f_2$ is:

$$G_{\text{rms}} = \sqrt{\frac{\int_{f_1}^{f_2} g^2 \, df}{f_2 - f_1}}$$

Where $G^2/r/f$ is a given reference value of power spectral density, usually the maximum specified value.

2.1.3.2 Distribution Curves - A probability density distribution curve may be obtained and compared with a gaussian distribution curve. The experimentally obtained curve should not differ from the gaussian curve by more than ±10 per cent of the maximum value directions, and in the order specified, as applicable. The measurement made before, during, and after the test shall be in accordance with 3.5 and if the specimen shall be monitored during test, the detail shall be as specified in 3.1 and 3.2.

3.5 Measurements - The measurement shall be performed before, during and after the test as specified in the relevant component specification.

4. INFORMATION TO BE GIVEN IN THE RELEVANT COMPONENT SPECIFICATION

(a) Monitoring instrumentation, if capable (See 3.1 and 3.2)

(b) Number and location of test points (See 3.2)

(c) Method of mounting and orientation (See 3.3)

(d) Test condition (I or II), letter (A - K); and duration of test (See 3.4)

(e) Order of application of Vibration direction, if applicable (See 3.4)

(f) Measurements before, during and after test (See 3.5)
(g) Any deviation from the normal test procedure.

3. TEST PROCEDURE

3.1 Monitoring - Monitoring involves measurements of the vibration excitation and of the test item performance. The required monitoring of specimen during test shall be specified in the relevant component specification along with details of the monitoring circuit, including the method and points of connection to the specimen.

3.2 Vibration input - The vibration magnitude shall be monitored on a vibration machine, on mounting fixtures, at locations that are as near as practicable to the test item mounting points. When the vibration input is measured at more than one point, the minimum input vibration shall normally be made to correspond to the specified test curve (see Fig. 24-1 and 24-2). For massive test item and fixtures, and for large force exciters or multiple vibration exciters, the input control value may be an average of the average magnitudes of three or more inputs. Accelerations in transverse direction, measured at the test attachment points shall be limited to 100 per cent of the applied vibration. The relevant component specification shall specify the number and location of the test points.

3.3 Method of Mounting - The specimen shall be mounted as specified in the relevant component specification. The orientation of the specimen or direction(s) of the applied vibration motion, and any special test fixtures or jigs required to run the test shall also be specified in the relevant component specification with sufficient detail to assure reproducibility of the input motion applied to the specimen. These details shall include the dimensions, the materials, temper etc. as applicable.

3.4 Testing - The test specimen, or a substitute equivalent mass, shall be mounted in accordance with 3.3., and the monitoring equipment attached, if applicable, in accordance with 3.1 and 3.2. The vibration machine shall then be operated and equalized or compensated to deliver the required frequencies and intensities conforming to the curves specified in test condition I (Fig 24-1) or test condition II (Fig 24-2), as specified. If the order of application of the different directions is critical, it also shall be specified in the relevant component specification. The specimen shall then be subjected to the vibration specified by the test condition letter (See Table 24-1 and 24-2’) for the duration of either 3 minutes, 15 minutes, 1% hours -or 8 hours, as specified in the relevant component specification, in each of three mutually perpendicular directions, and in the order specified, as applicable. The measurements made before, during and after the test shall be in accordance with 3.5 and if the specimen shall be monitored during test, the detail shall be as specified in 3.1 and 3.2.

3.5 Measurements - The measurement shall be performed before, during and after the test as specified in the relevant component specification.
4. INFORMATION TO BE GIVEN IN THE RELEVANT COMPONENT SPECIFICATION

(a) Monitoring instrumentation, if capable (See 3.1 and 3.2)

(b) Number and location of test points (See 3.2)

(c) Method of mounting and orientation (See 3.3)

(d) Test condition (I or II), letter (A-K); and duration of test (See 3.4)

(f) Measurement before, during and after test (See 3.5)

(g) Any deviation from the normal test procedure.
Fig 24-1  Test condition 1, random vibration test-curve envelope (see table 24-1)
SECTION-5

1. SUGGESTIONS FOR IMPROVEMENT

1.1 Any suggestion for improvement in this document may be forwarded to:

The Director,
Directorate of Standardisation,
Ministry of Defence,
"H' Block, DHQ PO,
New Delhi - 110 011.
A. METHOD OF ACHIEVING CONSTANT RELATIVE HUMIDITY

A-1 Atmospheres of various relative humidities can be obtained conveniently in an enclosed chamber in which a saturated solution of a suitable salt is exposed to the atmosphere in the chamber.

A-2 Salt capable of providing relative humidities at the temperatures stated are given in Table A-1.

**TABLE A-1 SALTS FOR SATURATED SOLUTIONS**

<table>
<thead>
<tr>
<th>RELATIVE HUMIDITY</th>
</tr>
</thead>
<tbody>
<tr>
<td>%</td>
</tr>
<tr>
<td>48 to 52</td>
</tr>
<tr>
<td>63 to 67</td>
</tr>
<tr>
<td>73 to 77</td>
</tr>
<tr>
<td>90 to 95</td>
</tr>
<tr>
<td>95 to 98</td>
</tr>
<tr>
<td>TEMPERATURE RANGE</td>
</tr>
<tr>
<td>°C</td>
</tr>
<tr>
<td>22 to 26</td>
</tr>
<tr>
<td>18 to 22</td>
</tr>
<tr>
<td>15 to 35</td>
</tr>
<tr>
<td>38 to 42</td>
</tr>
<tr>
<td>24 to 30</td>
</tr>
<tr>
<td>SALTS</td>
</tr>
<tr>
<td>Calcium nitrite (Ca(NO2)2 4H2O)</td>
</tr>
<tr>
<td>Sodium nitrite (NaNO^2)</td>
</tr>
<tr>
<td>Sodium chloride (NaCl)</td>
</tr>
<tr>
<td>Potassium di hydrogen phosphate (KH2PO4)</td>
</tr>
<tr>
<td>Potassium sulphate (K2SO4)</td>
</tr>
</tbody>
</table>

A-3 The saturated salt solution shall be exposed so that maximum surface is in contact with the air in the chamber, for example, by covering the floor of the chamber with a tray containing the saturated salt solution. There shall be an excess of solid salt in the liquid to ensure that the solution remains saturated. The surface of the liquid shall be free from any crust or film of grease, dirt etc.

