SD00313F/00/EN/15.13
71232684

Operating Instructions
Radiation Safety and Technical Reference Manual

U.S. Specific Licensees
For Radiation Source Container FQG63

Endress+Hauser
People for Process Automation

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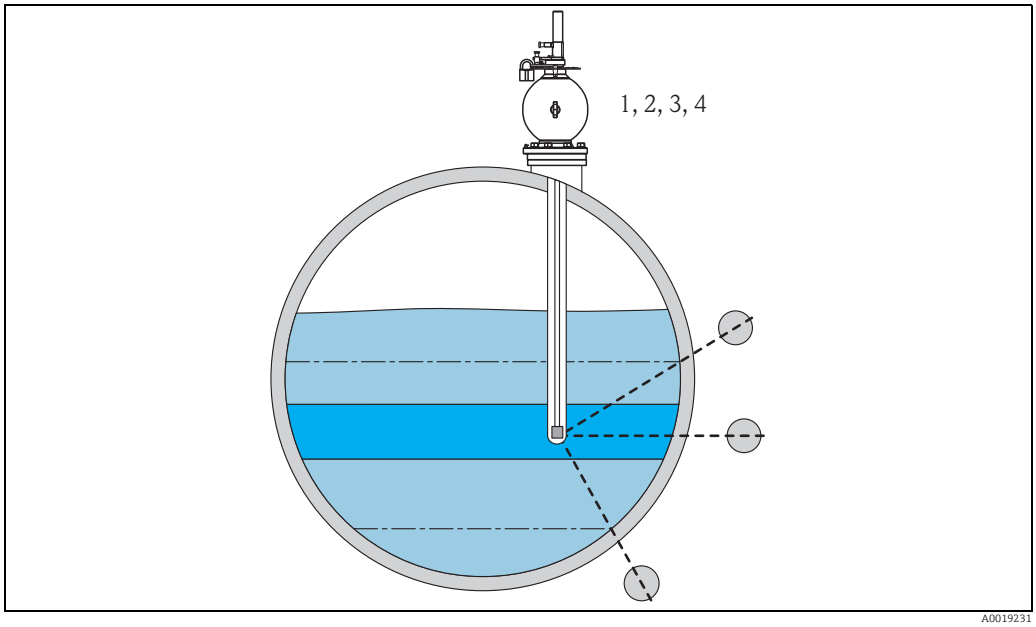
1 General information

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 effect 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.
The FQG63 source container is designed for applications that require the radioactive source to be positioned inside the process vessel.
When it is switched off, the radioactive source in the source container is surrounded by a steel casing filled with lead which screens off gamma radiation. When it is switched on, the radioactive source is located in a double-walled protection pipe inside the product vessel.



1 Level limit detection
2 Continuous level measurement
3 Density measurement
4 Interface 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 as1962, 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

FQG63 provides a Specific License.

1.2.1 Specific License

A Specific License authorizes the possession and use of particular source containers. It specifies the models they may possess and authorized activities. The license identifies the Radiation Safety Officer (RSO). This individual is responsible for the radiation safety program and all required records. Alternate radiation safety officers may also be identified on the license. Application requirements for a Specific License are contained in 10CFR Parts 30.32 and 30.33. Part 30.33 (a) requires that the applicant be trained and experienced in the use of devices and radioactive material being requested. This training is available through several authorized training companies.
The Specific Licenses details requirements and authorized activities which can be performed by the licensee. These activities might include authorization for leak testing, installation, relocation or removal of source containers, etc.

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 FQG63 source container described in this document contains the radioactive source, which is used for radiometric measurement of the level, density and interface. It screens off the radiation towards the surrounding area and only allows it to be emitted almost unattenuated in the measuring position if the source holder has been positioned in the double-walled protection pipe, which must be provided by the customer, using the flexible extension. In order to guarantee the screening effect and to exclude damage of the radiation source, all instructions given in this Technical Information 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 or by use in inappropriate installation environments.

