



Füllstand



Druck



Durchfluss



Temperatur



Flüssigkeits-
analyse



Registrierung



Systeme
Komponenten



Services



Solutions

Operating Instructions

Radiation Safety and Technical Reference Manual

U.S. General and Specific Licensees

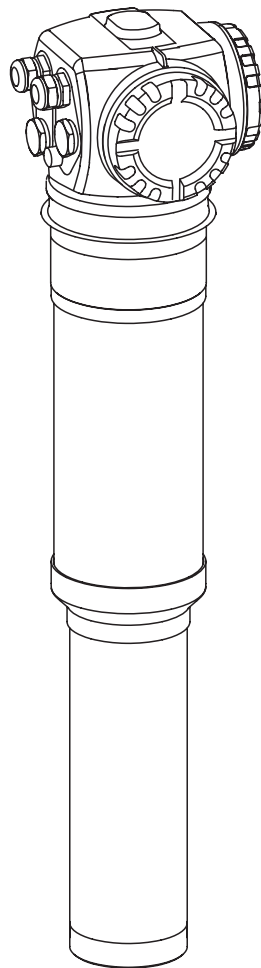
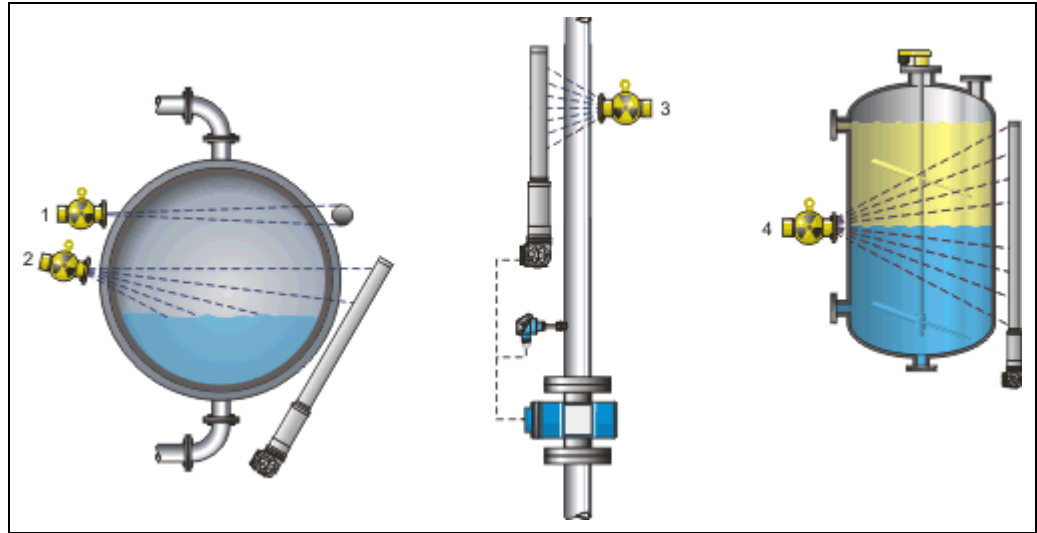


Table of contents

1	General information	4
1.1	Who we are	4
1.2	U.S. License Types	5
1.3	Basic Radiation Safety	6
1.4	Exposure to Radiation and Contamination	7
1.5	Regulating Radioactive Materials	8
2	General License	15
2.1	Safety Label For General Licensees	15
2.2	NRC Regulations For General Licensees	16
3	Specific License	18
3.1	Conditions	18
3.2	Mounting	18
3.3	Personnel Monitoring	18
3.4	Entry into vessel	18
3.5	NRC Regulations for Specific Licensees	18
4	Standard Routine Procedures	20
4.1	Receiving the Source Container	20
4.2	Source Container Mounting	20
4.3	Removal of a Source Container	22
4.4	Periodic Tests	23
4.5	Leak Test	24
4.6	Typical source container models	25
4.7	Maintenance	26
4.8	Non-Routine Maintenance	26
5	Incident Response	27
5.1	Emergency Measures	27
5.2	Emergency Procedures	27
5.3	Potential Emergency Situations	28
5.4	Equipment for Cases of Emergency	30
5.5	Important Safety Calculations	31
6	Source Container Models	33
6.1	Applications	33
6.2	Model QG020 and QG100	33
6.3	Model QG2000	34
7	References	35
7.1	Internet Sites and Information	35

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 (Gammapiilot 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



- 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 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

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 inches (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.

