SAFETY WARNING
RISKS ASSOCIATED WITH ELECTRON TUBES

This document draws the attention of equipment makers and users to the possible risks associated with electron tubes, so that the necessary personnel protection measures can be taken. Electron tubes present a certain number of potential risks, by the very nature of the physical principles included in their manufacture or operation, and because of the materials used to make these tubes.

The operation of electron tubes under inappropriate conditions, either due to lack of care or knowledge, can lead to serious risks to life and limb of personnel, independent of the risk of tube destruction and/or equipment damage.

Equipment manufacturers and end users bear the responsibility for informing themselves, for protecting against these risks, and for respecting local safety laws and regulations.

It is the user's responsibility to refer to the specifications and recommendations for electron tube use, as well as to the documents provided by the manufacturers of systems incorporating these tubes.

This document is based on current scientific knowledge at the time it was written.

WARNING
The following list is not exhaustive. The main known risks, which may or may not be associated, are described. The relative importance of each risk depends on the type of tube.

ELECTRICAL RISKS

The voltages needed for the operation of these tubes may be **fatal**. All operations should therefore be carried out in strict compliance with standard operating procedures by professionals who have been trained for and authorized to perform this work. This applies to all tube families, no matter what operating voltage they use.

Interlocks, grounding poles, etc. must prevent access to energized zones. Arrangements must also be made for capacitor discharge, e.g., bleeders, automatic grounding etc., after shutdown. In fact, an electron tube itself constitutes such a capacitor, and the appropriate measures must be taken to prevent handling of a tube until it has been completely discharged.

NON-IONIZING RADIATION

The exposure of personnel to the electromagnetic fields produced by electron tubes, even at low frequencies, must be limited to the minimum possible.

Direct exposure of the eyes to strong fields can lead to **blindness**. Never look into an operating waveguide, antenna, or the end of a coaxial line.

RF radiation can also affect the operation of pacemakers.

Avoid all electromagnetic leakage. Special care must be taken with connections, wave-guides, joints, couplings etc.

Never operate a tube without it being connected to a suitable matched load.

IONIZING RADIATION (X-rays)

The degree of danger of X-rays that may be generated by an electron tube increases as the applied operating voltage reaches 10 kV. This is especially true for metal tubes. The greater the tube current, the more dangerous the X-rays are. In certain types of tubes (magnetrons), the hardness of the X-rays emitted corresponds to a voltage two or three times greater than that actually applied to the tube.

The envelope of certain tubes can act as a screen or shield. In general, however, provision must be made for external X-ray shielding either around the tube only (in particular, the cathode and the collector of microwave tubes), or around the part of the equipment in which the tube is installed.

In practice, no detectable radiation appears for voltages of less than 20 kV. Special operating modes can, however, lead to the appearance of measurable doses. We suggest, in all cases, to take readings so that adequate protective measures can be defined and implemented.

For those tubes whose operation leads to the production of X-rays (for example, high power klystrons), THALES ELECTRON DEVICES S.A. has designed shielding enabling the most common exposure rules to be respected.

Nevertheless, we recommend that periodic checks be made, since tube aging can lead to modifications in the quantity of radiation emitted.

X-ray image intensifiers used in medical and industrial radiology are designed to be placed in the direct path of the X-rays emitted by a source. X-ray tubes are designed to radiate X-rays. These tubes must nevertheless have shielding defining the active zone and limiting the radiation present outside this zone to the accepted values. Equipment manufacturers are responsible for complying with regulations.

IONIZING RADIATION (Radioactive materials)

Certain tubes contain small amounts of radioactive material essential to their operation. In most of these tubes, the resulting activity is so weak that no special regulations apply. These tubes are, however, marked with the international "Radioactivity" symbol. The disposal instructions are found enclosed in the packaging.

In handling a broken tube, we recommend that users wear rubber gloves, an FFP2 mask and safety goggles. After handling, wash any part of the skin that may have come into contact with the internal tube parts.

A limited number of tube types are subject to special regulations. These tubes can only be obtained, kept, stored, and destroyed in accordance with rules that must be respected by all parties concerned. THALES has published a radiological protection guidebook that summarizes the rules applicable in France. These products are marked in compliance with these regulations.

IMPLOSION

Electron tubes are high-vacuum devices and the larger the area of their envelopes, the greater the force of the atmospheric pressure applied to the envelope. The insulating and radiation transparent parts, made of glass or ceramics, are less mechanically resistant than those parts made of metal. In the event of blows or strains, whether externally caused or spontaneous, they can break and implode violently, **projecting dangerous debris**.

Therefore, it is very important not to scratch the glass and ceramic parts of a tube, nor subject them to mechanical or thermal stress.

