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FEMA

Tech Talk provides accurate and timely information on topics of interest to the fire protection community. Topics are selected based on inquiries and suggestions that USFA receives from readers. To suggest a topic for a future edition of Tech Talk, please contact us.

Self-Illuminated Signs

This edition of *Tech Talk* looks at self-illuminated or self-powered lighting, which is sometimes used to mark exits. Background information about self-illuminated signs is presented, along with tips for reviewing plans and/or inspecting facilities that use or plan to use self-illuminated lighting features. Guidance for safe disposal of damaged or unused units is also included.

Figure 1. Gaseous Tritium Exit Sign

What is Self-Illuminated or Self-Powered Lighting

Self-powered lighting is a generic term that describes devices that emit light continuously without an external power source. The signs do not require electricity or batteries, and are most commonly installed where it is difficult to get electric power to the location where an exit sign is needed. Historic and architecturally significant buildings are common uses for this technology, although they are approved for use nearly anywhere.

Early self-powered lighting used radium paint, which posed serious health risks to the workers who manufactured and applied it, as well as to users of those early self-powered lighting devices. Modern devices, however, are generally considered to be safe and effective.

At present, there are two different types of self-illuminated signs in use, differentiated by the source of the illumination. The two types currently available are *photoluminescent* and *gaseous tritium* (Figure 1). Each is discussed in this edition of *Tech Talk*.

Code Requirements

Building and fire codes require that exits be marked with an approved sign that is readily visible from any direction of exit access. Both externally and internally illuminated signs are permitted, and signs are required to be legible in both the normal and emergency lighting mode. In practice, most exit signs are "hard wired" to the building electrical supply and are illuminated internally by light bulbs or light emitting diodes (LEDs). A backup battery may also be present in some units.

Figure 2.
UL Listing Mark

As is the case in all equipment-specific matters, the codes defer the details concerning which signs are or may be *approved* to nationally recognized independent testing laboratories. The most widely known of these independent testing laboratories is Underwriters Laboratories (UL). A product is considered to be *approved* by most Authorities Having Jurisdiction if it is *Listed* by UL, a status that is indicated by the UL mark on the product label (Figure 2).

Information on a sign's current UL listing, including the limitations and conditions associated with a listing, can be found in UL's Online Certifications Directory. To access the directory, go to UL's main site www.ul.com. Click on "Certifications" located in the red column at the left. UL's Category Code for self-illuminating exit signs is FWBX, *Exit Signs, Self-luminous* and *Photoluminescent*. It is important to note that the Directory includes only currently listed products—a product that is no longer being manufactured may not be included in the current edition of the Directory.

How are Exit Signs Tested or Listed?

The requirements that UL uses in considering whether an exit sign receives a listing are found in UL Standard 924, *Standard for Safety for Emergency Lighting and Power Equipment*. Both photoluminescent and gaseous tritium signs are available with UL listings. Some key factors about the testing and listing of these devices that code officials should be aware are discussed below.

Damp or Wet Locations: UL generally tests exit signs for use in **dry** locations. A manufacturer can request that a sign be subjected to additional testing, so that the sign can be listed and labeled as suitable for damp or wet locations. (Signs labeled as suitable for damp or wet locations have not been tested for exposure to ultraviolet light, so they may not be appropriate for use where sunlight or other UV rich light sources are ordinarily present.) If a sign has been tested and found suitable for use in damp or wet locations, the label should indicate this.

Temperature Range: UL normally investigates signs for use in ambient temperatures of 68–86 °F (20–30 °C). UL will also test for extended temperature ranges if a manufacturer requests this testing. If no temperature range is given in the listing or on the label, then 68–86 °F (20–30 °C) is the allowable range for normal temperature exposure. UL requires that signs tested to extended temperature ranges have that range indicated on the label.

Visibility Distance: UL tests exit signs for visibility from a maximum viewing distance of 100 feet (30 m). If a listed sign has **no** visibility distance stated on the label or in the listing, the sign is suitable for viewing distances of up to 100 feet (30 m).

In addition to the standard listing for 100 feet visibility distance, UL will also list an exit sign with visibility distances of 50, 75, 100, and 125 feet. When a sign is listed for a viewing distance of other than 100 feet, UL requires that the maximum distance be indicated on the device in a location where it will be visible after installation, so that an inspector can verify the viewing distance (Figure 3).

Figure 3. Typical label on a gaseous tritium exit sign. Note the UL listing mark, the visibility distance of 125 feet, and the replacement date of October 2021.

Life Expectancy: Exit signs whose visibility is expected to decline over time (such as gaseous tritium signs) are required by UL to be marked with a replacement date in a location where the date will be visible after installation. (See label on previous page.)