1.2.3 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 RSOs 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 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:

Time

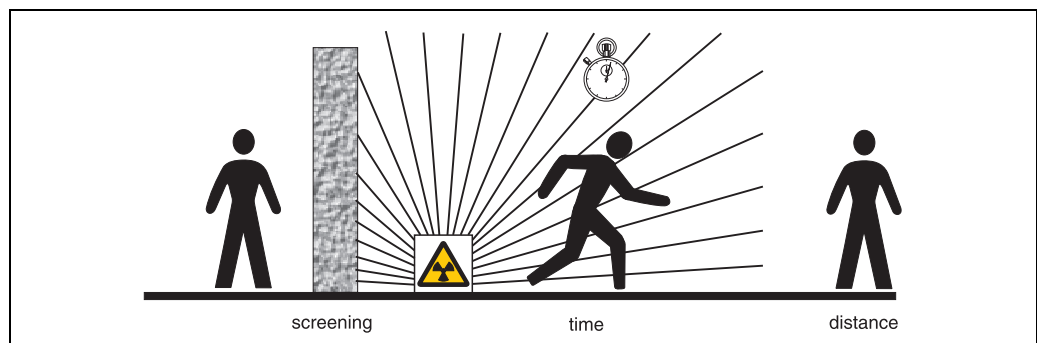
The dose a person receives is directly proportional to the amount of time spent in a radiation field. Time spent in an elevated radiation area should be kept to a minimum.

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.

Shielding

One should plan activities to keep as much shielding material as possible between the source and individuals working in the field. Source containers (e.g. QG020/100) and other high-density materials such as lead, iron, and concrete can be used for effective shielding of gamma emitting sources. All Endress+Hauser models have a shutter or other mechanism to attenuate the beam during installation, maintenance, emergencies, etc.



1.4 Exposure to Radiation and Contamination

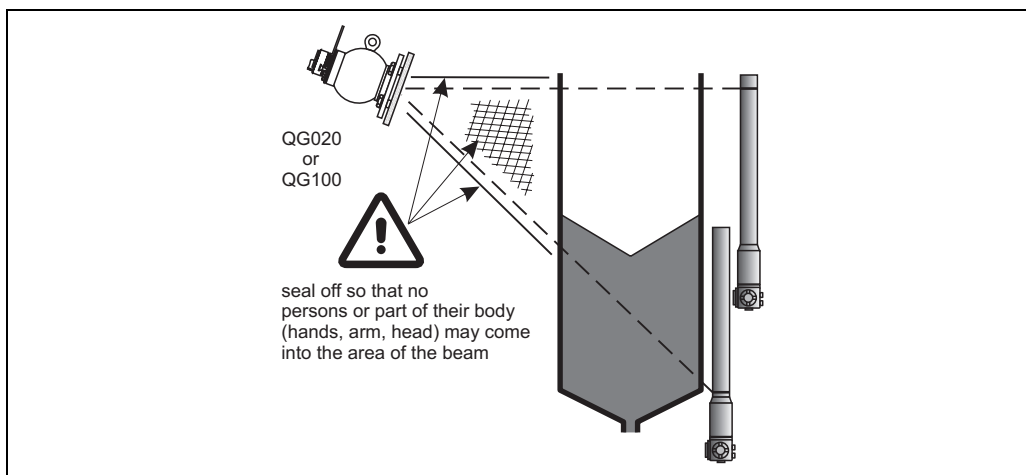
From the beginning, people have lived with ionizing radiation coming from several origins; including space (cosmic) and, the earth's crust (terrestrial). Individuals are also subjected to artificially generated radiation, with the highest exposures due to medical x-rays and treatments. Radioactive dose 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 C 66646 / 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 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 identified.



