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OPERATIONS & MAINTENANCE MANUAL. MAN-054

SENTINEL™ 1075 SCAR*Pro*.

GAMMA-RAY SOURCE PROJECTOR & TRANSPORT CONTAINER

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DANGER – IMPORTANT WARNINGS

These transport containers must only be used for radiography source assemblies that are approved for use. Please refer to Table 2 for a listing of source assemblies that are authorized for use in this gamma-ray source projector. This system 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 these radiographic gamma-ray source projectors 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 emits 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 system perform adequate radiation surveys of the gamma-ray source projector. 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 gamma-ray source projector 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.

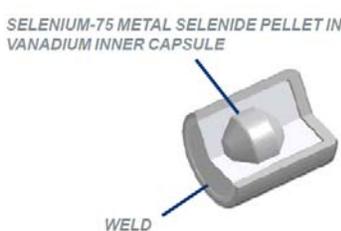
Do not use any components that are not approved for use with the radiography system, or after-market components that may compromise the safety designed into the system.

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™ 1075 SCARPro	
Primary Application	Industrial gamma radiography	
Device Configuration/ Mode	SCAR (with Collimator)	PROJECTOR
Device Weight (Maximum)	40 pounds (18 kilograms)	35 pounds (16 kilograms)
Device Overall Length	11.5 inches (292 mm)	11.2 inches (284 mm)
Device Overall Height	7.25 inches (184 millimeters)	
Device Overall Width	6.0 inches (152 millimeters)	
Device Capacity - Isotope	81 Curies Selenium-75	
Device Shielding Materials	Tungsten & Stainless steel	
Operating Temperature	-40°F to 300°F (-40°C to 149°C)	
Transport Approvals	Type A within the model SENTINEL 1075A overpack meets 49 CFR173, IAEA TS-R-1 (2009) and IAEA SSR-6 (2012)	
Transport Package Weight	60 pounds (27.2 kilograms) maximum Version 1 66 pounds (29.9 kilograms) maximum Version 2	
Compatible Sources	Refer to Table 2.	
Compatible Controls	Refer to Table 3.	
Compatible Guide Tubes	Refer to Table 4.	
Compatible Source Changers	Model 650L – See MAN-020 with applicable addendums.	
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.	

1.2 Source Assembly Specifications

Table 2 - Compatible Source Assembly Specifications – License Information		
Manufacturer	QSA Global, Inc., Burlington, Massachusetts, USA.	
Source Assembly	Model A425-6	
Capsule Design	Double Encapsulation	
Special Form Certificate	USA/0335/S-96	
Sealed Source and Device Registration Number	MA-1059-D-378-S	
ANSI/ISO Source Classification	97E64515	
Maximum Source Activity	81 Ci (3 TBq)	
Nuclide / Isotope	Selenium-75	 <p>SELENIUM-75 METAL SELENIDE PELLETT IN VANADIUM INNER CAPSULE</p> <p>WELD</p>
Isotope Gamma Energy Range	66 – 401 keV	
Isotope Half Life	120 days	
Isotope Output at 1 meter per Curie (37 GBq)	0.203R/hr (2.03mSv/hr)	
Isotope Output at 1 foot per Curie (37 GBq)	2.2R/hr (22.0mSv/hr)	
Selected Attenuation Data		
Material	Approximate Material Density (g/cm ³)	Se-75 Approximate Half Value Thickness Inches (mm)
Concrete	2.35	1.180 (30.0)
Aluminium	2.65	1.100 (27.0)
Steel	7.80	0.315 (8.0)
Lead	11.34	0.039 (1.0)
Tungsten	17.80	0.032 (0.8)
Depleted Uranium	18.70	-

1.3 Compatible Control Specifications

Table 3 - Compatible Controls Specifications					
					
Manufacturer		QSA Global, Inc., Burlington, Massachusetts, USA.			
Standard Control Lengths in Feet (ft.) & Meters (m)		<ul style="list-style-type: none"> ➤ 25 ft. (7.6 m) ➤ 35 ft. (10.7 m) ➤ 50 ft. (15.2 m) 			
Product code	Model number	Style	Odometer	Housing length	Unit weight
TAN66425	66425	Reel	Yes	25 ft (7.6 m)	21 lb (10 kg)
TAN66435	66435	Reel	Yes	35 ft (10.7 m)	24 lb (11 kg)
TAN66450	66450	Reel	Yes	50 ft (15.2 m)	27 lb (12 kg)
TAN69325	69325	Pistol Grip	Yes	25 ft (7.6 m)	21 lb (10 kg)
TAN69335	69335	Pistol Grip	Yes	35 ft (10.7 m)	24 lb (11 kg)
TAN69350	69350	Pistol Grip	Yes	50 ft (15.2 m)	27 lb (12 kg)
TAN69225	69225	Pistol Grip	No	25 ft (7.6 m)	21 lb (10 kg)
TAN69235	69235	Pistol Grip	No	35 ft (10.7 m)	24 lb (11 kg)
TAN69250	69250	Pistol Grip	No	50 ft (15.2 m)	27 lb (12 kg)
SAN88225	88225	Pistol Grip	No	25 ft (7.6 m)	14 lb (6 kg)
SAN88235	88235	Pistol Grip	No	35 ft (10.7 m)	17 lb (8 kg)
SAN88250	88250	Pistol Grip	No	50 ft (15.2 m)	22 lb (10 kg)
SAN88225R	88225R	Pistol Grip	No	25 ft (7.6 m)	14 lb (6 kg)
SAN88235R	88235R	Pistol Grip	No	35 ft (10.7 m)	17 lb (8 kg)
SAN88250R	88250R	Pistol Grip	No	50 ft (15.2 m)	22 lb (10 kg)
SAN88525	88525	Reel	No	25 ft (7.6 m)	18 lb (8 kg)
SAN88535	88535	Reel	No	35 ft (10.7 m)	21 lb (10 kg)
SAN88550	88550	Reel	No	50 ft (15.2 m)	26 lb (12 kg)

1.4 Compatible Guide Tube Specifications

Table 4 - Compatible Guide Tubes Specifications				
<i>EXTREME CONDITION SOURCE GUIDE TUBE</i>		<i>STANDARD SOURCE GUIDE TUBE</i>		
				