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 this manual and the relevant conditions as specified by the regulatory authority.
- The source holder with the radioactive source may only be operated in the double-walled protection pipe provided at the customer's site.
- The device shall not be operated or stored outside the specified parameters.
- Protect the device against extreme influences (i.e. chemical products, weather, mechanical impacts, vibrations) when operated or stored.
- Always secure the "OFF" position using the padlock.
- 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.
- 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

If the instrument is exposed to strong vibrations or mechanical impacts, the safety pin can become abraded. This may lead to a loss of the source insert. Stability and tightness of the swivel insert must be checked at regular 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 a 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

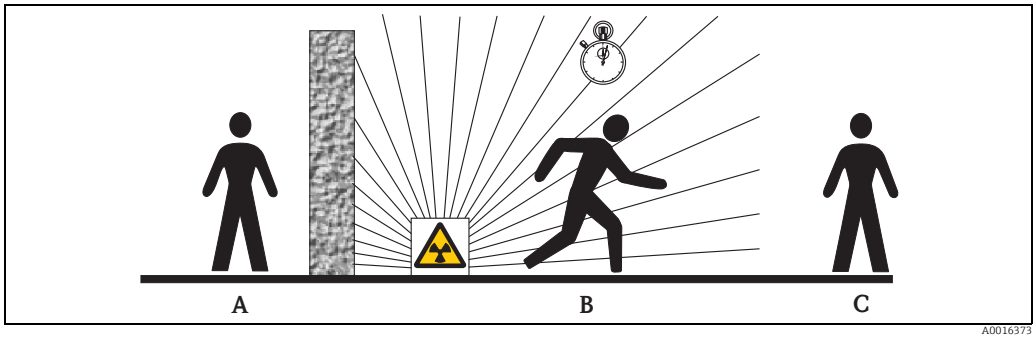
One should plan activities to keep as much screening material as possible between the source and individuals working in the field. Source containers (e.g. FQG63) and other high-density materials such as lead, iron, and concrete can be used for effective screening of gamma emitting sources. All Endress+Hauser 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 or four. As with time, an individual should endeavor to work as far from a source as feasible.



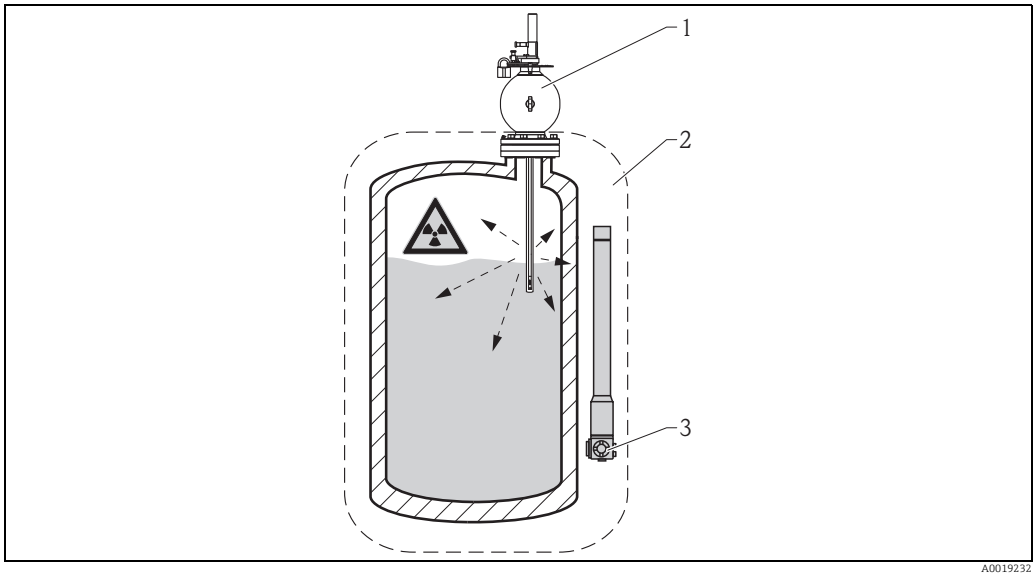
A Screening
B Time
C Distance

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 / ISO 2919 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 vessel is completely enclosed with the source container mounted against the vessel wall and the vessel walls provide suitable shielding properties. Access to the primary radiation beam should be restricted to the area near the detector. In case the vessel does not provide suitable shielding, the area around must be sealed off or shielded by suitable measures.



1 FQG63
2 Restricted Area
3 FMG60

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. The entry in the vessel is prohibited unless the source is shielded. That means, the source is retracted into the shielding and the source container 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 and 10 CFR 31.5.
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. Agreement State regulations must be compatible or more restrictive than the NRC regulations.
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 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.