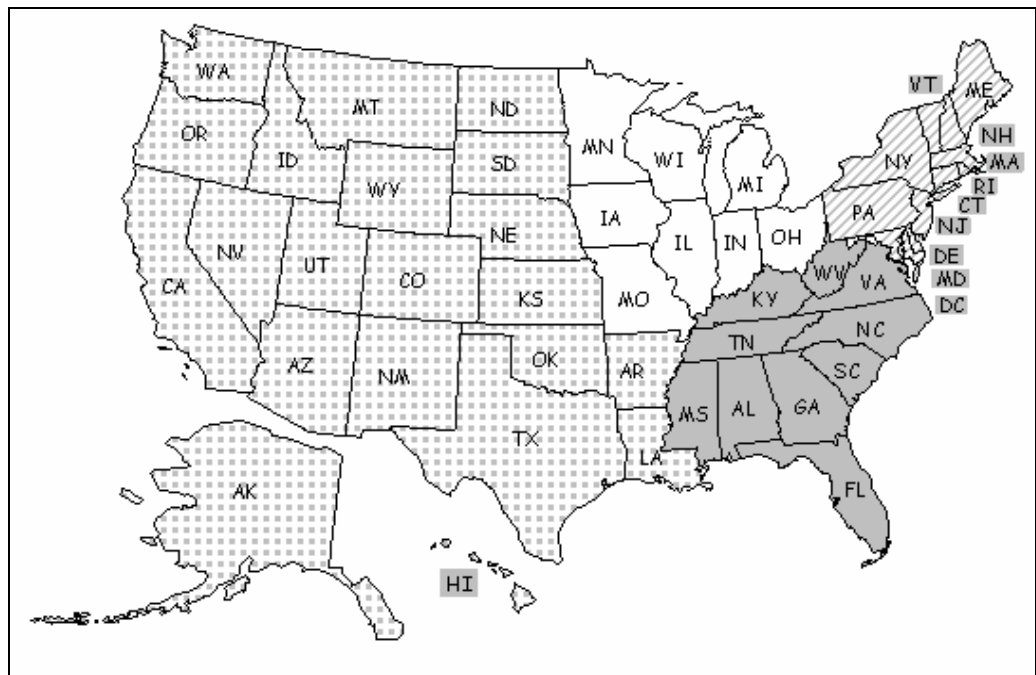
The interior of most piping systems are inaccessible. Access control procedures must be structured and implemented at the time of source container "startup" to ensure that personnel exposure does not exceed the regulatory limits for whole body or extremity dose. Vessel entry is prohibited unless the 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 31.12. 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 NRC Regional Map



1.5.2 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

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 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:

<p>CAUTION</p> <p><i>For detailed instructions and explanation see associated operation manual.</i></p> <p><i>Removal of this label is prohibited.</i> <i>Keep labels in legible condition.</i></p> <p><i>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. Abandonment and/or disposal only by persons specifically licensed by the NRC or an agreement state. If there is indication of failure of or damage to the shielding or source containment operation is prohibited. When locked in OFF position the device may be mounted by any person.</i></p> <p><i>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. Device must be tested for radioactive leakage and correct functioning of the shutter mechanism and the ON-OFF indicator at installation and at source replacement by persons specifically licensed by the NRC or an agreement state. After initial commissioning and testing follow up Testing shall be done at no longer than 6 month intervals, following the procedures stated in the instruction manual. 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.</i></p>
--

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 10CFR 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.

2.2.2 Abandonment/disposal

"Abandonment 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 turning device 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. The factory does not ship the lock combination or keys with the source container. Endress+Hauser provides the combination or keys only to the specifically licensed person performing the start-up and placing the source container in service.

2.2.5 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 3 year intervals, following the procedures stated in the 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 three years. Endress+Hauser suggests that you keep all records for as long as you have the device. Check your regulations for specific requirements.

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 evaluation by a trained individual.

3 Specific License

3.1 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.

3.2 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 $\mu\text{Sv/h}$ (5 mrem/h) at a distance of 12 inches or 30 cm from the surface of the source container (non-beam port area, when shutter is off).

3.3 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.

3.4 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.

3.5 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.

3.5.1 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.

3.5.2 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 RSO and authorized personnel
- Activities authorized by the license
- Training of authorized personnel
- Emergency procedures
- Operational procedures (leak tests, surveys, lockout, etc.)

3.5.3 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.

3.5.4 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

3.5.5 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. Generally and specifically licensed material must be transferred to an authorized licensee for storage or disposal.

3.5.6 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.

4 Standard Routine Procedures

This chapter reviews procedures for routine activities to be performed on or with nuclear gauges containing radioactive material. As previously indicated, authorized activities for generally licensed and specifically licensed devices are not the same. It is the licensee's responsibility to make himself familiar with and understand which activities he is authorized to perform.

4.1 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.

4.2 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.

4.2.1 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 containers.
- Check for sufficient room to cycle shutter.
- 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.

4.2.2 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.

4.2.3 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 30 cm (12 inches) 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.

4.2.4 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.

4.2.5 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.

4.3 Removal of a Source Container

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.

4.4 Periodic Tests

4.4.1 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 RSO 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 certain 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.

