

Design of Storage Areas for Troxler Gauges

Design Criteria

Storage areas must be designed and constructed to meet the following criteria:

1. Security against unauthorized removal or theft
2. Warning signs must be posted
3. Radiation dose in unrestricted areas must not exceed 2 mrem in any one hour and the dose to any member of the public shall not exceed 100 mrem in a year.

Selecting the Storage Location

The first step is to select a storage area. A number of considerations enter into selecting a good gauge storage location.

- The storage area should be one that is under the exclusive control of the licensee so that the gauge can be secured against unauthorized access.
- The storage area should be large enough to accommodate the maximum number of gauges that the licensee anticipates will need to be stored at that location and any shielding that may be necessary in order to reduce the radiation levels outside the storage area.
- Consider what is in the spaces adjacent to the storage area, including above and below. Ideally, the storage area would be located as far as practical from any areas that are frequently occupied by personnel to minimize incidental radiation exposure.

Posting Warning Signs

The entrance to the storage location must be posted with a sign bearing the radiation symbol (trefoil) and the words "Caution - Radioactive Materials". The colors should be yellow background with magenta or black lettering. If the dose rate anywhere within the storage area exceeds 5 mrem per hour, the area must be additionally posted with the words "Caution – Radiation Area".

The sign must be clearly visible to anyone entering the area. If the area has more than one entrance, then a sign should be posted at each entrance. Normally, the caution sign would be posted on the outside of the entrance door, but it is also acceptable to post the sign immediately inside the area such that any person entering the room would see the warning. If the gauge is stored inside a cabinet, a caution sign should be posted on the outside of the cabinet.

References: 10 CFR 20.1901 and 20.1902

Securing Gauges

The storage area must be designed to prevent unauthorized access and removal of gauges containing radioactive sources. A minimum of two independent physical controls that form tangible barriers must be used to secure portable gauges from unauthorized removal or theft whenever the portable gauges are not under the control and constant surveillance of the licensee. The lock on the handle of the gauge and the lock on the shipping case do not meet

this requirement because they do not prevent the theft of the gauge. Examples of acceptable security controls include:

- a. Keeping the gauge inside a locked storage room within a secured office, laboratory, or warehouse building.
- b. Keeping the gauge inside of a locked and fixed (immovable) storage cabinet within a secured office, laboratory, or warehouse building.

Reference: 10 CFR 30.34

Controlling Radiation Exposure

The storage area must be designed and constructed to minimize incidental radiation exposure to personnel from the radioactive sources in the gauges. Two requirements must be met:

1. The dose in unrestricted areas must not exceed 2 mrem in any one hour. In general, any area outside of the gauge storage area, whether occupied or not, will be considered an unrestricted area as defined in the radiation protection regulations.
2. The dose to any member of the public must not exceed 100 mrem in a year. A member of the public is generally considered to be any individual who does not operate the gauge or whose routine job does not involve working with radioactive material.

The licensee is required to demonstrate compliance with these requirements by dose calculation, measurement, or some combination of the two. Guidance and worksheets for performing public dose calculations can found in the Troxler Licensing Guide, Appendix G, Public Dose Calculation Worksheet.

The standard methods of time, distance, and shielding can be used to comply with the dose limits. Each of these methods are discussed briefly below.

Time

The dose will be directly proportional to the amount of time that gauges are in storage and the amount of time that personnel spend in areas adjacent to the storage area. For this reason, it is best to select a storage area where adjacent areas have relatively low occupancy factors.

Distance

The rule of thumb is that storing a gauge at least 15 feet from areas routinely occupied by personnel will ensure compliance with the dose limits for members of the public as well as for unrestricted areas. The dose rate from a single Troxler moisture-density gauge at a distance of 15 feet is generally less than 0.05 mrem per hour, thus a person exposed at that distance for 40 hours per week for 50 weeks per year (i.e., 2000 hours) would receive a dose of less than 100 mrem in a year. The above rule only applies to a single gauge. For multiple gauges, the distance at which the public dose limits would be met under the same assumptions is greater. For example, the distance would be 21 ft for two gauges and 26 ft for 3 gauges.

Shielding

Time and distance are generally the easiest and least expensive methods for controlling radiation exposure. However, if these methods are not adequate to ensure that dose limits will be met, then use of shielding may be necessary to reduce the dose rate.

The radioactive sources in moisture-density gauges emit both gamma and neutron radiation that are very penetrating. A common misconception is that keeping the gauges in the shipping case provides some shielding of these radiations. In fact, the shipping case provides little if any shielding. Nor does the typical hollow wall construction of most buildings provide a significant degree of shielding.

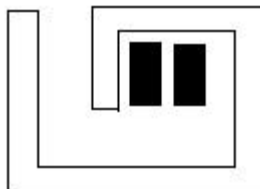
Gamma and neutron radiation interact with matter by different physical processes. Consequently, shielding materials that are good for gamma rays are not necessary good for neutrons and vice versa. For example, lead is very effective for shielding gamma rays, but not neutrons. The shielding effectiveness of a material for a particular type of radiation is expressed in terms of the half-value layer (HVL). The HVL is simply the thickness of material that will reduce the incident radiation intensity by one-half. The table below gives the HVL of several materials for the gamma and neutron radiation emitted by the Cs-137 and Am-241:Be sources in Troxler gauges.

| Half-Value Layers | | |
|--------------------------|---------------------------------------|--|
| Material | Cesium-137 Gamma Radiation | Am-241:Be Neutron Radiation |
| Concrete | 1.9 in. | 4.3 in. |
| Lead | 0.25 in. | - |
| Polyethylene | 3.8 in. | 2.4 in. |

When trying to shield both gamma and neutron radiation, one could use a combination of materials, such as lead and polyethylene. Alternatively, a single material that is somewhat effective for both types of radiation, such as concrete, could be used. Solid concrete blocks are reasonably effective for both gamma and neutron radiation, are relatively inexpensive, and are readily available.

Since shielding materials are heavy, it is not always practical to place much shielding above the gauges or overhead. For this reason, it is best to select a storage area where the areas above are not occupied by personnel to avoid the necessity of shielding in that direction.

Any shielding design should block all line-of-sight paths between the gauges and areas occupied by personnel or unrestricted areas. An example of the basic 'maze' type design which allows access to the storage area but blocks direct radiation paths is shown below.



After any shielding has been installed, radiation measurements should be made using an appropriate radiation detection instrument to verify that the dose rate design objectives have been achieved.