Photoluminescent Exit Signs

Figure 4.
Photoluminescent Exit Sign

How They Work: Photoluminescent signs (Figure 4) use microscopic crystals of strontium aluminate imbedded in plastic as the "power source." These crystals absorb ambient light during normal operations and then release this stored energy to glow brightly when the lights go out. They have a very limited ability to store this energy, so they must be charged constantly whenever the building is occupied. They are constantly absorbing and releasing light energy, even though you cannot see them glow while the lights are on.

Viewing Distance: Photoluminescent signs are available in different grades, based on the distance from which they can be viewed. Listings for viewing distances of 50 feet, 75 feet, and 100 feet are available. The UL listing for the sign will state the maximum viewing distance, as should the label on the sign. (Wired exit signs are normally listed for a 100 feet viewing distance.) Viewing distance is important, since it signifies the maximum distance between the sign and a building occupant.

Illumination Requirements: Since they are dependent on external illumination to "charge" the light source, photoluminescent signs are intended for installation only where the external illumination is deemed reliable and sufficient by the Authority Having Jurisdiction, and where the lighting controls are accessible only to authorized personnel. If a specific type or level (intensity) of lighting is needed to achieve the required visibility, UL requires that this information be marked on the sign in a location that will be visible after installation. Here are three examples of the marking from actual signs that show typical viewing distance and external illumination requirements/limitations. Each of these listed devices has different limitations.

Rated viewing distance 50 feet, minimum 5 ft-c fluorescent, external illumination.
Example 1

Example 1 is taken from a sign that is listed for 50 feet viewing distance. The external illumination is required to be fluorescent lights that provide an intensity of 5 foot-candles at the face of the sign.

Rated viewing distance 75 feet, minimum 5 ft-c fluorescent, external illumination.
Example 2

Example 2 illustrates a sign that is listed for 75 feet viewing distance. For this sign, the external illumination is required to be fluorescent lights that provide an intensity of 5 foot-candles at the face of the sign.

Rated viewing distance 50 feet, minimum 5 ft-c fluorescent, Mercury Vapor or Metal Halide external illumination.
Example 3

Example 3 is taken from a sign that is listed for 50 feet viewing distance. For this sign, the external illumination is required to be either fluorescent, mercury vapor, or metal halide lights that provide an intensity of 5 foot-candles at the face of the sign.

Measuring Illumination: Photoluminescent signs must be exposed to a minimum level of light whenever the building is occupied in order to charge the sign so that they will glow bright enough when the lights go out. It is important to understand how to properly measure illumination levels in order to evaluate whether an installation is or will be acceptable.

Illumination level is defined as a measure of the amount of visible light falling on a surface. Illumination is typically measured in units of foot-candles (ft-c) (the SI unit of illumination is the lux (lx) where 1 ft-c = 10.76 lx). In contrast, luminance is a measure of the light reflected off of a surface; it is associated with "brightness." Luminance is usually used when evaluating uniformly radiating area sources, such as backlit signs, and illumination is used to measure how much light is falling on a surface.

Illumination is measured by placing a light meter (Figure 5) on or directly against a surface and reading the value on the display. If there are many light sources, the meter reads the total illumination coming from all sources. A variety of digital light meters are available, including many that have a National Institute of Standards and Technology (NIST) certificate that demonstrates a degree of precision that should be used for all measurements used in enforcement actions.

Figure 5. Digital Light Meters

For example, if you are measuring stairway illumination, place the detector on the surface of the stair tread, not at eye level. If measuring exit path illumination, place the light meter on the floor in the exit path. When measuring illumination for photoluminescent signs, place the light meter on the surface of the wall where the sign will be installed, or directly on the face of the sign. The light sensor should be facing the same direction as the sign. When making measurements of illumination, keep the following important factors in mind:

- Be sure that the light meter is set to the type of lighting present (i.e., fluorescent, tungsten, daylight, sodium or mercury). Inaccurate readings can result if the correct type of light is not selected.
- Be sure that your hand or body does not cast a shadow on the light sensor; this will decrease the amount of light falling on the meter. This is especially important if the light meter in use does not have a light sensor on a cord.
- Take measurements at several positions. Lighting fixtures do not emit light in a uniform pattern, and you will likely notice a change in the illumination level as you place the meter in different positions. This will be more pronounced in exit paths than it will be on signs.
- Be sure that the light meter has been recalibrated within the past year. All measurement instruments need to be calibrated periodically to ensure that they are properly working, and light meters are no exception.

