Decisions on the Adoption of Radiation Protection Standards for Gaseous Tritium Light Devices

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Background Information

The Decision on the Adoption of Radiation Protection Standards for Gaseous Tritium Light Devices was adopted by the OECD Council on 24 July 1973. The Decision aimed to establish special standards to ensure that the users of gaseous tritium light devices and the whole population were protected against the hazards of ionizing radiations, while facilitating international trade in this field. The Decision was abrogated on 8 March 1996 because its standards had become technically obsolete in view of the evolution of protection concepts and standards and because the NEA had since abandoned activity in this field.

THE COUNCIL,

HAVING REGARD to Article 5(a) and (b) of the Convention on the Organisation for Economic Co-operation and Development of 14th December 1960;

CONSIDERING that the OECD Nuclear Energy Agency is charged with encouraging the elaboration and harmonization of legislation relating to nuclear energy in participating countries, in particular with regard to the protection of public health;

HAVING REGARD to the Decision of the Council of 18th December 1962 on the Adoption of Radiation Protection Norms [Doc. No. C(62) 187(Final)], the Annex to which was revised by the Steering Committee for Nuclear Energy on 25th April 1968 [Doc. No. NE(68)2];

CONSIDERING that in adopting these norms the Council decided, among other things, that necessary measures should be taken to ensure that adequate protection against the hazards of ionizing radiations for the population is provided and maintained wherever radioactive materials are possessed or used;

CONSIDERING the importance of establishing special standards to ensure that the users of gaseous tritium light devices and the whole population are adequately protected, while facilitating international trade in this field;

I. **DECIDES** that the Governments of Member countries shall ensure that appropriate measures are taken to provide adequate protection against the hazards of ionizing radiations for users of gaseous tritium light devices and for the whole population.

II. **RECOMMENDS** to the Governments of Member countries that the measures referred to in this Decision be based upon the Radiation Protection Standards for Gaseous Tritium Light Devices annexed hereto, and that the Prototype Tests described in the Annex to these Standards be applied to ensure that the manufacture of gaseous tritium light devices complies with the requirements set out in the Standards.

III. **DECIDES,** in addition, that the Radiation Protection Standards for Gaseous Tritium Light Devices shall be published.

RADIATION PROTECTION STANDARDS FOR GASEOUS TRITIUM LIGHT DEVICES

Foreword

The development of industrial uses of radionuclides - in particular as products or devices intended for use by the general public - makes it necessary to define well-devised national policies which should provide adequate protection of the public without unduly restricting the use of ionizing radiation and the benefits which might be derived for man. These policies should furthermore be sufficiently consistent in order not to hinder unnecessarily international trade in this field.

The task of the National Authorities will be facilitated by proceeding by successive stages and by setting up safety criteria to be applied to categories of products which have sufficiently similar characteristics in respect of technology and use to enable a common approach.

The use of radionuclides to produce luminosity appears at present to be one of the principal applications of ionizing radiation in products or devices intended for use by the general public. Besides the use of radioluminous paints and plastics there is a wide range of devices using luminous sources which mostly contain gaseous tritium.

Within the general frame of radiation protection rules, these standards are intended to promote the setting up of harmonised national policies concerning the approval, distribution, use and disposal of devices containing gaseous tritium to ensure adequate protection of the public against any radiation or contamination hazards which might result therefrom.

These standards have been established taking account of the recommendations of the International Commission on Radiological Protection (ICRP). They also follow the principles set out in the ENEA Guide for safety analysis and control of products containing radionuclides and available to the general public[*].

The terms used in these standards are appropriate where the national control system is such that no

products containing radionuclide are allowed to be manufactured or distributed unless they are specifically approved or exempted from the general prohibition by the competent National Authority. Where such a method of control has not been adopted it is recommended that the technical considerations set out in the standards regarding hazards should be accepted as a suitable basis for whatever system of control is used.

Introduction

Independently of the problem of protecting workers engaged in the manufacture and, where appropriate, maintenance and repair of gaseous tritium light devices and the sources which are contained therein, it is for the appropriate National Authorities to determine that the devices in question offer a sufficient degree of safety before approving their use, and to ensure that the use and disposal of such devices do not give rise to unacceptable radiation doses to individual members of the public and the population at large, in the sense defined in the ENEA Guide for safety analysis and control of products containing radionuclides.