4.4.2 Test of Shutter (ON-OFF) Mechanism

Inspect the container for proper shutter operation:

- To test the shutter mechanism, move the actuator either back and forth or rotate shutter handle several times between the OFF and ON positions.
- 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 in "ON."

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 shutter actually closes and opens; and the second confirms that indicators on the source container agree with the physical position of the shutter.

4.5 Leak Test

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.

4.5.1 Leak Test Procedure

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.



Caution!

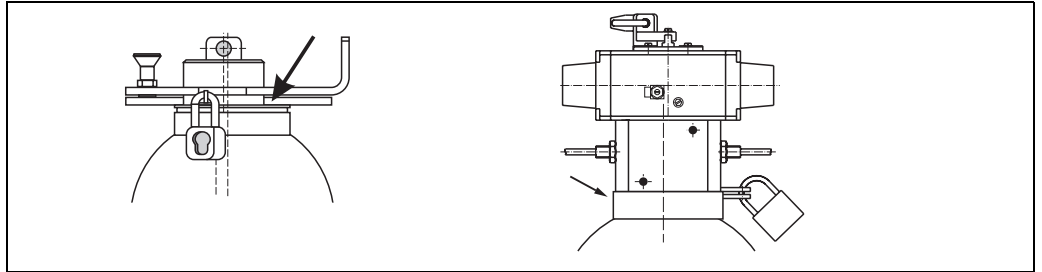
Carefully follow all instructions. Radioactive material removed from the source container, if present, can spread contamination if it touches any other object. Transfer the sample to the bag or container quickly but safely to prevent the spread of contamination.

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.

4.6 Typical source container models

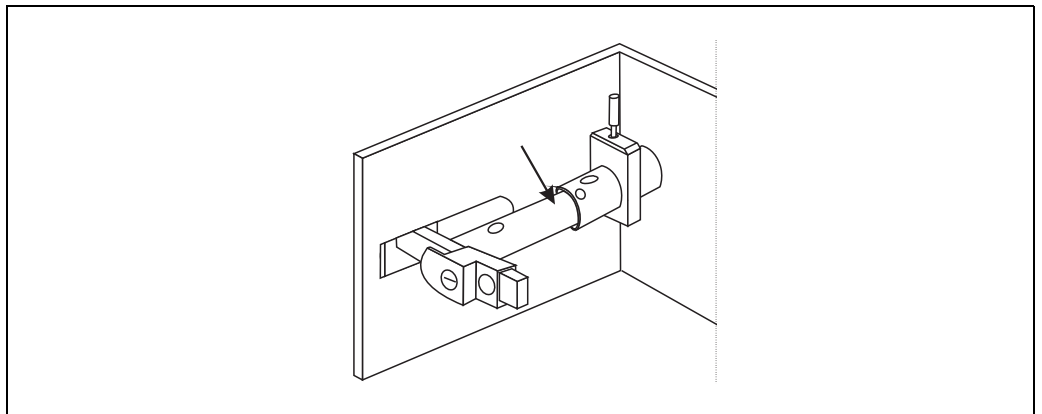
For the source container models shown, wipe the areas indicated:

4.6.1 Model QG020 and QG100



4.6.2 Model QG2000

Wipe along the annular gap (see figure 1) between the protection pipe and the source holder rod. This may be conducted when the source holder is in ON position acc. to the operation manual.



4.7 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).

4.7.1 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. The new label can be mounted on top of the original tag using silicone or other strong adhesive.

4.7.2 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.

4.8 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.

5 Incident Response

5.1 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 RSO.
- 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.

After the emergency has been resolved, the radiation safety officer should document the incident and make any necessary reports.

5.2 Emergency Procedures

5.2.1 Objective and Overview

This emergency procedure shall be put into effect immediately to minimize potential exposures to individuals

5.2.2 Procedure

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.

After the emergency has been resolved, the radiation safety officer should document the incident and make any necessary reports.

5.3 Potential Emergency Situations

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

5.3.1 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.

5.3.2 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 RSO 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.

5.3.3 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 RSO should notify the appropriate regulatory agency if exposures exceed any regulatory limit.

5.3.4 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
- 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 shutter cannot be turned 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.

5.3.5 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 RSO should evaluate the condition of source containers involved in the fire.

- If the source container is not rated "fire proof," 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.
- 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 $\mu\text{Sv/hr}$ (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.

5.4 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

5.5 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 Cs-137 or Co-60 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 $6 \mu\text{Sv}$ (0.6 mrem). Some meters are calibrated in units of μSv .