Disposal of Photoluminescent Signs: There is no unusual health or safety issue related to the materials used in photoluminescent signs and markings. (This applies to products that are available in the market. There may be concerns related to the raw materials and manufacturing processes that are not encountered in day-to-day use, but these are beyond the scope of this paper.) There are no Federal restrictions on the disposal of photoluminescent signs and markings. When no longer needed, they may be disposed of in the normal municipal waste stream. However, in order to reduce waste, consideration should be given to recycling and/or reusing the signs.

Gaseous Tritium (Radioluminescent) Light Sources

Gaseous tritium (trit-ee-uhm) light sources are growing in popularity in military and outdoor uses, and are increasingly common in consumer novelty items (Figure 6). Tritium gas is odorless, colorless, tasteless, and is lighter than air. Tritium is a radioactive isotope of the element Hydrogen, and has the chemical formula H_3. (Hydrogen gas is a diatomic molecule that has the chemical formula H_2.) Radioactive isotopes contain atomic nuclei which are unstable and are always trying to change to a more stable situation. In the process of making this change, energy is given off and this produces radioactivity. The process is called "decay." Although tritium is naturally produced by the interaction of cosmic rays with the atmosphere, it is commercially produced in a nuclear reactor.

Figure 6. Gaseous Tritium Powered Consumer Novelty Lights

Background Information – Radiation and Tritium

Radiation can occur in one or more of four basic forms:

- Alpha particles (α);
- Beta particles (β);
- Gamma Rays (γ); and
- X Rays.

ALPHA particles are the heaviest atomic particle and can be hazardous to the body even if their energy is low. BETA particles are actually electrons and have almost zero mass. The potential hazard, however, depends on the energy level. Because BETA particles are practically weightless, their energy level must be high before penetration of body tissues can occur. GAMMA and X Rays can penetrate body tissues readily, but the hazard is, once again, in proportion to the energy involved.

Internal contamination occurs when people swallow or inhale radioactive materials, or when radioactive materials enter the body through an open wound or are absorbed through the skin. Some types of radioactive materials stay in the body and are deposited in different body organs. Other types are eliminated in blood, sweat, urine, and feces.

Tritium emits **only** Beta radiation, no other type of radiation is emitted by the gas. The Beta emissions from tritium are very weak. In free air, the tritium Beta particle travels about 5mm (less than a quarter of an inch) and can be stopped simply by putting a piece of paper in the pathway. Tritium emits the lowest level of Beta radiation of all radioactive isotopes and the particles cannot penetrate even the thinnest layer of body skin. Although tritium is a radioactive isotope, gaseous tritium light sources emit no radiation as long as the gas remains sealed inside glass tubes (normal use). The Beta emissions from the tritium gas cannot penetrate the walls of the glass tube.

The main hazard associated with tritium is internal exposure by inhalation, which can only happen if the tubes are broken. The radiation dose is received mainly by inhaling into the lungs, where the tritium gas can mix with body fluids. Tritium is not transferred to bone marrow or other body organs where it may accumulate, and within a short time (from 1 to 15 days) the majority of the dose is expelled from the body through urination.

As with all ionizing radiation, exposure to tritium increases the risk of developing cancer. However, tritium exposure is likely to have a limited biological impact because it emits very weak radiation and leaves the body relatively quickly. In addition, because of tritium's short half-life, tritium must be ingested in large amounts to pose a significant health risk.

How Tritium Lights Work

Tritium light sources (Figures 7 and 8) are manufactured of borosilicate glass tubes (Pyrex). Borosilicate glass is preferred because it is a type of glass noted for its strength and resistance to breakage. The glass tube is coated on the inside surface with a phosphor-containing compound. The tube is filled with the radioactive tritium and the tube is then melted closed at both ends with a laser to contain the gas safely inside. In consumer products, the glass tube is usually further encased in an impact-resistant cylinder of transparent plastic for additional protection.

Figure 7. Tritium Powered Zipper Pull

Inside the tube, the tritium gas gives off a steady stream of electrons due to Beta decay. These particles excite the phosphor, causing it to emit a low, steady glow. Various preparations of the phosphorus compound can be used to produce different colors of light. In addition to the common phosphorus green, red, blue, yellow, purple, and orange light are available.

Tritium is an unstable isotope with a half-life of 12.3 years. (This means that in 12.3 years, half of the tritium energy has decayed, or half of the energy for light production has been expended.) The more tritium that is initially placed inside the tube, the brighter it is to begin with, and the longer it's useful life will be.