It is obvious, however, that the intrinsic relative safety of a given device will not suffice on its own to induce National Authorities to approve its use. In fact a number of factors will have to be considered in the safety evaluation of the device: the most prominent of these is the concept according to which any exposure to ionizing radiation may entail a risk of deleterious effects, and, therefore, unjustified applications must be avoided. Such an approach means that National Authorities should make in each particular case a careful evaluation of the real benefits for man which may be derived from the use of tritium in the product under consideration as compared with other applicable methods, in order to determine to what extent the hazards which might result from this product can be offset by the expected benefits[*]. Likewise, consideration should be given, when evaluating the product in question, to all other sources of ionizing radiation to which the public is also exposed as well as to the accumulation of doses thus received by individuals and the population at large.

Exposure hazard to members of the public from gaseous tritium light sources is virtually limited to internal contamination arising from the accidental breakage of a source. The hazard of external exposure is negligible in practice (see Appendix 1). In these standards the hazard arising from the breakage of a source is dealt with:

(i) by requiring the construction of the source to be such that breakage is very unlikely, and

(ii) by setting limits on the tritium activity of sources, so that the internal dose received by any individual as a result of an accidental breakage is within acceptable limits.

However, the position should be periodically reviewed to ensure that the number of devices put on the market and the total activity of tritium involved do not exceed acceptable limits and that the requirements for recovery or controlled disposal of GTLDs are properly applied.

Although some requirements for the construction of the sources are provided in the form of prototype tests, the standards are primarily designed for the devices in which gaseous tritium light sources are contained and not for the sources themselves, which should not be made available to the general public unless contained in a device.

1. Definition of terms used

1. 1. Gaseous tritium light source (GTLS)

A GTLS consists of a sealed glass container filled with gaseous tritium and coated internally with a phosphor (see Appendix 2).

1.2. Gaseous tritium light device (GTLD)

A GTLD is an instrument, piece of equipment, article or subassembly containing one or more GTLSs.

1.3. Activity

This term should be understood as the radioactivity measured at the time of manufacture of the source.

1.4. Radiological quantities and units

Definitions and symbols used for radiological quantities and units are those given by the International

Commission on Radiation Units and Measurements (ICRU).

2. Scope

2.1. These standards are intended to promote a uniform course of action by National Authorities in the procedures for authorising the manufacture, import, use and disposal of GTLDs, while ensuring that:

(i) members of the public are exposed by GTLDs to as little ionizing radiations as practicable;

(ii) radiation doses to individual members of the public and of the population at large from the use of GTLDs do not exceed a small fraction of applicable ICRP limits, as defined in the ENEA Guide for safety analysis and control of products containing radionuclides and available to the general public.

2.2. These standards do not cover sources or devices which do not comply with the definition in Sections 1.1. and 1.2. above.

2.3. These standards are not intended to cover the radiation protection of persons occupationally involved with GTLDs.

2.4. These standards shall not constitute an exemption from the requirements applicable to storage and transport of GTLSs and GTLDs, under national and international rules for radiation protection.

3. Principal considerations

3.1. The activity of tritium used in a GTLD should be as low as practicable.

3.2. No GTLS shall be used unless contained in a GTLD. No GTLS shall be directly accessible.

3.3. GTLDs shall not be used in toys, for personal adornment or for frivolous purposes.

3.4. Only tritium in the form of $3H_2$ or H^3H shall be allowed in a GTLS except for small amounts of tritiated water which may be present provided that, during the mission lifetime of the GTLS, the activity in the form of tritiated water does not exceed 2% of the total tritium activity and, for sources containing less than 50 mCi of tritium, does not exceed 1 mCi.

4. Requirements for manufacturing of GTLDs

4. 1. The manufacture of GTLDs shall be subject to authorisation.

4.2. An authorisation for manufacturing of a GTLD should be contingent upon an adequate demonstration that it performs a function which can be fulfilled only by using a radioactive substance or that the use of a radioactive substance to fulfill the function has evident advantages over any other practical method.

This function shall meet one or more of the following criteria:

(i) possible saving of life;

(ii) protection against personal injury;

(iii) improving the reliability or dependability of a device in respect to its safety functions;

(iv) the fulfilling of an advantage not covered by (i) to (iii) above, but judged of equal importance.

