

Special Documentation

Source Container FQG60

Radiometric Level Measurement

U.S. General Licensees

Radiation Safety and Technical Reference Manual

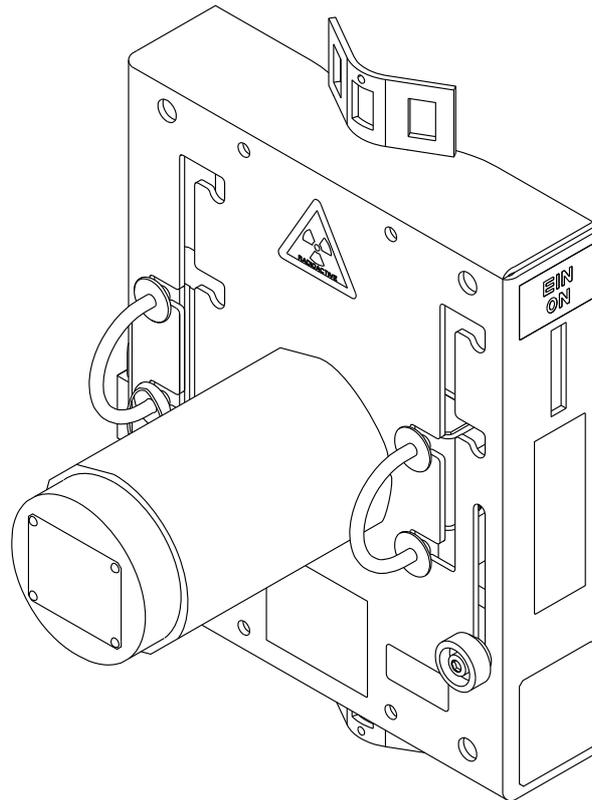
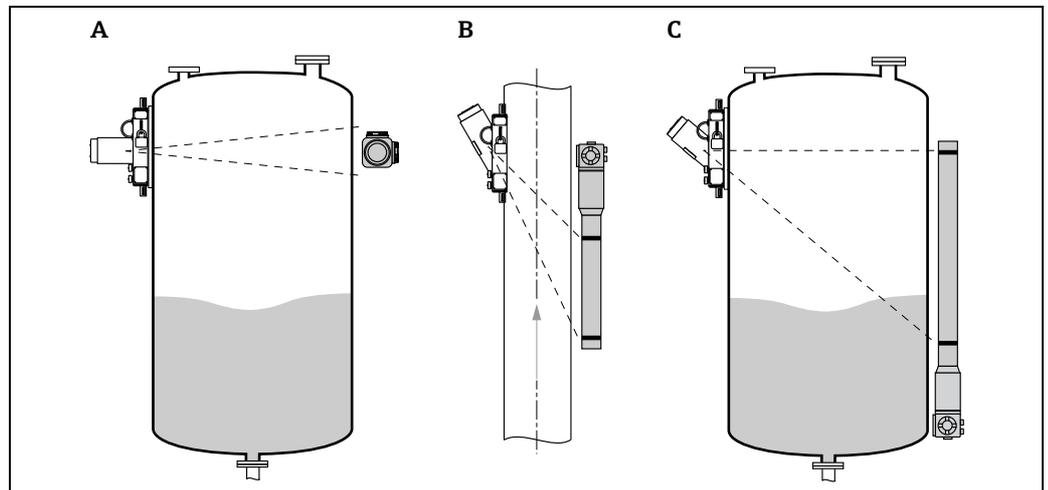


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1 General information

Radiometric measurement is based on the principle that radioactive materials - installed in a protective source container - emit gamma rays which are attenuated when they penetrate materials. The detector (Gammapilot M) mounted on the opposite side of the vessel transforms the received radiation into an electrical signal. The parameters that can affect the measurement, and hence the signal, are the rising level (continuous/point level measurement) or changing densities of the medium inside the tank or pipe.



A0019225

- A Level limit detection
- B Density measurement
- C Continuous level measurement

1.1 Who we are

Endress+Hauser is a global leader in the provision of measurement instrumentation, services and solutions for industrial process engineering. Endress+Hauser was founded in 1953 by Georg H. Endress and Ludwig Hauser. The company has developed from an instrumentation specialist to a provider of complete system solutions.

We offer a wide range of sensors, instruments, systems and services covering the areas of level, flow, pressure and temperature measurement, liquid analysis and recording, including the connection of field instruments to process control systems as well as automation and logistic solutions. Endress+Hauser can supply systems to perform a process measurement, monitoring or automation task accurately, cost effectively and with minimum disruption to your existing installations. Solutions are created in close cooperation with the customer.

As early as 1962, Endress+Hauser brought its first radiometric measuring system to the market. Since then, more than four decades have passed and this technology continues to provide decisive advantages.

1.2 U.S. License Types

An industrial nuclear gauge user in the United States must operate this device under a license from the U.S. Nuclear Regulatory Commission (NRC) or Agreement State. The license sets limits on what the user can do with the source container. Licenses are one of two types:

1. General
2. Specific

FQG60 provides a General License.

1.2.1 General License

A general license has the effect of issuing a license under certain conditions with minimal documentation. The detailed requirements for general licensees are in Title 10, Part 31.5 of the Code of Federal Regulations. General licensees located in Agreement States will need to get a copy of the equivalent regulations for their state and follow the appropriate regulations. The instruments that are issued under general license are usually designed and fabricated Distribution of generally licensed devices and their use must meet very strict criteria.

1.2.2 Endress+Hauser Generally Licensed Source Containers

Endress+Hauser distributes generally licensed containers under a specific license issued by the NRC. Gauges manufactured for distribution to a general licensee must have a radiation field low enough so that personnel should not receive a radiation dose over of 0.1 rem/year. In most installations, 5 mrem/hr at 12 in (30 cm) from the surface of the source container meets this requirement and is the accepted criteria. The general licensee must follow the conditions of the general license which are listed on a label attached to the source container.

1.3 Basic Radiation Safety

Gamma rays, which are emitted by radioactive materials such as Cesium 137 and Cobalt 60, are electromagnetic waves similar to light. Gamma energies, however, are many times higher than the light rays. The ability of gamma radiation to penetrate materials is related to its particular wave length and energy. The actual measuring principle is based on the absorption of radiation by the product to be measured: Either the material absorbs almost all of the radiation (level or limit switch applications) or the absorption changes while a fraction of the original radiation still reaches the transmitter even at maximum density (density or interface measurement).

Radiated energy affects the human body only when absorbed at an excessive rate. Dose from this radiant energy depends on several factors:

- The activity of the source.
- The distance from the source to part of the body.
- The portion of the body in contact or closest to the source.
- The presence of any shielding material between the source and the body.
- The total time that the body was exposed.

1.3.1 Safety Instructions

⚠ WARNING

The radiation source container contains radioactive material.

Designated use

The source container FQG60 described in these safety instructions contain the radioactive source, which is used for radiometric measurement of level, interface and density. They screen the radiation towards the surrounding and allow it to be emitted almost unattenuated and only in the direction of measurement.

In order to guarantee the screening effect and to exclude damage of the radiation source, all instructions given in this manual for mounting and operation as well as all regulations for radioactive protection are to be followed exactly. Endress+Hauser accepts no responsibility for any damage caused by incorrect use.

Basic instructions for use and storage

- Observe the applying rules and national regulations.
- Observe the radiation protection regulations in use, storage and for work on the radiometric measuring system.
- Observe warning signs and safety areas.
- Install and operate the device according to the manufacturer's instructions.
- The device shall not be operated or stored outside the designated parameters.
- Protect the device against extreme influences (i.e. chemical products, weather, mechanical impacts, vibrations) when operated or stored.
- Always safe the OFF position of the source insert using the padlock.
- Do not operate or store damaged or corroded devices. Contact the responsible radiation safety officer for appropriate instructions and measures when damage or corrosion occurs.
- Conduct the required leak testing procedure according to the applying regulations and instructions.

⚠ WARNING

Exposition to vibrations or mechanical impacts, may affect safety properties of the device and requires inspection in periodical intervals.

⚠ CAUTION

In case of doubt about proper condition of the device check the area around the device for leakage radiation and/or contact immediately the responsible radiation safety officer.

Safety instructions for switching on the radiation

Before switching ON the radiation beam it is necessary to ensure that no personnel are within the area of the radiation (or, indeed, inside the vessel). The radiation beam may only be switched ON by specially trained personnel.

1.3.2 ALARA Principles

When working with radioactive sources, one should minimize unnecessary exposure. Work related exposure to radiation must be kept to as low as reasonably achievable (ALARA). As of 1994 ALARA is not just a good idea it is the law and all licensees must have ALARA as part of their radiation protection program, of which Endress+Hauser subscribes to. Three important measures help to achieve this:

Screening

One should plan activities to keep as much screening material as possible between the source and individuals working in the field. Source containers (FQG60) and other high-density materials such as lead, iron, and concrete can be used for effective screening of gamma emitting sources.

All Endress+Hauser models have a shutter or other mechanism to attenuate the beam during installation, maintenance, emergencies, etc.