5.5.1 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 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: $k = 340$ (14)
- Cesium-137: $k = 85$ (3.5)

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
$R = (85) \times (0.74) / (1)^2$	$R = (3.5) \times (20) / (3.3)^2$
$R = 63 \mu\text{Sv/hr}$	$R = 6.4 \text{ mrem/hr}$

Total effective dose equivalent would be:

International units	Traditional units
$63 \mu\text{Sv/hr} \times 10 \text{ min} \times 1\text{hr}/60\text{min} = 10.5 \mu\text{Sv}$	$6.4 \text{ mrem/hr} \times 10 \text{ min} \times 1\text{hr}/60\text{min} = 1.0 \text{ mrem}$

5.5.2 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	Cs-137	Co-60
Concrete	2" (51 mm)	3 1/4" (83 mm)
Aluminium	1 1/2" (38 mm)	3" (76 mm)
Steel, Brass	1/2" /13 mm)	1" (25 mm)
Lead	1/4" (6 mm)	1/2" (13 mm)
Tungsten	3/16" /4.7 mm)	3/8" (9.5 mm)

5.5.3 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 μ Sv/hr (2 mrem/hr).

International units

- Cesium-137 Sources: Distance in meters = $2.1 \times \sqrt{\text{activity in GBq}}$
- Cobalt-60 Sources: Distance in meters = $4.1 \times \sqrt{\text{activity in GBq}}$

Example:

If the highest activity source is 3.7GBq of Cs-137

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 μ Sv/hr.

Traditional units

- Cesium-137 Sources: Distance in feet = $1.3 \times \sqrt{\text{activity in mCi}}$
- Cobalt-60 Sources: Distance in feet = $2.6 \times \sqrt{\text{activity in mCi}}$

Example:

If the highest activity source is 100 mCi of Cs-137

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.

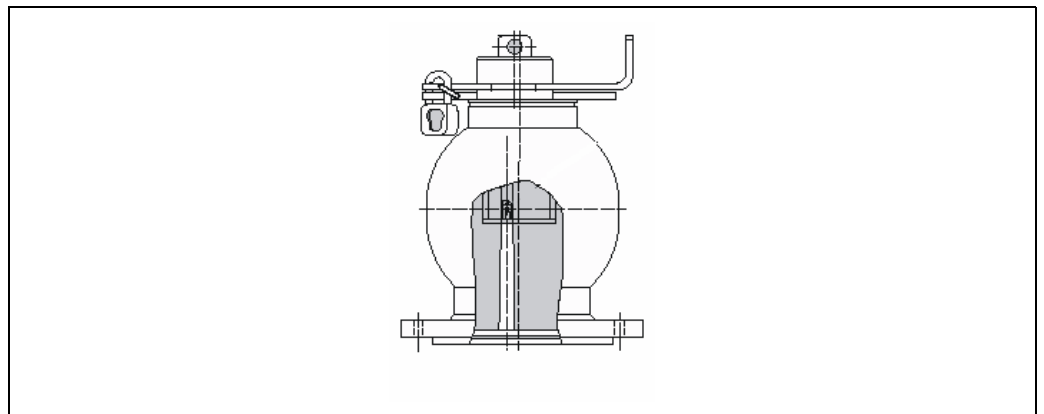
6 Source Container Models

6.1 Applications

The QG source containers series is used in combination with a gamma detector in measuring systems for fill level measurement, level limit detection, density and concentration measurement. All types are intended for fixed installations and do not move during use. The housing provides a flange or two mounting rails to attach the source container to a vessel, a frame or a pipe. For safe handling, e.g. during installation, a ring eyelet is provided on the housing. The source containers do not come into contact with the medium to be measured.

The physical form of the isotope is either metal (in case of Co-60) or a solid ceramic pellet (in case of Cs-137). 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 (TI213F or BA370F), Table 4-1, for specific for isotope. 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.

6.2 Model QG020 and QG100



The types QG 020 and QG 100 are of similar construction using identical safety and operation principles.

Basically they consist of the following parts: Housing with integrated cast lead shielding, mounting flange with cover plate, display plate, source insert with locking, source capsule.

Depending on the type the material of the housing is either coated or painted steel or coated or painted stainless steel, except the insert holder which consists of stainless steel in either case. The housing is of a welded construction and consists of the following parts welded together: Flange, spheroidal body, ring eyelet and insert holder. In case of QG 100 the body consists of two half shells welded together. The insert holder has the task to hold and secure the rotatable source insert, which has the function of a shutter mechanism.