4.3. Each manufacturer of a GTLD shall submit an application for an authorisation to the competent National Authorities. This application should contain adequate information relating to the design, manufacture, prototype testing, quality control procedures, and conditions of handling, storage and normal use of the GTLD in question, and demonstrate that it will meet the requirements in Sections 3. and 4.2.

The information should include in particular:

(i) A description of the GTLD and its intended use or uses.

(ii) The characteristics of each type of GTLS, including the activity of tritium, the fraction of tritium in the form of tritiated water, the form, dimensions, wall thickness and melting point of the glass container.

(iii) Details of the design and construction of the GTLD as related to encapsulation of the tritium and protection of the GTLSs, and to other safety features under normal and severe conditions of handling, storage and use of the GTLD.

(iv) The estimated total activity of tritium contained in all such GTLDs to be manufactured annually.

(v) The expected mission lifetime of the GTLD.

(vi) Proposals for prototype testing of the GTLD in addition to the minimum programme set out in the Annex, to demonstrate the effectiveness of the encapsulation of the tritium, protection of the GTLSs and other safety features under both normal and severe conditions of handling, storage and use of the GTLD.

(vii) Quality control procedures proposed to be followed in the production of the GTLD, to ensure that the quality of the GTLD is the same as the quality of the device on which the prototype tests were conducted.

(viii) Any additional information, including results of experimental studies and tests and description of disposal facilities, as may be required by the competent National Authorities.

4.4. Competent National Authorities when granting an authorization under 4. 3. should require the manufacturer to demonstrate that the GTLD withstands the prototype tests specified in Section 4. 3. (vi) above and the Annex hereto. Competent National Authorities should also be satisfied that the quality control procedures under Section 4. 3. (vii) are effectively applied to ensure that each GTLD meets the requirements approved by the National Authorities.

4. 5. The manufacturer of GTLDs authorised under Section 4. 3. shall submit to the competent National Authorities a report giving the total activity of tritium contained in every type of GTLD distributed by him.

4. 6. Subsequent minor improvements or modifications to a GTLD which has been approved by the competent National Authorities will not require a further application for an authorisation provided that the improved or modified GTLD remains in the same activity group (as defined in Section 6) and has the same general construction, application and use as the original approved GTLD. This shall be demonstrated by providing the competent National Authorities with an adequate description of such improvements or modifications.

4. 7. No authorisation shall be required for the manufacture of a limited quantity of a given GTLD produced for development purposes provided the aggregate activity of the devices within this quantity does not exceed 100 Ci. However, such manufacture shall be notified to the competent National Authorities.

5. Requirements for the import of GTLDs

5.1. The import of GTLDs shall be subject to authorisation.

5.2. In the case of import of GTLDs the requirements in Section 4. 1. to 4. 5. inclusive relating to manufacture shall apply mutatis mutandis to importers except that the information which may be required from the importer under Section 4. 3. (vi) and (vii) shall be in the form of a certificate from the exporter that these requirements have been complied with. This certificate shall be endorsed by the competent National Authorities of the exporting country.

5.3. Notwithstanding the provisions of Section 5. 2. the importer may be exempted from the requirements of Section 4. 2. to 4. 4. inclusive as applied to import on condition that the importer provides a certificate proving that the manufacture of the imported GTLDs has been authorised by the competent National Authorities in the country of origin in accordance with these Standards.

6. Requirements for use of GTLDs

6.1. The use of GTLDs containing up to 500 mCi shall be unrestricted provided the requirements in Section 4. 2. are fulfilled.

6.2. GTLDs containing between 500 mCi and 2 Ci may be exempted, partially or totally, by the competent National Authorities, from the requirements of 6. 3. if the function of the device meets the criteria in Section 4. 2. (i) or (ii)*. This exemption shall not affect however recovery and disposal requirements. If the function of the device does not meet the required criteria, the provisions of 6. 3. shall apply.

6.3. The use of GTLDs containing more than 2 Ci shall be controlled according to applicable national or international rules for radiation protection. Under such control, the use of GTLDs in this group shall be subject to notification or registration, unless specifically exempted from this latter requirement, as well as to recovery or disposal requirements.

7. Marking and labelling

7.1. GTLDs containing up to 500 mCi shall be marked with the symbol "T";

7.2. GTLDs containing more than 500 mCi shall be marked with the basic radiation trefoil symbol and the symbol T together with the curie content as follows "T. . .Ci";

7.3. Any GTLS exceeding 500 mCi in a GTLD shall be marked with a spot of the colour in international use to denote hazard.

