IS 2597-3 (1969): Code of Practice for the use of Electron Tubes, Part III: Transmitting and Industrial Tubes [LITD 4: Electron Tubes and Display Devices]

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IS : 2597 (Part III) - 1969

Indian Standard

CODE OF PRACTICE FOR USE OF ELECTRON VALVES

PART III TRANSMITTING AND INDUSTRIAL VALVES

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INDIAN STANDARDS INSTITUTION
MANAK BHAVAN, 9 BAHADUR SHAH ZAFAR MARG
NEW DELHI 1

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Indian Standard

CODE OF PRACTICE FOR USE OF ELECTRON VALVES

PART III TRANSMITTING AND INDUSTRIAL VALVES

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CODE OF PRACTICE FOR USE OF ELECTRON VALVES

PART III TRANSMITTING AND INDUSTRIAL VALVES

0. FOREWORD

0.1 This Indian Standard (Part III) was adopted by the Indian Standards Institution on 30 April 1969, after the draft finalized by the Electron Tubes and Valves Sectional Committee had been approved by the Electrotechnical Division Council.

0.2 This standard is intended to give general guidance to the designers of electronic equipment to be supplemented by data sheets from the valve manufacturers so that optimum efficiency, performance, life, etc, can be obtained.

0.3 This standard deals with the additional aspects that are to be covered in the use of transmitting and industrial tubes. The general and other more common aspects have already been dealt in IS: 2597 (Part I)-1964*, which is, therefore, a necessary adjunct to this standard.

0.4 In preparing this code, considerable assistance has been derived from B.S. CP 1005 (1962) 'Code of practice for the use of electronic valves', issued by the British Standards Institution.

0.5 The other parts of the standard published so far are:

IS: 2597 (Part I)-1964 Code of practice for the use of electronic valves: Part I Commercial receiving valves.

IS: 2597 (Part II)-1967 Code of practice for the use of electronic valves: Part II Special quality receiving valves.

1. SCOPE

1.1 This standard (Part III) covers recommendations for the use of high power thermionic valves for transmitting and industrial purposes.

*Code of practice for the use of electronic valves: Part I Commercial receiving valves.

2. TERMINOLOGY

2.1 For the purpose of this standard, the definitions contained in IS : 1885 (Part IV/Sec 1)-1965*, and IS : 2597 (Part I)-1964† shall apply.

3. GENERAL

3.1 This standard shall apply to large valves, for example, valves used in transmitters, large public address amplifiers, r.f. heating equipment, etc. It is additional to and shall be read in conjunction with the recommendations specified in IS : 2597 (Part I)-1964†.

4. HEATER OR FILAMENT VOLTAGE

4.1 Tungsten Filaments and Thoriated Tungsten Filaments

4.1.1 *Tungsten Filaments* — The life of a pure tungsten filament depends upon its operating temperature. Manufacturers usually state for each valve of this class a filament voltage corresponding to a particular value of emission. If less emission is required for a particular application, it is permissible to operate the filament at a lower voltage with resulting extension of its life. As a general guide, to conserve the available life of a tungsten filament its supply should be switched off or reduced during times of non-operation. Any equipment intended for intermittent operation should incorporate a means of reducing the filament voltage by specified percentage during the non-operational periods. However, valve manufacturers shall be consulted for specific guidance.

4.1.2 *Thoriated Tungsten Filaments* — Large valves should be operated as close to its rated value as possible.

4.1.2.1 The source of emission in a thoriated tungsten filament is a layer of thorium on the surface of the wire. The thorium in this layer is constantly being removed during operation and is replenished from within the wire. At full power rating the filament should be operated within a relatively narrow predetermined range of temperatures to maintain the balance between loss of thorium and replacement of the active layer of thorium. In special cases, at reduced ratings, improved life may be obtained by operating at reduced filament voltage, since the loss of thorium from the surface is dependent on the anode current.

4.1.2.2 Because of a progressive change in the carburized state of the filament during life, the filament resistance will change, with consequent alteration of filament current. At the end of its life, the hot filament resistance will usually be 10 to 20 percent less than at the start of its life. Allowance should be made for this effect, either in the rating of the filament

*Electrotechnical vocabulary: Part IV Electron tubes and valves, Section 1 Receiving valves.

†Code of practice for the use of electronic valves: Part I Commercial receiving valves.

transformer or by providing means for maintaining constant filament power. The latter method is generally preferable. Guidance should be sought from the valve manufacturer.