Manufacturer	QSA Global, Inc., Burlington, Massachusetts, USA.			
Product code	Length (See note)	Style	Description	
TAN48906	7 ft. (2.1 m)	Standard	Fixed End Stop	
TAN48931	7 ft. (2.1 m)	Standard	Fixed End Stop	
TAN48907	7 ft. (2.1 m)	Standard	Extension	
48998	21 ft. (6.4 m) 28 ft. (8.5 m) 42 ft. (12.8 m)	Standard	Single Guide Tube – Device Connect with End Stop	
48999	7 ft. (2.1 m)	Standard	Device Connect Extension	
95020	7 ft. (2.1 m)	Extreme	Fixed End Stop	
95075	7 ft. (2.1 m)	Extreme	Fixed End Stop	
95021	7 ft. (2.1 m)	Extreme	Extension	
95073	21 ft. (6.4 m) 28 ft. (8.5 m) 42 ft. (12.8 m)	Extreme	Single Guide Tube – Device Connect with End Stop	
95074	7 ft. (2.1 m)	Extreme	Device Connect Extension	
NOTE: Non-standard lengths up to 42 feet available upon request.				
WARNING – USE THE PROPER GUIDE TUBE COMBINED LENGTHS				
Control Set Length	Guide Tube Set (Maximum quantity & length)			Combined Guide Tube Length
	Fixed End Stop	Extension	Device Connect Extension	
25 ft.	1 (7 ft.)	1 (7 ft.)	1 (7 ft.)	21 ft.
35 ft.	1 (7 ft.)	2 (14 ft.)	1 (7 ft.)	28 ft.
50 ft.	1 (7 ft.)	4 (28 ft.)	1 (7 ft.)	42 ft.

1.5 General Gamma-Ray Source Projector Description

The SENTINEL™ 1075 SCAR*Pro* is a dual-mode gamma ray source projector designed for 24/7 gamma radiography applications using Selenium-75.

The SENTINEL 1075 SCAR*Pro* gamma-ray source projector can be configured in one of two radiography modes of operation. A collimator directly attached to the device allows for small controlled area radiography (SCAR) applications. When not performing SCAR, the collimator is replaced by a conventional front plate assembly for radiography applications requiring guide tubes.

Changing between the two configurations is quick, easy, and safe, but must only be done by qualified technicians with the proper tools and training.

Figures 1 and 2 show the device in each of the two operational configurations.



Figure 1 – SENTINEL 1075 SCAR

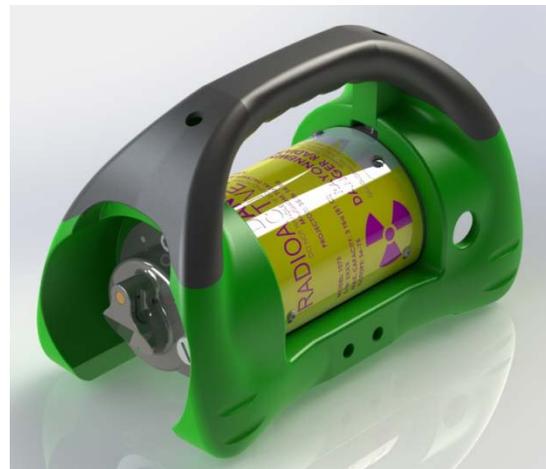


Figure 2 – SENTINEL 1075 Projector

The basic structure of the SENTINEL 1075 SCAR*Pro* has an all tungsten shield centrally located and securely mounted within a tubular stainless steel outer housing. The housing is oriented horizontally for stability and to provide easy access to the automatic source locking mechanism and the source assembly connector as well as the front plate or collimator. The automatic locking mechanism is fully compatible with all QSA approved remote controls and the front plate assembly is fully compatible with all QSA approved guide tubes/ projection sheaths listed in this manual.

The shield housing and nameplate is protected by a plastic jacket with integrated lifting handle and base supports and includes attachment provisions for mounting the exposure device to a pipe or some other work-piece for SCAR use.

To meet or exceed regulatory and performance standards for safety and reliability, the **SENTINEL 1075 SCAR*Pro*** gamma-ray source projector is designed, tested, and manufactured to the requirements of ANSI N432-1980, ISO 3999:2004(E), IAEA TS-R-1 (2009), IAEA SSR-6 (2012) USNRC 10CFR34, 10CFR71, and USDOT 49CFR173 requirements. Additionally the exposure device is designed, manufactured, and serviced under an ISO 9001 and USNRC 10CFR71 subpart H QA program. The QA program also includes the reporting requirements of USNRC 10CFR21 for suppliers of source and byproduct materials.