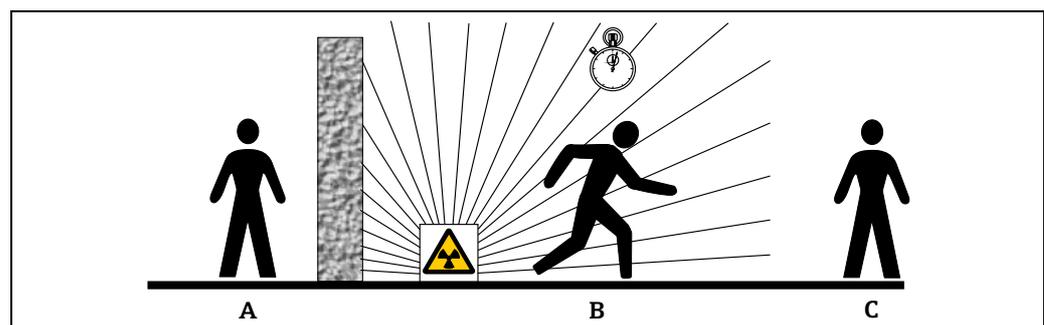
Time

The dose a person receives is directly proportional to the amount of time spent in a radiation field. Time spent in an elevated radiation area should be kept to a minimum.

Distance

Distance from the source of the radiation is important in minimizing exposures. The exposure rate of the radiation field decreases by the square of the distance from an unshielded point source.

This means when one increases the distance from an unshielded point source by a factor of two, the radiation field decreases by a factor of four. As with time, an individual should endeavor to work as far from a source as feasible.



A Screening
B Time
C Distance

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1.4 Exposure to Radiation and Contamination

From the beginning, people have lived with ionizing radiation coming from several origins; including space (cosmic) and, the earth's crust (terrestrial). Individuals are also subjected to artificially generated radiation, with the highest exposures due to medical x-rays and treatments.

Radioactive dose is measured in units of Sieverts or Rems. These units take into account different types of radiation and their potential effects on the human body. Individuals can reduce potential radiation doses by utilizing time, distance and shielding, i.e. using remote control instruments to handle radioactive materials.

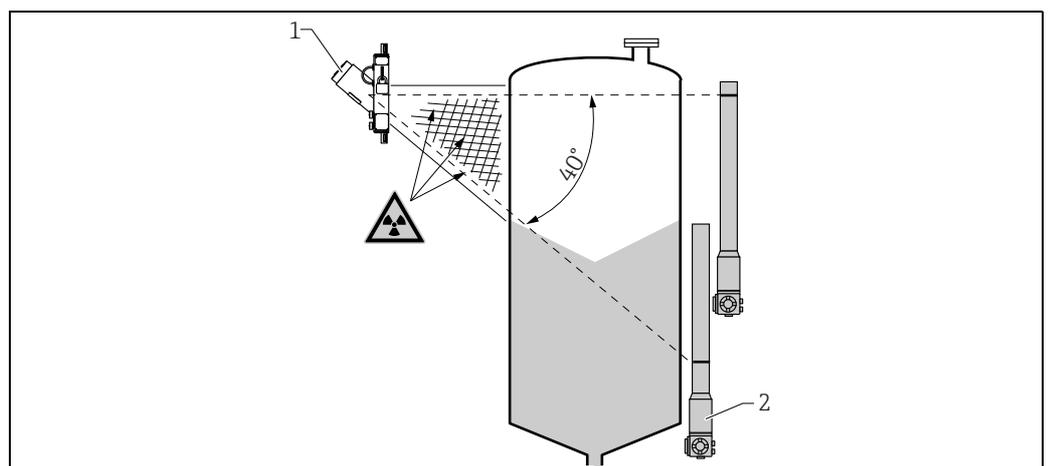
Radiation exposure or dose is not the same as radioactive contamination. Contamination can only occur via direct contact, inhalation, ingestions or absorption of radioactive materials. Radioactive material in the Endress+Hauser devices is doubly encapsulated, in accordance with ISO classification, typically C66646 / ISO2919 meeting the most stringent safety criteria in relation to stress, extreme temperatures and pressures as well as impact, vibration and puncture.

Contamination is only possible if the source capsule fails and radioactive material is disbursed.

An example of this would be a campfire. As you feel the heat of the fire you are in its radiation field. Contamination occurs if any part of the fire gets out of the fire area. Stainless steel encapsulated sources rarely fail, even under emergency conditions. Periodic leak tests are done to check for surface contamination.

1.4.1 Primary Radiation Beam

The potential for access to the primary radiation beam is determined by the location and installation parameters of the source container. Ideally, the pipe or vessel is completely enclosed with the source container mounted against the pipe or vessel wall. Access to the primary radiation beam should be limited to the opposite side of the pipe or vessel at the detector or inside of a tank. However, a distance between the source container and the product container often cannot be avoided if the measuring range is large and the container diameter small. If this space is sufficient for hands or other body parts to enter, this area must then be shielded.



1 FQG60
2 FMG60

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The interior of most piping systems are inaccessible. Access control procedures must be structured and implemented at the time of source container "startup" to ensure that personnel exposure does not exceed the regulatory limits for whole body or extremity dose. Vessel entry is prohibited unless the source is shielded and the shutter is locked. Various user-maintained lockout procedures prevent access to the inside of the vessel until meeting all safety conditions. All Occupational Safety and Health Administration (OSHA) regulations concerning confined space entry must be followed.

1.5 Regulating Radioactive Materials

The use of radioactive material, including nuclear gauges, is regulated by the U.S. Nuclear Regulatory Commission (U.S. NRC) or the equivalent agency of an Agreement State. The applicable sections of the U.S. NRC regulations are numbered 10 CFR Part 20, 10 CFR 31.5, and 10 CFR Part 32.51.

Agreement States are those which have an agreement with the NRC to regulate radioactive materials within the state. The NRC still maintains control of some material such as nuclear power plants.

The NRC and Agreement States update their regulations periodically. It is up to the licensee to keep up with changes to these regulations. Some states require registration of gauges using radiation material, regardless of the license type. In those cases, the licensee must meet the state requirements.

1.5.1 Legal requirements for radiation protection

Handling radioactive emitters is legally controlled. The radioactive protection regulations of the state in which your plant is located are to be complied with.

License requirements

A general or specific license is required for operating a plant which uses gamma radiation. Application for the License must be made to the NRC or the agreement state in which the plant resides.

Radiation Safety Officer

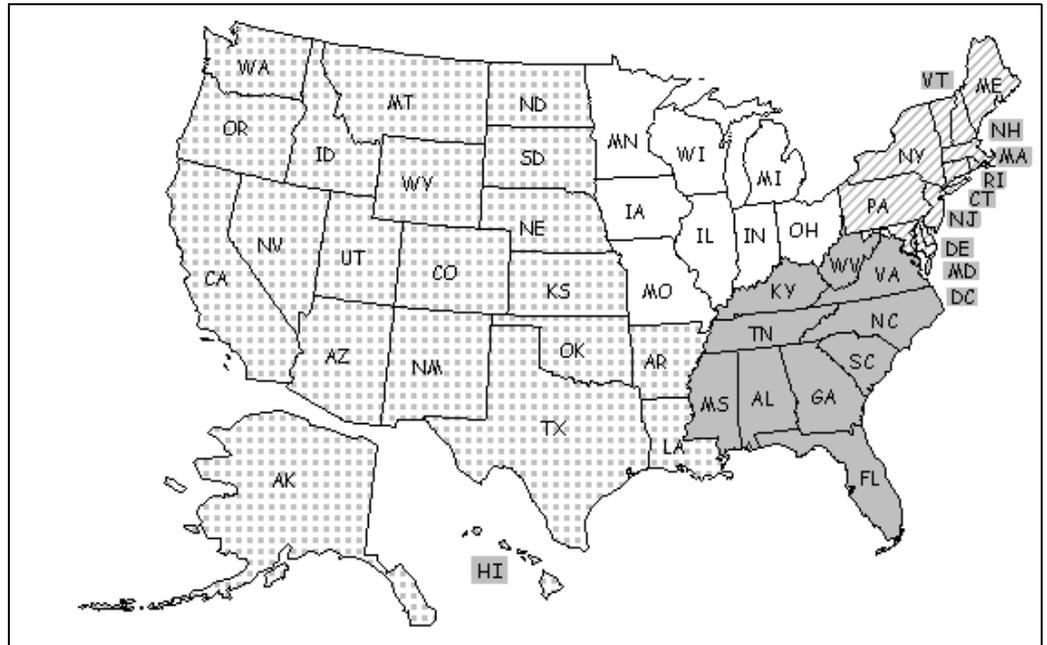
The operator of the plant must select an individual to become the Certified Radiation Safety Officer (RSO). The goal of the radiation safety officer is to develop and maintain the radiation safety program with procedures to keep the occupational doses to all people as low as possible.

The radiation safety officer will administer and or oversee site-specific safety training for all workers.

Control Areas

All control areas containing Nuclear gauges are to be clearly marked for all people to easily read. All people entering to do any type of work within the control area should be badge monitored per all safe practices as per NRC / State guideline dose limitations.