Figure 8. Tritium Powered Watch Face

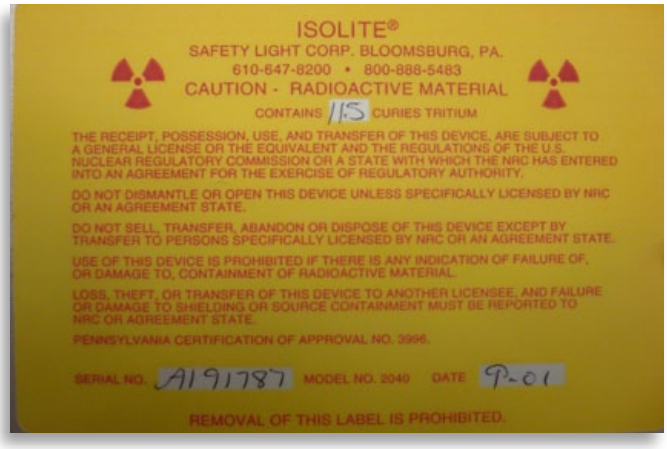
Tritium exit signs are typically available in three brightness levels guaranteed for 10, 15, or 20 year useful life expectancies. The difference between the signs is the amount of tritium that the manufacturer puts in the tube, which impacts the cost. Since the tritium component of the lighting is often more expensive than the rest of the item itself, manufacturers try to use as little as possible.

The tritium filled tubes are placed in a form that holds them in the proper position, and the form is placed in the sign housing along with other components.

Tritium Exit Signs

More than 2 million exit signs that use a gaseous tritium light source are estimated to be in use in the United States. Because these signs are available as UL listed units with 10, 15 or 20 year life spans, they will be with us for a long time. Tritium exit signs pose little or no threat to public health and safety and do not constitute a security risk. However, the U.S. Nuclear Regulatory Commission (NRC) requires proper accounting and disposal of all radioactive materials, including tritium powered illumination sources. Therefore, it is important to be able to recognize tritium signs.

Figure 9. Label from Tritium Exit Sign



How To Recognize a Tritium Sign: There are a couple ways to determine whether a sign contains tritium:

- The device should contain a permanent warning label (Figures 9 and 10) that mentions tritium (H_3), displays the three-bladed international radiation warning symbol, and states "Caution-Radioactive Material." Both UL and the NRC require this label. (See sample label.)

- Look closely at the front of the sign. If you can see glass tubes behind the clear plastic or glass face, then the sign contained tritium when it was manufactured.

- To verify the presence of tritium in the sign, try extinguishing all lights in the vicinity. If the word EXIT glows green, the sign may contain tritium. If all four letters in EXIT are fully lit, the sign is working properly. If not, the sign may be damaged.

Be aware that photoluminescent signs glow with a green color that is very similar to the glow from a tritium sign. You can tell the difference between photoluminescent signs and tritium signs by looking at the part of the sign that glows. Flat materials are photoluminescent, tritium signs have glass tubes filled with tritium gas.

The photo sequence in Figures 11-14 shows a tritium sign in different lighting conditions and partially disassembled. This shows the principal components of the sign.

Figure 10. Label on Tritium Exit Sign Frame

A Sequence of Photos Showing the Parts of a Tritium Exit Sign

Figure 11. This photo shows the normal appearance. The red Exit template and the prismatic lens are in place.

Figure 12. This photo shows the sign in the dark, with the glow visible. The Exit template and the prismatic lens are in place.

Figure 13. In this photo, the Exit template and the prismatic lens have been removed so that the tritium filled tubes are clearly visible.

Figure 14. This photo shows the tritium filled tubes with the room lights on. The tubes are still glowing, but the glow is not discernable due to the brightness of the room lights. The tubes are glued in a plastic tray that has the letters molded.

Issues to Consider During Plan Reviews or Inspections

Plan reviews and inspections typically include review of exit sign placement. The following additional factors should be considered when self-illuminated exit signs are used:

For Photoluminescent signage
• Is the sign listed by UL? What are the details of the listing?
• Is the sign to be installed in a dry location? If not, is the device listed for installation in damp or wet locations?
• Is the sign listed for the temperatures to which it is likely to be exposed during its lifetime?
• Is the listed viewing distance appropriate for the location where the device is proposed to be installed?
• Is the ambient lighting adequate to charge the device? Is the illumination level equal to or greater than the level specified in the listing. The illumination level should be measured in foot-candles (ft-c) with the light meter (Figure 15) positioned **parallel to and at the face of the sign** (not at the floor).
• Is the ambient lighting adequate to charge the device? Does the type of lighting planned or present match the type specified in the listing (if any is specified)? (fluorescent, mercury vapor or metal halide)
• Are the lighting controls adequate to ensure continued charging of the sign(s) when the building is occupied?
• Has the type of lighting or level of illumination present changed since the original installation?