7.4. GTLDs subjected to recovery or disposal requirements shall be labelled specifying the name of the manufacturer or importer, the date of manufacture, and any appropriate instructions concerning the recovery or disposal of the GTLD. If this is not practicable, a simplified labelling may be authorised by the competent National Authorities.

8. Recommendations concerning administrative control procedures

8.1. The following administrative procedures are recommended to ensure proper control over GTLDs whose use is subjected to special requirements under these Standards. They are aimed in particular at ensuring the recovery and properly controlled disposal of such GTLDs either during or after their mission lifetime.

8.2. Where the use of a GTLD under Section 6. 2. is not totally exempted from the requirements in Section 6. 3., it is left to the competent National Authorities to decide on the advisability of prescribing any administrative procedure related to the degree of exemption granted under 6. 2.

8.3. Users of GTLDs under Sections 6. 2. and 6. 3. above should be advised, by any appropriate administrative procedure to be established by the competent National Authorities, of the action to be taken for recovery or disposal.

8.4. When it is intended to use a GTLD under Section 6. 3. above, a notification or an application for registration of such use, as the case may be, should be submitted to the competent National Authorities. The information contained in the notification or in the application for registration should include indications about the nature and activity of the GTLD, its intended use and its place of use.

8.5. Where a registration for use is required, the competent National Authorities should supply the applicant with a special authorisation or certificate:

(i) stating the name of the applicant;

(ii) fixing the exact conditions of use and prohibit any other use;

(iii) requiring the applicant to notify the relevant authority immediately in the event of damage to, or loss of, the GTLD;

(iv) prescribing any necessary precautions to be taken during the repair or maintenance of the GTLD;

(v) prescribing the action to be taken for recovery or disposal.

8.6. Competent National Authorities should ensure that any GTLD under Section 6. 3. above is not handed over to the user until the National Authorities have been notified of the intended use, or until a special authorisation or certificate has been issued to the user as the case may require.

9. Surveillance

The competent National Authorities should maintain surveillance over the manufacture to ensure that all GTLDs meet the authorised specifications. The competent National Authorities should also maintain general surveillance over GTLDs subsequent to their manufacture or importation to ensure that individual and population exposures from the use and disposal of GTLDs are being maintained within acceptable limits. In particular, the competent National Authorities should ensure that records are kept of all necessary information relating to the disposal of spent devices (date, activities, place of disposal, etc.) on the one hand and to damage, defects, loss, etc., of GTLDs on the other hand. Such a surveillance will be facilitated by using the following information:

(i) reports provided by manufacturers or importers on the total activity of tritium contained in the GTLDs manufactured or imported;

(ii) reports which may be required by the competent National Authorities on defects noted in the course of use, which are likely to change the data used for the initial safety evaluation;

(iii) records which competent National Authorities may deem it desirable to be kept by manufacturers or importers of persons or institutions to which GTLDs have been transferred.

ANNEX

Prototype Tests

(Minimum programme)

The competent National Authorities must be satisfied that when the device is in ordinary use the source(s) will not become detached or suffer a loss of tritium. In addition the competent National Authorities must be satisfied that the source(s) will not become detached or suffer loss of tritium under the following test conditions.

1. Temperature test

The GTLD shall be heated in air to + 80°C within 5 minutes, kept at this temperature during one hour, then cooled to 0°C in less than 45 minutes and kept at this temperature during one hour. The National Authorities may set the limits to + 180°C and - 60°C respectively if more severe temperature conditions are foreseen during use.

After the test each GTLS shall be examined by visual inspection or luminosity control to check that no loss of tritium has occurred. This should be supplemented where appropriate by activity measurement.

2. Vibration test

The GTLD shall be subjected to three complete test cycles in the range of 25-500 cycles/sec. at 5 g. The test shall be conducted by sweeping through all the frequencies in the range at a uniform rate from the minimum to the maximum frequency and return to minimum frequency in 10 minutes or longer. Each axis of the GTLD shall be tested. In addition the tester shall dwell 30 minutes at each resonance frequency found. Examination after the test as in 1.