1.5.2 NRC Regional Map



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1.5.3 U.S. NUCLEAR REGULATORY COMMISSION AND AGREEMENT STATE OFFICES AS OF FEBRUARY 2011

ALABAMA

Office of Radiation Control
Alabama Department of Public Health
201 Monroe Street
The RSA Tower, Suite 700
P.O. Box 303017
Montgomery, AL 36130-3017
PH: (334)206-5391; FX: (334)206-5387

ALASKA

Radiological Health Program
Section of Laboratories
State of Alaska/DH&SS
4500 Boniface Parkway
Anchorage, AK 99507-1270
PH: (907)334-2107; FX: (907)334-2163

ARIZONA

Arizona Radiation Regulatory Agency
4814 South 40th Street
Phoenix, AZ 85040
PH: (602)255-4845 ext. 222; FX: (602)437-0705

ARKANSAS

AR Department of Health
Radioactive Materials Program
4815 West Markham, Slot H-30
Little Rock, AR 72205
PH: (501)661-2173; FX: (501)661-2849

CALIFORNIA

Radiologic Health Branch
P.O. Box 997414, MS 7610
Sacramento, CA 95899-7414
PH: (916)440-7942; FX: (916)440-7999

COLORADO

Hazardous Materials & Waste Management Division
Department of Public Health and Environment
4300 Cherry Creek Drive South
Denver, CO 80246-1530
PH: (303)692-3432; FX: (303)759-5355

CONNECTICUT

Division of Radiation
Dept of Environmental Protection
79 Elm Street
Hartford, CT 06106-5127
PH: (860)424-3029; FX: (860)424-4065

DELAWARE

Office of Radiation Control
Division of Public Health
P.O. Box 637
417 Federal St., Jess S. Cooper Bldg.
Dover, DE 19903
PH: (302)744-4546; FX: (302)739-3839

DISTRICT OF COLUMBIA

Department of Health
Environmental Health Administration
Radiation Protection Division
717 14th Street, NW, 6th Floor
Washington, DC 20005
PH: (202)724-8800; FX: (202)727-8471

FLORIDA

Bureau of Radiation Control
Florida Department of Health
4052 Bald Cypress Way, SE, Bin C21
Tallahassee, FL 32399-1741
PH: (850)245-4266; FX: (850)4787-0435

GEORGIA

Radioactive Materials Program
Department of Natural Resources
4244 International Parkway, Suite 114
Atlanta, GA 30354
PH: (404)362-2675; FX: (404)362-2653

HAWAII

Radiation Section
HI Department of Health
Indoor & Radiological Health Branch
591 Ala Moana Boulevard, Rm 133
Honolulu, HI 96813
PH: (808)586-4700; FX: (808)586-5838

IDOHA

Technical Services Administrator
Idoha Dept. of Environmental Quality
1410 North Hilton
Boise, ID 83706
PH: (208)373-0204; FX: (208)373-0143

ILLINOIS

Illinois Emergency Management Agency
Division of Nuclear Safety
1035 Outer Park Drive
Springfield, IL 62704
PH: (217)785-9868; FX: (217)524-4724

INDIANA

Epidemiology Res Center/Indoor & Radiological Health
Indiana Department of Health
2525 N. Shadeland Ave., E3
Indianapolis, IN 46219
PH: (317)351-7190 ext. 257; FX: (317)351-2679

IOWA

Bureau of Radiological Health
Iowa Department of Public Health
Lucas Office Bldg. 5th Floor
321 East 12th Street
Des Moines, IA 50319
PH: (515)281-3478; FX: (515)281-4529

KANSAS

Section Chief Radiation and Asbestos Control
KS Dept of Health & Environment
1000 SW Jackson, Suite 310
Topeka, KS 66612-1366
PH: (785)296-1565; FX: (785)296-0984

KENTUCKY

KY Cabinet for Health Services
Radiation Health Branch
275 East Main Street HS1C-A
Frankfort, KY 40621-0001
PH: (502)564-3700 ext. 3701

LOUISIANA

Emergency & Radiological Services Div.
Environmental Compliance
P. O. Box 4312
Baton Rouge, LA 70821-4312
PH: (225)219-3624; FX: (225)219-4044

MAINE

Radiation Control Program
Division of Health Engineering
11 State House Station
286 Water Street, Key Plaza, 4th Floor
Augusta, ME 04333
PH: (207)287-5677; FX: (207)287-3059

MARYLAND

Environmental Program Manager III
Radiological Health Program
Air & Radiation Management Adm.
Maryland Dept of the Environment
1800 Washington Blvd, Suite 750
Baltimore, MD 21230-1724
PH: (410)537-3300; FX: (410)537-3198

MASSACHUSETTS

Radiation Control Program
Department of Public Health
Schrafft Center, Suite 1M2A
529 Main Street
Charlestown, MA 02129
PH: (617)242-3035, x2001; FX: (617)242-3457

MICHIGAN

Radiological Protection Section
Waste and Hazardous Materials Div.
MI Dept of Environmental Quality
525 West Allegan Street
P.O. Box 30241
Lansing, MI 48909-7741
PH: (517)241-1253; FX: (517)241-1326

MINNESOTA

Indoor Environments and Radiation Section
Environmental Health Division
Department of Health
P.O. Box 64975
St. Paul, MN 55164-0975
PH: (651)201-4602; FX: (651)201-4606

MISSISSIPPI

Division of Radiological Health
Radioactive Materials Branch
State Department of Health
3150 Lawson Street, P.O. Box 1700
Jackson, MS 39215-1700
PH: (601)987-6893

MISOURI

Missouri Medical Radiation Control Branch
Health Facility Regulation
Dept of Health Senior Services
1617 Southbridge, P.O. Box 570
Jefferson City, MO 68102-0570
PH: (573)751-6083; FX: (573)751-6158

MONTANA

Radiological Health Program
Dept of Public Health & Human Services
Licensure Bureau
2401 Colonial Drive
P.O. Box 202953
Helena, MT 59620-2953
PH: (406)444-2868; FX: (404)444-3456

NEBRASKA

NE Dept. of Health & Human Services
Division of Public Health
301 Centennial Mall South
P.O. Box 95026
Lincoln, NE 68509-5026
PH: (402)471-0528; FX: (402)471-0169

NEVADA

Radiation Control Program
Bureau of Health Care Quality & Compliance
Nevada State Health Division
4150 Technology Way, Suite 300
Carson City, NV 89706
PH: (775)687-7540

NEW HAMPSHIRE

Radiological Health Section
Dept of Health and Human Services
29 Hazen Drive
Concord, NH 03301-6504
PH: (603)271-4588; FX: (603)225-2325

NEW JERSEY

Radiation Protection Programs
Division of Environmental Safety, Health & Analytical Programs
Dept. of Environmental Protection
P.O. Box 415
Trenton, NJ 08625-0415
PH: (609)984-5636; FX: (609)633-2210

NEW MEXICO

Radiation Control Bureau
Field Operations Division
Environment Department
Harold S. Runnels Bldg.
1190 St. Francis Drive, Rm S2100
Santa Fe, NM 87505-4173 or
P.O. Box 5469
Santa Fe, NM 57502-5469
PH: (505)827-1080; FX: (505)476-3232

NEW YORK

Bureau of Environmental Radiation
Protection and Environmental Exposure Investigations
547 River Street
Troy, NY 12180
PH: (518)402-7550; FX: (518)402-7554

Radioactive Waste Policy and Nuclear Coordination
New York State Energy Research & Development Authority
17 Columbus Circle
Albany, NY 12223-6399
PH: (518)862-1090 ext. 3274; FX: (518)862-1091

Radiation Control Permit Section Chief
Bureau of Hazardous Waste and Radiation Management
New York Department of Environmental Conservation
625 Broadway, 9th Floor
Albany, NY 12233-7255
PH: (518)402-8579; FX: (518)402-9025

Bureau of Radiological Health
New York City Dept. of Health
2 Lafayette Street, 11th Floor
New York, NY 10007
PH: (212)676-1556; FX: (212)676-1548

NORTH CAROLINA

Radiation Protection Section
Division of Environmental Health
Dept of Environmental & Natural Resources
3825 Barrett Drive
Raleigh, NC 27609-7221
PH: (919)571-4148 ext. 201; FX: (919)571-4148

NORTH DAKOTA

North Dakota Dept of Health
Division of Air Quality, 2nd Floor
918 East Divide Ave.
Bismarck, ND 58501-1947
PH: (701)328-5188; FX: (701)328-5200

OHIO

Bureau of Radiation Protection
Ohio Department of Health
264 North High Street
Columbus, OH 43215
PH: (614)644-2727; FX: (614)466-0381

OKLAHOMA

Radiation Management Section
OK Dept of Environmental Quality
P. O. Box 1677
Oklahoma City, OK 73101-1677
PH: (405)702-5155; FX: (405)702-5101

OREGON

Radiation Protection Services
Oregon Health Services
Department of Human Services
800 NE Oregon Street, Suite 640
Portland, OR 97232-2162
PH: (971)673-0499; FX: (971)673-0553

PENNSYLVANIA

Bureau of Radiation Protection
Dept. of Environmental Protection
P.O. Box 8469
Harrisburg, PA 17105-8469
PH: (717)787-2480; FX: (717)783-8965

PUERTO RICO

Radiological Health Division
Department of Health
P.O. Box 70184
San Juan, PR 00936-8184
PH: (787)274-5815; FX: (787)274-6829

RHODE ISLAND

RI Department of Health
Office of Facilities Regulations
3 Capitol Hill, Room 306
Providence, RI 02908
PH: (401)222-4520; FX: (401)222-3999

SOUTH CAROLINA

Dept of Health & Environmental Control
Bureau of Radiological Health
2600 Bull Street
Columbia, SC 29201
PH: (803)545-4420; FX: (803)545-4412

Dept of Health & Environmental Control
Bureau of Land and Waste Management
Division of Waste Management
2600 Bull Street
Columbia, SC 29201
PH: (803)896-4070; FX: (803)896-4001

SOUTH DAKOTA

Office of Health Care Facilities
Licensure & Certification
Systems Development & Regulations
615 East 4th Street
Pierre, SD 57501-1700
PH: (605)773-3356; FX: (605)773-6667

TENNESSEE

Division of Radiological Health
TN Dept of Environment & Conservation
L&C Annex, 3rd Floor
401 Church Street
Nashville, TN 37243-1532
PH: (615)532-0364; FX: (615)532-7938