4.1.3 *Switching of Tungsten Filament and Thoriated Tungsten Filament Valves* — It is recommended that the filament current of large tungsten filament and thoriated tungsten filament valves should be limited when switching on from cold, and that the current should be reduced slowly when switching off.

4.1.3.1 Convenient methods of limiting the filament current are: (a) switching in two or more steps, and (b) the use of a saturated-core filament transformer. In general, the surge filament current while switching-on the cold filament should not be allowed to exceed the limits specified by the valve manufacturers.

4.1.3.2 These precautions are required to minimize stress due to magnetic or thermal effects, and manufacturer's instructions normally state when they are necessary.

4.1.4 *R.F. or Pulse Operation of Heaters or Filaments* — For certain purposes, it is necessary to supply the heaters or filaments of valves from a power supply generated by an r.f. oscillator or from a pulse source. In such circuits it is often impracticable to keep within the tolerances mentioned previously, and valve manufacturers, having allowed for this in their valve design, specify wider tolerances for this application when necessary. Commonly the valve is a high voltage rectifier and it is, therefore, impracticable to measure the voltage by a normal voltmeter, or even by a electronic voltmeter, to check that the supply is correct.

4.1.4.1 In some cases the current may be checked directly with a thermal ammeter suitably insulated and calibrated for the frequency in use, but it is often more convenient to utilize a visual comparison of filament temperature. In this method a selected average valve is set up in close proximity to the one in the equipment, but its filament or heater is operated from dc or 50 c/s ac supply.

4.1.4.2 The voltage applied to the second valve is varied until careful observation of the colours of the cathodes indicates that their temperatures are equal; this voltage is taken as the operating figure. The measurement may be assisted by the employment of a suitable optical pyrometer and it is recommended that the valves be interchanged and a second measurement made, the mean being taken as the true figure.

4.2 Oxide Coated Cathodes — The precautions outlined in **3.4** of IS : 2597 (Part I)-1964* shall apply to oxide coated cathodes in large valves.

*Code of practice for the use of electronic valves: Part I Commercial receiving valves.

5. MOUNTING AND INSTALLATION OF LARGE VALVES

5.1 Mounting — All large valves should be mounted with the filament vertical. In some instances the manufacturers' data may state that care shall be taken to meet this requirement with some accuracy. The filament may sag towards the grid under its own weight unless the mounting is as specified.

5.1.1 With large valves, particular care should be taken to observe the provisions specified in **3.5.6** of IS:2597 (Part I)-1964*.

5.1.2 In mobile or portable equipment and in fixed installations subject to vibration, care should be exercised to ensure that the valve supports or chassis are suitably designed to protect the valve from mechanical shocks and vibration in excess of the limits specified by the manufacturer.

5.2 Corona Effects — Metal parts (particularly sharp points or edges) which might cause intense electrostatic fields should not be located in the vicinity of valves operating at high voltages since corona discharge may occur and cause damage to the valve. On installation, filament and flexible leads should be kept well clear of the envelope and adjacent conductors respectively. Wherever necessary, suitable corona rings may be provided on such metal parts.

6. APPLICATION OF VOLTAGES

6.1 General — The various voltages (namely, filament, grid bias and H. T.) to a valve shall be applied in the sequence specified by the manufacturer. The operation of cooling system, if any, in relation to the application of the voltages shall also be as stipulated by the manufacturer. Otherwise, the valves may either be destroyed or may have their useful life reduced.

6.2 Application of High Voltages — In high power valves, large electrodes may release sufficient gas during storage, causing a flash arc when a high voltage is subsequently applied. When the supply is from a low impedance source, this arc may be sustained and cause damage to the valve. Arcing is avoided by the clean-up of the gas during operation at a lower voltage. It is, therefore, advisable for high voltages to be applied in two or more steps.

6.2.1 For new valves or for valves kept in storage for a long period, it is also preferable to pause at each step for a period of at least 15 minutes. The manufacturer should be consulted for his recommendations, particularly in the case of new valves under development.

*Code of practice for the use of electronic valves: Part I Commercial receiving valves.

6.3 Application of Filament Voltages — It is advisable for new high power valves and for valves (either low power or high power) kept in storage for a long period, the specified filament voltage shall be applied and maintained for a period of at least 30 minutes or for a period specified by the valve manufacturer before the application of high voltages.