A-4 To ensure uniform conditions throughout the chamber, a fan shall circulate air over the surface of the saturated solution and around the components. Care shall be taken to allow free exposure of all the components to the conditions in the chamber.

A-5 If the velocity of the air is greater than 3 m/s, the relative humidity may be measured by wet and dry bulb thermometers. As an alternative to wet and dry bulb thermometers which require a known air velocity, a dew point thimble may be inserted into the chamber and used when the fan is not working. In either method, a viewing window is necessary to avoid opening the chamber.
APPENDIX B
(Clause 2.4 of Test Number-ISA)

B. TEST SET UP FOR TESTING STATIC UND OPERATIONAL SEALS

B.1 PRINCIPLE OF OPERATION

B.1.1 The component shall be mounted on the lid (of adequate thickness) of small sealed test chamber which is fitted with an air inlet nozzle, air line and valve (see Fig B-1)

B.1.2 Air shall then be pumped into the sealed component under test or test chamber, until the desired air pressure for the test is reached. This set up shall then be submerged in a liquid at the specified temperature. If the component leaks, a stream of air bubbles will be observed escaping from it.

B.1.3 A transparent, funnel shall be fitted with a long tube, the end of which can be sealed by a tap. The funnel shall then be submerged in the liquid with the tap open. Liquid shall then be drawn up the tube until it is filled and the tap is then closed. The tube shall be held in a vertical position and the mouth of the funnel moved over the component so that the stream of air bubbles can be collected. The transparent funnel or collector enables this to be done quickly. The air bubbles rise and travel up the neck of the funnel into the tube and collect at the top causing a depression of the liquid column. This set up is shown in Fig. B-2.

B.1.4 The rate of depression of the liquid meniscus is a measure of the leakage rate and can be measured by means of a calibrated scale and a timing mechanism, the air leakage rate being expressed in the form of cubic capacity per unit time.

B.1.5 The apparatus operates over a wide temperature range provided suitable liquids are chosen which at low temperature have a low viscosity and at high temperature remain stable almost to boiling point. Stability here means the non-escape of gases (or other movement which would mask the escape of air bubbles) and low volatility. Alcohol is a suitable liquid for the low temperature tests and paraffin for the high temperature tests.

B.2 OPERATION

B.2.1 The liquid in the container shall be first brought to the required temperature of the test and constantly stirred in order to keep temperature of the liquid uniform during the period of the test.

B.2.2 The air in the test chamber shall be at the requisite pressure which the test condition demands. The test chamber shall then be carefully immersed in the liquid, the location of any leak being immediately disclosed by a train of air bubbles rising to
the surface. A suitable time interval shall be allowed for the component to attain temperature stability.

B.2.3 The funnel of the collector shall be placed in the liquid with its mouth submerged and some of the liquid is drawn up the tube, by suction through a flask.

B.2.4 The funnel end shall then be moved over the stream(s) of air bubbles so that they are all collected and rise up the neck into the tube. Care must be taken to keep the collector tube vertical and also to maintain the depth of immersion of the mouth of the funnel at the same constant level as is used for calibration purposes.

B.2.5 The tube of the collector is calibrated in cubic centimetres and any leakage rate can be calculated by measuring the depression of the liquid meniscus during a known interval of time. The result can be readily expressed in cubic centimetres per hour.

B.3 CALIBRATION AND ACCURACY

B.3.1 The collector can be calibrated by drawing up a quantity of liquid into the tube and sealing off. A hypodermic syringe shall then be used as an air pump and known volumes of air shall be injected, in steps, through the liquid into the mouth of the funnel. At each step, the level of the displaced liquid shall be marked on the tube, or its scale until a suitable complete scale is obtained. During calibration, the mouth of the funnel shall be kept at a constant depth of immersion. Otherwise, a small calibration error may occur due to a change in pressure in the column caused by any variations in the head of liquid.

B.3.2 The air-leakage rate can be measured at any temperature or pressure, provided the whole of the tube and scale is maintained at the specified temperature. Normally, leakage rates shall be expressed at the laboratory ambient temperature and pressure and this can readily be done because the collected air at the top of the tube quickly attains the laboratory ambient temperature.

B.3.3 The overall accuracy of measurement of leakage rates depends on the individual accuracy of measurement of a number of factors, the chief among them being:

(a) The air pressure.
(b) The stability of the air pressure
(c) The volume of air in the collector tube.
(d) The time taken to attain a specified volume.
(e) The head or pressure of the liquid in the collector.
(f) The temperature of the liquid.

B.3.4 The errors introduced by the measurement of pressure (a) are directly proportional to the leakage rate and these errors, together with the errors introduced
by the measurement of temperature (f), can be assumed to be the overall accuracy of the apparatus since the errors introduced by (b), (c), (d) and (e) will normally be very small compared with (a) and can, therefore, be ignored.
APPENDIX ‘C’
Clause 7, 10, 11 of Section 1, 3.1.9 of test number 5 and 5 and 3.1.2 of test number 7)