TEXAS

Radiation Safety Licensing Branch Manager
Division for Regulatory Services
TX Dept. of State Health Services
P.O. Box 149347 - Mail Code 2835
Austin, TX 78714-9347
PH: (512)834-6679; FX: (512)8341-6716

Office of Permitting, Remediation & Registration
Texas Commission on Environmental Quality
P.O. Box 13087, MC 122
Austin, TX 78711-3087
PH: (512)239-6731; FX: (512)239-6362

UTAH

Division of Radiation Control
Dept. of Environmental Quality
168 North 1950 West
P. O. Box 144850
Salt Lake City, UT 84116
PH: (801)536-4257; FX: (801)533-4097

VERMONT

VT Department of Health
108 Cherry Street
P.O. Box 70
Burlington, VT 05402-0070
PH: (802)863-7238; FX: (802)865-7745

VERGINIA

Division of Radiological Health
Department of Health
109 Governor Street, Rm 730
Richmond, VA 23219
PH: (804)864-8151; FX: (804)864-8155

WASHINGTON

Division of Radiation Protection
Department of Health
P.O. Box 47827
Olympia, WA 98504-7827
PH: (360)236-3210; FX: (360)236-2255

WEST VIRGINIA

Radiation, Toxics and Indoor Air Div.
Office of Environmental Health Services
DHHR Bureau for Public Health
Capitol & Washington Streets
1 Davis Square, Suite 200
Charleston, WV 25301-1792
PH: (304)558-2981; FX: (304)558-1289

WISCONSIN

Radiation Protection Section
Division of Public Health
Dept of Health and Family Services
P.O. Box 2659
Madison, WI 53701-2659
PH: (608)267-4792; FX: (608)267-4799

WYOMING

Wyoming Office of Homeland Security
2421 E. 7th Street
Cheyenne, WY 82001
PH: (307)777-4951; FX: (307)638-7670

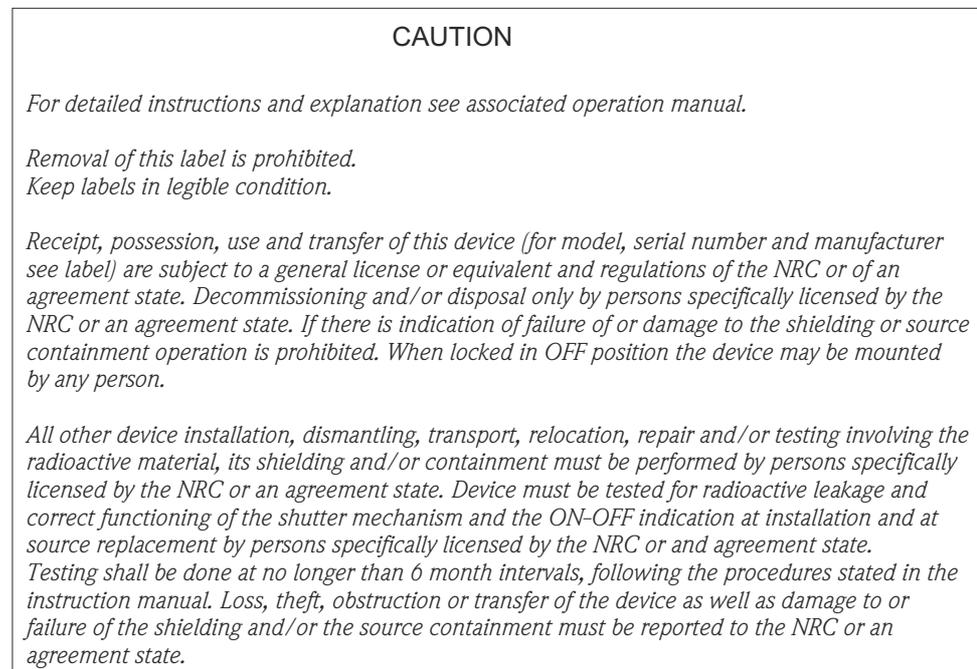
2 General License

The Code of Federal Regulation (CFR) Part 31.5 states, "A general license is issued to users of certain source containers that have been approved for distribution by the U.S. NRC." Endress+Hauser has a specific license from the NRC to distribute approved source containers to general licensees in U.S. NRC controlled areas and to those regulated by Agreement States. The general licensee user must follow the conditions of the general license. These conditions are shown on a label attached to the source container and a detailed explanation of the wording of the label follows.

2.1 Safety Label For General Licensees

In order to comply with the U.S. NRC regulations, a label has been attached to the source container that states the responsibilities of the general licensee. A copy of the label follows:

FQG60:

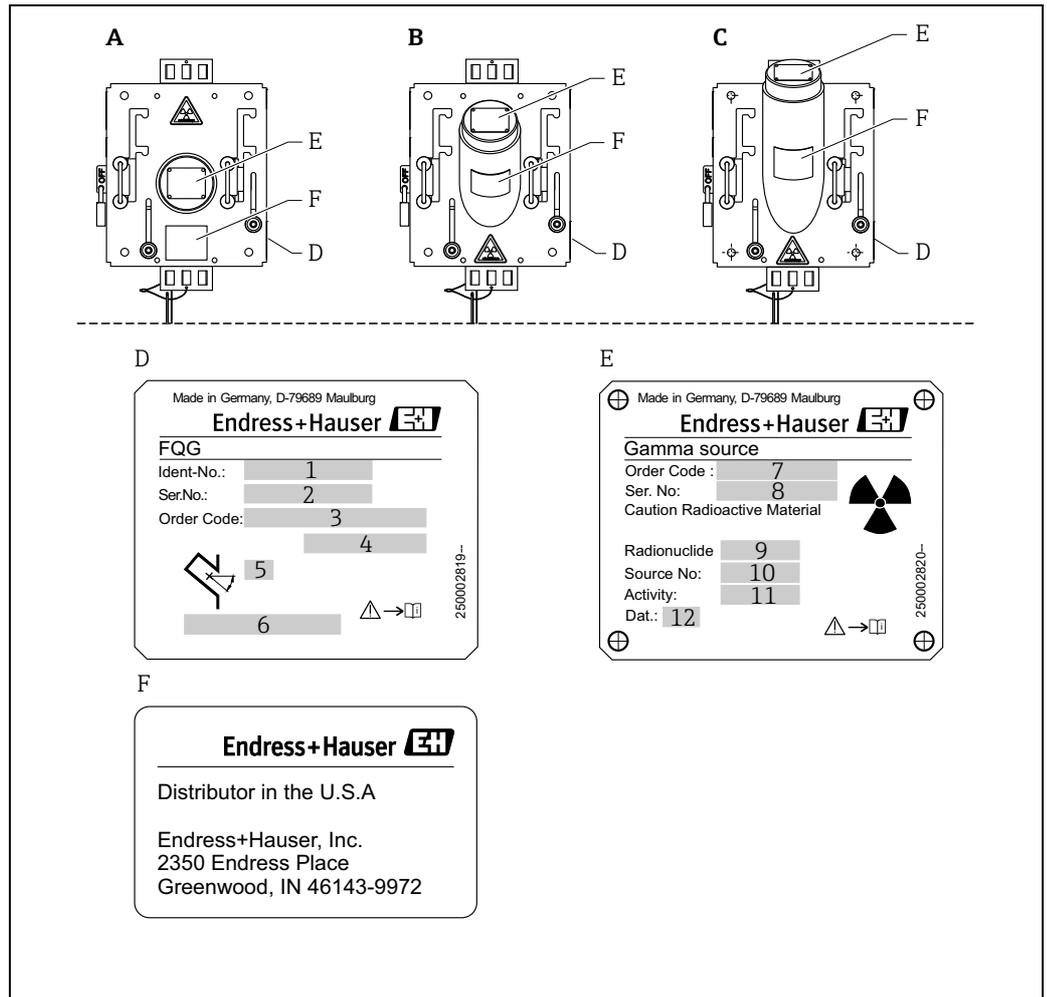


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2.2 NRC Regulations for General Licensees

2.2.1 Condition of Label

"Removal of this label is prohibited. Keep labels in legible condition. Receipt, possession, use and transfer of this device (for model, serial number and manufacturer see label) are subject to a general license or equivalent and regulations of the NRC or of an agreement state." Do not remove the label from the source container. Keep the label clean and legible. If the label becomes unreadable, contact Endress+Hauser for a replacement. The ability to read the tags and labels is an important item during inspections. This refers to U.S. NRC regulations in 10 CFR 31.5. The Agreement States have their own versions of this regulation. Even the simplest gauging devices containing radioactive material (i.e. smoke detectors, electrostatic eliminators) are distributed under general license authorization.



A0021565

- A Feature 240 "Emission Angle; Application", Option model 3 "20 deg; limit switch + density"
 - B Feature 240 "Emission Angle; Application", Option model 5 "40 deg; level"
 - C Feature 240 "Emission Angle; Application", Option model 4 "20 deg; density 30 deg diagonal radiation"
 - D Nameplate of source container
 - E Nameplate of radiation source (also functions as theft protection for source insert)
 - F Additional nameplate of NRC license
- 1 ID number of source container (abbreviated order code)
 - 2 Serial number of source container
 - 3, 4 Order code of source container as per product structure
 - 5 Radiation emission angle (when switched off)
 - 6 Local dose rate at a defined distance from the surface (when switched off)
 - 7 Endress+Hauser internal order code for the radiation source
 - 8 Endress+Hauser internal serial number for the radiation source
 - 9 ¹³⁷Cs
 - 10 Serial number of the source capsule (provided for source tracking, if required)
 - 11 Activity in MBq or GBq
 - 12 Date (month/year)

NOTICE

The local dose rate at a defined distance specified on the nameplates is based on a worst-case estimation when switched off and takes into account production-dependent fluctuations of the source activity and tolerances of the measuring devices. Therefore it may be slightly different from the local dose rate which was calculated from the specified attenuation factor.