6.4 Delayed Switching of H. T. — If the anode voltage is applied before the cathode is sufficiently hot to provide the required current, the voltage drop across the valve will be abnormally high and the resulting bombardment of the cathode with positive ions of unusually high velocity may cause serious damage to the emissive coating. This will result in a reduction of the useful life of the cathode, or, in extreme cases, a destructive anode-to-cathode arc. Therefore, most large directly-heated and all large indirectly-heated valves require the application of anode voltage to be delayed. For this purpose the use of an automatic time-delay switch is recommended. In smaller types this requirement often only applies to certain ratings. Where such delay is essential this is indicated in the manufacturer's data.

6.5 Valves operated at high voltage and with external electrode connections should be kept free from accumulated dust to minimize surface leakage and the possibility of arc-over. This should be done periodically, when the tube is cold, using a clean, soft, lint-free cloth (if possible, moistened with alcohol). All tube terminals and connectors shall be kept bright and clean to provide good electrical contact.

6.6 All large valves should be used under operating conditions and in circuits approved of or specified by the suppliers and in accordance with the general instructions contained therein.

7. VENTILATION AND COOLING

7.1 Natural Air-Cooled Valves — It is particularly necessary to ensure adequate heat radiation and circulation of cooling air round the valve envelope. The recommendations of **3.6** of IS:2597 (Part I)-1964* apply particularly in such instances.

7.1.1 Manufacturers frequently specify local limiting temperatures, for example, to ensure that excessive stress is not introduced at the glass-to-metal seal and to ensure the conduction of heat from electrodes. In particular instances, manufacturers stipulate the employment of terminal radiators. The use of polished surfaces facing the valves should be avoided, as they reflect heat into the valve. Consideration should also be given to the air flow in systems with free circulation. Any obstruction to the air flow around the valve should be avoided and openings at the top of the cabinet should be provided to allow hot air to escape. Clearance space around the

*Code of practice for the use of electronic valves: Part I Commercial receiving valves.

valve, should be provided in accordance with the manufacturer's recommendations. If design requirements necessitate the enclosing of the valve, special arrangements should be made to ensure that the limiting envelope temperature is not exceeded.

7.2 Forced Air Cooling — Many large valves are designed for forced air cooling; in such valves, heat is transferred from the electrodes to the cooling air stream by means of radiating fins through which cool air is forced. The volume and pressure of air required for a given electrode dissipation are specified by the manufacturer; due allowance should be made for pressure loss in the ducting, and any other obstruction to air flow.

7.2.1 In addition to the main air cooling, special air jets directed at certain parts may be recommended by the manufacturer. Air flow should be started before the application of voltages to the valve and continued for a period as recommended by the manufacturer after voltages have been removed.

7.2.2 It is not always appreciated that the inlet temperature of the cooling air may be affected by the hotter exhaust when, for example, the inlet and outlet ducts of a cooling system are in close proximity. Similarly, when equipment is operating in a room which is itself inadequately ventilated, the air available for cooling may reach an undesirably high temperature. Care should, therefore, be taken to avoid such contingeneies.

7.2.3 The use of an inlet filter in any air supply is recommended, particularly in dusty or dirty locations, to avoid clogging of the air ducts and also for the reason outlined in **3.6.5** of IS : 2597 (Part I)-1964*.

7.2.4 For automatic protection of valves against failure of any of the air supplies, power supplies to all electrodes (including the filament) should be interlocked with the air supply system, so that when ventilation fails, power supplies are cut off from the valve.

7.3 Water-Cooled Valves — The circulated cooling water should be as free as possible from all dissolved solid matter and the dissolved oxygen content should also be low. It is generally advisable that a closed water system using demineralized or purified water should be employed.

7.3.1 The resistivity of the cooling water should be not less than $3{\cdot}3/k\Omega^{3}$ and the inorganic solid content should not exceed thirty parts per million, but for some applications and some types of valve it may be desirable for the resistivity to be considerably higher and the solid content to be less. The valve manufacturer should in each case be consulted. If water containing appreciable dissolved solid matter is used for cooling, 'furring' of the anode and water pipes will take place. Such 'fur' acts as a thermal insulating layer on the anode and seriously interferes with the conduction

*Code of practice for the use of electronic valves: Part I Commercial receiving valves.

of heat from the anode to the cooling water. The resultant overheating of the anode may he sufficient to cause gas evolution resulting in failure and in extreme cases lead to local melting of the metal envelope itself. Dissolved oxygen in the water will cause the deposition of oxide on the hot anode surface and other metal surfaces and similarly interfere with the efficient conduction of the heat away from the valve. This oxide may be produced from metal in the piping and tanks.