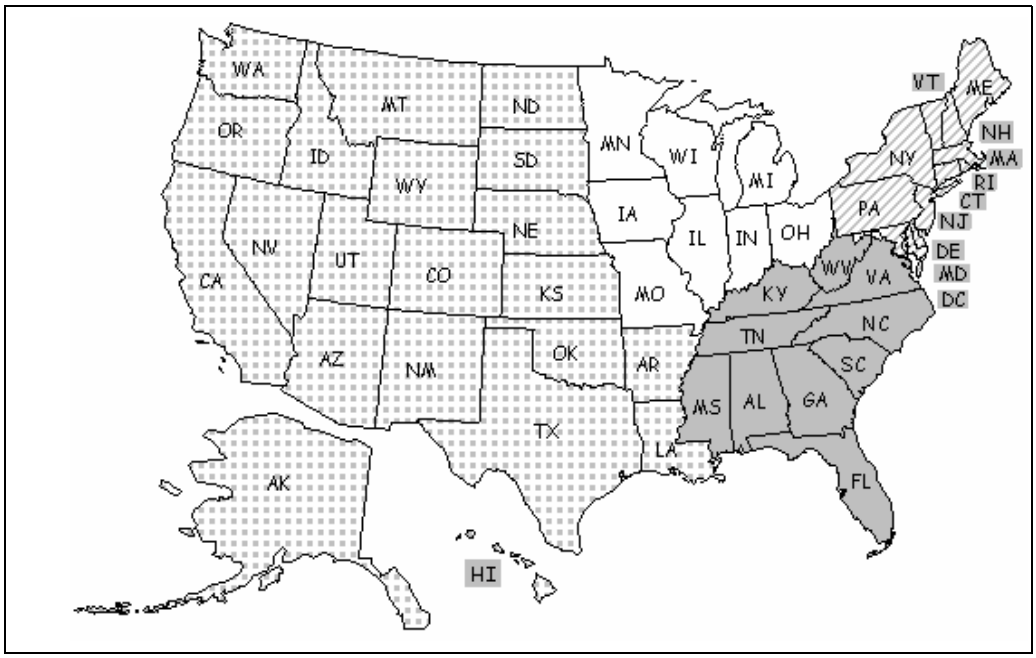
Radiation Safety Officer

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 JUNE 2008

HEADQUARTERS

Div. of Fuel Cycle & Material Safety
Office of Nuclear Safety & Safeguards
U.S. Nuclear Regulatory Commission
Washington, DC 20555-0001
Phone: 301/492-7000

CONNECTICUT, DELAWARE, NEW JERSEY, VERMONT, VIRGINIA, WASHINGTON DC, WEST VIRGINIA, PUERTO RICO, VIRGIN ISLANDS

U.S. Nuclear Regulatory Commission
Region 1
Nuclear Material Section B
475 Allendale Road
King of Prussia, PA 19406-1415
Phone: 610/337-5000

INDIANA, MICHIGAN, MISSOURI

U.S. Nuclear Regulatory Commission
Region III
Material Licensing Section
2443 Warrenville Road, Suite 210
Lisle, IL 60532-4352
Phone: 630/829-9500

ALASKA, HAWAII, IDAHO, MONTANA, SOUTH DAKOTA, WYOMING, GUAM

U.S. Nuclear Regulatory Commission
Region IV
Material Radiation Protection Section
612 East Lamar Blvd.
Suite 400
Arlington, TX 76011-4125
Phone: 817/860-8100

ALABAMA

Alabama Div. Of Radiation Control
RSA Tower
201 Monroe Street, Suite 700
Montgomery, AL 36104
Phone: 334/206-5391

ARIZONA

Arizona Radiation Regulatory Agency
4814 South 40th Street
Phoenix, AZ 85040
Phone: 602/255-4845

ARKANSAS

Arkansas Department of Health
Radioactive Materials Program
4815 West Markham, Slot H-30
Little Rock, AR 72205
Phone: 501/661-2173

CALIFORNIA

California Dept. of Health
Radiologic Health Section
P. O. Box 997414, MS 7610
Sacramento, CA 95899-7414
Phone: 916/327-5106

COLORADO

Colorado Dept. of Health
Radiation Control Division
4300 Cherry Creek Drive South
Denver, CO 80246-1530
Phone: 303/692-3030

FLORIDA

Department of Health
Bureau of Radiation Control
4052 Bald Cypress Way SE, Bin #C21
Tallahassee, FL 32399-1741
Phone: (850) 245-4266

GEORGIA

Georgia Department of Natural Resources
Radioactive Materials Program
4244 International Parkway, Suite 114
Atlanta, GA 30354
Phone: 404/362-2675

ILLINOIS

Illinois Department of Nuclear Safety
1035 Outer Park Drive
Springfield, IL 62704
Phone: 217/785-9948

IOWA

Iowa Department of Public Health
Bureau of Radiological Health
Lucas State Office Building
321 East 12th Street
Des Moines, IA 50319
Phone: 515/281-4942

