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OPERATIONS & MAINTENANCE MANUAL. MAN-033 April 2020

SENTINEL™ 959M SCAR.

GAMMA-RAY SOURCE PROJECTOR

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DANGER – IMPORTANT WARNINGS

This gamma-ray source projector must only be used for radiography source assemblies that are approved for use. Please refer to Tables 1-5 for a listing of source assemblies that are authorized for use in this design. The container must be operated only by trained and qualified radiographers who have read and understand this Operating Manual or by trained assistants working under their direct supervision.

WARNING

The use of this radiographic exposure device by unqualified personnel or when safety procedures are not fully met, could result in life-threatening dangers.

Do not use this container for unauthorized, damaged or cropped source assemblies.

The radioactive source assemblies utilized in this container emit high levels of highly penetrating radiation during use.

An unshielded radiation source at close range can cause **injury, sickness or death** to anyone who is exposed to it even for a short period of time.

A radiation source **must not** be touched by the hands under any circumstances.

Since gamma radiation cannot be detected by the human senses, strict operating and emergency procedures must be followed. The proper use of calibrated and operable survey meters must be employed to avoid potentially dangerous levels of radiation exposure.

Proper dosimetry including film badges or thermoluminescent dosimeters, optically stimulated luminescence badges (OSL); direct reading pocket dosimeters and audible alarm ratemeters must be worn during all radiographic operations.

It is imperative that the users of this container perform adequate radiation surveys of the exposure device. Surveys must be performed using a calibrated survey instrument before, during and after source exchanges, source exposures, and before transport to determine if the source assembly is properly shielded within the container. The failure to perform an adequate radiation survey can cause unnecessary exposure to personnel resulting in a reportable incident.

It is very important, and required by national regulations, to prevent access by unauthorized persons to radiographic equipment and to the area where radiography is performed.

Take advantage of the three basic radiation protection methods to minimize radiation exposure:

Time: Spend less time near the radiation source.

Distance: Increase your distance in a direction away from the radiation source.

Shielding: Use effective shielding between you and the radiation source.

Do not perform any unauthorized modifications to the radiographic exposure device or components of the radiography system.

It is important that trained and qualified radiographers perform or supervise a daily safety inspection of the radiography system for obvious defects prior to operation of the system.

Do not use any components that are not approved for use with the radiography system, or after-market components that may compromise the safety designed into the system.

1. TECHNICAL SPECIFICATIONS.

1.1 Gamma-Ray Source Projector Specifications

Table 1 - Exposure Device Specifications	
Manufacturer	QSA Global, Inc., Burlington, Massachusetts, USA.
Device Model	SENTINEL™ 959M SCAR
Primary Application	Industrial gamma radiography
Device Configuration/Mode	SCAR (Small Controlled Area Radiography)
Device Weight (Maximum)	41 lbs (18.6 kg)
Device Overall Length	11.5 in (292 mm)
Device Overall Diameter	4.5 in (114 mm)
Device Capacity - Isotope	81 Ci (3 TBq) Selenium-75 or 15 Ci (555 GBq) of Iridium-192
Device Shielding Materials	Depleted Uranium (DU)
DU Weight (Maximum)	24 lbs (11 kg)
Operating Temperature	-40°F to 300°F (-40°C to 149°C)
Operational Approvals	ANSI N432-1980 Type 2 Exposure Device ISO 3999:2004(E) Category X Exposure Device
Transport Approvals	Type A within the Model 959A Transport Package meets 49 CFR173, IAEA TS-R-1 (2009) and IAEA SSR-6 (2012)
Compatible Sources	Refer to Table 2.
Compatible Controls	See Section 1.3.
Inspection Requirements	Daily pre-operational inspection for obvious damage to the system.
Maintenance Requirements	Most national regulations require inspection and maintenance of the system at quarterly intervals. The complete annual servicing ensures the integrity of the system. Shorter frequencies of inspection and maintenance are required when the system is operated under severe operating environments. In some cases, the system should be serviced immediately after certain jobs in severe environmental working conditions.

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1.2 Source Assembly Specifications

Table 2 - Compatible Source Assembly Specifications – License Information	
Manufacturer	QSA Global, Inc., Burlington, Massachusetts, USA.
Source Capsules	Model X540/1 (Se-75); Model 875 Series Inner (Ir-192)
Capsule Design	Single Encapsulation
Special Form Certificates	USA/0502/S-96 (X540/1); USA/0392/S-96 (875 Series Inner)
Source Assembly Model	959M04
Sealed Source and Device Registration Number	MA-1059-D-361-S (USA); R-061-3025-2 (Canada)
ANSI/ISO Source Classification	97C64344 (X540/1); 97C43515 (875 Series Inner)

Table 3 – Radionuclide Specifications		
Nuclide / Isotope	Selenium-75	Iridium-192
Isotope Gamma Energy Range	66 – 401 keV	206 – 612 keV
Isotope Half Life	120 days	74 days
Isotope Output at 1 meter per Curie (37 GBq)	0.203 R/hr (2.03 mSv/hr)	0.48 R/hr (4.8 mSv/hr)
Isotope Output at 1 foot per Curie (37 GBq)	2.2 R/hr (22 mSv/hr)	5.2 R/hr (52 mSv/hr)

Table 4 - Selected Attenuation Data			
Material	Approximate Material Density (g/cm ³)	Se-75 Approximate Half Value Thickness Inches (mm)	Ir-192 Approximate Half Value Thickness Inches (mm)
Concrete	2.35	1.180 (30.0)	1.700 (43.2)
Aluminium	2.65	1.100 (27.0)	-
Steel	7.80	0.315 (8.0)	0.512 (13.0)
Lead	11.34	0.039 (1.0)	0.200 (5.1)
Tungsten	17.80	0.032 (0.8)	0.130 (3.3)
Depleted Uranium	18.70	-	0.050 (1.3)

1.3 Control Unit Specifications

The Model 86550 or JB193-000 control units are used with the SENTINEL™ 959M SCAR exposure device. They are designed to pressurize the projector's actuating mechanism through the use of a hand pump or an auxiliary air supply. They are equipped with a pressure gauge to monitor operating pressure. The standard control unit is equipped with 16 ft (5 m) control hose for attachment to the actuator fitting. Controls with longer control hoses are available. The 86550 control unit console measures 10¾" (27.3 cm) long by 8¾" (22.2 cm) wide by 8½" (21.6 cm) high and weighs 8½" lbs (3.9 kg).

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Alternate, equivalent control units, evaluated and approved for use with the SENTINEL™ 959M SCAR exposure device by QSA Global, Inc., may be used instead of the Model 86550 control unit.

1.4 Fixture Kit Specifications

The Model 95999 fixture kit is available for use with the SENTINEL™ 959M SCAR exposure device. This kit allows the SENTINEL™ 959M SCAR to be attached and positioned onto pipes for radiographic exposures. Contact QSA Global, Inc. regarding other kits for special applications may also be evaluated for use upon inquiry.

1.5 General Gamma-Ray Source Projector Description

The SENTINEL™ 959M SCAR is a physically small, lightweight, portable industrial radiographic exposure device where the source does not leave the device during operation. The SENTINEL™ 959M SCAR is used primarily for the radiography of steel, brass and copper pipes and pipe joints and is useful for radiography of standard or difficult joint geometries. The basic radiography system consists of the SENTINEL™ 959M SCAR Radiographic Exposure Device and the Model 86550 (or equivalent) Pneumatic Control Unit.

The system may be used with up to 15 Curies (555 GBq) of Iridium-192 or 81 Curies (3 TBq) of Se-75. Sources of lesser activity are available. The sealed source is contained in a SENTINEL™ 959M SCAR04 source rod and this rod is retained into place in the device by the actuator mechanism which is attached to the housing weldment. The source is located in the secure, stored position by the source return spring and the source rod is locked in place when in the stored position by the plunger lock on the device.

The source in the SENTINEL™ 959M SCAR may only be changed by a user licensed to do so. Source changing of this device requires the use of a shielded cell and specially designed tools. Because of this QSA Global, Inc. recommends that all devices be returned to the manufacturer for source replacement. During this source replacement the device will be completely inspected and maintained.

The SENTINEL™ 959M SCAR is a welded steel housing with attached actuator and cover components. Shielding for the device is provided by a depleted uranium shield housed within the housing weldment. The shield incorporates a beam port 40° high by 40° wide which provides a highly directional, tightly collimated radiation beam. This collimated radiation beam significantly reduces the physical size of barrier areas required around the device during operation. The top shell cover protects the actuator mechanism and provides two handles for lifting the device.

The pneumatic actuator is spring loaded in the shielded (OFF) direction. When the air pressure is reduced on the exposing side of the piston, the spring will cause the radioactive source to move to the shielded position. Therefore, in the event of a failure of an air line, the source will automatically be stored in the shielded position.

The SENTINEL™ 959M SCAR exposure device is designed, tested and manufactured to meet the requirements of ANSI N432-1980 and meets the requirements of a Category X device under ISO 3999:2004(E). The device is transported as part of a Type A package that meets the requirements of IAEA TS-R-1 (2009 Edition), IAEA SSR-6 (2012), 10 CFR 71 and 49 CFR 173.

Additionally, the exposure device is designed, manufactured and serviced under an ISO 9001:2015 QA program and a USNRC 10 CFR 71 Subpart H QA program. The QA program includes the reporting requirements of USNRC 10 CFR 21 for suppliers of source and byproduct materials.

