ANSI/HPS N43.4-2005

American National Standard

Classification of Radioactive Self-Luminous Light Sources

Approved: 2005

American National Standards Institute, Inc.

Published by

Health Physics Society
1313 Dolley Madison Blvd.
Suite 402
McLean, VA 22101

Printed in the United States of America

Foreword (This foreword is not a part of American National Standard Classification of Radioactive Self-Luminous Light Sources, N43.4)

The radiation from radioactive material is used as a source of energy for activating phosphors to produce light in self-luminous watches and clocks, instrument dials, aircraft exit markers, luminous switches, etc. Safety in the design and use of radioactive materials in self-luminous products continues to be of concern to the industry, regulatory bodies and the general public.

In 1967 Committee N43 was organized under the sponsorship of the National Bureau of Standards (now the National Institute of Standards and Technology) to replace Sectional Committee Z54. The scope of the new committee is “standards pertaining to products and equipment, for non-medical scientific, industrial, and educational uses, involving ionizing radiation sources including radioactive materials, accelerators, and x-ray equipment but excluding nuclear reactors.”

The responsibility to develop standards for self-luminous sources was assigned to Subcommittee N43-2. In 1975 a standard for classification of radioactive self-luminous light sources was approved by the USA Standards Committee N43-2 Subcommittee and published as American National Standard N-540 (NBS Handbook 116), issued January 1976. This standard was reaffirmed as ANSI 43.2 (R1989). In 1985 Committee N43 was organized under the sponsorship of the Health Physics Society. The N43.4 Subcommittee published ANSI/HPS 43.4-2000 in September 2000. This standard is an elaboration and refinement of ANSI/HPS N43.4 for self-luminous sources. The N43.4 Subcommittee is responsible for preparing this standard.

Realizing that questions may arise from time to time concerning interpretations of this standard, provisions have been made for an Interpretations Committee in order that uniform handling of questionable cases may be provided. It is recommended that anyone using this standard and desiring an interpretation of a questionable case communicate with the Health Physics Society. Suggestions for improvement gained in the use of this standard shall be welcome. They should be sent to the Health Physics Society, 1313 Dolley Madison Blvd., Suite 402, McLean, VA 22101.

An American National Standard implies a consensus of those substantially concerned with its scope and provisions. An American National Standard is intended as a guide to aid the manufacturer, the consumer, and the general public. The existence of an American National Standard does not in any respect preclude anyone, whether that person has approved the standard or not, from manufacturing, marketing, purchasing, or using products, processes, or procedures not conforming to the standard. American National Standards are subject to periodic review and users are cautioned to obtain the latest editions. Producers of goods made in conformity with an American National Standard are encouraged to state in their own advertising, promotional material, and on tags or labels that the goods are produced in conformity with particular American National Standards.

CAUTION NOTICE: The American National Standards Institute (ANSI) has established Essential Requirements that apply to activities related to the development of consensus for approvals, revision, reaffirmation, and withdrawal of American National Standards.

Members of Subcommittee N43-4 that had responsibility for the development of ANSI N-540-1975 (NBS Handbook 116) are listed below:

Robert F. Barker, Secretary
Arthur C. Chandler, Jr.
Harry H. Dooley, Chairman
Major Fecteau
Marvin E. Gonshery
Will Hegarty
Elmer Hites
Warren M. Holm
Alphus L. Jones
James C. Malaro
Robert C. McMillan
Donald McSparron
Walter T. Neal
Gail Schmidt
R.F. Stewart
Darwin Taras
C.W. Wallhausen
Richard N. Walz

Members of Subcommittee N43.4 that had responsibility for the development of ANSI/HPS N43.4-2000 are listed below:

David P. Alberth
Gordon M. Lodde, Chairman
Frances Szrom

Members of Subcommittee N43.4 that had responsibility for the development of ANSI/HPS N43.4-2004 are listed below:

David P. Alberth
Gerald A. Falo
Anthony Kirkwood
Gordon M. Lodde, Chairman
Frances Szrom