In general, the tube should be placed temporarily with the front resting on a soft, flexible surface, without any abrasive particles, or on a cradle approved by THALES ELECTRON DEVICES S.A. Equipment must be designed to continuously protect the personnel in its vicinity.

Never attempt to open a vacuum tube, whatever the type. This will liberate the strains created at tube fabrication and will have the same effects as an accidental implosion.

HIGH TEMPERATURES

High-power tubes dissipate very large amounts of heat. The corresponding energy is evacuated by circulation of air, oil or water, or by the generation of vapor. The cooling liquid can be at temperatures higher than 100°C and under several bars of pressure in the case of water. The untimely opening or break in a line can release very hot oil, water or steam, which can cause **serious burns**.

Users should install flow rate and pressure control devices, and periodically check that they are operating correctly.

In the case of tube cooling by circulating air, surface temperatures can reach several hundred degrees centigrade.

Certain tube parts, not directly cooled, can also reach a temperature of several hundred degrees centigrade. Temperatures may sometimes continue to rise after tube shutdown, due to thermal inertia.
Therefore, it may be necessary to continue cooling the tube for a certain time after shutdown.

The volume, temperature, flow rate, and pressure characteristics generally do not require that the tube and the system in which it is used be subject to special regulations. The equipment maker and user are responsible for checking that a given installation conforms to the applicable regulations.

Precautions and instructions must be established to prevent personnel from coming into contact with insufficiently cooled tubes.

BERYLLIUM OXIDE (BeO)

Some tubes, notably microwave tubes, have beryllium-oxide (BeO) parts in their structures. Solid pieces of BeO present no danger, as long as they remain whole and unaltered, but BeO-laden dust, fumes, and particles of BeO are **extremely toxic if inhaled.** To prevent the penetration of BeO into the body through cuts or scratches, tube parts made of beryllium-oxide must never be touched with bare hands. In the event of contact, the contaminated hands and skin must be washed thoroughly before eating or smoking.

If a BeO part is accidentally broken, adhesive paper should be used to pick up the shards and protect the edges at the break. Surfaces that may retain particles should be "wet" cleaned, using water or alcohol. Then place the shards and cleaning rags or sponges in plastic bags marked **"DANGER" "Beryllium-oxide"** and have these bags removed by a specialized organization.

Never carry out any mechanical or chemical operations on the BeO parts, such as grinding, sanding, scraping, etching etc.

Only a few THALES ELECTRON DEVICES S.A. tubes have external structural parts made of beryllium-oxide. These ceramic parts are always marked with colored rings or have a bulk coloring (blue). A protective cardboard covering is printed with a safety warning. All such coverings must be removed before operating a tube.

Tubes having internal structural parts made of BeO (or other beryllium-based compounds) are marked with a THALES ELECTRON DEVICES S.A. warning label. Since this label could be masked or torn off, however, we strongly recommend that our microwave tubes never be opened.

BERYLLIUM

X-ray generation tubes contain one or more windows of metallic beryllium, and are indicated by the following label:
Warning! Beryllium
These windows are accessible from the external surface of the tube. Use the same precautions as with beryllium-oxide.

MISCELLANEOUS

In using microwave tubes, original equipment manufacturers (OEMs) may find it necessary to pressurize the associated wave-guides with such gases as freon or sulfur hexafluoride. Should an electrical discharge occur within these gases, there is the chance that **highly toxic and corrosive** by-products (such as phosgene or beryllium fluoride), could result. All precautions must be taken before authorizing access to the tube.

Some tubes (mercury vapor thyratrons) contain mercury, which is a **toxic** substance. Be very careful to ensure that no mercury leaves the sealed tube. Disposal of these tubes must be handled by a specially accredited organization.

In certain equipment, the tube-operating systems can cause disagreeable and possibly tiring noise, including infra and ultrasound. This is especially true in the case of pulsed operation of high-power tubes, disruptive discharges, etc.

Some electron tubes have powerful permanent magnets or electromagnets associated with them, which may cause various disturbances. These tubes and their packing materials carry informative and warning labels.

Some tubes are heavy, and therefore require the use of lifting machines, and various accessories, that come in close contact with the tubes. These machines and accessories must be inspected periodically.

Lead is used in some tubes as a shield against ionizing radiation (X-rays). Cobalt is used in samarium cobalt magnets employed in some traveling wave tubes or klystrons. These materials should never be subjected to grinding, sandblasting, scraping, chemical attack or similar processes.

TUBE DISPOSAL AT END OF LIFE

Tubes must be disposed of according to applicable regulations in each country. In the case of grid tubes, make sure that the thorated tungsten, which is slightly radioactive, is separated from the other materials, so that it can be stored then eliminated in an appropriate manner.

Tubes bearing the symbol  should be eliminated according to national regulations. THALES ELECTRON DEVICES S.A.. can take charge of the disposal process for a fee.

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