2.2.2 Decommissioning/disposal

"Decommissioning and/or disposal only by persons specifically licensed by the NRC or an agreement state."

This section means that the source container cannot be abandoned, sold for scrap, or placed in the trash. If the source container is no longer needed, it can only be removed by and shipped to someone with the proper license to remove or receive the radioactive material. There will come a time when the source container will need to be replaced or removed, either because of decay or an application is no longer needed. Because of the radioactive nature of the material proper disposal procedures must be followed.

There are specially designated facilities that can dispose of or recycle radioactive material. If your source container needs to be removed, contact us or an authorized company for the proper procedure.

For inquiries on the NRC or State regulations, contact your state Agency or the NRC.

2.2.3 Failure or damage

"If there is indication of failure of or damage to the shielding or source containment, operation is prohibited."

If the source container is damaged in a way that interferes or inhibits operation of the shutter mechanism, the device must be taken out of service until it is repaired or replaced. Special precautions may need to be used when handling a damaged device. Contact Endress+Hauser for assistance.

2.2.4 Source container mounting

"When in the OFF position the device may be mounted by any person. All other device installation, dismantling, transport, relocation, repair and/or testing involving the radioactive material, its shielding and/or containment must be performed by persons specifically licensed by the NRC or an agreement state."

These devices are heavy and the detectors are fragile, so one must be careful when uncrating source containers and detectors.

Contact Endress+Hauser for advice if any of the following situations are observed:

- There is damage to the crate indicating potential damage to the source container.
- The lock is missing, broken, or not locked (Do not install the source container if the lock is missing, broken, or unlocked.)

The General Licensee may authorize an individual to mount the source container, install airlines (if source container has a pneumatic actuator), install wiring for the detector and turn detector on (for testing) provided that the shutter is in the OFF position. After installation, a person specifically licensed must perform specific tasks to commission the source container.

This involves:

- Unlocking the shutter and moving it to the ON position.
- Testing for proper operation of the shutter and the shutter position indicator.
- Performing and documenting the initial radiation field intensity survey and occupancy evaluation.
- Performing initial leak test.

Only a person specifically licensed by the U.S. NRC or an Agreement State is allowed to remove the source container from its mounting. The Endress+Hauser factory ships the source container with the source container shutter locked OFF with a padlock.

2.2.5 Post-installation check

Leak and shutter tests

Device must be tested for radioactive leakage and correct functioning of the shutter mechanism and the ON/OFF indication at installation and at source replacement by persons specifically licensed by the NRC or an agreement state. Testing shall be done at no longer than

- 6 month intervals for leak test
- 6 month intervals for all other specified tests

following the procedures stated in the referring instruction manual.

After mounting the source container, an individual who is specifically licensed, must verify that the installation meets the requirements of the registration. To do this, that person must perform the following:

- A radiation survey to verify exposures levels.
- A leak test to verify that no loose radioactive material is present.
- Check the ON/OFF or shutter mechanism to verify that the source container is working correctly and that shutter position indicators are visible and operating.

Most records must be kept for a minimum of 36 months. Endress+Hauser suggests that you keep all records for as long as you have the device. Check your regulations for specific requirements.

Measuring the local dose rate

The local dose rate in the vicinity of the source container must be measured immediately after it has been mounted.

⚠ CAUTION

Depending on the installation, radiation can also occur through scattering. In such cases it must be screened by the use of additional lead or iron shielding. Render or mark all control and exclusion areas as prohibited for unauthorized entry.

Behavior on empty process vessel

⚠ CAUTION

After the proper mounting of the source container, the control area around the empty tank has to be measured. If it is necessary, this area must be blocked off and marked. If there is an entry into the interior space of the tank, it has to be closed and marked with a sign "radioactive". The entry is only allowed after checking all safety regulations by the responsible radiation safety officer. If maintenance operations are carried out in or at the vessel, it is mandatory to switch the radiation OFF.

2.2.6 Transfer, loss, theft or damage

"Loss, theft, obstruction or transfer of the device as well as damage to or failure of the shielding and/or the source containment must be reported to the NRC or an agreement state."

In addition to notifying the U.S. NRC or the Agreement State agency, Endress+Hauser should also be notified so that help can be provided. If the source container is involved in a fire or explosion, barricade or rope off the area until the situation can be evaluated by a trained individual.

2.2.7 Disposal or recycling

Regulations that govern the disposal of radioactive materials are covered in 10 CFR 20.2001 or compatible Agreement State regulations. When the source container is no longer needed, contact an authorized licensee to discuss transfer, disposal or recycle. Generally licensed material must be transferred to an authorized licensee for storage or disposal.

3 Standard Routine Procedures

This chapter reviews procedures for routine activities to be performed on or with nuclear gauges containing radioactive material. It is the licensee's responsibility to make himself familiar with and understand which activities he is authorized to perform.

 Also observe Technical Information/Operating Instructions TI00445F/00.

3.1 Receiving the Source Container

When receiving a source container from Endress+Hauser, refer to the following list to ensure the source container has arrived in proper condition.

1. Visually inspect package and source container for damage.
2. Make sure the ON/OFF mechanism is closed and locked.
3. Check to be sure that the shipment is complete.
4. If the source container is not to be installed immediately, place the package in a storage area that is isolated and secure.
5. Control access to the source container.
6. Maintain original receipt paperwork.
7. While not required, a survey and leak test can be performed if there is any concern regarding condition of the source container.

A radiation field can always be measured around the source container. You should expect to measure a low radiation field around the source container even if it is in perfect condition. One can compare the readings from the shipping paperwork to measured levels around the package to determine if some damage or shifting of the contents has occurred.

3.2 Source Container Mounting

The physical installation of the source container can be done by anyone with basic radiation safety awareness training and knowledge of source containers, provided the source is locked in the OFF position. The following are examples of proper procedures for the installation of the source container.

3.2.1 Checklist

The following items should be checked prior to beginning physical installation of a source container:

- Physical condition of the shipping container.
- Confirm that shutter is closed and locked.
- Check that the mounting bracket and area can accommodate the manufacturer's estimated weight and specifications of the source container.
- Check for sufficient room to move shutter.
FQG60: Consider clearance between shutterplate and pipe or vessel, too.
- Consider any high temperature, vibration, caustic, or other environmental conditions.
For example
 - Is insulation needed to protect the source container from high temperature?
 - Is any additional protection required (i.e. hood or cover) to prevent caustic material from settling on source containers?
- Gather sufficient personnel and any special equipment necessary for installation.
- Source containers are heavy. Plan for physical aspects/requirements of installation.

 Observe the installation requirements and restrictions stated in Technical Information/ Operating Instructions TI00445F/00!

3.2.2 Commissioning

Commissioning of a source container entails several mandatory steps. Treat each placement or relocation as a new installation requiring commissioning. Each time the source container-detector orientation (geometry) is broken/changed commissioning activities must be completed. Commissioning is the process of getting the mounted source container ready for use and consists of the following:

- Preliminary radiation survey
- Leak test
- Installation radiation survey
- Shutter operation test

Only a specifically licensed individual can perform the commissioning. A calibrated survey meter must be used during the entire procedure.

3.2.3 Radiation Survey

- A calibrated and operable survey meter must be used.
- Measure and record the radiation levels in all directions around the source container and detector to identify any unusual radiation pattern.
- Perform this survey with the shutter both ON and OFF.
- If the radiation field is comparable, consistent with Endress+Hauser specifications, proceed with a leak test.
- If the radiation field is greater than 50 $\mu\text{Sv/hr}$ (5 mrem/hr) at 12 in (30 cm) from the installed container:

Special posting or restrictions of the area may be required (10 CFR 20.1902)

- Verify with the manufacturer that this condition is normal for the type and activity of source and source container installed
- Estimate the dose personnel may receive based upon work requirements near the installed container

Personnel can be categorized into two groups, each with a different dose limit:

- Members of the Public can receive 20 $\mu\text{Sv/hr}$ (2 mrem/hr) and 1,000 $\mu\text{Sv/yr}$ (100 mrem/year). This includes all individuals not specifically trained, and designated as Occupationally Exposed. They are usually individuals who do not work directly with the source containers.
- Occupationally exposed individuals can receive 50,000 μSv (5,000 mrem) per year with no specified rate limit. Individuals in this group have received appropriate training for work with or in the immediate vicinity of source containers.

Additional shielding may be required to prevent personnel from accessing the beam and/or to minimize the radiation dose in certain areas. Notify personnel of the presence of radioactive materials and precautions necessary to minimize exposure (i.e. posting and training).

If the radiation fields are above 20 $\mu\text{Sv/hr}$ (2 mrem/hr) on the detector side of pipe or tank, shielding or area restrictions may need to be implemented.

3.2.4 Shutter Function Test

The purpose of this test is to verify that the shutter is functional, easily operable, and the indicator is in agreement with the shutter position.

3.2.5 Radiation Fields in or Around Vessels

Written lock-out/tag-out procedures must be written for source containers mounted on tanks, other accessible locations, or with enough space between the container and the vessel for someone to get a portion of their body into the beam.

Many of these locations would be considered by OSHA to be a confined space, for other than radiation readings, requiring lock-out/confined space documentation consistent with OSHA rules.