KANSAS

Kansas Dept. of Health & Environment
Bureau of Radiation Control
1000 SW Jackson, Suite 310
Topeka, KS 66612-1366
Phone: 785/296-1562

KENTUCKY

Radiation Health Branch
Cabinet for Health & Family Services
275 East Main Street, MS HS-1C-A
Frankfort, KY 40621-0001
Phone: 502/564-3700

LOUISIANA

Louisiana Dept. of Environmental Quality
Radiation Protection Division
P. O. Box 4312
Baton Rouge, LA 70821-4312
Phone: 225/219-3041

MAINE

Radiation Control Program
Division of Health Engineering
11 State House Station
286 Water Street, Key Plaza, 4th Floor
Augusta, ME 04333
Phone: 207/287-5677

MARYLAND

Radiological Health Program
Air & Radiation Management Administration
Maryland Dept. of the Environment
1800 Washington Boulevard, Suite 750
Baltimore, MD 21230-1724
Phone: 410/537-3300

MASSACHUSETTS

Radiation Control Program
Department of Public Health
305 South Street, 7th Floor
Jamaica Plain, MA 02130
Phone: 617/727-6214

MINNESOTA

Minnesota Department of Health
Radioactive Materials
625 Robert Street North
P O Box 64975
St. Paul, MN 55164-0975
Phone: 651/201-5000

MISSISSIPPI

Radioactive Materials Branch
Div. of Radiological Health
P. O. Box 1700
Jackson, MS 39215-1700
Phone: 601/987-6893

NEBRASKA

Nebraska Department of Health
Div. of Radiological Health
P. O. Box 95026
Lincoln, NE 68509-5026
Phone: 402/471-2168

NEVADA

Bureau of Health Protection Services
Radiological Health Section
4150 Technology Way, 3rd Floor
Carson City, NV 89706
Phone: 775/687-7550

NEW HAMPSHIRE

Radiological Health Section
Dept. of Health & Human Services
29 Hazen Drive
Concord, NH 03301-6504
Phone: 603/271-4588

NEW MEXICO

New Mexico Environmental Improvement Div.
Community Services Bureau
P. O. Box 26110
Santa Fe, NM 87502-6110
Phone: 505/827-1557

NEW YORK

New York Department of Labor
Div. of Safety & Health
Radiological Health Unit
345 Hudson Street, Mail Stop 7F
New York, NY 10014
Phone: 212/352-6120

NORTH CAROLINA

NC Dept. of Environment
Health & Natural Resources
Division of Radiation Protection
Radioactive Materials Section
3825 Barrett Drive
Raleigh, NC 27609-7221
Phone: 919/571-4141

RHODE ISLAND

Rhode Island Radiation Control Agency
206 Cannon Building
75 Davis Street
Providence, RI 02908
Phone: 401/277-2438

SOUTH CAROLINA

SC Dept. of Health & Environmental Control
Bureau of Radiological Health
2600 Bull Street
Columbia, SC 29201
Phone: 803/545-4420

OKLAHOMA

Oklahoma Department of Environmental Quality
Radiation Management Section
P. O. Box 1677
Oklahoma City, OK 73101-1677
Phone: 405/702-5155

OREGON

Oregon Health Division
Radiation Control Section, Suite 705
800 NE Oregon #21
Portland, OR 97232- 2162
Phone: 971/673-0499

PENNSYLVANIA

Oregon Health Division
Radiation Control Section, Suite 705
800 NE Oregon #21
Portland, OR 97232- 2162
Phone: 971/673-0499

TENNESSEE

Tennessee Dept. of Public Health
Division of Radiological Health
3rd Floor, L&C Annex
401 Church Street
Nashville, TN 37243
Phone: 615/532-0364

TEXAS

Texas Department of State Health Services
Bureau of Radiation Control
Radiation Safety Licensing Branch
P. O. Box 149347 - Mail Code 2835
Austin, TX 78714-9347
Phone: 512/834-6688

UTAH

Utah Division of Radiation Control
168 North 1950 West
P. O. Box 144850
Salt Lake City, UT 84114-4850
Phone: 801/536-4250

WASHINGTON

Radioactive Materials Section
DOH-Div. Of Radiation Protection LE-13
Airdustrial Park, Building #5
P. O. Box 47827
Olympia, WA 98504-7827
Phone: 360/236-3300

WISCONSIN

Radiation Protection Section
Division of Public Health
Dept. of Health & Family Services
P. O. Box 2659
Madison, WI 53701-2659
Phone: (608) 267-4792 Fax: (608) 267-4799

2 Specific License

2.1 Conditions

The tasks that a licensee can perform with their source container are stated in their specific license. The licensee must read and understand the conditions stated in their license.
The NRC and Agreement States periodically amend the regulations. The licensee is responsible for maintaining a current copy. Some states require registration of gauges containing radioactive sources. The licensee must check with the appropriate Agency or regulations for compliance requirements.
Source container registry sheets will state the approved leak test interval. The sealed source capsules used in the Endress+Hauser source containers can be authorized for intervals up to 36 months, if requested on the specific license application.