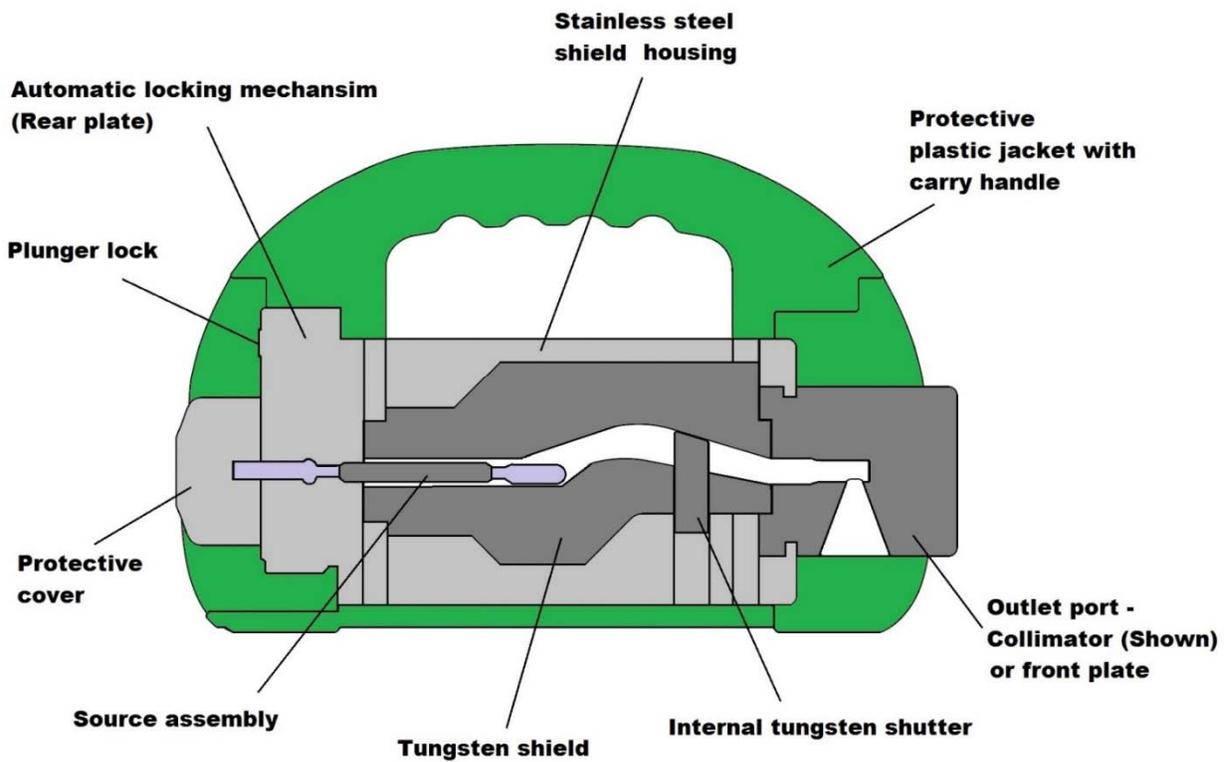


Figure 3 – SENTINEL 1075 SCARPro Gamma-Ray Source Projector

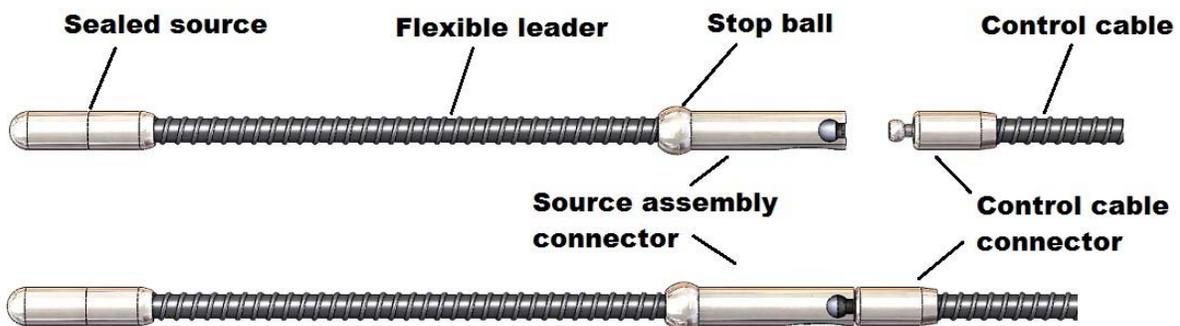


Figure 4 – Source Assembly (Shields not shown) & Remote Control Cable Connectors

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1.6 Notice

This industrial radiography system is used as a gamma-ray source projector and a Type A shipping container for QSA Global, Inc. source assemblies. The purpose of this manual is to provide information that will assist qualified radiographers in using the SENTINEL 1075 SCAR*Pro* 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 or perform source changes, 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.

Prior to the initial use of the gamma-ray source projector as a shipping container in the USA, the user must register with the Office of Nuclear Material Safety and Security, U.S. Nuclear Regulatory Commission. The user should have in his possession a copy of the Certificate of Compliance issued for the gamma-ray source projector, which may be obtained from QSA Global, Inc. customer service centers upon request. This also applies to users from Agreement States and other regulatory jurisdictions.

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.

1.7 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.

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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.

QSA Global, Inc. has obtained equipment and transport package approvals for the SENTINEL 1075 SCAR*Pro* from the Commonwealth of Massachusetts, and the Canadian Nuclear Safety Commission. In Canada, the radiography equipment approvals require use of approved remote controls, control cables, projection sheaths, sealed source assemblies, and remote control cranks in conjunction with the SENTINEL 1075 SCAR*Pro* gamma-ray source projector. For additional information on compliance with and/or status of Type A certifications, 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.

Personnel operating this equipment must be completely familiar with this manual and they must read and understand these important safety alerts before proceeding.

IMPORTANT SAFETY ALERTS
NOTICE: Can cause minor problems and reminders.
CAUTION: Can cause equipment damage or potential problems.
WARNING: Can cause serious or fatal injury.
DANGER: Will cause serious or fatal injury.



WARNING



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 before using the system. Do not compromise on safety. Always perform the daily inspection of the exposure device, projection sheaths and remote controls prior to use.

Any foreign material (dirt, mud, ice, etc.) must be removed before using the system. Inspect, clean, and test the equipment as described in this manual to ensure long term safety and reliability.

Do not use any component that is not approved for use with this radiography system or any after-market component as they may compromise the safety features designed into the system.

Defective equipment that is discovered during the daily inspection must be removed from service until repaired or replaced.

The user of this equipment must follow the operating instructions, in the order shown, to ensure safe operations and compliance with government regulations.

2.1 Job Site Safety Precautions



WARNING: JOB SITE SAFETY PRECAUTIONS



Personal Safety Instruments

The radiographer and radiography assistants must at all times wear a film badge or TLD and pocket dosimeter with a range of 0-2mSv (0-200mRem). 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 (2mR/hr) up to 10mSv/hr (1,000mR/hr).

Canadian regulations require that survey meters used for industrial radiography be capable of measuring from 2 μ Sv/hr (0.2mR/hr) and up to 100mSv/hr (10R/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 only be performed 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. When using guide tubes with the 1075Pro configuration, whenever possible, the use of a collimator (beam limiter) provides effective shielding to reduce radiation levels outside of the central beam. It is recommended that collimators be used at temporary job sites to minimize occupational exposure to radiation.

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.

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2.2 Gamma-ray Source Projector Mode Change

The operating mode of the exposure device can be changed by anyone trained and qualified to do so and by following the instructions provided in this section. One of the two styles of outlet port assemblies is normally already attached to the device.

Figure 5 shows the device with both outlet port assemblies removed. The removed front plate assembly is shown on the right in the figure and the removed collimator assembly is shown on the left.