3. External pressure test

The GTLD shall be put into a test chamber and exposed to 0. 25 and 2. 0 bars for four periods of 15 minutes each, the pressure being returned to atmosphere between each period. The test shall be conducted in air. Examination after the test as in 1.

4. Impact test

The conditions under which an impact test shall be carried out will be specified by the competent National Authorities. In any case the height of fall involved in such a test shall not be less than 1 metre. Examination after the test as in 1.

5. Crushing test

The conditions under which a crushing test shall be carried out will be specified by the competent National Authorities if they consider such a test to be necessary. Pressure of 106 Pa (approximately 10 kg/cm^2) should be regarded as a maximum requirement. Examination after the test as in 1.

APPENDICE 1

Radiation Protection Considerations

In assessing the potential exposure of individual members of the public to gaseous tritium light sources, consideration should be given to the risk of external radiation in normal conditions of use and to the possibility of internal radiation in the event of an accidental release of tritium.

Exposure from an intact source

Tritium decays with the emission of a beta particle of maximum energy about 18 keV; the corresponding maximum range is about 0. 6 mg/cm^2. Clearly, there is no practicable form of containment through which such beta particles would be transmitted, and any external radiation from a GTLS is therefore due solely to bremsstrahlung. The bremsstrahlung dose rate at the surface of (or at a given distance from) a GTLS cannot be predicted simply from a knowledge of the activity of tritium. The dose rate, and the effective energy of the bremsstrahlung depend on the form of the containment.

Measurements made on a variety of these devices indicate that the dose rate at the surface of a thin-walled one (i.e. one having a wall thickness of about 0. 1 mm. glass) is of the order of 100 millirads per hour per curie, while that at the surface of a thicker walled one (1 mm. glass with an outer covering of 2 or 3 mm. plastic) is of the order of 1 millirad per hour per curie. The measurements also indicate that the effective energy of the bremsstrahlung is usually in the range 8 to 14 keV. It must be remembered that because of the small dimensions of these sources, the inverse square law ensures a very rapid fall off in dose rate with distance from the source. Thus, the thin-walled source, referred to above, would probably be cylindrical with typical dimensions: length 10 mm, external diameter 0.5 mm. The dose rate at 10 mm. from such a source is two orders of magnitude lower than the surface dose rate (this is for points on a line through the centre of the source and at right angles to its axis). Furthermore, a member of the public is normally exposed to a GTLS only when the source is incorporated into some instrument or other object which provides considerable shielding.

When considering the doses which may be received by various organs as a result of exposure to bremsstrahlung from GTLS the attenuation by tissue must also be taken into account. The half-value thickness of 10 keV photon radiation in water is about 0. 14 cm., and the attenuation provided by the tissue overlaying the blood-forming organs, ovaries and testes (at nominal depths 5 cm., 7 cm. and 1 cm. respectively) is therefore considerable.

Thus, it appears that the external dose rate from gaseous tritium light devices is so low in existing applications that it may be discounted*.

Accidental exposure due to the breakage of a source

In the event of a GTLS being broken, persons in the vicinity will be exposed to a hazard from the tritium released. The degree of hazard depends, inter alia, on the fraction of the released tritium which is in the form of tritiated water vapour.

Two identifiable hazards ensue from the breakage of a GTLS:

(i) Submersion in a cloud of tritium gas, and

(ii) The intake of tritiated water, via lung and skin, into the blood.

Submersion in a cloud of tritium gas leads to irradiation of the skin and the surfaces of the airways of lung. It can be argued that, since the depth of the basal layer of the epidermis is considerably greater than the range of tritium beta particles, the hazard to skin can be ignored; however, such an argument does not apply to the airways of the lung. In any event, when exposure takes place to comparable concentrations of tritium gas and tritiated water vapour, the risk from the intake of tritiated water vapour (and the subsequent irradiation of body tissue) is of a considerably higher order of magnitude than that from submersion. Thus, according to ICRP(1), the MPC_a for continuous exposure of a member of the public to tritiated water vapour and to tritium gas are 2×10^{-7} and 4×10^{-5} μ Ci/cm^3 respectively.

When considering the accidental exposure of a member of the public to the tritium released from a broken GTLS, the figure for the maximum permissible annual intake of tritiated water vapour is more helpful than the MPCa for continuous exposure. This figure may be estimated from the report of Committee 2 of ICRP (1) but a more recent calculation has been made by Vennart (2). This calculation takes into account the change in value of QF for tritium beta particles from 1. 7 to 1 which was adopted

by the ICRP at their Oxford meeting in 1969. According to Vennart, the maximum permissible annual intake of tritiated water for a member of the public is 5 mCi.