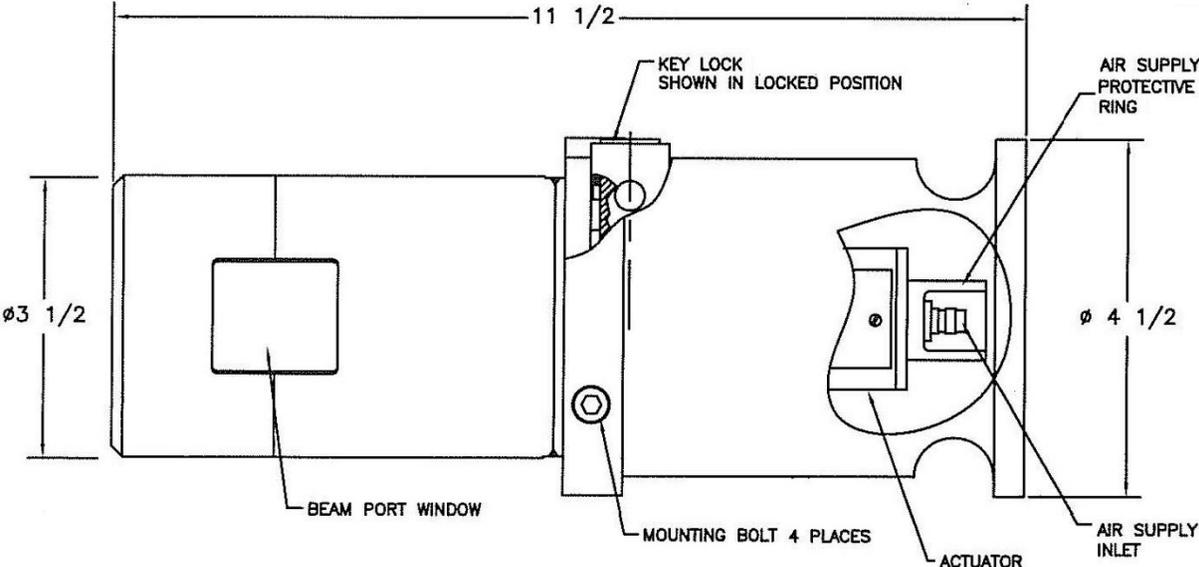


Figure 1 – SENTINEL™ 959M SCAR External View

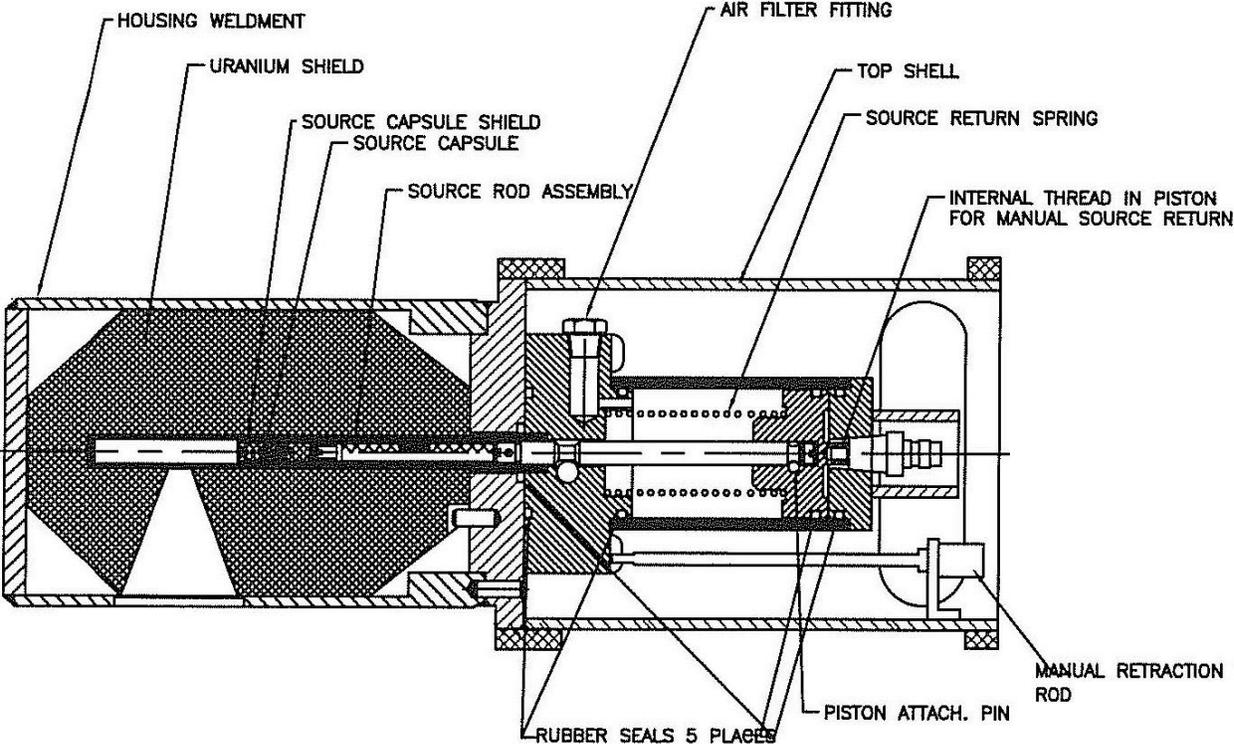


Figure 2 – SENTINEL™ 959M SCAR Cross-Sectional Component View

1.6 Operating Distance

The design and operation of the SENTINEL™ 959M SCAR gamma-ray source projector allows for significant reduction in the size of restricted areas required surrounding the device and therefore eliminates the need for large area evacuations at construction sites during operation. The intrinsic safety provided by the SENTINEL™ 959M SCAR allows for significantly reducing occupational exposure to radiographers by eliminating the "open-air flash dose" experienced using crank-out devices and the inability for extremities to get within a distance of 50 mm of the fully exposed source.

The separation distance between operator and the beam port of the gamma-ray source projector is determined by the remote control hose length used. Typically for the SENTINEL™ 959M SCAR, this distance is 16 ft (5 m), although other hose lengths are available upon request.

Since the SENTINEL™ 959M SCAR projector is designed for SCAR applications, and the radiation beam is limited and controlled directionally, the operator can typically be located closer to the SENTINEL™ 959M SCAR device than for radiography devices that utilize guide tube assemblies which project the source outside of the projector during radiation exposures.

1.7 ISO 3999:2004(E) Category X Compliance

The SENTINEL™ 959M SCAR gamma-ray source projector is classified as a Category X device. It is "unique in nature" since it is used to perform small controlled area radiography involving difficult joint geometries. This allows the device to be used for radiography in congested work sites while creating a minimal affected radiation zone during operation. Due to the type of radiography performed using this device, use of the SENTINEL™ 959M SCAR projector requires a more technically trained radiographer, pre-planning of work to be performed and in some cases it relies on procedural controls instead of device design features to meet the same level of operational safety suggested in the regulatory references.

The SENTINEL™ 959M SCAR projector was designed using the applicable specifications of ISO 3999:2004(E) for a Category X device. Partial compliance with the requirements in ISO 3999:2004(E) is allowed for this device under the Category X classification and its special operational requirements. The SENTINEL™ 959M SCAR gamma-ray source projector complies with ISO 3999:2004(E) requirements, except for the following:

- 5.4.2: Secured Position Indicator – Since this device may be used in awkward or difficult joint geometries, placement of a visual indicator on the device which would be visible under all operational orientations and positions is not feasible. The SENTINEL™ 959M SCAR relies on procedural controls of a radiation survey by the trained operator to verify the source has returned to the fully shielded position after an exposure.
- 5.8.6: Crushing and Bending, Kinking and Tensile Tests for Remote Control – Damage to the pneumatic hose running from the control unit to the device will cause a loss or reduction to the air pressure supplied to the SENTINEL™ 959M SCAR which will terminate the exposure and default the source assembly to the stored position.
- 8: Source identification tag including activity in Ci's and becquerels – The source activity is provided in Cis but not in becquerels on the identification tag. Since the activity in becquerels can be obtained by direct conversion of the curie activity, the intent of the ISO requirement is met with no undue safety hazard imposed on device users.

1.8 Notice

This industrial radiography system is used as an exposure device and part of a Type A shipping container for QSA Global, Inc. source capsules. The purpose of this manual is to provide information that will assist qualified radiographers in using the SENTINEL™ 959M SCAR gamma-ray source projector. The user must be thoroughly familiar with this instruction manual before attempting operation and use of this equipment.

In order to use this equipment, users within the USA must be specifically licensed to do so. Applications for a license should be filed with the Materials Licensing Section of the appropriate U.S. Nuclear Regulatory Commission regional office or with the appropriate Agreement State office. All users within Canada must have a Canadian Nuclear Safety Commission license.

It is the responsibility of users of this equipment outside of the United States to comply with all local, national and international regulatory, licensing and transportation rules and regulations as they apply in their respective countries.

1.9 Warranty and Limitation of Liability

QSA Global, Inc. (herein referred to as the manufacturer) warrants its product, which it manufactures and sells, to be free from defects in material and workmanship for a period of one year from the date of shipment. This warranty shall not apply to any product or parts which have been subjected to misuse, improper installation, repair, alteration, neglect, accident, abnormal conditions of operation, or use in any manner contrary to instructions.

The manufacturer's liability under such warranty shall be limited to replacing or repairing, at its option, any parts found to be defective in such respects, which are returned to the manufacturer, transportation prepaid; or at its option, to returning the purchase price thereof.

The warranty on other manufacturer's components shall be that of the original manufacturer whose warranty shall be binding.

In no event shall the manufacturer be liable for any incidental or consequential damages, whether or not such damages are alleged to have resulted from the use of such product in accordance with instructions given by or referred to by the manufacturer.

QSA Global, Inc. assumes no liability or responsibility for the usage of any radioactive material or device generating penetrating radiation used in connection with this product. The use of such material or generators in any manner other than prescribed in the U.S. Nuclear Regulatory Commission, equivalent Agreement State, International Licensing Authority, or permitted by any regulation of the U.S. Nuclear Regulatory Commission, Agreement State, or International Regulatory regulations may constitute a violation of such license terms.

All other warranties, except those warranties expressly stated herein, including without limitation warranties of, merchantability and implied warranties of fitness, are expressly excluded.

The warranty on this device is specifically limited to its use only with sealed sources and connectors, parts, and accessories manufactured by QSA Global, Inc.

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QSA Global, Inc. has received equipment approvals for the SENTINEL™ 959M SCAR gamma-ray source projector from the Commonwealth of Massachusetts and the Canadian Nuclear Safety Commission. In Canada, the equipment approval requires the use of registered and approved remote controls (Model 86550) and accessories (Pipe Fixture Kit 95999). For additional information on compliance with Type A approvals, USNRC 10CFR34, ANSI N432-1980 or ISO 3999: 2004(E) please contact QSA Global, Inc.

QSA Global, Inc. shall not be liable for any errors or omissions contained herein and the provision by QSA Global, Inc. of the information set out in this manual does not in itself constitute acceptance of any liability on the part of QSA Global, Inc.

2. OPERATING INSTRUCTIONS.

2.1 Job Site Safety Precautions

Instruments

The radiographer and radiography assistants must at all times wear a film badge or TLD and pocket dosimeter with a range of 0-2 mSv (0-200 mRem). Regulatory requirements in the USA also require that an audible alarm ratemeter be worn at temporary jobsites. Specifically, those locations that are not permanent radiographic installations equipped with functional door interlocks and audible/visual alarms.

Radiographers in the USA must also have a survey meter capable of measuring in the range 20 μ Sv/hr (2 mR/hr) up to 10 mSv/hr (1,000 mR/hr). Canadian regulations require that survey meters used for industrial radiography be capable of measuring from 2 μ Sv/hr (0.2 mR/hr) and up to 100 mSv/hr (10 R/hr). In any regulatory jurisdiction, always verify survey meter requirements affecting the range and calibration requirements prior to engaging in industrial radiography operations.

An audible 'chirper' pocket alarm may be required in some countries.

Restricted Area

Radiography must be performed only in a restricted area that is marked with the appropriate radiation warning signs and secured against unauthorized entrance.

Distance

Since the source emits high levels of radiation it is good practice to operate the system from as great a distance as possible.

Shielding

Whenever possible, situate the radiographic exposure area in a room with suitably thick walls, floor, ceiling and doors.

Surveillance

Only trained and qualified radiographers, or assistants working under their direct supervision, may operate radiography systems. The radiographer must be physically present at the site and able to control and limit access to the restricted area.

Locking

Keep the exposure device locked while assembling the system and when not being used to perform radiography. Locked is defined as the exposure device's lock is fully engaged with the key removed. Store the key in a secured location.

2.2 Operational Instructions



WARNING



It is essential that the 5 STEPS set out below are followed in the correct order to ensure safe operation and compliance with regulations.