	<h1>DANGER</h1>	
<p>An internal shielded shutter <u>must first be closed</u> before removing either the collimator or front plate.</p> <p>When the shutter is open, a safety interlock system prevents the removal of the collimator or front plate.</p> <p>Tampering with or bypassing the interlock system in an attempt to move the shutter to the open position with assemblies removed will increase radiation levels at the front outlet port.</p>		

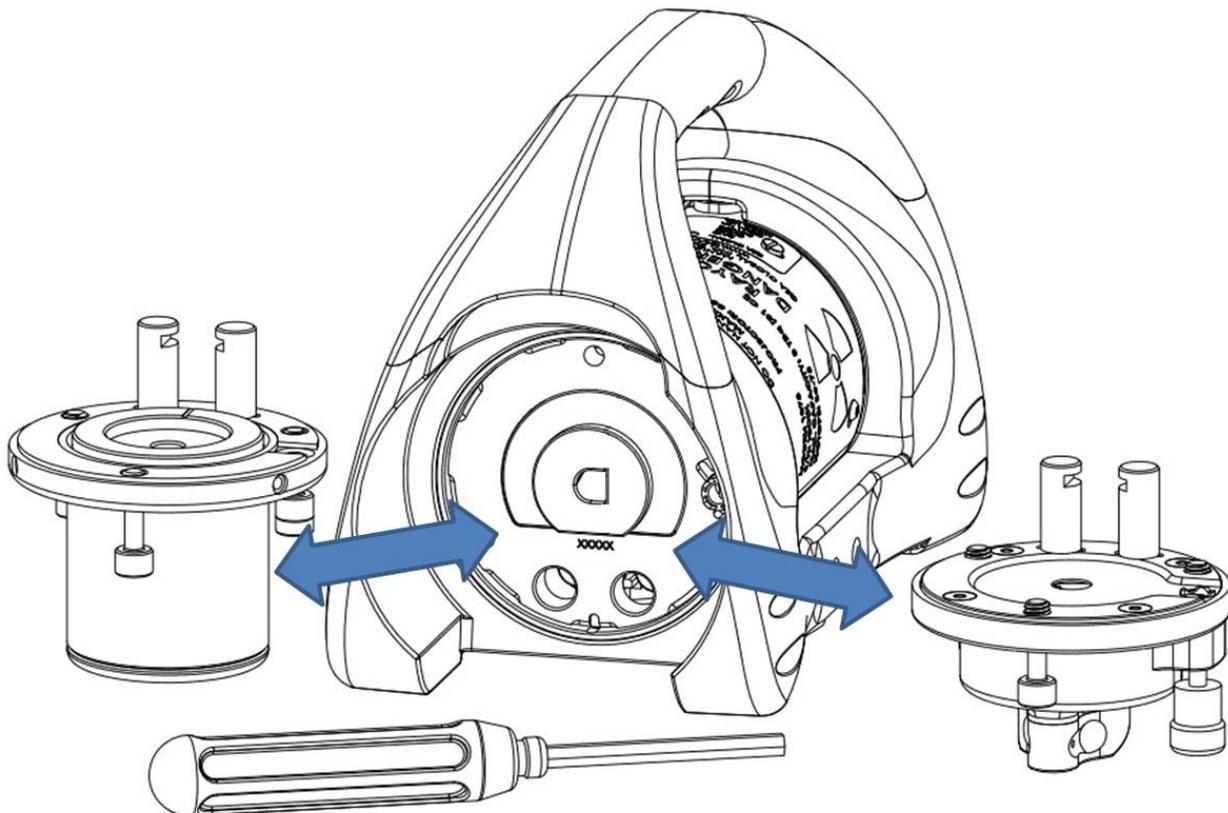


Figure 5 – SENTINEL 1075 SCARPro with Outlet Port Assemblies Removed

STEP 1 (Mode Change)

Gamma-ray source projector Survey

Protection against radiation incidents begins with proper survey meter use. Operators must inspect the survey instrument to verify that it is operating properly in accordance with 10 CFR 34.31 and applicable company specific operating procedures.

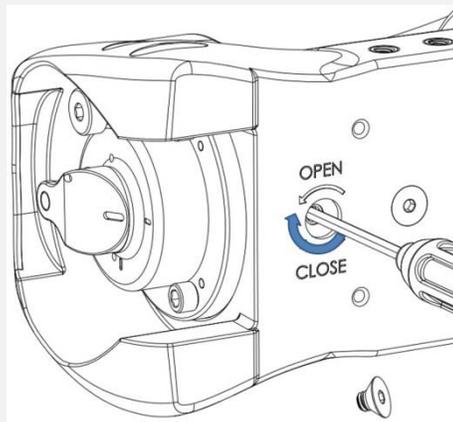
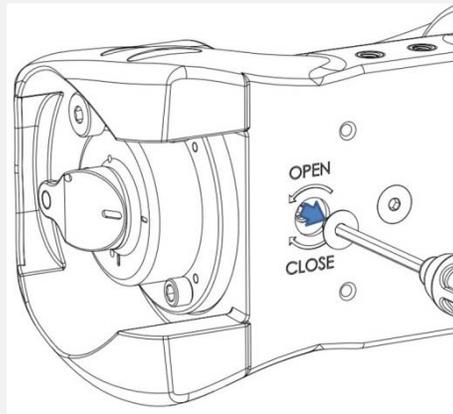
Check the operation of the survey meter by measuring the radiation level at the surface of the gamma-ray source projector. The radiation level measurement should not exceed 2 mSv/hr (200 mR/hr) on any surface of the gamma-ray source projector. Use this measurement for verification surveys of the source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

(Perform a daily inspection of all equipment used according to the daily inspection section.)

STEP 2 (Mode Change)

Close the internal shutter before removing an outlet port assembly

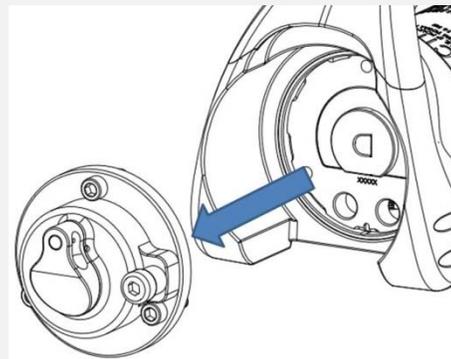
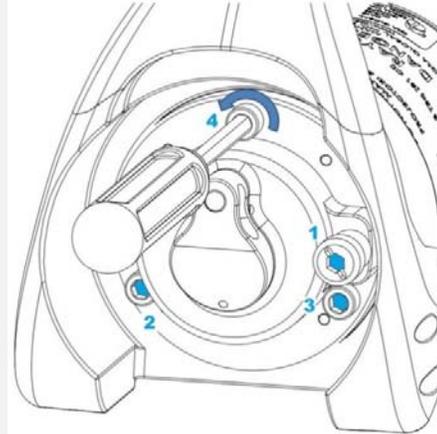
1. Lay the exposure device on its side to access the base.
2. Locate the shutter adjusting screw identified by the "OPEN" & "CLOSE" markings. The shutter adjusting screw is protected under the flat head screw.
3. Remove the flat head screw with a 3/16 inch hex wrench. Install screw back after adjustments.
4. The shutter adjusting screw can now be accessed and adjusted.
5. Insert the 3/16 inch hex wrench into the shutter adjusting screw.
6. To close the shutter before a mode change, turn the screw clockwise until it stops turning. **DO NOT** force the screw to turn.