This standard was consensus balloted and approved by the ANSI-Accredited HPS N43 Committee on July 23, 2004. At the time of balloting, the HPS N43 Committee had the following membership:

Chair	Gordon M. Lodde
Vice Chair	William Morris
ABB Industrial Systems Inc.	John R. Dukes
Alliance of American Insurers	Thomas F. Bresnahan
American Automobile Manufacturers Association	Donald A. Greschaw
	William Watt (alt.)
	David A. Felinski (alt.)
American Conference of Governmental Industrial Hygienists	Gordon M. Lodde
American Crystallographic Association	Camden Hubbard
American Insurance Services Group	Stewart M. Fastman
American Iron and Steel Institute	Anthony LaMastra
	Peter A. Hernandez (alt.)
American Public Health Assoc., Inc.	Jesse Lieberman
American Society for Nondestructive Testing, Inc.	K. Dieter Markert
American Society for Testing and Materials	Marvin M. Turkanis
American Welding Society	Edward L. Criscuolo
Atomic Energy Control Board	R. E. Irwin
Conference of Radiation Control Program Directors	Mike Henry
	Bart Lago (alt.)
Health Physics Society	Sandy Perle
	William Harris (alt.)
National Council on Radiation Protection and Measurements	Susan M. Langhorst
National Institute of Standards and Technology	Douglas M. Eagleson
	James W. Tracy (alt.)
Nuclear Regulatory Commission	John P. Jankovich
Underwriters' Laboratories, Inc.	Peter Boden
	David Dini (alt.)
Univ. of California (Los Alamos Nat'l Lab)	VACANT
U.S. Dept of the Air Force, Office of the Surgeon General	Ramachandra K. Bhat
U.S. Dept of the Army, Office of the Surgeon General	Frances Szrom
U.S. Dept of the Army, Army Material Command	Gregory R. Komp
U.S. Dept of Energy	Peter O'Connell
	Joel Rabovsky (alt.)
U.S. Dept of the Navy	David E. Farrand
	William Morris (alt.)
	Steven Doremus (alt.)
U.S. Dept of Health and Human Services - Public Health	H. Thompson Heaton
	Frank Cerra (alt.)
Individual Members	John C. Taschner
	David Lee

Table of Contents

Tables

Classification of Radioactive Self-Luminous Light Sources

1. Scope

This standard establishes the classification of certain radioactive self-luminous light sources according to radionuclide, type of source, activity and performance requirements. The standard does not attempt to establish design or safety standards, but leaves the design features to the judgment of the supplier and user, provided that the performance requirements are met.

This standard does not specify the luminance of the self-luminous light source; however, many of these sources are used for safety proposes. Therefore, the luminosity must be commensurate with the intended use of the source(s).

Note: Radioactive self-luminous light sources used in or on timepieces are not covered by this standard. The following documents apply to radioluminous timepieces:

a. International Atomic Energy Agency, Radiation Protection Standards for Radioluminous Timepieces, Safety Series No. 23, Vienna, 1967.
b. International Association for Standardization, Radioluminescence for Time Measurement Instruments – specifications (ISO 3157), Geneva, 1975.
c. Nuclear Energy Agency, Radiation Protection Standards for Gaseous Tritium Light Devices, Organization for Economic Co–operation and Development, Paris, 1973.

The objectives of this standard are to establish minimum prototype testing requirements for radioactive self-luminous light sources, to promote uniformity of marking such sources, and to establish minimum physical performance for such sources.

This standard is primarily directed toward ensuring adequate containment of the radioactive material. Other factors, such as quality control, external radiation levels, radiotoxicity of the radionuclide, its chemical and physical form, and quantity of radioactive material in the source, also shall require consideration in view of the ever-present objective of keeping exposures as low as is reasonably achievable (ALARA). Compliance with this standard does not necessarily satisfy all requirements for manufacture and use that may be imposed by governmental regulatory agencies.

2. Definitions

The definitions and terms contained in this standard, or in other American National Standards referred to in this document, are not intended to embrace all legitimate meanings of the terms. They are applicable only to the subject treated in this standard.