- STEP 1 Exposure Device Survey**
- STEP 2 Connecting the Remote Control Cable**
- STEP 3 Exposing and Retracting the Source Assembly**
- STEP 4 Dismantling Equipment**

STEP 1

Exposure Device Survey

Check the operation of the survey meter by measuring the radiation level at the surface of the exposure device. The radiation level measurement should not exceed 2 mSv/hr (200 mR/hr) on any surface of the exposure device. Use this measurement for verification surveys of the source assembly's return to the fully shielded/secured position within the exposure device after each radiographic exposure.

STEP 2

Ensure the control hose has received a daily inspection according to the daily inspection section of this manual. Position and secure the exposure device for the radiographic exposure. Connect the control hose to the control unit and exposure device optimizing the distance between the control unit and the exposure device. Ensure the control unit toggle switch is in the "Off" or "Vent" position.

STEP 3

Exposing and Retracting the Source Assembly

1. Ensure that no personnel are inside the Restricted Area or exposure room. Ensure that the proper signs are posted and required warnings are in operation.
2. Release the plunger lock on the exposure device. At the control unit confirm the toggle switch is in the "Off" or "Vent" position. The control unit is equipped with a pressure gauge to monitor operating pressure.
3. Using the handle, increase pressure at the control unit until 25-30 psi is reached. Move the toggle switch to the "Expose" position to make the radiographic exposure. Increase pressure to ensure that 25-30 psi is maintained during the radiographic exposure (see Figure 3).

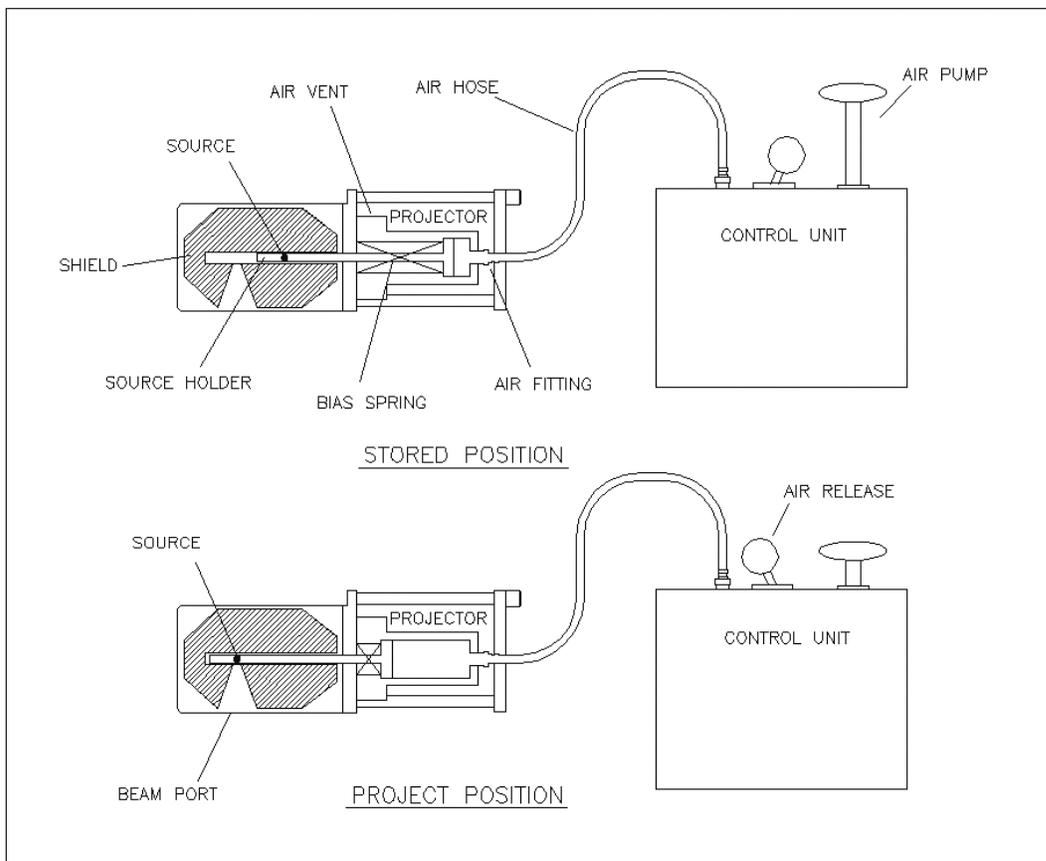


Figure 3 – SENTINEL™ 959M SCAR Principles of Operation



WARNING



Remain clear of the beam port area of the exposure device to minimize personal exposure.
Always approach the device while observing your survey meter.
During radiation surveys, survey the entire circumference of the exposure device with a survey meter to ensure the source is fully shielded and properly secured.

STEP 3 Continued

4. During the radiographic exposure, use the survey meter to check the boundary dose rate, but spend as little time as possible in and near the restricted area to minimize personal exposure.
5. After the exposure is complete, Move the toggle switch to the “Off” or “Vent” position.
6. Survey the entire circumference of the exposure device with a survey meter to ensure the source is fully shielded and properly secured. The survey meter should indicate the same radiation level as observed before the exposure. If surveys are acceptable, engage the plunger lock to secure the source assembly in the device.



WARNING



If the survey reading of the device after the exposure is not the same as measured before the exposure or the plunger lock cannot be engaged, the source may not be in the fully shielded position. Treat the situation as an EMERGENCY.

STEP 4

1. Disconnect the control hose from the control unit and the actuator fitting of the exposure device. Place the locked SENTINEL™ 959M SCAR into the 959A transport case (or equivalent storage container) and secure.
2. Perform a storage survey on the surface of the exposure device to verify the dose rate is less than 200 mR/hr (2 mSv/hr) and record.
3. Store and secure the device in a clean dry storage area where it cannot be tampered with or removed by unauthorized personnel. The storage area selected should minimize effects from explosion or fire to the stored materials. A radioactive material warning notice must be posted on the door or entrance of the storage area. The door or entrance must be locked to prevent access by unauthorized personnel.

2.2 Emergency Source Retraction

If radiation levels exceed 200 mR/hr (2 mSv/hr) at the surface of the device or the lock plunger cannot be depressed when the source should be in its stored position, notify your supervisor or Radiation Safety Officer. The following procedure defines the steps that may be taken to manually return the source to its stored position.

- a. Approach the exposure device from the side opposite the beam port with a survey meter.
- b. Unscrew the knurled knob from the handle ring of the exposure device and remove the source retraction tool (the knurled knob is an integral part of the tool).
- c. Remove the actuation control hose from the exposure device.
- d. Insert the small end of the source retraction tool through the air fitting on the exposure device and screw it clockwise into the source rod.
- e. Pull back on the tool to pull the source to its stored position and lock the exposure device by depressing the lock plunger.
- f. Unscrew the source retraction tool and screw it back into its storage tube.

3. DAILY INSPECTION INSTRUCTIONS.

3.1 Introduction

Radiographic exposure devices and associated equipment must be maintained regularly by trained and qualified personnel to ensure consistent and safe operation of the radiographic system. Manufacturers base the recommended inspection and maintenance requirements on the system's design, application, materials, anticipated work cycles, environmental factors of use under normal and abnormal conditions of industrial radiography and while in the transport system.

A program of systematic maintenance will prolong the working life of the device and associated equipment in addition to ensuring safety during use. By most national regulations, routine maintenance of the system is required at intervals not to exceed 3 months in addition to the daily inspections for obvious defects. The complete annual servicing ensures the integrity of the SENTINEL™ 959M SCAR gamma-ray source projector.

Maintenance program administrators must recognize the need for maintenance intervals that are less than the recommended 3 month or annual frequencies, especially in cases where the systems are used in severe environmental conditions. Maintenance program administrators must ensure the systems are completely serviced immediately after certain jobs in severe conditions. Extreme or severe conditions may include, but are not limited to:

- Conditions where the equipment was immersed in water or mud.
- Subjected to high-concentrations of particulate such as fly ash or sand.
- Subjected to hot radiography conditions.
- Subjected to salt-water conditions, caustic or acidic materials.
- Subjected to accidental drops or falling objects.
- Whenever subjected to extreme environmental conditions.

The routine maintenance performed every 3 months involves cleaning, inspection, and operational checks of the system. The complete maintenance (performed once a year – or at the time of source re-loading) involves a complete disassembly of the actuator and lock mechanisms, cleaning, inspection and operational tests of the entire system.

The complete annual maintenance of the system can only be performed by QSA Global, Inc. or individuals trained and qualified by QSA Global, Inc. who are licensed to perform this operation and have access to an exposure cell for unloading of the device prior to maintenance operations. Annual maintenance should not be performed by the user of this device unless authorized by QSA Global, Inc. based on training, and licensed by their respective regulatory agency to perform this operation.

Care should be taken to prevent radiological incidents that can occur from neglect, accidental damage, abuse and lack of inspection and maintenance.

The following instructions should be followed carefully to ensure safe and proper operation of this equipment.

3.2 Daily Inspection of the System

A daily inspection of the gamma radiography system for obvious defects is essential to ensure the equipment is in a safe and proper operating condition. It is important that all radiographers perform or supervise this inspection prior to the first radiographic exposure of the shift regardless of any previous inspections that may have been performed that day. As an example, damage to a component of the system may occur during transport of the equipment to the job-site. If damaged equipment were used without detection, the result may be the inability to retract the source assembly into the exposure device and secure it.

The results of a daily inspection should be recorded and include the date, the name of the inspector and what specific equipment was inspected. If any defective or damaged components are discovered during the daily inspection, the component must be removed from service and identified with a status indicator (tag, label, or tape) to prevent inadvertent use by other radiography personnel. Defective or damaged components must be repaired or replaced before reuse in radiographic operations. The three main components of the radiography system consisting of the radiographic exposure device (and transport case if used), remote control unit (including the control hose) and pipe clamping/fitting apparatus (if applicable) must be inspected.

Radiographers must take a proactive role in preventing incidents, by performing or directly supervising a simple, but thorough daily inspection of the radiography system. The implications that affect safety and the importance of the daily inspection must be emphasized and understood by the entire radiography staff.

3.3 Daily Inspection of the Gamma-Ray Source Projector

- a. Survey the surface of the exposure device or device in the transport case to ensure the radiation level is less than 2 mSv/hr (200 mR/hr), even when containing a source assembly with the maximum allowable activity. This survey provides a function check of the survey instrument that it is responding to radiation, in addition to providing the radiographer with a reference measurement that can be compared to confirmatory surveys after terminating each radiographic exposure.
- b. Inspect the labels on the exposure device or the transport case to ensure they are legible and securely attached to the unit. The warning label containing the trefoil should be legible from a distance of at least 3 ft (approximately 1 m). This label warns the individuals in the immediate vicinity of the presence of radioactive materials and permits them to take measures to minimize their exposure to radiation. The printed verbiage and the radiation symbol must be legible. The trefoil symbol becomes the warning for those individuals who cannot read or understand the written warning, 'Caution or Danger, Radioactive Material'. Inspect the legibility and attachment of the source identification tag that describes the radioactive source contained within the exposure device.
- c. Inspect the exposure devices to ensure the top cover is securely attached over the actuator mechanism. Inspect the plunger lock to ensure the lock will engage when the plunger is depressed and the key is removed.
- d. Inspect the actuator fitting for damage which would prevent attachment of the control hose in a secure fit.
- e. Check the threads on the source rod and the manual retraction rod by inserting the manual retraction rod into the actuator fitting and threading these items together.