The welded housing assembly is cast with lead and closed by the cover plate welded to the flange so that the lead screening is hermetically sealed to the ambient. Plates at the inner wall of the spheroidal body prevent the lead screening from loosening.

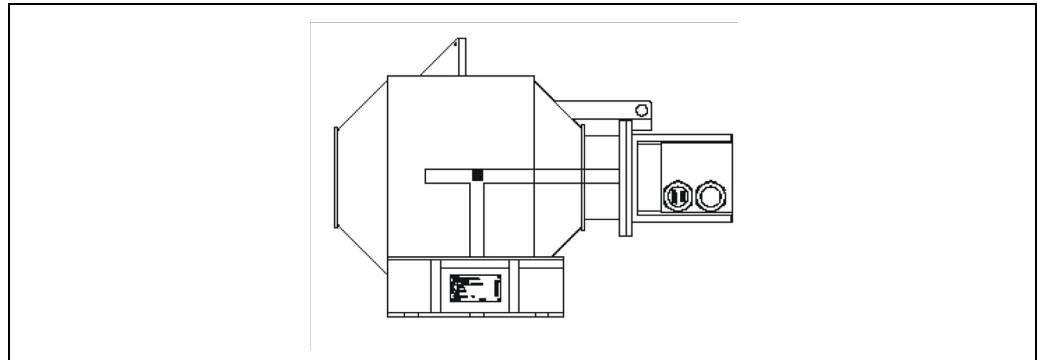
The emission channel is formed within the lead screening and is directed towards the mounting side. In the vertical plane the emission angles 5°, 20° and 40° are available depending on the type, in the horizontal plane the emission angle is 6° independent of the type.

Due to the shutter principle the emission channel is about 9.5 mm (0.37 inch) excentric to the centerline of the housing. The location of the emission channel is marked on the outer surface of the cover plate.

On the top of the housing the display plate is welded to the insert holder. The stainless steel display plate carries the ON/OFF labels and optional labels.

The complete information on construction and operation can be found in the technical description document (TI428F) for these models.

6.3 Model QG2000



QG2000 basically consists of the following parts: Housing with integrated cast lead shielding, protective hood, mounting rails, source support bar with locking and indication measures. In this model the radiation beam is switched ON/OFF by moving the source support bar axially to its end positions. The shutter mechanism, and the ON/OFF indication labels are covered by a protective hood, which can be secured at the locking plate with a padlock in the closed position (off) only.

All parts and components of the source container are made of stainless steel. Additionally the housing and its protective hood optionally may be coated or painted. The housing is of a welded construction and consists of the following parts welded together: mounting rails, cylindrical body, lifting eye, emission channel assembly with guide pipe for the source support bar.

Sheet metal parts within the lead screening form the emission channel.

Depending on the specific type the emission channel is directed radially to or rectangular to the mounting rails. In the first case the opening angle is either 20° or 40°, in the latter case the opening angle is either 20° or 40° as a standard or customized from 5° to 120°. The axial opening angle is always 6° independent of the type. The area of the emission window is indicated on the surface by the sheet metal strip closing the emission channel.

Between the body of the housing and the protective hood a compensation compartment is located to compensate increased volume required by liquefied lead in case of fire. This compartment is an integral part of the housing.

The welded housing assembly is cast with lead and closed by the cover plate welded to the compensation compartment and the guide pipe so that the lead screening is hermetically sealed to the ambient. Due to the inner construction and the shape of the housing the lead screening is form locking connected.

On the bottom of the housing body two mounting rails reinforced by cross braces are welded to the exterior wall, on the top a lifting eye is welded on for safe handling. The protective hood is fastened on the cover plate by two stainless steel allen screws using the bayonet lock principle. Each screw is secured against loosening by a small bolt. Between the hood and the plate an O-ring seal is applied, the windows of the ON/OFF indication are sealed by gaskets.

The complete information on construction and operation can be found in the technical description document (TI427F) for these models.

7 References

7.1 Internet Sites and Information

7.1.1 NRC Home Page

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

7.1.2 Listing of Agreement State Programs with Phone Numbers

<http://www.hsrdo.ornl.gov/nrc/asframe.htm>

7.1.3 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/>

7.1.4 Radiation Technology Inc.

<http://www.radiationtechnologyinc.com>

7.1.5 Occupational Safety & Health Administration

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

www.endress.com/worldwide

Endress+Hauser 
People for Process Automation