Activity: The number of spontaneous nuclear transformations occurring in a given quantity of material during a suitably small interval of time divided by that interval of time. It is commonly expressed in curies (Ci). The Systeme International (SI) unit for activity is the becquerel (Bq). One Ci is equal to 3.7×10^{10} Bq.

Brightness (or luminance): The luminous intensity of the surface of a self-luminous light source in a given direction per unit projected area of the surface, viewed from that direction. Luminance is measured in candela per square meter.

Capsule: A protective envelope used to prevent leakage of the radioactive material.

Container: A general term to designate any enclosure which surrounds the encapsulated radioactive material.

Device: Any piece of equipment designed to utilize a self-luminous light source(s).

Distributor: Any person or organization supplying self-luminous light sources.

Fixed sources: Sources intended for usage at a specific location(s), designed for environmental conditions existing at the

intended location(s), and to be used, except for accidental or unavoidable circumstances, under environmental conditions for which the source was designed.

Leakage: A transfer of radioactive material from the self-luminous light source to the environment external to any encapsulation.

Manufacturer: Any person or organization fabricating a self-luminous light source(s).

Mobile sources: Sources designed to meet certain anticipated environmental conditions, not necessarily intended for usage at any specific location(s), and known to be subject to possibly frequent or severe environmental changes.

Model: Descriptive term or number to identify a specific self-luminous light source design.

Non-leachable: Term used to convey that the radioactive material is virtually insoluble in water and not convertible into dispersible products.

Prototype source: The original source model that serves as a pattern for the manufacture of all sources identified by the same model designation.

Prototype testing: The performance testing of a new source design before sources of such design are put into actual use.

Quality control: Such tests and procedures as are necessary to establish that the sources comply with the performance characteristics for that source design as defined in Table 3 of this standard.

Radiotoxicity: The toxicity attributable to the radiation emitted by a radioactive substance within the body.

Self-luminous light source: A source consisting of a radionuclide firmly incorporated in solid and/or inactive materials or sealed in a protective envelope strong enough to prevent any leakage of the contained radioactive substances to the environment under ordinary circumstances of use and incorporating a phosphor for the purpose of emitting light. Self-luminous light sources include:

Dry powder sources (D): in which the activated phosphor is introduced into a sealed container without the use of any binding medium,

Painted sources (P): in which a radionuclide is intimately mixed and bound with the phosphor and incorporated into a capsule,

Separable sources (S): in which the radionuclide, bonded to or in a supporting stratum, and the phosphor constitute independent elements that can be isolated from each other, and

Gaseous sources (G): in which the phosphor is coated on the inside wall of or on a component within the container in which the radionuclide, in gaseous form, is contained.

Shall: Where “shall” is used for a provision specified herein, that provision is intended to be a requirement if the intent and objectives of this standard are to be met.

Should: Where “should” is used indicates provisions that are not required but are recommended as good practices.

Source holder: A mechanical support for the self-luminous light source.

3. General conditions

Self-luminous light sources considered in this standard are of four general types: dry powder sources (D), painted sources (P), separable sources (S), and gaseous sources (G).

3.1 Activity Level (Table 1)

Table 1 establishes the maximum activity, in curies, of an individual classification of each type of source under this standard. The radionuclides most commonly used and those exhibiting potential use in self-luminous sources are listed in Table 1.

3.2 Self-luminous light source performance tests (Table 2)

Table 2 provides a listing of the tests for evaluating the physical performance of self-luminous sources under average environmental conditions in which a self-luminous source, or source-device, shall be used. The tests are based on normal and abnormal use (typical accidents considered) but do not include exposure to fire or explosion. The tests shall be run consecutively, in the order shown in Table 2.

Table 2 does not cover all source-use situations. If the environmental conditions to which a source is expected to be exposed in use differ from the particular environment shown, the specifications for the source and the test requirements shall be considered on an individual basis by the supplier, the user, and the regulating authority.