STEP 3 (Mode Change)

Remove an outlet port assembly

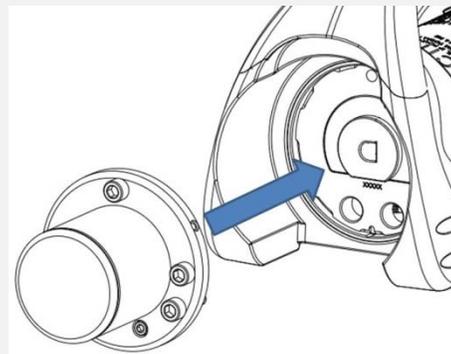
1. Both the collimator and the front port assembly are removed from the device the same way. The instructions below show the removal of the front plate assembly as an example.
2. Place the device upright on its base.
3. Use a $\frac{1}{4}$ inch hex wrench to loosen the four socket head screws. These screws are captive in the assembly and need not be removed from the plate assembly.
4. Pull the outlet port assembly straight out away from the end of the device.
5. Store the removed assembly in the carry case.



STEP 4 (Mode Change)

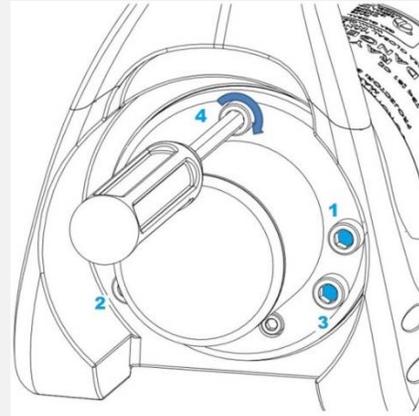
Attach an outlet port assembly

1. Both the collimator and the front port assembly are removed from the device the same way. The instructions below show the attachment of the collimator assembly as an example.
2. Keep the device upright on its base.
3. Verify the beam port is directed as desired before installation.
4. Align the two pins on the collimator assembly with the holes in the mating face of the device.
5. Push the collimator assembly straight onto the end of the device against the mating face.



STEP 4 Continued (Mode Change)

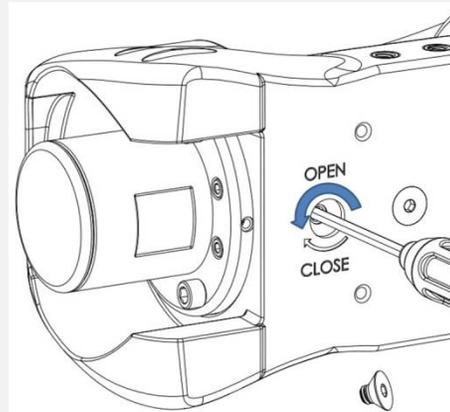
6. Use a ¼ inch hex wrench to tighten the four captive screws.



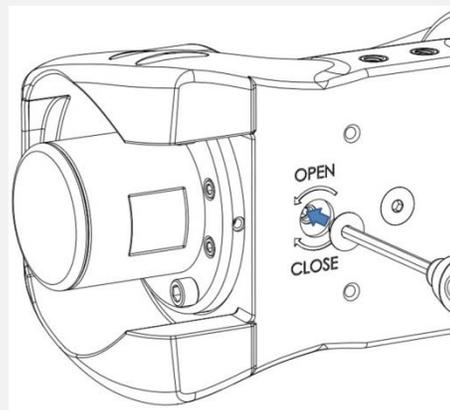
STEP 5 (Mode Change)

Open the internal shutter after attaching an outlet port assembly

1. Lay the exposure device on its side to access the base.
2. Ensure the flat head screw is not covering the shutter adjusting screw.
3. Insert the 3/16 inch hex wrench into the shutter adjusting screw.
4. To open the shutter after a mode change, turn the screw counter-clockwise until it stops turning. **DO NOT** force the screw to turn.



5. Install the flat head screw with a 3/16 inch hex wrench to cover and protect the shutter adjusting screw.



2.3 Gamma-ray Source Projector Mode Use

The front plate assembly must be securely attached to the exposure device before using the device in projector mode. The following instructions describe the method for proper source guide tube attachment to the device. For collimator use in SCAR mode, refer to Section 2.4. For remote control attachment, refer to Section 2.5.