2.2 Mounting

The source is loaded in a source holder which is inserted into in a lead-filled metal housing. All Endress+Hauser source containers have "ON/OFF" positions indicating the location of the source. Typically, Endress+Hauser source containers are designed with maximum radiation fields of 50 µSv/h (5 mrem/h) at a distance of 12 in or 30 cm from the surface of the source container (non-beam port area, when shutter is OFF).

2.3 Post-installation check

2.3.1 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.

2.4 Personnel Monitoring

The Radiation Safety Officer will determine whether or not personnel monitoring is required, based upon occupancy studies performed on the site, and requirements stated in 10 CFR20.1502 or Agreement State regulations. Dosimetry may or may not be issued to Occupationally Exposed Individuals, based upon their estimated annual dose.

2.5 Entry into vessel

Special precautions are required when a source container is used on a vessel large enough to permit entry of personnel. A lock-out/tag-out procedure must be in place and followed prior to authorizing entry into any monitored vessel. An appropriate warning sign indicating the presence of radioactive material and the requirement for proper lock-out/tag-out procedure must be posted at the entrance to the tank.

2.6 NRC Regulations for Specific Licensees

As mentioned before, the conditions under which a licensee may possess and use radioactive material area specifically stated in the license document. The following are a few of the items about which licensees must be knowledgeable.

2.6.1 Terms

Licenses are generally issued for periods of five to ten years. A radiation safety officer must be identified by name. This individual is responsible for carrying out the requirements in the license and the radiation safety program. Any changes in personnel require an amendment to the license.

2.6.2 Radiation Protection Program

The CFR Title 10, Part 20.1101 Subpart B states that each specific licensee shall develop, document, and implement a radiation protection program. The program should include all of the licensed activity procedures and how the licensee will comply with the provisions in the license and with the regulations. The goal of a well run radiation protection program is to keep Occupationally Exposed and Members of the Public doses "as low as reasonably achievable" (ALARA). For the specifically licensed radiation protection program: one of the requirements is an annual review. This entails the review of the conditions and procedures of the license, making sure that they are up-to-date and relevant to the operations. Records of the review must be maintained for inspection.

The radiation safety program must include the following information at a minimum:
- Identity of the radiation safety officer and authorized personnel
- Activities authorized by the license
- Training of authorized personnel
- Emergency procedures
- Operational procedures (leak tests, surveys, lockout, etc.)