Since, for exposure to similar concentrations of tritium gas and tritiated water vapour, the hazard from the tritiated water vapour is much the greater, it is important to know what fraction of the tritium content of a GTLS may be expected to be in the form of water vapour. The rate of change of tritium gas to tritiated water vapour either by exchange with hydrogen or oxidation depends on the square of the concentration of tritium, and the rates are very small at concentrations equal to MPCa (3) (4) (5). Thus, most of the change will occur in the GTLS before breakage with any traces of water vapour or oxygen which have been left in the source. Measurements have shown (6) (7) that the fraction is generally in the region of 1% to 2%. However, they also show that in the event of a GTLS being broken, the tritiated water vapour content in particular is released quite slowly - perhaps only half being released in the first hour (7).

In the event of the breakage of a GTLS, it is useful to make an estimate of the tritium content which would lead to an intake of 5 mCi of tritiated water (the maximum permissible annual intake) for a person in the vicinity of the breakage. If it is assumed that:

(i) the tritiated water vapour content of a GTLS is not more than 2% of the total tritium content, and

(ii) a person in the immediate vicinity of the breakage takes in not more than a tenth of the triatiated water vapour in the GTLS before breakage,

then it follows that the smallest tritium content of a GTLS, which could lead to a maximum permissible annual intake of tritiated water subsequent to the breakage of the source, is 2, 5 curies. It should be noted that the few accident statistics available indicate that breakages are extremely rare. Further, the slow rate at which tritiated water vapour is desorbed from a broken GTLS implies that assumption (ii) above is very cautious.

It should be stressed however that these radiation protection considerations may have to be reviewed in the light of new scientific evidence on the toxicity and metabolism of tritium in man, which might affect the validity of the present state of knowledge on which these considerations are based.

References

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(2) J. Vennart, Health Physics, 16, 429-440, 1969.

(3) J. Y. Yang and L.H. Gevantman, Report USNRDL-TR-471, 1960.

(4) G.J. Casaletto, L.H. Gevantman and J. B. Nash, Report USNRDL- TR-565, 1962.

(5) J. Eakins, AERE Harwell Report R 6791, 1971.

(6) R. G. Niemeyer, USAEC Report ORNL-TM-2539, 1969.

(7) B. E. Lambert, Radiological Protection Service, private communication.

APPENDIX 2

Technical Data on GTLSs

Gaseous tritium light sources are fabricated in the form of sealed glass containers, internally coated with a phosphor and filled with tritium gas (1) (2).

The glass containers are in general made of borosilicate glass which is resistant to thermal shocks and has a transformation temperature of about 550° C. Even at this temperature, borosilicate glass contains tritium very well and in fact temperatures of 700-800° C are required to liberate the tritium. The permeability velocity constant of tritium through these glasses at room temperature is reported to be 7.2×10^{-18} Ci. mm/cm^2. sec. cm. Hg by Niemeyer (3) which can be considered inconsequential from the safety standpoint. The glass container may have a wide variety of shapes and sizes, limited only by glass-working techniques. However, to achieve optimum luminosity one of the tube's dimensions must be shorter than the path of a beta particle from tritium; this varies according to the gas pressure, but is

not longer than about 1 cm. Therefore, the cylindrical form is preferred. The wall thickness of the glass varies between 0. 1-2.0 mm and has to be 1/4 to 1/5 of the external diameter for reasons of manufacture.

The inner surface of the glass container is coated with a phosphor. Zinc or zinc-cadmium sulphides are used mostly because they emit a bright green light, have no chemical toxicity and undergo very low radiation damage. To remove all but the merest trace of water vapour and gaseous contaminants the glass container is evacuated to 10^{-4} mm of mercury pressure while simultaneously being baked to 350° C. The tritium gas is fed into the glass container immediately after the baking under evacuation has been completed.

The tritium gas used has a specific activity up to 2. 6 Ci/cm^3 at STP. To purify the gas it is adsorbed on finely dispersed activated metallic uranium at room temperature. All contaminants will either react irreversibly with the uranium, or will not react and will be removed in the vacuum system. Water vapour is in the former category and will react to form stable uranium oxides and either tritium or hydrogen gas. To feed the tritium gas into the glass container it is desorbed from the uranium at 400° C.