7.3.2 Except where the valve anode is at earth potential, excessive conductivity of the water or insufficient hose column length will result in leakage current which, through electrolytic action, will damage metal connections in the water-cooling system.

7.3.3 Rates of water flow and maximum water outlet temperature are normally specified by the manufacturer. Cooling water should be circulating before power is applied to the filament and should continue circulating for sufficient time to conduct away the residual heat after the supply voltages have been cut off. The heat from the filament alone may cause serious damage in the absence of cooling water. The water outlet temperature from the anode should be continuously monitored during operation and should generally not be allowed to exceed 70°C or the value recommended by the manufacturer.

7.3.4 It is also desirable to periodically clean the anodes to remove surface contamination and scale formation, if any. This can be done by dipping the anode in a dilute hydrochloric acid of 5 to 10 percent concentration.

7.3.5 Power supplies to all electrodes (including the filament) should be interlocked with the water supply system so that in the event of a failure of the water supply the power supplies are cut off from the valve. Where water or forced air-cooled filament-leads or grid-seals are used, similar precautions should be taken.

7.4 Vapour Cooled Valves — In this method, the heat is dissipated through water vapour. This method is an improvement over air and water cooling systems, where high powers are concerned. It consists in immersing the anode (fitted with a specially shaped radiator) into a tank containing a few litres of distilled water. The water around the radiator is brought to its boiling point and converted into steam, thus absorbing the latent heat of vaporization from the anode. The steam generated flows through a steam separator and enters the heat exchanger, where the steam is condensed and the coolant returns to the boiler. Since the heat dissipation of the valve is absorbed by a change in state of the coolant, the efficiency is greater and the water requirements much smaller, as compared to a water-cooled valve. Since the boiler is at anode potential, it should be mounted on insulators capable of withstanding high r.f. voltage. In addition, insulating sections are to be built into the water and steam-piping adjacent to the boiler. The efficiency of the vapour cooling is dependant on the anode and boiler design.

7.4.1 Only distilled water should be used as the coolant. If some impurities are contained, scale may deposit on the anode and the efficiency of cooling may be reduced. To remove scales, the anode is cleaned by dipping it in dilute hydrochloric acid of 5 to 10 percent concentration.

7.4.2 It is important that the level of water in the boiler is maintained within limits, as recommended by the manufacturer. Too high and too low a level of water in the boiler are injurious to the valve. The inside of the boiler should also be checked periodically for precipitation. A protective system should be provided to guard against low and high water levels in the boiler.

7.4.3 When replacing a valve or distilled water, sufficient time should be allowed for the boiler to cool, to prevent the operators from getting scalded.

7.5 Cooling of Other Electrodes — Where forced air-cooled filament leads and/or grid seals are used, it is to be ensured that the specified air flow is started prior to the application of filament voltage and continued for some time even after removal of all voltages. The manufacturer should be consulted for his recommendations.

8. MULTI-VALVE WORKING

8.1 When valves are used in parallel or push-pull, separate grid resistors should be provided for each valve. Means should also be provided for balancing the operating conditions to avoid exceeding the rating of any valve. Since it is unlikely that two or more valves will have precisely identical characteristics, the load may not be equally shared between them. Further, although they may be approximately matched initially, it is unlikely they will remain matched during life. If balance is not continuously maintained, it is recommended that the maximum anode current drawn per valve should be 10 percent less than the rating for one valve.

9. SAFETY PROTECTION

9.1 General — In all applications the valves should be provided with adequate safety protection against damage or failure due to operational over load (*see* **9.2**) and inadequate cooling (*see* **7**). In addition high power valves should be protected against any flash-over (*see* **9.3**) and excessive temperatures (*see* **9.4**). The necessary safety devices should be provided in accordance with the protection recommended by the manufacturers of valves.

9.2 Protection Against Operational Overloads — Overcurrent relays should be provided in the anode and grid circuits to trip h.t. supply at 120 percent of the normal currents within 50 milliseconds and h.t. should not be reapplied before a minimum period of 100 milliseconds or as specified by the manufacturers of the valves. Overcurrent protection should be provided individually in case of valves in parallel or in push-pull.