For Gaseous Tritium signage
• Is the sign listed by UL? What are the details of the listing?
• Is the sign to be installed in a dry location? If not, is the device listed for installation in damp or wet locations?
• Is the sign listed for the temperatures to which it is likely to be exposed during its lifetime?
• Is the listed viewing distance appropriate for the location where the device is proposed to be installed?
• Is the sign out of date? Check the expiration date, manufacture date, and/or life span on the label.
• Is the sign intact? Are all of the tritium tubes intact and still functioning?

Figure 15. Digital Light Meter used to measure light level

Inspectors may also want to consider advising building owners of the precautions to be taken in the event that a tritium sign is damaged, and/or of the regulations governing proper disposal.

Disposal of Damaged, Exhausted Units, and/or Units no Longer Needed

Tritium has been identified in landfill leachate in both the United States and abroad. Recent studies have pointed to discarded self-luminous exit signs that have been improperly disposed in landfills as the predominant source of this contamination. Crushed signs release the tritium gas, which can combine with water to form tritiated water, which is radioactive.

The NRC requires proper accounting and disposal of all radioactive materials. The regulatory requirements for these "generally licensed" devices are spelled out in NRC regulations at 10 CFR Part 31 and in Regulatory Issue Summary 2006-25. Proper handling and accounting are important, because a damaged or broken sign could cause mild radioactive contamination of the immediate vicinity, requiring a potentially expensive clean up.

Tritium Exit Signs Must NOT be Disposed of as Normal Trash

To dispose of a sign properly, NRC regulations require that the owner transfer the sign to a manufacturer, distributor, licensed radioactive waste broker, or a licensed low-level radioactive waste disposal facility. These facilities may charge a fee for this service. Within 30 days of disposing of a sign, the owner is required to file a report to either the State radiation control office or the NRC that includes:

1. The device manufacturer's (or distributor's) name, model number and serial number;
2. The name, address, and license number of the person receiving the device; and
3. The date of the transfer.

If being sent to the NRC, reports should be sent to Director, Office of Federal and State Materials and Environmental Management Programs, ATTN: GLTS, U.S. Nuclear Regulatory Commission, Washington, D.C. 20555-0001.

Damaged Gaseous Tritium Lighting

While damage to tritium exit signs is rare, it is most likely to occur when a sign is dropped during installation or smashed during demolition or remodeling activities. If not damaged during demolition, tritium exit signs could be broken when they are illegally dumped in community landfills.

If the tubes in the exit signs are damaged, the tritium, which exists in the sign as a gas, can escape into the local area. Most likely, it will quickly disperse in the air since it is lighter than air. Because a damaged exit sign will have relatively high levels of tritium in it, you should not handle it.

Guidance from the U.S. Environmental Protection Agency (EPA)

Disposal of a damaged or broken sign should be arranged through the manufacturer or a health physics consultant. When an exit sign containing tritium is damaged and the sealed tube within the sign is broken, you should:

- **Leave** the sign alone; do not touch it.
- **Evacuate** the area immediately.
- **Isolate** the area; do not allow entry.
- **Ventilate** the area to the outside.
- **Identify** all individuals possibly exposed.
- If you think you have been contaminated, you should:
  - **Shower** with soap and water (or at least wash face and hands).
  - **Change clothing** and put the potentially contaminated clothes in a sealed plastic bag for testing to confirm exposure.
  - **Drink plenty of fluids** to help the tritium leave the body more quickly.
  - **Collect** a urine sample for testing to confirm or rule out internal exposure. Follow NRC, State, or health physics consultant's advice on where to send the samples for analysis.
  - **Call** your local fire or police departments, your State's radiation control office, or the NRC Regional Office.
- **A Health Physics consultant** will be able to provide detailed monitoring and decontamination advice.

The protective clothing required for cleanup usually consists of gloves and booties. The broken sign should be placed in an air-tight container by a health physics consultant. If silica gel is available, it should be placed in the container with the broken sign. The silica gel will collect any tritiated water. At a minimum, the broken sign and any miscellaneous pieces should be double bagged and sealed in plastic. Disposal of the broken sign should be arranged through the manufacturer or a health physics consultant.

The EPA has developed an online training course providing detailed, easy-to-follow guidelines for identifying, using, and disposing of tritium EXIT signs. The course discusses the importance of proper use and disposal. This FREE training is ideal for State and local officials; for owners, managers, and maintenance personnel of public places including schools, hotels, malls, dorms, and theaters; and for green building designers. To access the training online, go to www.trainex.org and search for "Tritium EXIT Signs, Responsible Management."