Table 1. Maximum activity in curies[a] of an individual self-luminous light source

Radionuclide	Dry powder (D)	Painted (P)	Separable (S)	Gaseous
Tritium (T)	1	5	5	50[b]
Carbon (C-14)	0.06	0.3	0.3	30 (CO_2)
Chlorine (Cl-36)	0.006	0.03[c]	0.03	3
Nickel (Ni-63)	0.06	0.3	0.3	—
Krypton (Kr-85)	0.006[d]	0.03[d]	0.03[d]	30
Technetium (Tc-99)	0.06	0.3	0.3	—
Promethium (Pm-147)	0.06	0.3	0.3	—
Thallium (Tl-204)	0.006	0.03	0.03	—
Lead (Pb-210)	0.0003	0.0015	0.0075	—
Radium (Ra-226)	0.00002	0.0001	0.0005	—
Thorium (Th-230)	0.00002	0.0001	0.0005	—
Americium (Am-241)	0.00002	0.0001	0.0005	—

[a]One Ci is equal to 3.7 X 10^{10} Bq.
[b]Tritium oxide content shall not exceed the greater of (a) 1% of tritium in source or (b) 1 mCi.
[c]Cl salt.
[d]Kryptonate (krypton is a gas at the operating temperature of the self-luminous devices).

Table 2. Self-luminous light source performance tests

Type of test[a]	Performance test levels				
	1	2	3	4	X[b]
Discoloration	12 h lamp	12 h lamp	12 h lamp	12 h lamp	Special
Temperature	No test	0°C and 50°C	–30°C and 65°C	–55°C and 80°C	Special
Thermal shock	No test	0°C to 50°C	–30°C to 65°C	–55°C to 80°C	Special
Pressure (reduced)	No test	226 mm Hg abs.	175 mm Hg abs.	87 mm Hg abs.	Special
Impact	No test	Free fall to steel plate 1 m; 2x	Free fall to steel plate 1 m; 20x	Free fall to steel plate 1 m; 20x and 3 m; 2x	Special
Vibration	No test	Simple harmonic motion having an amplitude of 0.075 cm (0.03 in) or an amplitude of 0.75 cm (0.3 in) and a maximum total excursion of 0.15 cm (0.06 in), the frequency being varied uniformly between the approximate limits of 10 Hz and 55 Hz and return to 10 Hz, shall be traversed in approximately one (1) minute			Special
		10 minutes	30 minutes	60 minutes	
Immersion	No test	Immersion in cold bath, 15 minutes. Immediate (one minute max) transfer to hot bath, 15 minutes. Immediate (one minute max) transfer to cold bath. A dye may be used to observe obvious, gross penetration.			Special
		0°C to 50°C 2 cycles	0°C to 65°C 2 cycles	0°C to 80°C 5 cycles	

[a]Tests are to be performed in the order shown. All temperatures specified ± 3°C.
[b]Test level X is used for environmental conditions more severe than the test conditions of level 4.

Table 3. Performance standards for classification of self-luminous light sources[a]

Source activity (% of Table 1)[b]	Intended usage	Classification	Performance test level (Table 2)						
			Discoloration	Temperature	Thermal shock	Pressure (reduced	Impact	Vibration	Immersion
< 0.1%	Any	1	1	1	1	1	1	1	1
≥ 0.1% to < 1%	Any	2	1	2	2	2	2	2	2
≥ 1 % to < 10%	Fixed	3	1	3	3	3	2	2	2
	Mobile	4	1	3	3	3	3	3	3
≥ 10% to < 100%	Fixed	5	1	3	3	3	3	3	3
	Mobile	6	1	3	3	3	4	4	4
> Table 1	Maximum normal environment	7	1[c]	4[c]	4[c]	4[c]	4[c]	4[c]	4[c]

[a]The above figures are minimum requirements for applications involving normal usage. Where special environmental conditions are involved, either more or less stringent than what might be considered normal, the user shall specify the abnormal condition or conditions, or request the necessary class change.

[b]Source activity as a percentage of Table 1.

[c]Or "Special," as required for specific abnormal environmental condition(s). Use an X where applicable to indicate the special test(s).

If the environmental conditions are more severe than the test conditions of Level 4 in Table 2, “special” tests shall be developed by the supplier that satisfy the user and the regulating agency.