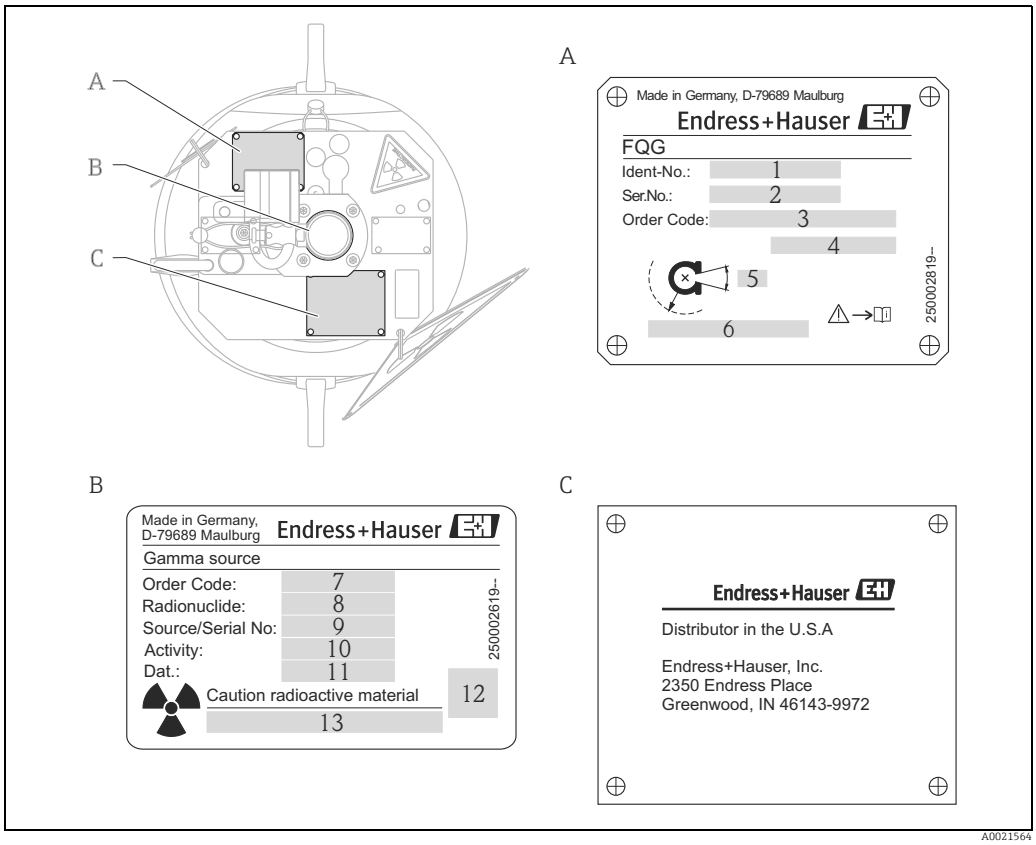
2.6.3 Documentation records

Endress+Hauser recommends that you maintain records for as long as you have ownership of the device. Following are examples of records which must be maintained as a part of the radiation protection program:
- Initial radiation survey
- Periodic leak test results
- Periodic shutter function tests
- Receipt of the source container
- User training
- Transfer or disposal of the material
- Annual Audits of the program

Records must be maintained for various intervals. It is the licensee's responsibility to know the intervals required by their regulations.

2.6.4 Labeling and posting

The following requirements are for labeling and posting:
- Each source container must bear a label that states the type and activity of radioactive material and the assay date of the source. The label must have the regulatory defined radiation symbol. Endress+Hauser attaches an approved label to the source container prior to shipment. It is the licensee's responsibility to maintain the labels in a good condition. The legibility of the tags and labels are an important item during inspections.
- Posting requirements are stated in 10 CFR 20.1902, and each sign is specifically defined.
- Another posting that must be displayed is form NRC-3 "Notice to Employees" or the equivalent Agreement State form. This form must be posted in an area(s) where employees can easily observe it on their way to and from regular work activities involving gauges.



A *Nameplate of source container*
B *Nameplate of radiation source*
C *Additional nameplate of NRC license*

1 *ID number of source container (abbreviated order code)*
2 *Serial number of source container*
3/4 *Order code for source container as per product structure*
5 *Radiation emission angle (not relevant in source container, radiates 360° in ON position)*
6 *Local dose rate at a defined distance from the surface*
7 *Endress+Hauser internal order code for the radiation source*
8 *"Cs137" or "Co60"*
9 *Serial number of the source capsule (provided for radiation tracking, if necessary)*
10 *Activity in MBq or GBq*
11 *Date (month/year)*
12 *Data matrix code (optional)*
13 *Marking "Hochradioaktive Strahlenquelle" (according to German regulations), if required*

NOTICE

The local dose rate at a defined distance specified on the nameplate refers to the OFF position. It is based on a worst-case estimation 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 can be calculated from the specified attenuation factors.

2.6.5 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. Specifically licensed material must be transferred to an authorized licensee for storage or disposal.

2.6.6 Agency Notification

Regulations require Agency notification for specific incidents within specified time intervals which can range from immediate verbal notification to up to 30 days written notification. Required reportable incidents are identified in the regulations and include radiation exposures in excess of any limits, contamination, loss or theft of a source, etc.
The Endress+Hauser service department may also be notified for assistance if needed.

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 TI00446F/00/EN.

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 for double-walled protection pipe with flange and necessary sealing.
- Check that the mounting bracket and area can accommodate the manufacturer's estimated weight and specifications of the source containers.
- Check for sufficient room to cycle shutter and to retract extension element.
- 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 very heavy. Plan for physical aspects/requirements of installation.

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 (extension element in ON and OFF position).
- If the radiation field is comparable, consistent with Endress+Hauser specifications, proceed with a leak test.
- If the radiation field is greater than 50 µSv/hr (5 mrem/hr) at 12 inches (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 µSv/hr (2 mrem/hr) and 1,000 µSv/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 µSv/hr (2 mrem/hr) on the detector side and around the 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 the indicator is in agreement with the shutter position, and the extension element is firmly assembled.