Mounted source containers must be evaluated to ensure that the gap between source container and vessel is not sufficiently large enough to allow any portion of an individual's body to access the radiation beam. If access is possible, the area should be blocked or restricted.

The following steps should be completed before a tank or vessel is entered:

- Verify that the source container is locked in the OFF (shutter closed) position.
- The person in charge of individuals entering the tank should monitor the entryway.
- Verify closed shutter with a calibrated survey meter or the system electronics. The detector will show off-scale readings. Measured fields should be very close to background.
- After work is completed, make sure the vessel is vacant and the entrance door secured before returning the source container to the ON position.

3.3 Removal of a Source Container

⚠ CAUTION

All maintenance such as removal or replacement of the source container may only be carried out by supervised personnel, who have been specially trained in radiation procedures according to local regulations or handling approval. Ensure that the contents of the handling approval is valid. Local conditions are to be observed. All work to be carried out may only be done from a safe (shielded!) location. Safety procedures must also be carried out to protect personnel from all possible risks. The disassembly of the source container can only be executed during OFF position. Make sure, the OFF position is secured with a padlock.

Before removal of the source container, perform the following steps:

- Make sure the source container is in good physical condition.
- Severely corroded source containers may require special handling and shipping requirements.
- Close and lock the shutter.
- Have sufficient personnel and proper equipment available to remove the unit.
- Provide appropriate training for involved individuals, based upon assigned duties.
- Be prepared to handle the weight of the unit which may be sufficient to unbalance insufficiently supported elevated platforms or machines. The approximate weight of the source container is listed in the registry sheet.
- A radiation survey with a calibrated meter is to be performed in order to assess the radiation levels around source container. The radiation levels around the unit should be comparable to the original survey pattern.
- A current leak test on the source container is required. If the source container is to be moved to a new location or put in storage a current leak test certification is acceptable.
- The removal of a source container must be supervised by a specifically licensed individual.

3.3.1 Dismounting

FQG60

1. Secure the source container at the fastening lug with a lifting eye.
2. Loosen the screws from the mounting of the source container at the vessel or at the pipe.
3. Lift the source container by means of a suitable tool.

3.3.2 Procedure after termination of the application

Internal measures

As soon as a radiometric measuring device is no longer required, the radiation source on the source container must be switched off. The source container shall be removed in accordance with all relevant regulations and saved in a lockable room having no through traffic. The responsible authorities shall be informed of these measures. The access to the storage room shall be measured out and signed. The radiation safety officer is responsible for protecting against theft.

The radiation source in the source container must not be scrapped with the other parts of the plant. It should be returned as quickly as possible.

3.3.3 Return

To address the disposal sources call your local Endress+Hauser office for assistance and service if needed. There are no returns to Endress+Hauser from within the United States.

3.4 Periodic Tests

The following periodic tests have to be conducted at no longer than 6 month intervals:

3.4.1 Inventory and Inspection

Each device should be checked for the following items:

- Ensure that the source container location matches the location listed on the inventory sheet. If it doesn't, report immediately to the radiation safety officer for follow-up.
- Physical inventory of the source container and mounting brackets.
- The presence and legibility of the tags and labels.
- General area condition. Make sure there is no build up of dirt, rust or corrosion on or around source container. If the inspection indicates that some aspect of the source container needs repairing or replacing, contact Endress+Hauser for assistance.

3.4.2 Test of Shutter (ON/OFF) Mechanism

Inspect the container for proper shutter operation:

- In order to test the shutter mechanism, move the shutter plate several times between ON and OFF.
- The actuator should move easily but not freely. A shutter that moves too easily may be broken.
- Use one of the two methods listed below to ensure that the shutter mechanism is operational:
 - Use a calibrated portable radiation survey meter to take a measurement at the back of the detector housing. The readings should be significantly different when the shutter is ON (high) and OFF (low).
 - Use the gauge electronics to monitor the radiation levels while moving the shutter to the OFF position. In this case the readings should be higher (on a density application) when the shutter is OFF and drop when shutter is ON.
 - In lieu of the aforementioned methods a visual inspection in regard of the position of the shutter plate may be applied.

The records of these tests should be maintained for a minimum of 36 months or as required by the regulations. Test documentation should include the date and name of individual performing the test. Two different tests are necessary when performing a shutter check. One determines whether or not the shutter actually closes and opens; and the second confirms that indicators on the source container agree with the physical position of the shutter.

Remove the padlock (when in OFF position) acc. to the operation manual. Perform the following procedure:

1. Move the shutter plate several times from OFF to ON and from ON to OFF position acc. to the instruction manual. The shutter shall be easily moveable and must not show corrosion at the visible area.
 - If the shutter is not movable from ON to OFF position follow the instruction in section "Emergency Procedures" (→ 32).
 - If the shutter is rough-running or indicating potentially malfunction secure the source holder in OFF position and contact the responsible radiation safety officer for further instructions.
 - In case of corrosion follow the instructions in section "Visual check" (→ 27).
2. When found the shutter mechanism in acceptable condition follow the instructions manual for correct positioning in ON or OFF position.

3.4.3 Visual check

If considerable corrosion is visible at the housing measure the radiation level around the device. If values occur exceeding the normal operation level, cordon off the area and contact immediately the responsible radiation safety officer for instructions. In every case corroded devices should be exchanged as soon as possible. Corroded interlocks, corroded padlocks or corroded source inserts require immediate exchange.

3.5 Leak Test

NOTICE**Leak test**

- ▶ Leak tests are not only required as routine checkup but also whenever an incident occurs that may damage the sealed source or the shielding.
- ▶ In such a case the leak test procedure shall be defined by the responsible radiation safety officer observing the applicable regulations and considering the source container and all involved parts of the process vessel. The leak test shall be conducted as soon as possible after the incident.
- ▶ The following leak test procedure is intended to be conducted routinely during continuous operation, during continuous storage or when placing back the source container into operation after storage. It does not consider incidents that may have damaged the sealed source or shielding.
- ▶ Leak tests shall be performed at no longer than 6 month intervalls or according to the intervall specified in the associated sealed source and device registration certificate.

The following statements deal with the leak testing of gauging devices:

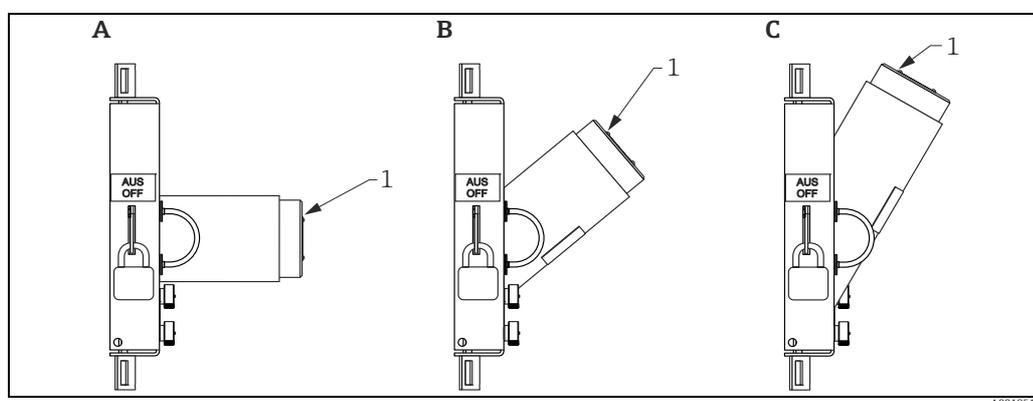
- All sealed sources supplied by Endress+Hauser are welded double encapsulated stainless steel capsules.
- Possibility of leakage from the source capsule is very small.
- The source capsule is enclosed in a lead-filled container to provide shielding of the gamma radiation.
- If the source capsule should fail, the design of the source container is such that the probability of external contamination is minimal.
- Anyone may perform the wipe test on the source container, but only a person, or company, specifically licensed by the NRC or an Agreement State may do the analysis.
- The general concept of the leak test is to determine if the source capsule has failed, resulting in radioactive material outside of the unit. The radioactive material will be removed by the wiping action and will be detected when it is analyzed. Follow the instructions on the specific leak test kits.
- Each individual source/gauge requires its own leak test kit.
- The analysis of the leak test swab requires special instruments and must be performed by a specifically licensed company.

3.5.1 Leak Test Procedure

Leak tests shall be performed by a person or an organization authorized by NRC or an Agreement State to provide leak test services or using a leak test kit supplied by an organization authorized by NRC or an Agreement State to provide leak test kits. Leak test kits shall be used according to its supplier's instructions. Records of the leak test results shall be maintained.

The leak testing procedure can vary from supplier to supplier. One should follow the instructions included in each test kit. DO NOT clean the source container prior to taking the sample. The concept is to remove any loose radioactive material exterior to the unit. It is not necessary to disassemble the source container for the leak test. Wiping the external surface is sufficient. The wipe may be taken with the shutter "ON" or "OFF". If the shutter is in the "ON" position, use caution to ensure that your hand does not get in the radiation beam. If one is performing a leak test using an approved mailable kit, detailed instructions including a diagram of where to take wipes should be included and followed. If one does not elect to use an approved mailable kit, then contact Endress+Hauser for instructions.

Perform the following procedure unless otherwise instructed:



- A Limit Switch and Density measurement (Feature: Emission Angle, Application; Option model: 3)
 B Density measurement (Feature: Emission Angle, Application; Option model: 5)
 C Level measurement (Feature: Emission Angle, Application; Option model: 4)
 1 Wiping surfaces for the leak test along the edge of the nameplate

- Wipe at the following positions:
 - FQG60; Feature 240, Option model 3, 5, 4: along the edges of the name plate
 This may be conducted when the source holder is in the ON or OFF position.
- Have the samples analyzed by an authorized organization. A source is considered to be leaking if more than 185Bq (0.005 μ Ci) is detected on a leak test sample.