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3.4 Daily Inspection of the Control Unit

- a. Uncoil the control hose. Inspect the control hose for any cuts or damage which would prevent an airtight seal between the control unit and the exposure device.
- b. Ensure the control hose connects securely to both the actuator fittings of the device and the control unit.
- c. With the gamma-ray source projector in the locked position (plunger lock engaged) and the control unit in the 'Off' or "Vent" position, attach the control hose to the control unit and gamma-ray source projector and pressurize the control unit to 25-30 psi. If the unit cannot be pressurized to this level, pressure is leaking from the system between the control unit and control hose to the gamma-ray source projector and this problem should be corrected for reliable exposures with the SENTINEL™ 959M SCAR device.

3.5 Daily Inspection of the Pipe Clamping/Fitting Apparatus

Inspect all device attachment apparatus to ensure it is fit for use and has no damage that would prevent safe securement to the pipe/device or fail during a radiographic exposure.

4. QUARTERLY AND ANNUAL MAINTENANCE REQUIREMENTS.

Radiographic gamma-ray source projectors and associated equipment must be maintained regularly by trained and qualified personnel to ensure consistent and safe operation of the radiographic system. The routine inspection and maintenance also ensures that the integrity of the Type A transport packages are maintained in compliance with the package approval requirements.

Manufacturers base the recommended inspection and maintenance requirements on the system's design, application, materials, anticipated work cycles, environmental factors of use under the normal and abnormal conditions of industrial radiography and while in the transport system. A program of systematic maintenance will prolong the working life of the radiographic gamma-ray source projector and associated equipment in addition to ensuring safety during use. By most national regulations, routine maintenance of the systems is required at intervals not to exceed 3 months in addition to the radiographer's daily inspections for obvious defects. The complete annual servicing ensures the integrity of the system.

Maintenance program administrators must recognize the need for maintenance intervals that are less than the required 3-month interval especially in cases where the systems are used in severe environmental conditions. Maintenance program administrators must ensure the systems are completely serviced immediately after certain jobs in severe conditions. Extreme or severe conditions may include, but is not limited to conditions where the equipment was:

- Immersed in water or mud.
- Subjected to high-concentrations of particulate such as fly ash, sand or foundry green-sand.
- Subjected to hot radiography conditions.
- Subjected to salt-water conditions, caustic or acidic materials.
- Subjected to accidental drops or falling objects.
- Whenever subjected to extreme environmental conditions.

The routine maintenance performed every 3 months requires partial disassembly, cleaning, inspection, re-lubrication and operational checks of the system. The complete maintenance (performed once a year) involves a complete disassembly, cleaning, inspection, re-lubrication and operational tests of the entire system.

Trained and qualified individuals within the licensee's organization can perform equipment maintenance. QSA Global, Inc. service engineers are available to provide maintenance on the systems at the licensee's premises or at one of the service centers.

4.1 Quarterly Inspection of the System

4.1.1 Quarterly Inspections

Routine quarterly maintenance of the equipment involves performance of the same daily inspections describe under Section 3. Further, inspection of the gamma-ray source projector should include evaluation for any signs of wear or obvious damage. If deficiencies are found during this maintenance, the gamma-ray source projector must be withdrawn from service until repairs are accomplished and the results of subsequent operational tests and inspections are satisfactory.

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NOTE: Repair or service of the SENTINEL™ 959M SCAR gamma-ray source projector involving the actuator mechanism, plunger lock assembly or the device body weldment must be performed by QSA Global, Inc. (or individuals trained and qualified by QSA Global Inc.) Individuals trained and qualified by QSA Global, Inc. must also be licensed to perform this operation and have access to an exposure cell for unloading of the device prior to performing service/repairs.

4.1.2 Routine (Quarterly) Maintenance Records

Records of all equipment inspected and maintained during the routine maintenance must be recorded. Records should indicate:

- The date of inspection and maintenance.
- Name and signature of the qualified individual performing the required inspections.
- Problems found and maintenance or repairs performed.
- Model number and serial number of the gamma-ray source projector and transport container.
- Associated equipment that was inspected and maintained.
- Part numbers and associated lot numbers or serial numbers of replacement parts installed.

4.2 Annual Maintenance Requirements

4.2.1 Gamma-ray source projector Requirements

Radiographic gamma-ray source projectors used under normal environmental conditions should only require complete maintenance once a year (or at source re-loading). Annual maintenance of the equipment involves performance of the same inspections describe under Section 4.1 Quarterly Inspection of the System. Further, inspection of the gamma-ray source projector includes the inspections in this section.

The complete maintenance of the gamma-ray source projector requires the disassembly of the gamma-ray source projector to enable a detailed inspection of all major components. Therefore, the inspection and maintenance requires transfer of the source assembly from the gamma-ray source projector to an alternate shielded location prior to performance.

NOTE: Annual inspection of the SENTINEL™ 959M SCAR gamma-ray source projector involves unloading of the source rod assembly prior to subsequent disassembly of the actuator mechanism and plunger lock assembly. Annual inspections must be performed by QSA Global, Inc. (or individuals trained and qualified by QSA Global Inc.) Individuals trained and qualified by QSA Global, Inc. must also be licensed to perform this operation and have access to an exposure cell for unloading of the device prior to performing service/repairs.

The following inspections MUST be performed only by QSA Global, Inc. or individuals trained and qualified by QSA Global, Inc. to perform these inspections.

- a. Remove the top shell protective cover from the device by removing the four ¼-20, ½" long mounting bolts. Examine the protective cover weldment for damage (e.g., cracked welds, rusting, etc.) that would adversely impact its ability to perform its protective function when attached to the SENTINEL™ 959M SCAR body weldment.
- b. Examine the body weldment for damage (e.g., cracked welds, rusting, etc.). If cracks are observed in the welds or excess denting/rusting is evident, remove from service.
- c. In a properly shielded, remote manipulator cell, unload the source rod assembly from the SENTINEL™ 959M SCAR body weldment. After removal of the source rod assembly, unload the source capsule from the source rod holder by removing the retaining pin and unthreading the source holder components.

- d. Perform a contamination wipe of the source capsule and the source rod holder. Acceptable results of a radio-assay must indicate removable contamination is less than 0.005 μCi (<185 Bq). If results exceed this limit, contact your Radiation Safety Officer.
- e. Remove the SENTINEL™ 959M SCAR and source rod assembly components (minus the source capsule) from the shielded, remote manipulator cell.
- f. Remove the actuator assembly including the source rod assembly from the SENTINEL™ 959M SCAR body weldment. Inspect the condition of the source return spring. Replace if necessary.
- g. Inspect the condition of the base screws and the actuator attachment bolts as well as the top cover bolts. Ensure threads engage.
- h. Perform an operational check of the plunger lock mechanism. Replace if necessary.
- i. Replace the rubber seal rings (5 places) within the actuator assembly.
- j. Check the threads on the source rod and the manual retraction rod by threading these items together. If unable to thread together easily, pursue further with thread inspection tools and reject the non-conforming component.
- k. Reassemble the actuator assembly. Reload the device if necessary. Complete full re-assembly of the device per the device drawings.
- l. Perform a functional test of the device and control unit to ensure all items are operable after re-assembly.

If deficiencies are found during this maintenance, the gamma-ray source projector must be withdrawn from service until repairs are accomplished and the results of subsequent operational tests and inspections are satisfactory.

4.2.2 Quality Class A Considerations

Some items that comprise the SENTINEL™ 959M SCAR gamma-ray source projector are critical for safe radiological operation and are classified as Quality Class A items or components. Quality Class A items can be structures, components and systems whose failure or function could directly result in a condition adversely affecting public health and safety. Replacement parts associated with the SENTINEL™ 959M SCAR inspected in Section 3.5 that are classed as Quality Class A are all components of the source rod assembly (excluding the source rod assembly pin) and the ¼-20, 1¼" long base plate screws. Replacement parts from QSA Global, Inc. for these items are clearly marked with lot numbers and contain instructions to maintain traceability.

Personnel performing annual device maintenance must recognize their responsibilities of maintaining the integrity of the gamma-ray source projector and maintain control of Quality Class A items and components by:

- Maintaining traceability of Quality Class A replacement items or components to a specific gamma-ray source projector.
- Use of manufacturer specified items to maintain the integrity of the gamma-ray source projector according to the certifications. Do not use generic grade items or components that do not meet original design specifications.
- Performance of periodic inspections to verify the Quality Class A items are not excessively worn from long use or have been damaged by accidents.
- Use and handling of the system consistent with its design and intended application.
- Promptly notifying the manufacturer in the event a Quality Class A item or component which contains a defect or deviates from the original design specifications. This action will initiate a formal evaluation of the defect or deviation.

4.2.3 Annual Maintenance Records

Records of all equipment inspected and maintained during the annual maintenance must be recorded. Records should indicate:

- The date of inspection and maintenance.
- Name of the qualified individual performing the required inspections.
- Problems found and maintenance or repairs performed.
- Model number and serial number of the gamma-ray source projector.
- Associated equipment that was inspected and maintained.
- Part numbers and associated lot numbers or serial numbers of replacement parts installed.

4.2.4 Leak Testing of the Radioactive Sealed Source

Periodic leak tests of the radioactive sealed source are required by most national and international regulations. The leak test provides a confirmation of the integrity of the hermetically welded sealed source by determining the amount of removable contamination. In most regulatory jurisdictions, a leak test of a sealed source must be performed every 6 months or prior to its first use after removal from storage. Acceptable results of a radio-assay must indicate removable contamination is less than <185 Bq (0.005 μ Ci). To perform a wipe of the radioactive sealed source, perform the following steps:

- a. Survey the entire exterior surface of the gamma-ray source projector to ensure the dose/rates are less than 2 mSv/hr (200 mR/hr).
- b. Prepare a Model 518 wipe test swab according to the instruction sheet. Fill in all required information for the source on the leak test form. Omission of the isotope, source model and serial number, etc. will delay processing of the wipe test.
- c. Wipe the actuator fitting on all accessible surfaces. (Since the source never leaves the gamma-ray source projector, leak tests are performed on the nearest accessible surface to the gamma-ray source projector where contamination would most likely migrate if the source integrity was breached).
- e. Carefully withdraw the wipe test swab from the outlet port while observing the survey instrument. Withdraw the plastic bag over the wipe test wand without touching. Always assume the sample is contaminated.
- f. In a low background (no radiation) area, switch the survey meter to the lowest scale and obtain a background measurement. Leaving the survey meter stationary, move the plastic wrapped swab towards the survey meter's detector to determine if a gross quantity of contamination is on the wipe test. If the survey meter measures greater than 1 μ Sv/hr (0.1 mR/hr), contact QSA Global, Inc. for instructions. If there is no measurable increase above background, the sample may be sent to the SENTINEL™ laboratory for radio-assay. The SENTINEL™ laboratory will send a leak test certificate after performing the radio-assay. Retain this certificate in your records.