3.3 Performance standards for classification of self-luminous light sources (Table 3)

Table 3 establishes test requirements for self-luminous light sources according to intended usage and source activity. These performance requirements are minimums for applications involving normal usage (including typical accidents). Where generally extreme environmental conditions may be encountered, a “special” test appropriate to that situation shall be developed. There also may be situations where a source in its intended usage shall encounter only one extreme environmental condition. Under such a condition the general classification shall be modified to accommodate the abnormal condition.

3.4 Fire and explosion

Table 2 does not consider exposure of the source or source-device to fire and explosion. In the evaluation of self-luminous light sources and source-devices, the manufacturer and user shall consider the probability of fire and explosion and the possible results. Factors that should be considered in determining the need for tests more stringent than those suggested for specific classes in Table 3 are: consequences of loss of activity, quantity of material in the source, radiotoxicity, physical form of the material environment in which the source is used, and protection afforded the source or source-device combination.

It is recognized that the possibility of fire or explosion exists in many areas where light sources are used. However, light sources, because of certain inherent characteristics, cannot always be constructed so as to completely resist the effects of fire or explosion. Therefore, special test requirements shall be specified where the probability of fire or explosion is known to be abnormally high. These special tests shall include temperature, thermal shock, pressure and impact resistance.

3.5 Radiotoxicity and solubility

Except as limited by Section 3.4, radiotoxicity of the radioactive material and its solubility shall be considered only when the activity of the source exceeds the value shown in Table 1. If the activity exceeds the value shown in Table 1, the classification of the source shall be considered on an individual basis. If the activity does not exceed the values shown in Table 1, then Table 3 may be used without consideration of either radiotoxicity or solubility.

4. Classification and testing

4.1 Classification procedures

The performance classification of a specific type of self-luminous source or source device shall be determined as follows:

4.1.1 Determine from Table 1 the activity allowable for that type of source.

4.1.2 If the desired quantity of radioactive material does not exceed the allowable quantity of Table 1 and no abnormal fire or explosive hazard exists, the performance requirements for classification of the type of source may be taken directly from Table 3. If a significant fire or explosive hazard exists, the factors listed in Section 3.4 shall be evaluated and applied.

4.1.3 If the desired quantity of radionuclide exceeds the allowable limits of Table 1, a separate evaluation of the specific source use and source design shall be made in accordance with Section 3.5.

4.1.4 Performance requirements may be determined directly from Table 3 for normal usage. When conditions of use indicate that abnormal resistance to one or more environmental conditions is necessary or desirable, suitable test conditions may be selected from Table 2 and substituted for those normally specified in Table 3. Since Table 3 is arranged in order of increasing severity, sources of an established classification may be used in any application having less severe, specific performance requirements.

4.2 Testing

The verification of the classification (Section 5) of each source type shall be determined by subjecting a minimum of two samples of production sources consecutively to the performance test specified, or by evaluation of prior test data on sources of comparable size and identical materials of construction.

For self-luminous light sources normally mounted in devices, the complete device should be tested. Where the source constitutes a part of a complete assembly that may not adapt to the performance test, the source only or the source in its holder should be subjected to the specified test.

Compliance with the test shall be determined by the ability of the self-luminous light source to maintain its integrity and brightness after each test is performed, i.e., retain its radioactive material and maintain, within the limits specified in Section 8, its physical and operating characteristics. In the event any of the source units fails the test series, the source design shall be considered unacceptable.

5. Classification designation

The classification of a self-luminous light source shall be designated by a series of letters and digits in accordance with the following designation scheme:

5.1 The first one or two characters shall designate the radionuclide and, with the exception of tritium, shall consist of the chemical symbol of the element, using the letter “T” for tritium, “Kr” for krypton-85, “Pm” for promethium-147.

5.2 The first character following the radionuclide identification shall be a digit, from 1 to 7, taken from Table 3, which shall indicate the classification assigned on the basis of the tests to which the source has been subjected. For emphasis, that digit shall be underlined.