NOTICE

This limit is valid for the US. National regulations may define other limits.

In case of an indeed leaking source:

- Contact the responsible radiation safety officer for instructions.
- Take appropriate measures to control a potential spread of radioactive contamination from the source. Secure the source.
- Notify the authority of the fact that a leaking source has been detected.

CAUTION

Carefully follow all instructions. Radioactive material removed from the source container, if present, can spread contamination if it touches any other object. Transfer the sample to the bag or container quickly but safely to prevent the spread of contamination. If the test result is positive, indicating the presence of radioactive material above the regulatory limit, the analyzing lab will notify you by FAX, email, or telephone. Contact the appropriate regulatory agency and Endress+Hauser for assistance. Arrangements must be made with Endress+Hauser, or another specifically licensed person, to remove source container from service.

3.6 Servicing and inspection

In designated use, operated under the specified ambient and operation conditions, no inspection or servicing of the device is required.

If nevertheless inspection is considered as necessary - i.e. within the framework of routine inspections of the installation following checks are recommended on demand:

- visual check regarding corrosion of housing, weld seams, outer parts of shutter, padlock, snap hook and the label "source data" including groove pins (access protection)
- check of the movability of the shutter (ON/OFF function)
- visual check of the readability of the labels and the condition of the warning symbols
- check of the stability and tightness of the source container

Country specific regulations may require frequent inspections of the radiation source container.

3.7 Maintenance

Anyone possessing a source container is authorized to perform routine maintenance on the unit. Routine maintenance does not change the geometry of the source container-detector and does not interfere with the normal operation of the unit.

A preventative maintenance program should be implemented to prevent corrosion and wear on equipment. Routine maintenance of source containers and detectors could include but not be limited to the following activities:

- Cleaning and removal of foreign material from around source container or detector.
- Collecting leak test samples (see above procedures).
- Opening or closing the shutter (see above procedures).
- Cleaning and painting the source container (if needed).

3.7.1 Cleaning a Source Container

Process material or dirt may build up in or around the source container or beam port area. This material may interfere with the process measurement and should be removed. Be careful when removing material so as not to interfere with operation of the gauge. One can use any method of cleaning, brushing or hand removal of material to clean the area. Additional, more aggressive methods may be used, such as high-pressure water or compressed air. It is not necessary or advisable to remove the source container to clean it. Do not use solvents that are corrosive to the source container. If labels have become unreadable, contact Endress+Hauser for replacements.

NOTICE

Non-routine repair or maintenance must be performed by the gauge manufacturer or distributor or a person specially authorized by NRC or an Agreement State.

Maintenance

- Not required when operated within specifications.

Cleaning

- Clean from substances which may have impact on safety functions.
- Maintain cleaning in appropriate intervals.
- Clean the adhesive labels only wet with water.
- When cleaning the device, all instructions concerning radiation protection have to be observed.

⚠ CAUTION

If there is any doubt about correct function or proper condition of the device contact immediately the responsible radiation safety officer for advice.

3.7.2 Painting

Endress+Hauser source containers have been in service for many years and have not required painting, but this is dependent on the environment. If painting is required, contact Endress+Hauser for assistance.

3.8 Non-Routine Maintenance

In order to perform non-routine maintenance, you must have a specific license that states you have permission to do so. Examples of non-routine maintenance are welding to modify the source container mounting, relocating the source container, or replacing corroded mounting brackets.

If bolts, brackets or other fastening elements have been weakened due to rust, they need to be replaced. With proper training and agency approval, specific license authorizations may be received to perform some of these procedures. Major modifications which alter functional design of the source container are prohibited. Licensees requiring this type of assistance should contact Endress+Hauser.

3.9 Exchange of source

It is not allowed to exchange the source on site.

4 Incident Response

4.1 Emergency Measures

If the source container or the radiation source is damaged by accident or another unforeseen event or if the radiation source is lost by other means, the following emergency measures shall be initiated:

- Inform the radiation safety officer immediately.
- Immediately evacuate, restrict and post the area, allowing access only to individuals authorized by the radiation safety officer.
- Production must be halted immediately if there is a risk that the radioactive material has gotten into the material being measured. Potentially contaminated material must be secured and must not be further used before it has been tested.
- Response personnel should be advised of potential radiation hazards.

As soon as the emergency measures have been initiated, the authorities responsible for radiation must be informed by the radiation safety officer. The radiation safety officer should document the incident and make any necessary reports.

4.2 Emergency Procedures

4.2.1 Objective and Overview

This emergency procedure shall be put into effect immediately to minimize potential exposure to individuals and to secure an area in the interests of protecting personnel where an exposed source is known, or suspected, to exist. Such an emergency exists when a radioisotope is exposed either by it becoming separated from the source container or a shutter mechanism cannot be put into OFF position. This procedure will safeguard an area until an appropriate radiation safety officer can attend site and advise on corrective action. The custodian of the radioactive source (the customer's designated "authorized person") is responsible for observing this procedure.

4.2.2 Procedure

- Determine the unsafe area by measurement (on site) or by calculation knowing the size and type of source installed from the records.
- Restrict the area, placing barrier tape and appropriate warning signs at a distance where radiation levels exceed 20 $\mu\text{Sv/h}$ (2 mrem/hr).
- If the shutter will not close, keep individuals out of the radiation beam.
- If it is not practical to restrict the entire area or if the source is no longer in the source container, it may be necessary to secure and shield the source. Here the inverse square law should be observed; i.e. radiation intensity decreases inversely with the square of the distance. The source should only be handled using pliers or tongs and held as far away from the body as possible. The time taken to complete the activity should be minimized by rehearsal prior to execution.
- If part of the area is accessible (e.g. a vessel in the event of a level gauge installation where there is a possibility that a person might enter), the source housing should be unbolted from its mounting. Put emission channel towards a very thick wall (e.g. from steel or lead). Personnel should at all times be behind the source housing, not in front of the emission channel (shutter plate).
- After the emergency has been resolved, the radiation safety officer should document the incident and make any necessary reports.
- Make necessary notifications to local authorities as well as the NRC within 24 h.
NRC's Operation Center: 301-816-5100 or 301-951-0550
- After thorough assessment of the damage, the responsible radiation safety officer, in conjunction with NRC and/or local authorities and Endress+Hauser, shall agree a remedy to the specific problem.

4.3 Potential Emergency Situations

The following are examples of possible problems that can be foreseen with source containers.

4.3.1 Stuck Shutter

Stuck shutters can result from several situations, such as physical damage, rust or dirt around the shutter. A stuck shutter is usually not an emergency situation in itself. If ignored or handled improperly, individuals may be at risk of unnecessary radiation exposure. A stuck shutter is usually discovered during a routine inspection or an emergency when the shutter needs to be closed.

Perform the following emergency response procedure if a shutter is stuck in the open position:

- If the source container is dirty or rusted, one can clean the exterior with a brush, hand removal of debris, or careful lubrication with penetrating oil compatible with the process. More aggressive methods such as high-pressure washing or compressed air are also acceptable.
- If the shutter still does not close and one needs it shut for removal or for work in the vessel, leave the source container where it is until you have contacted the manufacturer. One of the safest places for the source container to be is in its mounted position.
- Do not proceed with the job.
- As a temporary solution to proceed with the work, one may be able to place enough shielding material in front of the source opening to attenuate the radiation field. (Use a survey meter to verify radiation levels.) This method should only be considered temporary until the unit can be repaired or replaced.

4.3.2 Lost or Missing

If for some reason a source container is believed to have been stolen or lost, the following actions should be taken:

- Begin a dedicated search for the lost or missing device.
- Interview employees who may have been in the area.
- Determine when the source container was last known to be present.
- Search all areas where the container could have been placed, i.e. storage areas, dumpsters, trash bins, etc.

Upon determination that the source container cannot be located, the radiation safety officer should immediately notify the appropriate regulatory agency by telephone or FAX and follow-up with a written report. Requirements of information to be included in the written notification are contained in the regulations.

Continue a diligent investigation to determine why the incident occurred, and what steps are required to ensure it is not repeated.

4.3.3 Entering into a Tank or Vessel

Perhaps the most avoidable unnecessary radiation exposure is caused by individuals entering a tank or vessel before the shutter has been closed or the radioactive source has been retracted into its protective housing.

- This unnecessary exposure can be prevented by following lock-out/tag-out procedures.
- A simple preventive measure is to mark each manway with a sign indicating the presence of radioactive sources.
- Before any person enters a vessel, the source shutter must be in the OFF position. Individuals should be trained in advance to recognize postings identifying monitored vessels.
- Contractors hired to work on vessels must be made aware of the presence of radioactive sources and procedures to be followed.

If safety precautions are ignored and people enter a vessel while the shutter is still ON, perform the following procedure:

- Evacuate the vessel.
- Interview involved individuals to determine how long they were in the vessel and at what location.
- Calculate exposure by measuring the radiation field in the vessel and accounting for time in the radiation field; or by using the equations in the "Important Safety Calculations" section of this manual.
- Determine the isotope and its current activity based upon the container label or records.
- In making dose calculations, one must also take into consideration the materials and thickness of vessel side walls. Contact Endress+Hauser for assistance in making these calculations.
- If involved workers express a concern or want medical evaluation, such should be provided.
- The radiation safety officer should notify the appropriate regulatory agency if exposures exceed any regulatory limit.