In the event you are informed by the radio-assay laboratory that your leak test results indicate greater than >185 Bq (0.005 μ Ci), you must immediately remove from service the radioactive sealed source, the gamma-ray source projector and all remote controls, source guide tubes, collimators, lab stands, etc. that were used in conjunction with that sealed source. You must cause the equipment to be repaired or decontaminated and notify the regulatory agency (USA) within 5 days (check local regulations for reporting requirements). Contact the sealed source manufacturer for assistance.

5. SAMPLE TRANSPORTATION INSTRUCTIONS.

The following instructions are samples for the transport of this radiographic gamma-ray source projector/transport container and source assembly within the United States and are based on current transport regulations. Shippers of radioactive materials in regulatory jurisdictions outside the USA must ensure full compliance with all current and applicable transport regulations. Listed are the regulations that should be referenced for the legal transport of radioactive materials:

- International Atomic Energy Agency requirements No. TS-R-1 (2009 Edition) and SSR-6 (2012) 'Regulations for the Safe Transport of Radioactive Materials' and the IAEA 'Code of Conduct on the Safety and Security of Radioactive Sources' - IAEACODEOC/2004.
- International Air Transport Association, 'Dangerous Goods Regulations'.
- International Civil Aviation Organization, 'Technical Instructions for the Safe Transport of Dangerous Goods by Air'.
- International Maritime Organization, 'International Maritime Dangerous Goods Code'.
- U.S. Department of Transportation, Title 49 Code of Federal Regulations Parts 171 through 178.
- U.S. Nuclear Regulatory Commission, Title 10, Code of Federal Regulations, Parts 20, 34 & 71.
- Canadian Nuclear Safety Commission, Nuclear Safety and Control Act, 'Packaging and Transport of Nuclear Substances Regulations'; 'Nuclear Substances and Radiation Devices Regulations'.
- Transport Canada, 'Transport of Dangerous Goods Regulations'.
- Transport in the United Kingdom: Refer to the regulations as listed on the ADR approval Certificate.

5.1 Transport Package Requirements

The SENTINEL™ 959M SCAR when transported in the Model 959A transport package meets the requirements of a Type A transportation package.

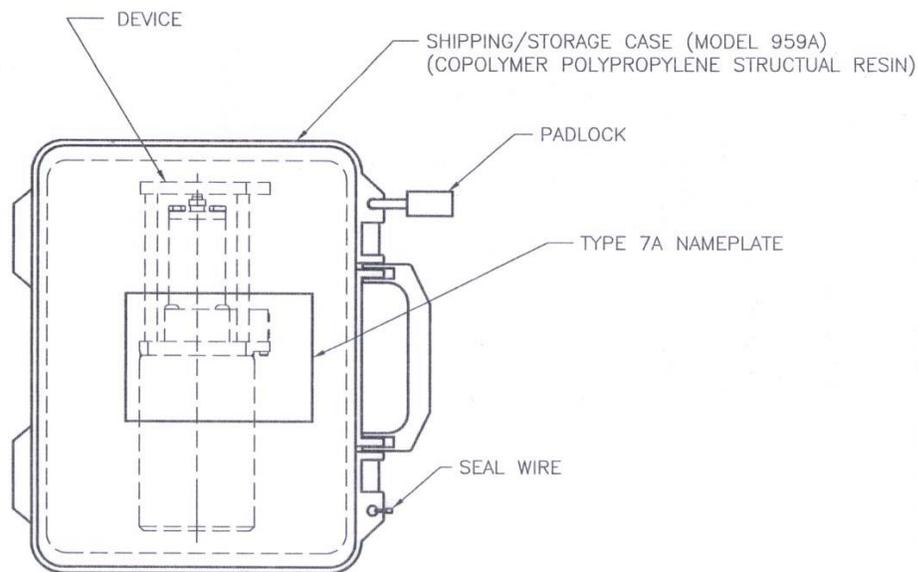


Figure 4 – SENTINEL™ 959M SCAR in 959A Transport Case

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As a shipper of radioactive material, you must perform a pre-shipment inspection to verify conformance to the Type A approval for each individual shipment of radioactive material. This verification assures the package's integrity is not compromised, which may cause a reduction of safety while in the transport system.

Visually inspect the transport package:

- Assure the source assembly is properly secured in the locked position. The selector ring must be in the LOCK position, the protective cover in place, the plunger lock engaged and the key removed.
- Assure all screws are present and secured.
- Assure the front port is properly secured.
- Assure the seal wire is properly installed, if used.
- Assure the 'Danger, Radioactive Material' label is securely attached and visible on the package. Assure that the label is legible and not defaced.
- Assure the other information on the label is legible (the warnings and trefoil, the model number and serial number and the Type A specification identification).
- Visually assure all welded areas are not cracked. If there is any evidence of cracked welds contact QSA Global, Inc. prior to shipment.
- Assure all the conditions of the Certificate of Compliance are met and the transport package has all the required markings.
- Wipe test the transport package over an area of 300 cm² and assure the level of removable contamination is less than 0.0001 µCi per cm².

If the package fails any of the inspections described, remove the container from use until it can be brought into compliance with the Type A approval.

5.2 Receipt of Radioactive Material

- a. A radioactive material package must be accepted from the carrier at the time it is delivered. [10CFR20.1906(a)(1)]
- b. If a radioactive material package is to be held at the carrier's terminal for pickup, arrangements must be made to receive notification from the carrier of the arrival of the package at the time of arrival. The package must be picked up expeditiously upon receipt of notification (within three hours if practicable). [10CFR20.1906(c)]
- c. Monitoring as described below must be performed as soon as practicable but at least within three hours if received during normal working hours or within three hours of the next work day if received after normal working hours. [10CFR20.1906]
 - Upon receipt of a package of radioactive material, the package shall be placed in a restricted area. Assure appropriate personnel are notified.
 - Survey the entire exterior surface of the package at the time of receipt and assure that the maximum radiation level does not exceed 2 mSv/hr (200 mRem/hr). Survey all sides of the device at 1m from the exterior surfaces of the packages and assure that the maximum radiation level does not exceed 0.1 mSv/hr (10 mRem/hr). If either of these limits are exceeded, notify the Radiation Safety Officer immediately. Record the maximum radiation levels measured at the package surface and at 1m from the package surface on the Receiving Report. [10CFR20.1906(d), 10CFR71.47]

Note: If any of these limits are exceeded, the Radiation Safety Officer must immediately notify the USNRC (or applicable governing agency) and the final delivering carrier.

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- d. Inspect the package for any evidence of physical damage. Record the results of this inspection on the Receiving Report. Also record on the Receiving Report the date, source model number, source serial number, radionuclide, activity, the individuals name making the record, transport package model number, mass or activity of the depleted uranium and the package serial number. [10CFR34.63]
- e. Assure that the package is locked or place the package into an outer locked container and secure the package in accordance with your license requirements. [10CFR34.35, 10CFR34.23]
- f. Keep a copy of the Operating Manual for the package on file to assure you have the proper opening and handling instructions. Assure that the instructions are followed and any noted special precautions are performed. [10CFR20.1906(e)]

Note: For licensees transporting special form sources in licensee owned or operated vehicles to and from a work site are exempt from the contamination monitoring requirements. The radiation survey required upon receipt must still be performed. [10CFR20.1906(f)]

- g. If you are receiving a nationally tracked source (Category 1 or 2 quantities) from another licensee, complete the report: USNRC form 748 and submit the report by the close of the next business day after the transaction. [10 CFR 20.2207 and Appendix E]. Some regulatory jurisdictions require reporting of depleted Uranium shielding of the transport container in addition to the radioactive materials. Verify current national regulatory and security requirements to ensure compliance.

5.3 Shipment of Radioactive Material

- a. Pre-shipment training requirements:

Prior to shipping hazardous materials, personnel must be trained in accordance with 49CFR172, Subpart H and be retrained every three years. Training shall include:

- General awareness/familiarization training.
- Function specific training.
- Safety training, providing:
 - Emergency response information.
 - Measures to protect employees from potential hazards associated with hazardous material to which employees may be exposed in the workplace, both radioactive and chemical hazards.
 - Employer safety measures implemented to protect employees.
 - Methods and procedures for accident avoidance, i.e. proper procedures for handling hazardous material packages.
 - OSHA or EPA training, MSDS information.
 - Transportation security training for organizations that are required to have a security plan. Haz-Mat employees must be trained in the security plan and its implementation including awareness of security risks and how to recognize and respond to security threats. [49CFR172.800, 10CFR30, IAEA CODEOC/2004]
 - If shipments involves use of a Declaration of Dangerous Good form, all personnel involved with the shipment must be trained in IATA/ICOA/IAEA requirements every two years.

An appropriate test must be administered and the following documentation must be kept:

- Employee name.
- Date of most recent training.
- Description, copy or location of the training methods.
- Name of person performing training.
- Certification that person has been trained and tested.

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Documentation should be kept in one file, i.e. all radiation safety related training used as part of the Hazmat training should be included.

- b. Prior to shipment maintain copies on file of the most current Type A approval and Special Form certifications, and assure the package and its contents meet the following requirements:
 - The radioactive contents and form are authorized for use in the package.
 - The package is in good physical condition for transport.
 - All locks and outlet port fittings are properly installed and seal wired where required.
 - All conditions of the Type A approval are met [10CFR71.87]. Maintain copies of the current Type A and special form certifications on file.
- c. Assure that the source is secured in the proper shielded position in the shipping package as described in Section 2 of this operations manual. Perform a pre-shipment inspection as described in Section 5.1 under the Transport Package requirements and verify the package is assembled as described in the Type B(U) certification (or Type A approval as applicable).
- d. As applicable, attach a security seal with an identification mark to the package closure that serves as a tamper indicator. [49CFR173.412(a)]
- e. If the shipping package is to be packaged inside a crate or other outer packaging, the outer packaging must be strong enough to withstand the normal conditions of transport and must not reduce the safety of the package. The shipping package must be placed within the outer package with sufficient blocking to prevent shifting during transportation. [49CFR173.25]
- f. Survey the entire exterior surfaces of the package and assure that the maximum radiation level does not exceed 2 mSv/hr (200 mRem/hr). Survey 1 m from all sides of the exterior surfaces of the package and assure that the maximum radiation level does not exceed 0.1 mSv/hr (10 mRem/hr). Determine the proper shipping labels to be applied to the package using the criteria of Table 1. [49CFR172.403]

Note: If shipping the container inside an overpack or convenience box in the back of a vehicle, survey and label both the inner 959A package and the overpack. Placarding the vehicle is dependent on the category of label applied to the overpack if used. [49CFR173.448]

- g. Properly complete two shipping labels indicating the contents (e.g. Se-75 or Ir-192), the activity of the source (in Becquerels or multiples of Becquerels, e.g. GigaBecquerels (GBq)) and the transport index. The transport index is used only on Yellow II and Yellow III labels and is defined as the maximum radiation level in mRem/hr at 1 m from the package surface (see Table 1). [49CFR172.403(g)]
- h. Assure that any old shipping labels have been removed from the package. Apply two properly completed labels to two opposite sides of the package (excluding the bottom surface). [49CFR172.403(f)]
- i. For air shipments within the USA, the package must be labeled with '**Cargo aircraft only**' labels. Ensure that these labels do not cover any other package markings or labels. [49CFR172.448 & 173.448(f)].
- j. Mark the outside of the package with the proper shipping name and identification number (i.e., 'Radioactive Material, Type A Package, Special Form, UN3332') if not already marked. Place the letters RQ (stands for Reportable Quantity) next to the proper shipping name when shipping more than 10 Ci (370 GBq) of Se-75 or Ir-192. [49CFR172.300]

Table 1

	Maximum Radiation Level at Surface	Maximum Radiation Level at 1 Meter
Radioactive White I 	0.5 mRem/hr (0.005 mSv/hr)	None
Radioactive Yellow II 	50 mRem/hr (0.5 mSv/hr)	1.0 mRem/hr (0.01 mSv/hr)
Radioactive Yellow III 	200 mRem/hr (2 mSv/hr)	10 mRem/hr (0.1 mSv/hr)

For a package, both the transport index (TI) and the surface radiation level conditions shall be taken into account in determining which is the appropriate category of radioactive material label. Where the TI satisfies the condition for one category but the surface radiation level satisfies the condition for a different category, the package shall be assigned to the higher category of the two. For this purpose, category White-I shall be regarded as the lowest category.