5.3 The first character following identification of the general classification test shall designate the type of source, as classified in Table 1, using the letter “D” to identify a dry powder, “P” for painted, “S” for separable and “G” for gaseous.

5.4 The first character following identification of the type of source shall indicate whether the activity (curie content) does or does not exceed the maximum amounts given in Table 1. Use a “C” to indicate that the amount does not exceed Table 1 limits and “E” to indicate that the activity exceeds Table 1 limits.

5.5 If the source testing involved any specific tests more or less stringent than normal for the indicated classification (“C” or “E”), the series shall be followed by seven additional digits to indicate the level at which each specific test was performed. Table 2 shows seven tests and five test levels for each. Using the applicable designator for test levels (1 to 4 or X), indicate the deviation from the general test level in the manner illustrated in the following examples:

5.5.1 Assume that a source under consideration is one containing two curies of gaseous tritium, is intended for a mobile type application involving abnormal shock resistance, and has been tested in accordance with classification 4, except for the more severe impact test requirements of test level 4. The proper designation for such a source would be T4GC1333433.

5.5.2 The proper designator for a similar gaseous source involving no abnormal conditions and tested in accordance with the requirements of the performance standards classification 4 would be T4GC.

5.5.3 Accordingly, the proper designation for a 0.4-Ci tritium gas source, involving no abnormal conditions and tested in accordance with test level 2, is T2GC. If the same source had successfully been subjected to a more severe impact test, e.g., level 4, this information may be shown by the expanded designation T2GC1222422.

6. Product identification

The ANSI classification designation shall be marked on the self-luminous light source, source container or source holder and the accompanying documents. If space limitation does not permit such marking, the classification designation shall appear on accompanying documents.

7. Performance testing procedures

7.1 General

The testing procedures described below are acceptable and recommended procedures for conducting the performance tests prescribed in Table 2. Procedures demonstrated to be at least equivalent are also acceptable. Tests shall be run *consecutively* on the same source, in the order shown in Table 2. Unless otherwise specified, the test shall be performed at 23°C ± 10°C, at barometric pressure of 710 mm to 790 mm (28 in to 31 in) mercury and at a maximum relative humidity of 80%. Temperature changes, unless otherwise specified, shall be gradual to reduce the possibility of thermal shock.

7.2 Discoloration

7.2.1 Equipment. Weatherometer or Sunlamp, Corex D filter (or equivalent), calcium chloride, 8 liters or larger, glass container.

7.2.2 Procedure. (a) Expose test sources in weatherometer for 12 hours, alternating one-half hour wet and dry cycles, or (b) expose sources for 12 hours at a distance of 20 centimeters to the light from a sunlamp, filtered by a Corex D filter (or equivalent). All tests shall be performed in air with ambient temperatures of 27°C ± 10°C and a relative humidity of 95 to 100%. The source shall be irradiated with the light impinging on the translucent surface of the source.

7.2.3 Evaluation. Test sources shall be examined visually and any discoloration or other effects observed. The light spectrum and output after the test shall be compared with that before the test. When measured with a visual photometer or a color-corrected photocell, no greater loss of luminosity than 20% shall be observed.

7.3 Temperature test

7.3.1 Equipment. The heating or cooling equipment shall have a test zone volume (that volume at essentially constant temperature) of at least five times the volume of the test specimen. The temperature of the test chamber shall be determined by at least two temperature measuring instruments that have been calibrated within the last two years, and the average of the readings shall be taken as the true temperature.

If a gas or oil-fire furnace is used for the temperature test, an oxidizing atmosphere shall be maintained at all times.

7.3.2 Procedure. All temperature tests shall be performed in air. All test sources shall be held at or above the maximum (or at or below the minimum for low-temperature tests) test temperature for a period of at least one hour. The test sources shall be allowed to remain in the test chamber until they return to ambient conditions.

7.3.2.1 Sources to be subjected to temperatures below ambient shall be cooled to the test temperature in less than 45 minutes.

7.3.2.2 Sources to be subjected to temperatures above ambient shall be heated to the test temperature in less than 5 minutes.