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 extension element is retracted and that the source container is locked in the OFF 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.
- Retract extension element to OFF position. Close and lock the shutter. Detach extension element subsequently.
- 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

1. Secure the source container at the eyebolts.
2. Loosen flanged connection, screw off the mounting screws of the flanges.
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

3.4.1 Inventory and Inspection

At least semi-annually, 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 extension element 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 and extension element. 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:
- To test the shutter mechanism, move the extension element back and forth to it's end position inside the source container. Then retract extension element to it's OFF position and rotate shutter several times between the OFF and ON positions, according to the operation manual.
- The shutter should move easily but not freely. A shutter that moves too easily may be broken.
- The source holder must not show corrosion at the visible area.
  - If the source holder is not movable from ON to OFF position follow the instruction in section "Emergency Procedures" (→ 🖹 28).
  - If the shutter or the extension element is rough-running or indicating potentially malfunction secure the source in OFF position and contact the responsible radiation safety officer for further instructions.
  - In case of corrosion follow the instructions in section "Visual check" (→ 🖹 23).
- Use one of the two methods listed below to ensure that the extension mechanism is operational:
  - Use a calibrated portable radiation survey meter to take a measurement at the back of the detector housing or outside the vessel. The readings should be significantly different when the extension element is in ON position or in OFF position (retracted).
  - Use the gauge electronics to monitor the radiation levels while moving the extension element to the OFF position. The readings should be change significantly when the extension element is moved from ON to OFF position.

  The records of these tests should be maintained for a minimum of three years 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 source can be moved to OFF position. And the second confirms that indicators on the source container agree with the physical position of the shutter. When found the shutter mechanisms in acceptable condition follow the instruction 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 source container or corroded extension element, interlock, padlock or source holder rod 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 every 6 month 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 (OFF position).
- If the source capsule should fail, the design of the source container and the source holder rod is such that the probability of external contamination is minimal, provided the source container is operated within the specified conditions.
- 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.
- The source capsule is enclosed in a protection cap which is part of the extension element.

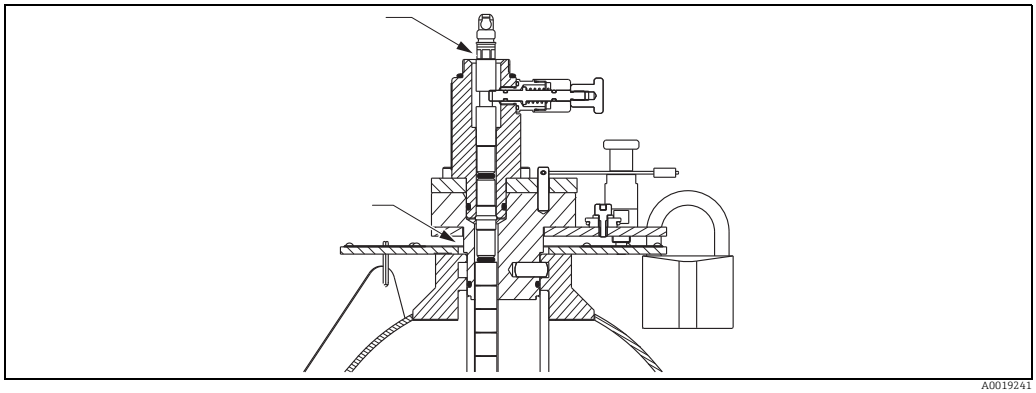
3.5.1 Leak Test Procedure

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 only be taken with the source in OFF position. 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.

Wipe along the annular gaps as marked in the following figure:



A0019241

Conduct leak test only when locked in OFF position.

⚠ CAUTION
The wipe may only be taken with the source in OFF position.

Have the samples analized by an authorized organization. A source is considered to be leaking if more than 185Bq (0.005 µCi) is detected on a leak test sample.

NOTICE
This limit is valid fo 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 source insert, locking bolts and padlock
- Check of the movability of the source insert (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 holder
- Visual check of the extension element; it may not exhibit breaks, damage or corrosion
- Stability and tightness of the connection of source holder and extension element
- Visual check of the seals between the adapter flange and container and between the adapter flange and FQG63
- Visual inspection of the reference O-ring

⚠ CAUTION

Incorrect function or unproper condition of the device

- ▶ If there is any doubt about correct function or proper condition of the device contact immediately the responsible radiation protection officer for advice.
- ▶ Repairs or maintenance work other than the usual inspection may be accomplished only by the manufacturer, by the suppplier or by an authorized person.

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. Though painting is not required the source container should be maintained in a fairly usable condition. After cleaning, painting can be used to address rust or surface corrosion issues. No specific color is mandated for the source container, but a color that is easy to see may help in the identification of misplaced source containers. Do not paint over the labels, tags, or indicators on the source container.
Make sure that the painting does not impair the function or safety features.