The TI is the maximum radiation level measured in mRem/hr at a distance of 1 m from the external surfaces of the package. When recording the TI, the dose rate units of mRem/hr are not listed, for example a reading of 20 μ Sv/hr (2 mem/hr) would indicate a TI = 2.0. (Note that the TI is rounded to the nearest tenth value.)

- k. If the shipping package is inside a crate or other outer packaging, mark the outside package with 'RQ' (if applicable), the 'UN Identification Number', followed by the 'proper shipping name'. The word 'OVERPACK' must be marked on the outside package. The required markings must be in letters a minimum of ½ inch (13 mm) high. [49CFR172.310; 49CFR173.471; 49CFR173.25]
- l. Assure that the levels of removable radioactive contamination on the outside surface of the outer package do not exceed 0.37Bq (10^{-5} μ Ci) per cm². [49CFR173.443]
- m. Properly complete the shipping papers indicating:
 - 1 United Nations identification number, Proper shipping name, Class Number '7', and (i.e. 'Radioactive Material, Type A Package, Special Form, UN3332').
 - 2 The letters RQ must appear before or after the proper shipping name when shipping more than 10 Ci (370 GBq) of Se-75 or Ir-192.
 - 3 Name of the radionuclide (e.g., Selenium-75 or Iridium-192).
 - 4 Physical and chemical form (i.e. Special Form).
 - 5 Activity of the source in Becquerels or other appropriate multiples of Becquerels on the DOT label and the shipping papers. Note: number of Curies x 37 = number of GigaBecquerels (GBq).

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- 6 Category of label applied (i.e. Radioactive Yellow II).
- 7 Transport Index.
- 8 DOT Type A Specification 7A for a Type A shipment.
- 9 Shipper's certification: **'This is to certify that the above-named materials are properly classified, described, packaged, marked and labeled, and are in proper condition for transportation according to the applicable regulations of the Department of Transportation.'** [49 CFR 172.204(a)(1)].

NOTE: For shipments in company vehicles to and from job sites within the USA, the shipper's certification is not required.

- 10 The shipping papers must indicate your company's emergency telephone number. The telephone number must have 24-hour coverage in case of an emergency concerning your shipment. The telephone number must be clearly visible on the shipping paper and must be answered by a person that can provide immediate emergency response information. Beepers and pagers are not acceptable. [49CFR172.604].
- n. For air shipments, the shipping papers must meet the requirements specified in IATA for a Shipper's Declaration for Dangerous Goods. In addition to the information listed in Step 5.3(m) of this part, the following information needs to be specified:

- 1 Air waybill number: Enter the number of the air waybill to which the declaration form will be attached. (This may be amended by the carrier.)
- 2 Aircraft limitations: Specify that the shipment is within the limitations for 'Cargo aircraft only.' A notation can be added in the handling information box of the Shipper's Declaration which states 'This shipment may be carried on passenger aircraft outside U.S. jurisdiction'.
- 3 Airport of departure: Enter the full name of the airport or city of departure, which may be amended by the carrier.
- 4 Airport of destination: Enter the full name of the airport or city of destination, which may be amended by the carrier.
- 5 Shipment type: Specify the shipment type as 'Radioactive'.
- 6 Under quantity and type of dangerous goods, specify the number of packages (of same type and content), their type of package and activity in Becquerels or multiples thereof (units used must be clearly indicated) in each package, including packages in overpacks.

(If relevant) Indication of use of overpack and dimensions of the overpack (including dimensional units). When an overpack is used, the wording **'Overpack used'** must be inserted on the declaration form immediately after all the relevant entries relating to the packages within the overpack. In such cases, packages within overpacks must be listed first. Dimension units must be in sub-multiples of meters.

- o. The 24-hour emergency number required by Step 5.3(m)(10) of this part, must appear in the 'Additional Handling Information' section of the Declaration for Dangerous Goods.

For air shipments within the USA, the following statement must be included:
"This shipment is within the limitations prescribed for cargo aircraft only."

- p. For shipment of special form radioactive material, the Special Form Certificate of Competent Authority for the radioactive source must be included. (e.g. USA/0502/S-96 or USA/0392/S-96).

- q. The shipper's certification must be as follows:

'I hereby certify that the contents of this consignment are fully and accurately described above by the proper shipping name, and are classified, packaged, marked and labeled/placarded, and are in all respects in proper condition for transport according to applicable International and National governmental regulations. I declare that all of the applicable air transport requirements have been met.'

The information on the Declaration for Dangerous Goods must be entered strictly in accordance with the order specified in the latest edition of the International Air Transport Association, Dangerous Goods Regulations.

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Questions regarding completion of a Shipper's Declaration for Dangerous Goods should be directed to the Radiation Safety Officer.

If you are shipping a nationally tracked source (Category 1 or 2 quantities) to another licensed recipient, complete the report: USNRC form 748 and submit the report by the close of the next business day after the transaction. [10CFR20.2207 and Appendix E, IAEA CODEOC/2004]. Some regulatory jurisdictions require reporting of depleted Uranium (DU) shielding of the transport container in addition to the radioactive materials. Verify current national regulatory and security requirements to ensure compliance.

5.4 Shipment of Empty Uranium Shielded Containers

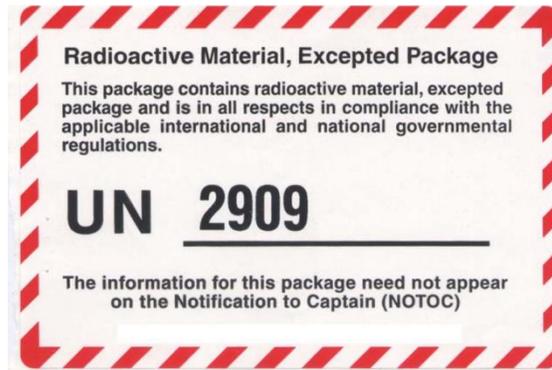
- a. Assure that the package does not contain a radioactive source. Perform the following procedure to confirm there are no unauthorized source assemblies within the container:
 - Transfer the authorized source assembly from the gamma-ray source projector in accordance with the source changer operations manual.
 - After removing the source assembly and disconnecting the source assembly, attach the jumper (dummy connector without a serial number) to the male connector of the control cable.
 - Retract the control cable and jumper and disconnect the controls from the locking mechanism.
 - Insert the protective cover into the locking mechanism, rotate the selector ring into the lock position, engage the plunger lock and remove key. Remove the source guide tube and close the outlet port cover.
 - Remove the source identification tag from the gamma-ray source projector and place it with the source assembly.
 - In some regulatory jurisdictions, 'empty' labels or tags must be attached to the empty SENTINEL™ 959M SCAR in the 959A package assembly.
- b. If the shipping package is to be placed inside a crate or other outer packaging, the outer packaging must be strong enough to withstand the normal conditions of transport and must not reduce the safety of the package. The shipping package must be placed within the outer package with sufficient blocking to prevent shifting during transportation. [49CFR173.25].
- c. Assure that the levels of removable radioactive contamination on the outside surface of the outer package does not exceed 0.4 Bq (10^{-5} μ Ci) per cm^2 based on wiping an area of at least 300 cm^2 . [49CFR173.443].
- d. Survey the package at the surface and at one meter from the surface to determine the proper shipping labels to be applied to the package.

Note: If the surface radiation level does not exceed 5 μ Sv/hr (0.5 mRem/hr) and there is no measurable radiation level at 1m from the surface, continue with the instructions in Step 5.4(e) below and skip Step 5.4(f). If either of these levels are exceeded, skip Step 5.4(e) and continue with the instructions in Step 5.4(f).

- e. If the surface radiation level does not exceed 5 μ Sv/hr (0.5mRem/hr) and there is no measurable radiation level at one meter from the surface, no label is required.
 - 1 The outside of the inner packaging or, if there is no inner packaging, the outside of the packaging itself bears the marking 'Radioactive'.
 - 2 The outside of the package must be marked with UN2909.
 - 3 When shipping by air, excepted packages are exempt from the requirement for use of Dangerous Goods Declaration.
 - i. For air shipments [IATA 10.8.8.3], the 'Quantity and Type of Dangerous Goods' box must read:

"Radioactive Material, excepted package, articles manufactured from depleted uranium, UN2909."

- ii. Required after 1 January 2007, the outside of the package must include the following label [IATA 10.7.4.4.3]:



- f. If the surface radiation level exceeds 5 $\mu\text{Sv/hr}$ (0.5 mRem/hr), or if there is a measurable radiation level at 1m from the surface, use the criteria of Table 1 to determine the proper shipping labels to be applied to the package.
- 1 Mark the outside of the outer shipping package with the proper shipping name and identification number: **Radioactive Material, Low Specific Activity (LSA-I) UN2912, Class 7**. If the container is packaged inside a crate or other outer packaging, mark the outer package with the word **'Overpack'**.
 - 2 Properly complete the shipping papers, indicating:
 - Proper shipping name, identification number and class (i.e. Radioactive Material, Low Specific Activity (LSA-I), Class 7, UN2912).
 - Name of the radionuclide (i.e. depleted Uranium-238).
 - Physical and chemical form (i.e. Solid Metal).
 - Activity of the uranium in Becquerels or other appropriate multiples of Becquerels.

NOTE: Number of Curies x 37,000 = number of MegaBecquerels (MBq). The activity in millicuries for U-238 equals 0.16 x the shield weight in pounds (i.e. for a SENTINEL™ 959M SCAR with a 24 lb shield, the approximate activity is 0.16 x 24 lb = 3.8 mCi).

- Category of label applied (i.e. Radioactive Yellow II).
- Transport Index.
- USDOT specification number, 'USA DOT 7A TYPE A'.
- Shipper's certification:

'This is to certify that the above-named materials are properly classified, described, packaged, marked and labeled and are in proper condition for transport according to the applicable regulations of the Department of Transportation.' [49CFR172.204(a)]

Note: For shipments in company vehicles to and from job sites, the shipper's certification is not required.