7.3.3 Evaluation. Test sources shall be examined visually for any evidence of failure and, in the absence of any evident failure, shall be used in the succeeding thermal shock test. In the event of any uncertainty regarding possible failure, the person performing the test may, at his or her option, subject the source(s) to the final immersion test before proceeding with the next test. See Section 8 for additional details.

7.4 Thermal shock test

7.4.1 Equipment. Same as Section 7.3 Temperature test.

7.4.2 Procedure. Use the same sources that were used in temperature test. Heat the source(s) to the maximum test temperature (required for that particular class) and hold at this temperature for at least 15 minutes. Transfer the source, in 15 seconds or less, to the cold chamber, held at or below the minimum temperature required for the particular class. If water is used for the cold test, it shall be flowing at a rate of at least 10 times the source volume per minute, or, if the water is stationary, it shall have a volume of at least 20 times the source volume.

7.4.3 Evaluation. Test sources shall be examined visually for any evidence of failure and, in the absence of any evident failure, shall be used in the succeeding pressure test. In the event of any uncertainty regarding possible failure, the person performing the test may, at his or her option, subject the source(s) to the final immersion test before proceeding with the next test. See Section 8 for additional details.

7.5 Pressure (reduced) test

7.5.1 Equipment. The apparatus used for the pressure test shall consist of a vacuum pump, vented to a suitable exhaust system, and a suitable sealed chamber having means for visual observation of the sources under test. The pressure gauge shall be recently calibrated and should have a range at least 10% greater than the test pressure.

7.5.2 Procedure. The test sources shall be put into the chamber and exposed to the test pressure for four periods of 15 minutes each, the pressure being returned to atmospheric pressure between each period.

7.5.3. Evaluation. Test sources shall be examined visually for any evidence of failure and, in the absence of any evident failure, shall be used in the succeeding impact test. In the event of any uncertainty regarding possible failure, the person performing the test may, at his or her option, subject the source(s) to the final immersion test before proceeding with the next test.

7.6 Impact test

7.6.1 Equipment. Rigid steel plate. Support or shelf for sources. The steel plate shall be rigidly mounted on an unyielding surface so that it shall not deflect appreciably during the test.

7.6.2 Procedure. Mount the source support above the steel plate at the appropriate height. Place the source to be tested on the support and, using any device or means that shall not have a tendency to orient the source, push the source from the support and allow it to free fall and impact the steel plate in a random manner. Repeat the required number of times specified for the particular test level.

7.6.3 Source orientation. The source shall be oriented in such a manner to ensure both edge impact as well as face impact.

7.6.4 Evaluation. Each test source shall be examined visually for any evidence of failure and, in the absence of any evident failure, shall be used for the succeeding vibration test. In the event of uncertainty regarding possible failure, the person performing the test may, at his or her option, subject the source(s) to the final immersion test before proceeding with the next test. See Section 8 for additional details.

7.7 Vibration test

7.7.1 Equipment. The equipment shall be capable of providing a simple harmonic motion having an amplitude of 0.075 centimeter (0.03 in) or an amplitude of 0.75 centimeter (0.3 in), and a maximum total excursion of 0.15 centimeter (0.06 in), the frequency being varied uniformly between the approximate limits of 10 Hz and 55 Hz.

7.7.2 Procedure. Test sources shall be subjected to the above simple harmonic motion for the time interval indicated for the specific test level. The entire frequency range, between 10 Hz and 55 Hz and return to 10 Hz, shall be traversed in approximately one (1) minute.

7.7.3 Evaluation. Test sources shall be examined visually for any evidence of failure and, in the absence of any evident failure, shall be used for the succeeding immersion test. See Section 8 for additional details.

7.8 Immersion test

7.8.1 Equipment. Hot and cold baths.

7.8.2 Procedure. Immerse the test source(s) in a water bath, maintained at 0°C, and allow to remain for 15 minutes. Immediately (one minute maximum) transfer the sources(s) to a hot water bath, maintained at the temperature specified for the particular test level (± 3°C), and allow to remain for 15 minutes. Immediately (one minute maximum) transfer to the cold bath and allow to remain for 15 minutes. Repeat the cycle as indicated for the specific test level. A dye may be used to observe any gross penetration.