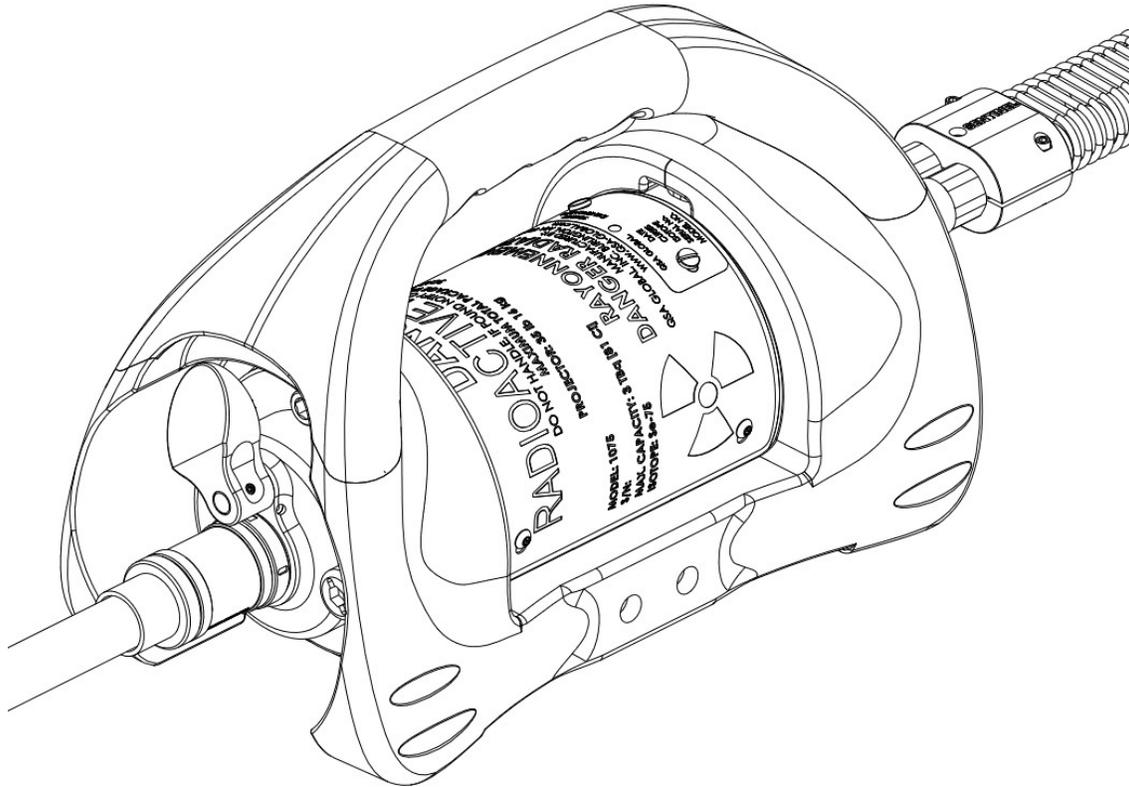


Figure 6 – SENTINEL 1075 SCARPro in Projector Mode (with Front Plate Assembly).

STEP 1 (Projector Use)

Gamma-ray source projector Survey

1. Ensure the survey meter is calibrated and working properly.
2. Measure the surface of the exposure device to ensure any reading does not exceed 2mSv/hr (200mR/hr).
3. Use these initial readings for a later comparison with the confirmatory survey readings taken once the source has been retracted back into the exposure device after exposure.

STEP 2 (Projector Use)

Pre-Use Equipment Inspection

1. Visually inspect the equipment for damage, excessive wear, and any foreign material that could impair safe operation.
2. Remove the equipment from service if it does not operate safely.

STEP 3 (Projector Use)

Source Guide Tube (projection sheath) Preparation for Use

1. Before using the guide tubes, ensure they have been inspected per Section 3.3 of this manual.
2. Position and secure the source stop (exposure head) guide tube at the radiographic focal location using either a tripod stand with swivel clamps or some other suitable means for securing the source stop.
3. Ensure there is a source stop on the guide tube.
4. Use a collimator (beam limiter) to direct the primary beam away from unwanted directions.
5. Find a stable location for the exposure device and lay down the guide tubes as straight as possible. Keep guide tube bends equal to or greater than 20 inches (0.5 meters) to avoid restricted source assembly movement.
6. The guide tubes must not contact any heated surface hotter than 140°F (60°C).
7. Prevent possible damage to the guide tubes by making sure the area is clear of any potential falling objects, vehicles, doorways, etc.

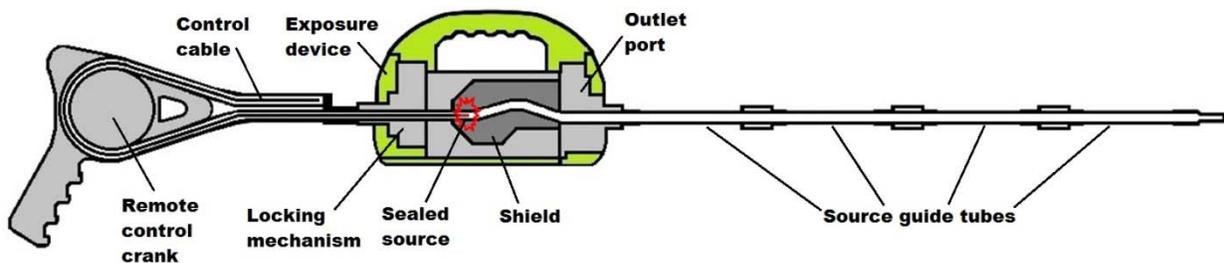


Figure 7 – SENTINEL 1075 SCARPro in Projector Mode (Source Secured)

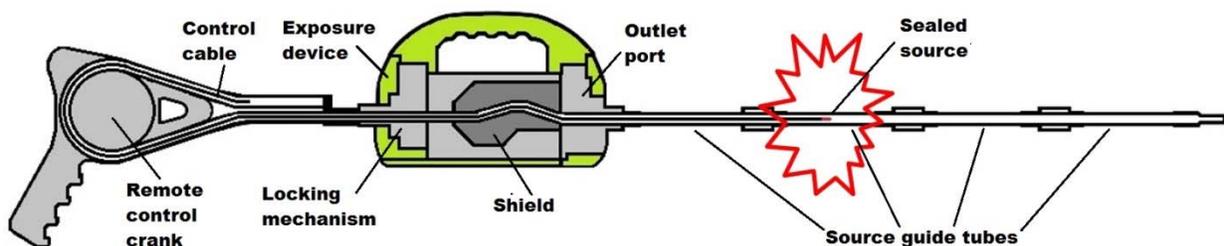


Figure 8 – SENTINEL 1075 SCARPro in Projector Mode (Source in Transit)

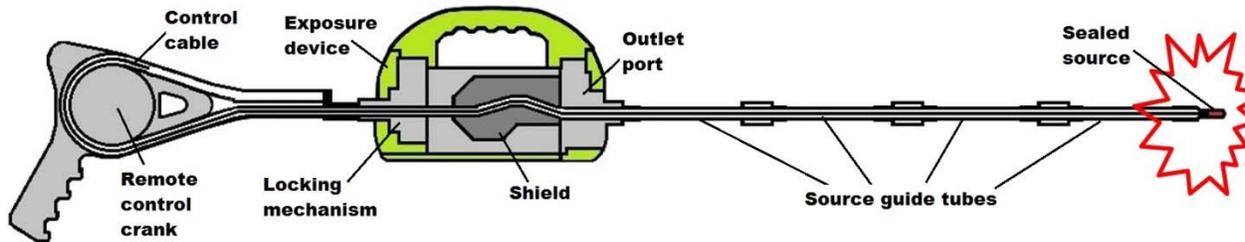
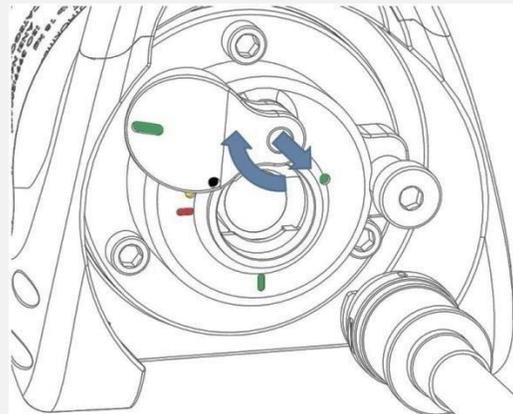