For air shipments, the following Shipper's Certification may be used:

'I hereby certify that the contents of this consignment are fully and accurately described above by proper shipping name and are classified, packaged, marked and labeled/placarded, and are

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in all respects in proper condition for transport according to applicable International and national governmental regulations. I declare that all of the applicable air transport requirements have been met'

- For air shipments, the package must be labeled with a '**Cargo aircraft only**' label and the shipping papers must state: '**This shipment is within the limitations prescribed for cargo only aircraft**'.
 - Your company's 24-hour emergency telephone number.
 - The weight of the package including the unit of measurement of the hazardous material covered by the description (e.g. 100 lb. Note: For air shipments, the weight must be in multiples of kilograms.)
- 3 For air shipments, the shipping papers must meet the requirements specified in IATA for a Shipper's Declaration for Dangerous Goods. In addition to the information listed in this Section, the following information needs to be specified:
- Air waybill number: Enter the number of the air waybill to which the declaration form will be attached. (This may be amended by the carrier.)
 - Aircraft limitations: Specify that the shipment is within the limitations for 'Cargo aircraft only.' A notation can be added in the handling information box of the Shipper's Declaration, which states '**This shipment may be carried on passenger aircraft outside U.S. jurisdiction**'.
 - Airport of departure: Enter the full name of the airport or city of departure, which may be amended by the carrier.
 - Airport of destination: Enter the full name of the airport or city of destination, which may be amended by the carrier.
 - Specify contents (isotope) on the USDOT hazard labels as LSA-I.
 - Shipment Type: Specify the shipment type as 'Radioactive'.
 - Under Quantity and Type of Dangerous Goods, specify the number of packages (of same type and content), their type of packaging and activity in Becquerels or multiples thereof (units used must be clearly indicated) in each package, including packages in overpacks that are labeled as LSA-I.

(If relevant) Indication of use of overpack and dimensions of the overpack (including dimensional units). When an overpack is used, the wording 'Overpack' must be inserted on the declaration form immediately after all the relevant entries relating to the packages within the overpack. In such cases, packages within overpacks must be listed first. Dimension units must be in sub-multiples of meters.

- The 24-hour emergency number required in this Section, must appear in the 'Additional Handling Information' section of the Declaration for Dangerous Goods.

The information on the Declaration for Dangerous Goods must be entered strictly in accordance with the order specified in the latest edition of the International Air Transport Association, Dangerous Goods Regulations. Questions regarding completion of a Shipper's Declaration for Dangerous Goods should be directed to the Radiation Safety Officer [49 CFR 172.402(b); 49 CFR 172.204(c)].

5.5 Carriage of Radioactive Material

- a. Assure that the vehicle used is in good condition and carries the normal complement of safety equipment including Radiation Area signs, a length of rope, spare tire, fire extinguisher, a set of vehicle tools and a set of flares. Assure that the glove compartment contains the vehicle registration certification and an operating flashlight. Additionally, assure that the operator has a calibrated and operable survey meter and assure that all individuals traveling in the vehicle are wearing both a film badge and a direct reading pocket dosimeter.
- b. Assure that the transport package is properly packaged, marked and labeled and assure that the proper shipping papers are completed in accordance with the instructions for shipping radioactive material. The shipping papers must be accessible from the driver's seat.
- c. Place the transport package in the vehicle. Properly brace and secure the package against movement in the vehicle. [49CFR177.842(d)]
- d. Survey the driver's compartment to assure that the radiation level does not exceed 0.02 mSv/hr (2 mRem/hr). [49CFR177.842(g)] Note: This requirement is mandatory only for exclusive use shipments by a common carrier. [49CFR173.441(b)(4)]
- e. If the vehicle is transporting a package bearing a Radioactive Yellow III label, the vehicle must be placarded on all four sides with a Radioactive placard.

Note: Operation of a vehicle which is required to be placarded requires compliance with the Federal Motor Carrier Safety Regulations of 49CFR Parts 390-397 and the Driver Training requirements of 49CFR177.827; 49CFR177.804.

- f. Complete the Radioactive Material Transport Checklist (see attached example). Forward a completed copy to the Radiation Safety Officer upon completion of the carriage.
- g. If the vehicle becomes disabled on the road, do not leave the vehicle unguarded when going for help. A message for help may be sent by a passing motorist or the police may be enlisted to guard the vehicle.
- h. Should any kind of accident occur, make an immediate radiation survey to determine if any radiation levels are unusually high. If unusual radiation levels exist, establish the boundary of the restricted area. Keep all persons out of this area and get police assistance, if possible. Notify the Radiation Safety Officer as soon as possible, but do not leave the scene without assuring that the police or some other responsible party will keep people out of the area.
- i. Collect information pertinent to the accident, such as names of witnesses, names of people involved, and names of police, license numbers and circumstances of the accident. Call the Radiation Safety Officer promptly and give him as much information as possible.
- j. If a source should escape from the packaging, the vehicle operator should make no attempt to restore the source by himself. He should wait for assistance from the Radiation Safety Officer.
- k. If the vehicle is going to be used for storage of radioactive material at a temporary job site:
 - The vehicle's storage access entrance must be posted with 'Caution Radioactive Material' signs.
 - The vehicle must be secured/locked so that there is no unauthorized access.
 - Radiation levels must be below 20 μ Sv/hr (2 mR/hr) outside the vehicle to meet unrestricted area requirements.
 - Vehicle must meet new security requirements where applicable.

- I. In the event of a transport emergency or accident involving this package, follow the guidance contained in “2016 Emergency Response Guidebook: A Guidebook for First Responders During the Initial Phase of a Dangerous Goods/Hazardous Materials Incident”, or equivalent guidance documentation.

- m. Security during transport in company vehicles:

Whenever portable and mobile radiographic gamma-ray source projectors are removed from the permanent facility's approved storage area and placed into the transportation system, company trustworthy and reliable (T&R) employees that have been Haz-Mat trained will perform the following security duties during transport of radioactive materials:

- After the radioactive material package is prepared in accordance to current transport regulations, the package must be secured and locked in the designated area of the transport vehicle. The door to the storage area of the vehicle is closed locked to prevent unauthorized access to the darkroom during transport from the facility to the job-site. Shipping or receiving radioactive materials shall be accomplished in a designated area of the permanent facility.
- While containing radioactive material packages, the vehicle is also a temporary storage area (whenever the package is not under continuous, direct surveillance by a T&R employee). The package must be locked in the vehicle as described above and the driver / passenger doors of the vehicle are to be locked. The alarm system and the transport vehicle disabling devices are activated.
- Whenever the transport vehicle is stopped for refueling, coffee stops, etc. the ignition keys are removed from the vehicle. If the T&R employee(s) leave the vehicle unattended, the vehicle must be completely locked and alarmed as described above.
- During transport to and from job-sites, T&R employees informed to:
 - Minimize the number of vehicle stops for fueling, beverages, meals, etc to minimize exposure to security risks.
 - Do not engage in any conversation with strangers concerning vehicle contents or job-site destinations.
 - Be aware of their surroundings and the people during stops, a car-jacking usually takes place at traffic lights.
 - Know what action is required under the security plan by the T&R employee if a car on the highway is following them, photographing their truck, if the truck is disabled on a highway, if the truck was involved in an accident and cannot be driven away.
 - Know what immediate response is required by a T&R employee if the vehicle is stolen or the radioactive material package is lost or stolen.
 - Have the ability to communicate immediately with the Trustworthy and Reliable Official (TRO) should they need assistance or have a security related question.
 - Know to report immediately to the TRO if an unauthorized party attempts to steal or gain access to the radioactive material being transported.
 - Know what actions are required if the vehicle's alarm is triggered while parked, indicating an attempted intrusion.
 - Know that all T&R employees are to safeguard all transport security documents and information regarding shipments of RAM from unauthorized disclosure.
 - Know that whenever the radioactive materials are removed from the transport vehicle at the job-site, the radioactive material must be under continuous, direct surveillance by the T&R employees until it is returned to the designated area of the transport vehicle.
 - Know the purpose and reason for the increased security requirements of the USNRC, USDOT and Department of Homeland Security agencies.

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T&R employees returning from job-sites will unload the radioactive material from the transport vehicle. They will secure the radioactive material in the facility's designated storage area and activate the storage area's security alarm system.

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Suggested Radioactive Material Transport Checklist:

Date _____ Operator _____

Destination _____

Transport container model _____ Serial number _____

Radionuclide _____ Activity _____

Type of label applied _____ Transport index _____

Survey meter model _____ Serial number _____

Calibration date _____ Film badge _____

Dosimeter serial number _____ Initial reading _____

Final reading _____

Radiation area signs _____ Packing list _____

Rope _____ Bill of lading _____

Radioactive material sign _____ Emergency equipment _____

Radiation survey _____ Driver's compartment _____ mRem/hr or μ Sv/hr

(Record highest reading) Vehicle (45.72 cm or 18 in from surface) _____ mRem/hr or μ Sv/hr

Packages properly marked and labeled (including transport index) _____

Packages secured in vehicle _____ Vehicle placarded _____

Shipping papers properly completed _____

Remarks: _____

Operator's signature _____

6. DEFINITIONS & TERMS.

Area alarm

An area radiation level monitor that provides a highly visual warning when the radiation level exceeds a pre-set threshold. Commonly referred to as Gammalarms, use is required by most jurisdictions in permanent radiographic installations and they are often used in conjunction with door interlocks and audible alarms. Portable area alarms are required by some jurisdictions for radiography performed at temporary job-sites.

Alarm ratemeter

An alarm worn by radiography personnel that provides a continuous audible warning when the alarm ratemeter detects a radiation level in excess of a pre-set threshold of 5 mSv/hr (500 mR/hr). This redundant safety alarm is required by regulation for temporary job-site radiography within the USA.

Apparatus for industrial gamma radiography

Apparatus including an gamma-ray source projector, a source assembly as applicable, a remote control, a projection sheath, an exposure head and accessories designed to enable radiation emitted by a sealed radioactive source to be used for industrial gamma radiography purposes. Also known as: isotope radiography system, isotope radiography kit.

Automatic securing mechanism

An automatically activated mechanism located on the radiographic gamma-ray source projector designed to restrict the source assembly in the secured position.

Beam limiter

A shielding device for confining the elements of a beam of radiation to an assigned solid angle. Beam limiters are generally manufactured from lead, tungsten and depleted Uranium and are pre-positioned over/on the radiation source's working position. Also known as: collimators.

Control crank

A control cable cranking device that is a component of the remote controls. The control crank is used at a distance by the radiography personnel to move the radiation source to and from the device, through projection sheaths to and from the exposure position. Manual control crank mechanisms are commonly used, but automatic exposure controllers are available which can be operated from a greater distance and allows preset timing and automatic expose and retract modes. Also known as: wind-outs, crank-outs and hand-cranks.

Control cable

A cable or other mechanical means used to project and retract the source assembly out from and into the radiographic gamma-ray source projector by means of remote control. The control cable includes the means of attachment to the source holder. Also known as: remote control cable, drive cable, Teleflex™ cable.