Bath volume, or temperature control, shall be such that bath temperature does not change by more than ± 3°C during the test cycle.

7.8.3 Evaluation. The radioactivity in the hot and cold baths shall be determined. The radioactivity in the liquid shall not exceed 1 microcurie for painted tritium sources, 50 nanocuries for gaseous tritium sources, or 5 nanocuries for other sources. See Section 8 for additional details.

8. Evaluation

Determination of compliance with the performance test requirements shall be made on all sources in accordance with the procedures described below, after the sources have been subjected to the entire test sequence. These evaluations shall be made in addition to the evaluation procedures specified for the individual tests.

8.1 The test sources shall be examined visually for any evidence of failure, visible leakage or degradation.

8.2 The test sources shall be subjected to loss-of brightness measurements.

8.3 The test sources shall be tested for loss (i.e., emersion) of radioactive contents as follows:

8.3.1 Each source shall be wet wipe-tested. An acceptable wipe (smear) test consists of wiping all external surfaces of the source thoroughly with a piece of filter paper or other suitable material of high wet strength and absorbent capacity, moistened with a solvent that shall not attack the material of which the outer surfaces of the source are made, and which, under the conditions of this test, has been demonstrated to be effective in removing the radionuclide involved. Measure the total activity on the paper. It shall not exceed 1 microcurie for painted tritium sources or 5 nanocuries for other sources. Wipe tests are not required for gaseous sources.

8.3.2 Each source shall be soak-tested for 24 hours in a volume of water about equal to or greater than 10 times the volume of the source. The source shall be removed and the activity in the solution measured. The activity in the solution shall not exceed 1 microcurie for painted tritium sources, 50 nanocuries for gaseous tritium sources, or 5 nanocuries for other sources. Gaseous krypton sources are exempted from the soak test.

8.3.3 Leakage of gas from gaseous sources shall be monitored by enclosing the source in a closed system or through suitable means to determine rate of leakage. Leakage shall not exceed 5 nanocuries in 24 hours. Tritium sources shall be exempted from the test.

9. Additional tests for special uses

Under certain environmental conditions, additional tests, not applicable to all sources, may be required or desirable. The following covers one such additional test. Other additional tests should be developed as special situations become evident.

9.1 Dust resistance

9.1.1 Equipment. Humidity chamber, heat source, dusting chamber, carbon black, MgO_2 or other opaque powder.

9.1.2 Procedure. Prepare test sources as follows:

9.1.2.1 Rub service of source to create surface charge. Dust source using the procedure described under Section 9.1.3.

9.1.2.2 Exposure test source for one hour in air with a relative humidity of 95% to 100%. Dust source using the procedure described under Section 9.1.3.

9.1.2.3 Expose source for one hour in air at 80°C ± 10°C to drive plasticizer or residual solvent using the procedure described under Section 9.1.3.

9.1.3 Sources prepared under each procedure above should be mounted or suspended in the dusting chamber, in the position in which they are to be used, and dusted with opaque powder to simulate dust-laden air or atmosphere. Dusting powder should be introduced in an air stream in such a manner that the air stream does not impinge directly on the translucent surface of the source but creates a dust suspension, resembling a dust-laden atmosphere. Expose the source for thirty minutes in such an atmosphere.

9.1.4 Evaluation. Remove the source without disturbing the surface and measure brightness through any accumulated dust, or make such measurement without removing the source from the chamber. The luminosity shall not be less than 80% of the pretest value.

10. References

International Association for Standardization (IAS). *Radioluminescence for Time Measurement Instruments – specification (ISO 3157)*. Geneva: IAS; 1975.

International Atomic Energy Agency (IAEA). *Radiation Protection Standards For Radioluminous Timepieces*. Vienna: IAEA; Safety Series 23;1967.

Nuclear Energy Agency (NEA). *Radiation Protection Standards for Gaseous Tritium Light Devices*. Paris: Organization for Economic Co-operation and Development; 1973.