Figure 9 – SENTINEL 1075 SCARPro in Projector Mode (Source Exposed at End Stop)

STEP 4 (Projector Use)

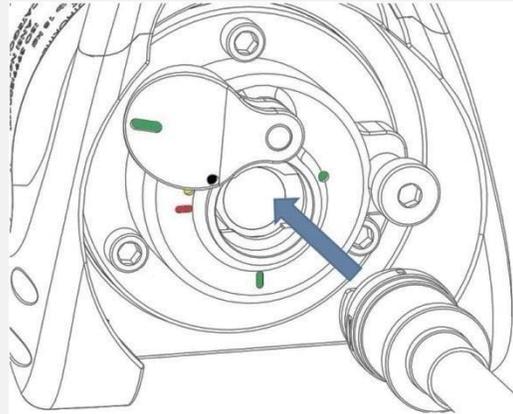
Connect the source guide tube(s) to the gamma-ray source projector

1. Before attaching the guide tubes to the device, ensure they have been inspected per Section 3.3 of this manual.
2. Remove any protective caps from the guide tube ends if present.
3. With the outlet cover knob in the closed position (**BLACK** painted dot will be aligned with the **GREEN** painted dot), grip and pull the cover knob.
4. Rotate the knob 1/4 turn clockwise and release (**BLACK** dot will now be near the **YELLOW** (caution) dot on the plate).

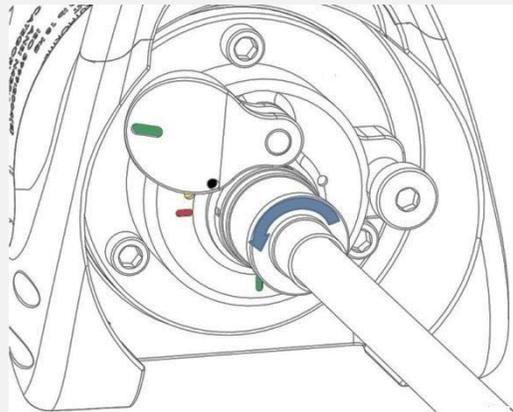


STEP 4 Continued (Projector Use)

5. Insert the guide tube bayonet fitting into the open port by aligning the **GREEN** slots.

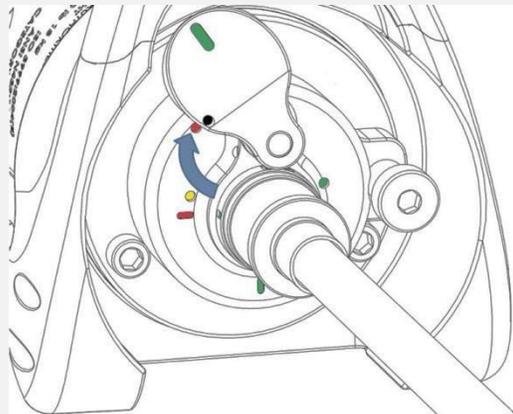


6. Rotate the guide tube fitting 1/4 turn counter-clockwise.



7. Rotate the port cover knob up clockwise until it stops at the 11 o'clock position.

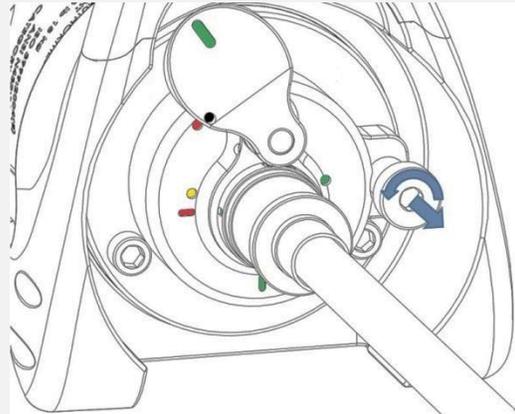
The **BLACK** dot will now be near the **RED** (opened) dot on the plate indicating the outlet port shielding has moved to the open position.



STEP 4 Continued (Projector Use)

8. Grip and pull the spring-loaded interlock knob. Rotate the knob 1/8 turn counter-clockwise and then release it into detent position. Push on the knob to ensure it is seated.

NOTE: This step will allow the lock slide on the automatic securing mechanism of the rear plate to move for source projection.



2.4 SCAR Mode Use

The collimator assembly must be securely attached to the exposure device before using the device in SCAR mode. The following instructions describe the method for proper SCAR device setup. For projector mode use, refer to Section 2.3. For remote control attachment, refer to Section 2.5.