Control cable sheath

Rigid or flexible tube for guiding the control cable from the remote to the radiographic gamma-ray source projector and providing physical protection to the control cable. The control cable sheath includes the necessary connections for attachment to the radiographic gamma-ray source projector and to the remote control. Also known as: control cable housing, conduit.

Gamma-ray source projector (container)

Radiographic gamma-ray source projectors are used to remotely project the radiation source to a predetermined exposure position when required and to securely maintain it and shield it when it is not in use. Current equipment requirements require devices be designed and tested to ISO/ANSI standards and pertinent transportation regulations for transport containers. Also known as: projector, gamma ray projector (G.R.P.), camera, pill-box, source-box, exposure container.

Exposure head

Device which locates the sealed source included in the source assembly, in the selected working position and prevents the source assembly from projecting out of the projection sheath. Also known as: source stop, end stop, snout and head-hose.

Locked position

Describes the condition when the lock on a radiographic gamma-ray source projector or transport container is fully engaged to lock the source assembly in place and the key is removed from the lock. This condition prevents unauthorized personnel access to the sealed source assembly locked within the device.

Maximum rating

The maximum activity expressed in Becquerels and Curies that cannot be exceeded, of a sealed source specified by radionuclide by the manufacturer when contained within a radiographic gamma-ray source projector or a transport container.

Plunger lock

A mechanical device with a key used to lock or unlock the radiographic gamma-ray source projector or transport container.

Projection sheath

A flexible or rigid tube for guiding the source assembly from the radiographic gamma-ray source projector to the working position, having the necessary connections for attachment to the radiographic gamma-ray source projector and the exposure head or including the exposure head itself. The projection sheaths also provide protection of the source assembly and attached control cable from water, dirt, sand and other foreign materials usually present at radiography environments. Also known as: source guide tubes, guide tubes, source tubes, head-hoses. Examples of rigid projection sheaths include j-tubes, probes, jet engine probes.

Remote control

The mechanical device that enables the source assembly to and from a working position by operation from a distance away from the radiographic gamma-ray source projector. The remote control includes the control crank mechanism (normally a hand-crank), and where applicable, also the control cable, the control cable sheath and the necessary connections and attachments. See additional description under 'control crank'.

Reserve sheath

Remote control sheath (conduit) containing the length of control cable, necessary for the projection of the source assembly.

Sealed source

Radioactive source sealed in a capsule or having a bonded cover, the capsule or cover being strong enough to prevent contact with and dispersion of the radioactive material under the conditions of use and wear for which it was designed. Commonly referred to as: the 'source' or the 'pill'.

Secured position (shielded position)

Condition of the radiographic gamma-ray source projector and source assembly, when the sealed source is fully shielded and restricted to this position within the radiographic gamma-ray source projector.

Note: When in the secured position during radiographic operations, the radiographic gamma-ray source projector may be unlocked.

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Simulated source

A sealed source whose structure is such as that of the sealed radioactive source, but not containing any radioactive material. Also known as: mock source, dummy source, phantom source, dummy pill.

Source assembly

A source holder with a sealed source attached or included. In cases where the sealed source is directly attached to the control cable without the use of a source holder, the source assembly is the control cable with the sealed source attached. In cases where the sealed source is not attached to the control cable nor included within the source holder, the sealed source is the source assembly.

In the case where a simulated source is attached to or included with a source holder or control cable, this becomes a simulated source assembly.

Flexible type source assemblies are also known as 'pigtailed'. The source assembly is most commonly referred to as the 'source'.

Rigid or chain link type source assemblies are also known as: source rods, source pencils, source trains, source chains.

Source holder

A holder or attachment device, by means of which a sealed source or simulated source can be:

- directly included in the radiographic gamma-ray source projector (category I apparatus - an gamma-ray source projector in which the source assembly is not removed for exposure).
- fitted at the end of the control cable (category II apparatus - an gamma-ray source projector from which the source assembly is projected out through a projection sheath to the exposure head for exposure. The exposure is remotely operated.)

Source holders may be an integral part of the source assembly or may be capable of being dismantled for sealed source replacement.

Source changers

A lockable Type A or Type B transport container used to transport new sealed source assemblies, exchange them and return depleted sealed source assemblies to the manufacturer. Source changers are also utilized for storage of sealed source assemblies. Also known as: source exchangers, storage containers.

Working position

Condition of the exposure container and source assembly when in the position intended for the Performance of industrial gamma radiography.

7. EMERGENCIES AND PERSONNEL SAFETY.

7.1 Emergencies

During the termination of a radiographic exposure, observation of the survey meter provides an indication of source movement while cranking the remote control handle. After retracting the sealed source into the gamma-ray source projector, radiographers are required to perform a confirmatory survey of the gamma-ray source projector, the projection sheaths and beam limiter when used. Performing a confirmatory survey after a radiographic exposure is required by regulation and is the only method that the radiographer should rely on to determine if a source assembly is in the fully shielded position within the gamma-ray source projector. If the radiographer measures any radiation level that indicates the sealed source is not fully shielded while performing the confirmatory survey, the radiographer must first recognize that problem exists and then follow his company's emergency procedures. Emergency conditions are those problems in which the source assembly cannot be returned to the shielded position by normal means, specifically the remote control crank mechanism. The majority of problems experienced by radiographers are where the source assembly becomes disconnected or when the source assembly becomes jammed in the projection sheath while in an exposed position. The important safety points for radiographers to follow are:

- Always perform a confirmatory survey after each exposure.
- If higher than expected radiation levels are measured, recognize that an emergency exists.
- Follow emergency procedures.
- Do not attempt to retrieve the sealed source. Secure the area and notify the Radiation Safety Officer.

The radiography crew is limited to the following basic steps that must be adhered to under regulations in the USA (verify national regulations for controlled and supervised areas) :

- 1 Immediately leave the area and maintain continuous surveillance of high radiation area.
- 2 Adjust the restricted area boundary to ensure the measured dose/rate is < 2 mR/hr.
Do not allow anyone into the area.
- 3 Immediately notify the Radiation Safety Officer.
- 4 Do not leave the area unattended under any circumstances. Maintain security of the area until the Radiation Safety Officer arrives at the site.

Do not under any circumstances attempt to retrieve the source. Performing source retrieval is a licensed activity that allows only specially trained RSOs to respond to an emergency. This regulatory requirement is the result of overexposures to radiographers attempting to handle emergency retrievals by themselves.



WARNING



An unshielded source must not be picked up or handled at close range under any circumstances. An unshielded source at close range can cause serious injury or death to anyone who is exposed to it, even for a short duration of time.

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7.2 Training

Formal classroom training in radiation safety, supervised hands-on training and certification by an independent certifying organization of radiographers are essential components for radiological safety in isotope radiography and is a regulatory requirement in the United States and Canada.

Sentinel™, QSA Global, Inc. provides radiation safety, inspection & maintenance and retrieval training at the Baton Rouge, Louisiana and Burlington, Massachusetts facilities. On-site training is available by arrangement.

7.3 Access to Restricted Areas

The site where radiography is performed must be separated from other work areas by as much distance as possible. If applicable, check for occupation of the areas above and below the radiography site.

Clearly defined boundaries must be set up and warning signs displayed to provide warning and prevent access to the radiography site by unauthorized personnel before any exposure begins.

No one should enter the boundary marking a 'Restricted Area' or 'Controlled Area' without a film badge or TLD, direct reading pocket dosimeter (or electronic pocket dosimeter) and alarm ratemeter (if required).

A pocket 'chirper' alarm is required in some countries to provide radiography personnel with an immediate audible warning of a high radiation intensity.

7.4 United States Regulations

'High Radiation Area' signs must be posted where a dose of 1 mSv (100 mRem) could be received in any one hour. The radiographers must provide continuous direct surveillance of the area or when a permanent installation is used, the entrance must be equipped with door interlocks, audible and visual warnings.

'Radiation Area' signs must be posted where dose of 5 μ Sv (5 mRem) could be received in any one hour.

'Restricted Area' must be identified and posted where a dose of 20 μ Sv (2 mRem) could be received in any one hour or 1 mSv (100 mRem) in one year.

In practice, the 'Radiation Area' and 'Restricted Area' are combined and identified by the use of a rope barrier. The area is posted with the 'Radiation Area' signs where the maximum dose will not exceed 20 μ Sv (2 mR) in any one hour or 1 mSv (100 mRem) in a year. The practice of using the 'Radiation Area' sign at the 'Restricted Area' boundary clearly defines why the area has been restricted. Additionally, the trefoil (radiation) symbol provides a visual warning for those individuals who cannot read.

During a radiographic exposure, a calibrated and operable survey meter must be used to confirm the dose rate at the 'Restricted Area' boundary and adjusted if the dose rate exceeds the limit of 20 μ Sv (2 mRem) in one hour.

During the radiographic exposure, the radiographers must maintain continuous direct surveillance of the 'High Radiation Area' in addition to ensuring that no one enters their posted 'Restricted Area'.

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7.5 EU Regulations

A 'Controlled Area' must be marked with a barrier at a distance where the radiation intensity will not exceed 7.5 $\mu\text{Sv/hr}$ (0.75 mR/hr). The boundary dose rates must be noted and the record kept for 2 years. During radiographic operations, only classified radiation workers are allowed inside this area.

A 'Supervised Area' is defined as the area where the boundary dose rate limit must not exceed 2.5 $\mu\text{Sv/hr}$ (0.25 mR/hr). No barriers or notices are required here, but the radiographer must be vigilant to ensure that personnel in this area do not enter the 'Controlled Area'.

7.6 Personnel Monitoring

All personnel who enter a 'Restricted' or 'Controlled' area or are present during radiographic operations are required to wear the appropriate personnel monitoring devices as required by the regulatory jurisdiction. These devices can include; film badges; thermoluminescent dosimeters (TLD); optically stimulated luminescence badges; direct reading pocket dosimeters; electronic pocket dosimeters; alarm ratemeters; and audible alarms. Calibrated and operable survey meters must be used to determine radiation levels when conducting radiographic operations.

8. DISPOSAL.

By international regulations, radioactive materials that are no longer required must be transferred to a licensed recipient for final disposition. Radioactive source assemblies that have depleted beyond their useful working life may be returned to authorized recipients using a source changer authorized for the specific model source assembly.

Authorized recipients will provide any specific conditions to the shipper as required by regulatory authorities. As a minimum, sources that are transferred for a final disposition must be within a current leak test and properly secured within an authorized package before shipment.

Damaged, cropped, modified or contaminated source assemblies may require special handling and special transport containers. Notify the authorized recipient for specific instructions in these circumstances.

Depleted Uranium (DU) shielded gamma-ray source projectors that are removed from service due to severe damage, worn through 'S' tubes or decommissioning reasons must be sent to a licensed recipient for final disposition. If the Type A transport status of a damaged gamma-ray source projector/package is impaired, the gamma-ray source projector must be transported without radioactive source assemblies. DU shielded exposure devices sent for final disposition must be properly packaged, surveyed, marked and labeled before placement into the transportation system.

Contact QSA Global, Inc. for assistance in the transfer of DU shielded gamma-ray source projector for final disposition.

9. CONTACT INFORMATION.

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