4.3.4 Damage on Fall or Collision

Source containers may be damaged as a result of falls or collisions. Personnel should be made aware of potential damage due to the following:

Falls

- Rusty bolts or weld failures resulting in containers falling from installed locations.
- Support equipment failing during installation or removal of source container.
- Bolts that have vibrated loose or were not installed properly at time of installation.

Collisions

Vehicle runs into source container.

Recommended Actions

- Survey the source container and compare results with the installation survey pattern.
- If the survey is comparable, the shielding is probably intact.
- Test to see if the shutter is working properly. If it is, lock it OFF.
- If the shutter cannot be moved to the OFF position, please refer to the stuck shutter procedures, and call the manufacturer for assistance.
- Perform a leak test to confirm the source has not been compromised.
- If contamination is present, take steps to contain it. A simple method of containing contamination is to cover the source container with a plastic bag.
- If the radiation pattern is comparable to the original, the source shutter mechanism is operating properly, and there is no evidence of contamination, the unit can be returned to service.
- If the survey indicates the source container has been damaged or shielding compromised, it must be taken out of service.
- Contact the source container manufacturer or a specifically licensed individual to arrange for or advice on the safe removal, packaging, and shipment of the source container. If warranted, place shielding materials around the source container to decrease radiation levels.

4.3.5 Damage on Fire

Evacuate and restrict the area to emergency response individuals. Priorities would include treatment and removal of injured employees, and fighting the fire. After these activities are completed, the radiation safety officer should evaluate the condition of source containers involved in the fire.

- Assume that some of the lead shielding has melted.
- Survey the damaged source container and compare results with initial installation survey.
- Examine the source container environment for any damage to the mounting structure (bolts, brackets) replacement of insulation or cooling system if such was supplied.
- Leak test the source container for removable contamination.
- Check the shutter for proper function.
- If the survey results indicate an elevated radiation field:
 - Rope and post the area at 20 $\mu\text{Sv/hr}$ (2 mrem/hr).
 - Record names of all personnel who may have been in the restricted area.
- Contact Endress+Hauser or a specifically licensed individual for further assistance.

Endress+Hauser manufactures a series of fireproof source containers designed to withstand most fires. The probability of a source capsule failing, even under fire or explosion conditions, is extremely rare.

4.4 Equipment for Cases of Emergency

Items that may be useful in a time of a major emergency include:

- Initial radiation surveys of source containers
- List of emergency procedures and phone numbers for help
- Calibrated survey meters
- Leak test supplies
- Radiation signs and rope
- Gloves
- Temporary shielding materials
- Dosimeters and film badges
- Plastic bags for contaminated items
- Batteries for survey meter
- Tape measure

4.5 Important Safety Calculations

The best method for determining an individual's dose rate is to measure the radiation field intensity with a survey meter. From a Cs137 or Co60 source, which are gamma emitters, the exposure rate in $\mu\text{Sv/h}$ (mR/hr) can be read directly from a calibrated meter.

Most meters are still calibrated in the traditional unit of Roentgen, more than likely in milliroentgens (mR) or microroentgens (μR). For gamma rays, mrem/hour would be equal to the radiation field intensity in mR/hour. For example, if the measured radiation field intensity three feet from the source is 0.6 mR/hr, a person standing three feet from the source would have a dose equivalent of 6 μSv (0.6 mrem). Some meters are calibrated in units of μSv .

4.5.1 Dose Rate Calculation

In cases where a survey meter is unavailable, the exposure rate from an unshielded point source can be calculated. Complete this equation to find the exposure rate (mR/hr) from an unshielded point source. This can be from a source capsule itself or from the beam port of a source container. This formula will not work from a shielded source.

$$R = (k) \times (A) / d^2$$

Where the terms in international units (traditional units):

R= dose rate in $\mu\text{Sv/hr}$ (mrem/hr) to be calculated

A= Activity of the source in GBq (mCi) which can be found on the source container label

d= Average distance to source in meters (feet)

k= Constant, which depends on type of isotope in the source capsule

- Cobalt-60: k = 350 (14.4)
- Cesium-137: k= 88 (3.6)

Example

Suppose the estimated exposure time in a radiation field from an unshielded point source is 10 minutes at a distance of 1 m (3.3 ft) with a Cs-137 source activity of 0.74 GBq (20 milliCuries).

The calculated dose rate would be:

International units	Traditional units
$R = (88) \times (0.74) / (1)^2$	$R = (3.6) \times (20) / (3.3)^2$
$R = 65 \mu\text{Sv/hr}$	$R = 6.6 \text{ mrem/hr}$

Total effective dose equivalent would be:

International units	Traditional units
$63 \mu\text{Sv/hr} \times 10 \text{ min} \times 1\text{hr}/60\text{min} = 10.8 \mu\text{Sv}$	$6.4 \text{ mrem/hr} \times 10 \text{ min} \times 1\text{hr}/60\text{min} = 1.0 \text{ mrem}$

4.5.2 Emergency Shielding Material

Lead is used as shielding material in source containers based on its density. But in emergency situations lead may not always be accessible. Several materials can be used as temporary shielding. The following table states the thickness of several materials which can be used to decrease the radiation intensity to one half its original value. These thicknesses are also known as half-value layers.

Approximate Shielding Half-value Layers

Material	Cs137	Co60
Concrete	2 in (51 mm)	3.27 in (83 mm)
Aluminium	1.5 in (38 mm)	2.99 in (76 mm)
Steel, Brass	0.51 in (13 mm)	0.98 in (25 mm)
Lead	0.24 in (6 mm)	0.51 in (13 mm)
Tungsten	0.19 in (4.7 mm)	0.37 in (9.5 mm)

4.5.3 Suggested Distance From Unshielded Sources

Having a pre-planned course of action prior to an emergency occurring enables authorized individuals to promptly respond to any incident. The following data will assist in determining distances for restricted access. To calculate this ahead of time, plan for the worst case:

- Assume the source is completely unshielded.
- Use the highest activity source.
- Plan to restrict at dose rates of 20 $\mu\text{Sv/hr}$ (2 mrem/hr).

International units

- Cs137 Sources: Distance in meters = $2.1 \times \sqrt{\text{activity in GBq}}$
- Co60 Sources: Distance in meters = $4.1 \times \sqrt{\text{activity in GBq}}$

Example:

If the highest activity source is 3.7 GBq of Cs137

Distance in meters = $2.1 \times \sqrt{3.7} = 4$ meters

According to this calculation, personnel should remain 4 meters from this source in the event of an emergency to receive a dose rate of less than 20 $\mu\text{Sv/hr}$.

Traditional units

- Cs137 Sources: Distance in feet = $1.3 \times \sqrt{\text{activity in mCi}}$
- Co60 Sources: Distance in feet = $2.6 \times \sqrt{\text{activity in mCi}}$

Example:

If the highest activity source is 100 mCi of Cs137

Distance in feet = $1.3 \times \sqrt{100} = 13.0$ feet

According to this calculation, personnel should remain 13 feet from this source in the event of an emergency to receive a dose rate of less than 2 mrem/hr.

5 Source Container Models

5.1 Applications of FQG60

The FQG60 source container is used in combination with a gamma detector in measuring systems for level measurement, level limit detection, density and concentration measurement. The housing provides holes to attach the source container to a vessel or provides means to apply the FHG61 suspension kit (accessory) at pipes or tubes \varnothing 1.97 to 11.8 in (50 to 300 mm). The source container does not come into contact with the medium to be measured.

The physical form of the isotope is a solid ceramic pellet (Cs137). The isotope material is covered by a hermetically sealed, double walled stainless steel source capsule. The source capsules have ANSI/ISO classifications, see technical information (TI00439F/00). The capsule is included into a stainless steel source insert (source holder), which is assembled inside the source container housing (stainless steel). In the proximity of the source capsule (stainless steel) chemical compatible materials (stainless steel) only are used. Lead/stainless steel combination at the shutter plate is protected by coating or painting against the environment.

5.2 Scope of delivery and Operating and Safety Instructions

- Radiation Source Container FQG60
- Radioactive source (built in)
- Radiation warning sign
- Operating Instructions TI00445F/00 (FQG60)
- Radiation Safety Manual (this document)

 Observe both Operating Instructions TI00445F/00 and Radiation Safety Manual SD00335F/00 (this document).

5.3 Delivery

The source container must be shipped with the radioactive source already installed. The shutter will be secured in the OFF position with a padlock and security seal. The shipment will be a "Type A" package and all marking, labeling and documentation will comply with U. S. Department of Transportation (DOT) regulations. Transport will be by common carrier, or other entity authorized to carry radioactive material.

Shipments to General Licensees (a regulatory license issued for certain inherently safe devices containing sealed sources) cannot be made until we have written authorization from the user which contains the name and telephone number of the person on site who will be responsible for the device. Contact our local sales center for questions or assistance.

6 References

6.1 Internet Sites and Information

6.1.1 NRC Home Page

This site has links to the Regulations and Guides: <http://www.nrc.gov/>

6.1.2 Listing of Agreement State Programs with Phone Numbers

<https://scp.nrc.gov/asdirectory.html>

6.1.3 Of Particular Interest

Consolidated Guidance About Materials Licenses: Program-Specific Guidance About Fixed Gauge Licenses (NUREG -1556, Vol. 4)

<http://www.nrc.gov/reading-rm/doc-collections/nuregs/staff/sr1556/v4/>

6.1.4 Radiation Technology Inc.

<http://www.radiationtechnologyinc.com>

6.1.5 Occupational Safety & Health Administration

<http://www.osha.gov/>



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www.addresses.endress.com