9.2.1 A protection resistance of 10 to 100 Ω, depending on the normal anode current, may be introduced in the anode load to limit the flow of current until overcurrent relays come into operation.

9.2.2 An under-bias relay may be incorporated to prevent application of h.t. voltage when the grid-bias is below a certain predetermined level.

9.2.3 Suppressors for parasitic oscillations should be provided in anode and grid circuits.

9.2.4 Provision should exist for reduction of h.t. for test and adjustment purposes. This may be done either by star/delta arrangement in h.t. transformer or by other suitable methods.

9.3 Protection Against Internal Flash-Over in High Power Valves — Frequent internal flash-over in high power valves will result in permanent damage to valves unless devices for high speed protection are provided. The usual method is to provide an instantaneous by-pass of the direct current h.t. supply to earth. This is generally achieved by means of electronic shorting devices or triggered spark gaps so that protection could be afforded within 50 microseconds.

9.4 Protection Against Excessive Temperature — The manufacturers of valves may be consulted regarding the necessity of incorporating thermal fuses in order to protect against excessive temperature due to any cause.

10. STORAGE AND TRANSIT

10.1 The recommendations of **3.16** of IS:2597 (Part I)-1964* are particularly important for large transmitting valves. In addition, any rack employed should be designed to protect the valve from excessive shaking or vibration and be so constructed that no stresses are imposed on the glass to metal seals or the glass envelope.

It is strongly recommended that large transmitting valves should be transported in their original packing.

10.2 Valves are weak especially against lateral vibrations and shocks and it is necessary to avoid dropping, upside down handling, or direct and indirect vibrations and shocks during transportation.

*Code of practice for the use of electronic valves: Part I Commercial receiving valves.

10.3 When handling transmitting tubes, they should be held by the strong metal parts and not by the glass parts. Placing the tubes directly on the floor should be avoided. They should be placed slowly on a cushion only.

11. ADDITIONAL REQUIREMENTS FOR VALVES USED IN EQUIPMENT FOR INDUSTRIAL APPLICATIONS

11.1 Rating — Many transmitting valve types designed primarily for use in communication equipment may also be used in industrial application. In some instances the ratings for such valves have been determined by the valve manufacturer only for the former type of service. The service condition associated with industrial application can be more severe than those normally associated with communication service, hence close co-operation should exist between the industrial equipment designer and the valve manufacturer.

11.1.1 The more severe conditions are mainly due to the wide variations in load impedance usually encountered. These can cause correspondingly large variations in grid current, anode current, grid dissipation and anode dissipation. The risk of exceeding the valve ratings is therefore increased.

11.1.2 Particular attention is invited to **3.3** of IS : 2597 (Part I)-1964*.

11.1.3 Designer of industrial equipment should allow in their design for additional factors of safety within the absolute maximum ratings published by the valve manufacturer for communication service.

11.2 Protection — To avoid damage to the valve in the event of an overload, it is recommended that the minimum protection incorporated in industrial equipment should include rapid action devices to cut off h.t. voltage if the anode or grid current exceeds the manufacturer's maximum rating. If the anode dissipation at zero grid-bias exceeds the valve rating, then grid under-current protection is also recommended in case oscillation ceases while h.t. is on. Where water or forced air cooling of the valves is used, protection against failure of the coolant is necessary (*see* **7**). To avoid excessive grid dissipation due to variable anode load in industrial applications, non-linear circuit elements like glow-lamps may be incorporated in the grid circuit.

11.2.1 The permissible operating conditions will vary according to the type of power supply used and the adequacy of protection incorporated in the equipment may involve considerable reduction of anode input as compared with adequately smoothed and protected supplies.

11.3 Installation — Designers of industrial equipment should pay attention to the mechanical construction of the connectors to the valve since these valves will be changed and handled by unskilled personnel.

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*Code of practice for the use of electronic valves: Part I Commercial receiving valves.

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TO
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PART III TRANSMITTING AND INDUSTRIAL VALVES

Alterations

(*First cover page, pages* 1 *and* 3, *Title*) — Substitute the following for the existing title:

'*Indian Standard*

CODE OF PRACTICE FOR THE USE OF ELECTRON TUBES

PART III TRANSMITTING AND INDUSTRIAL TUBES'

Substitute 'electron tubes' *for* 'electronic valves' and 'electron tubes and valves' wherever it appears in the standard.

Substitute 'tube' *for* 'valve' wherever it appears in the standard.

(ETDC 39)

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