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 or brackets 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 are indication of potential damage of the protection pipe of the vessel or 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 the extension element or the shutter cannot be moved to 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 µSv/h (2 mrem/hr).
- In case of a shutter that will not close:
  - 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 and laid face down on the ground or put emission channel towards a thick wall. The ring-eyelet on the housing should facilitate safe handling.
  - Personnel should at all times be behind the source housing, not in front of the emission channel (flange).

  In case the extension element is not retractable:
  - 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 container should be unbolted, removed together with the inner protection pipe from its mounting and laid down on the ground. The protection pipe should be immediately completely covered with a suitable shielding. Personnel should at all times keep maximum possible distance from the protection pipe. Personnel should at all times be behind the source container, not in front of the emission channel (flange of the source container) or near extension element or near the protection pipe. The eye bolts on the housing should facilitate safe handling.
- 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 shutter or stuck extension element can result from several situations, such as physical damage, rust or dirt. 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 source needs to be moved to OFF position.

Perform the following emergency response procedure if a shutter is stuck in the ON 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. Make sure that no one can enter the vessel.

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 extension element must be retracted and 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.
- Source holder rod fallen into the protection pipe of the vessel due to multiple critical operation errors.

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 shutter mechanism is working properly. If it is, lock it OFF.
- If the source 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.
- If the source holder rod has become separated from the extension element inside the protection pipe of the vessel call the manufaturer immediately for assistance.

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 theses 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.
- Check the shutter mechanism for proper function, i.e. retract the extension element into the source container housing and turn shutter to OFF position.
- In case the source cannot be moved into the source container housing special actions have to be taken depending on the situation.
- In case the source is retracted to OFF position:
  - Leak test the source container for removable contamination.
  - Examine the source container environment for any damage to the mounting structure (bolts, brackets) replacement of insulation or cooling system if such was supplied.
  - If the survey results indicate an elevated radiation field:
    - Rope and post the area at 20 µSv/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 µSv/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 of 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 µSv/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 meter (3.3 feet) 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 µSv/hr	R = 6.6 mrem/hr

Total effective dose equivalent would be:

International units	Traditional units
63 µSv/hr x 10 min x 1hr/60min = 10.8 µSv	6.4 mrem/hr x 10 min x 1hr/60min = 1.0 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 µSv/hr (2 mrem/hr).

International units

- Cs137 Sources: Distance in meters = 2.1 x √ (activity in GBq)
- Co60 Sources: Distance in meters = 4.1 x √ (activity in GBq)

Example:

If the highest activity source is 3.7 GBq of Cs137
Distance in meters = 2.1 x √ 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 20µSv/hr.

Traditional units

- Cs137 Sources: Distance in feet = 1.3 x √ (activity in mCi)
- Co60 Sources: Distance in feet = 2.6 x √ (activity in mCi)

Example:

If the highest activity source is 100 mCi of Cs137
Distance in feet = 1.3 x √ 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 FQG63

For FQG63 with extension element (rope) the source is placed in a double walled built in protection pipe (provided by customer) and has no contact with the medium to be measured. The source container is designed to hold the radioactive source during radiometric level limit measurement, level measurement, density measurement and interface measurement. The radiation is damped, when the source is in the position OFF. In position ON the radioactive source with an extension element is located inside the process vessel.

The physical form of the isotope is either metal (in case of Co60) or a solid ceramic pellet (in case of 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 document (TI00439F/00/EN). The capsule is included into a stainless steel source insert (source holder), which is assembled inside the source container housing (stainless steel or coated steel). In the proximity of the source capsule (stainless steel) chemical compatible materials (stainless steel) only are used. Steel/stainless steel combinations are protected by coating or painting against the environment and are only used at places where they do not come into contact with the source capsule, the source holder, or the shutter mechanism.

5.2 Scope of delivery and Operating and Safety Instructions

- Radiation Source Container FQG63
- Radioactive source (built in)
- Extension element
- Adapter flange
- Radiation warning sign
- Operating Instructions TI00446F/00/EN (FQG63)
- Radiation Safety Manual (this document)

Observe both Operating Instructions TI00446F/00/EN, Radiation Safety Manual SD00313F/00/EN (this document) and the Technical Information TI00439F/00/EN for source capsule data.

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 Specific Licensees cannot be made until we have a copy of the Specific License authorizing receipt, possession and use of the radioactive material. Endress+Hauser will be happy to assist with procuring this license if desired.
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

http://www.hsrd.ornl.gov/nrc/asframe.htm

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/

www.addresses.endress.com

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