Because of this procedure water vapour in a finished GTLS can originate in an incomplete baking step only, but it is known that water can be firmly bound onto active surfaces and difficult to remove. Therefore in a GTLS tritium as tritiated water can be present in a concentration of 2% or less. Only in very small sources with a low tritium content the concentration may rise up to 5%. A higher content of water vapour reduces considerably the brightness of the GTLS. Should any tritium gas be released into the atmosphere, it is converted there to tritiated water at a rate of far less than 1% per day in dry or humid air at room temperature (4) (5) (6).

The beta particles of tritium have a maximum energy of 18. 6 keV and an average energy of 5. 5 keV. They are completely absorbed by absorbers of only 0. 6 mg/cm2 and therefore do not penetrate glass walls of the thickness mentioned. Any external radiation from a GTLS is therefore due solely to brems Strahlung*. The tritium pressure in a gaseous tritium light source is normally below atmospheric pressure (50 cm Hg is a typical figure) but up to 2. 5 atm. can be achieved by special techniques. Due to absorption of the beta particles in the tritium gas itself, brightness does not increase linearly with tritium pressure. The rate of brightness increase is greatest when the quantity of tritium is very small. Thus pressurisation of tritium has the greatest effect with very small sources. The light yield is about 0. 18μ Candela/mCi which corresponds to the values obtained with luminous tritium paints.

The brightness of most gaseous tritium light sources can be increased by painting the reverse side of the glass container with a high reflectivity paint. This reflects light back into the bulb and as gaseous tritium sources are translucent up to 100% of reflected light passes right through. Gaseous tritium light sources emitting light of different colours are also on the market, but not of the same brightness. Though the amount of energy emitted as light is essentially constant, the human eye is more sensitive to some colours than to others. The following table gives the relative brightness of several colours:

Colour	green	yellow	white	orange	red	blue
Relative brightness	100	95	75	55	45	35

Gaseous tritium light sources are up to 25 times brighter (per unit area) than paints. The loss of brightness of these light sources compared to luminous tritium paints is slower by a factor of about 2. Up to 8 years are required before the brightness has dropped to 50% of its original value.

Gaseous tritium light sources have a relatively good mechanical strength. They may be dropped without breaking from a height of 1 m. and submitted to thermal shocks. In spite of this it must always be taken into account that it is a glass container and therefore in all applications of gaseous tritium light sources an adequate protection of the sources against excessive stress should be provided. In many of today's applications each GTLS is covered with an elastic transparent plastic sleeve or embedded in a non-hardening resin. This reduces the probability of breakage and will prevent a quick release of the tritium gas in case of breakage.

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Mr. J. Duggan (Consultant)	United Kingdom
Dr. P. Tempus (Consultant)	Switzerland

Members of the second Expert Group (1972)

Dr. A. Lafontaine (Chairman)	Belgium
Prof. J. Chanteur	France
Mr. de Cizancourt	"
Mr. J. Hamard	"
Dr. L.A. König	Germany
Dr. A. Schieferdecker	"
Dr. C.E. Rasmussen	The Netherlands
Dr. B.G. Pettersson	Sweden
Prof. W. Minder	Switzerland
Mr. A.M. Freke	United Kingdom
Dr. P. Tempus (Consultant)	Switzerland

In adopting this Decision, the Council:

1. **NOTED** the Note by the Secretary-General of 10th July 1973 [Doc. No. C(73)138];

2. **AGREED** to publication of the Decision and of the Radiation Protection Standards for Gaseous Tritium Light Devices attached thereto.

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[*] "Basic approach for safety analysis and control of products containing radionuclides and available to the general public", ENEA/OECD, Paris, June 1970.

[*] For detailed discussion of the risk/benefit balance concept, see the afore-mentioned ENEA Guide, pp. 15-16.

[*] This provision has been accepted by the French authorities insofar as the activity of the individual sources contained in such GTLDs does not exceed 500 mCi.

[*] In the great majority of existing applications in the United Kingdom the dose rate at 1 cm, measured in air, from any point on the surface of a GTLD has not been found to exceed 0.1 mrad per hour.

[*] See Appendix 1.

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