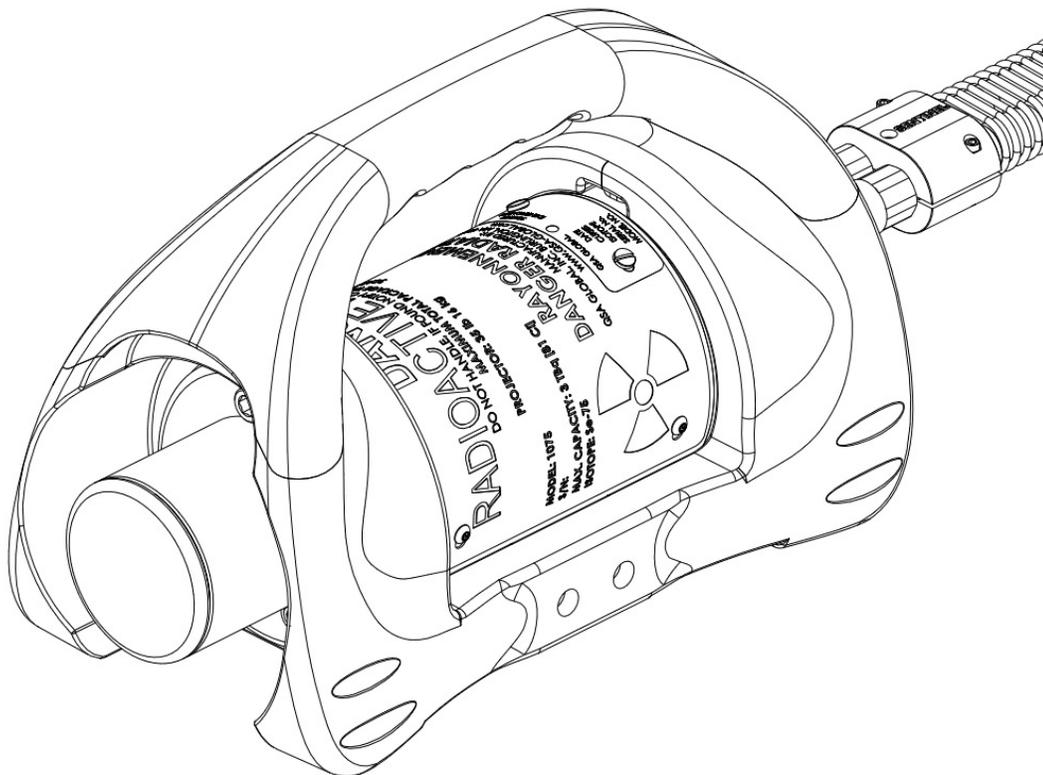


Figure 10 – SENTINEL 1075 SCARPro in SCAR Mode

QSA GLOBAL.

STEP 1 (SCAR Mode Use)

Gamma-ray source projector Survey

1. Ensure the survey meter is calibrated and working properly.
2. Measure the surface of the exposure device to ensure any reading does not exceed 2mSv/hr (200mR/hr).
3. Use these initial readings for a later comparison with the confirmatory survey readings taken once the source has been retracted back into the exposure device after exposure.
4. In addition to surveying the exposure device, the qualified radiographer must also survey the SCAR collimator (or entire length of guide tubes, if used).

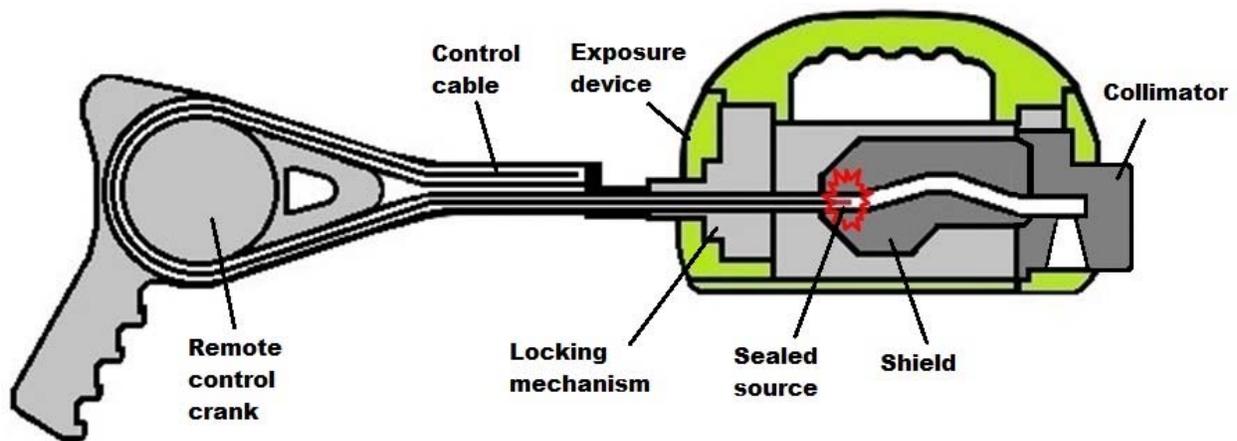


Figure 11 – SENTINEL 1075 SCARPro in SCAR Mode – Source Secured

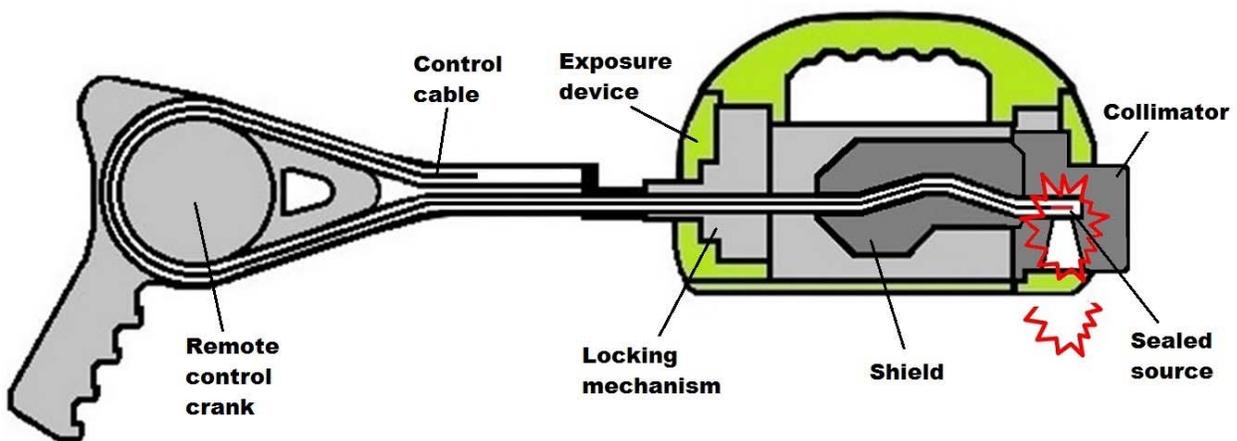


Figure 12 – SENTINEL 1075 SCARPro in SCAR Mode – Source Exposed

2.5 Source Projection and Retraction (Exposures)

A safety interlock feature requires that either the collimator assembly or the front plate assembly must be securely attached to the exposure device before the source can be exposed. If neither assembly is present, the interlocks within the device will prevent movement of the source from the shielded/secured position.

A separate safety interlock feature requires a guide tube to be connected before the front outlet port can be opened fully.

The following instructions describe the method for proper remote control use with the device. For projector mode use, refer to Section 2.3. For SCAR mode use, refer to Section 2.4.

CAUTION

Ensure that the exposed length of the control cable is greater than the total length of the source guide tubes and projector. See the technical specifications section for recommended limits.

If the total guide tube length exceeds the exposed drive cable length, then:

- The source assembly cannot be projected all the way to the source stop of the terminating source guide tube and be correctly positioned for the exposure.
- The source assembly may not reach a collimator; therefore, restricted area dose rates may be higher than expected.
- The control cable end may be cranked beyond the drive wheel of the remote controls if the drive cable is not fitted with a safety retaining spring. This scenario must be treated as an EMERGENCY.

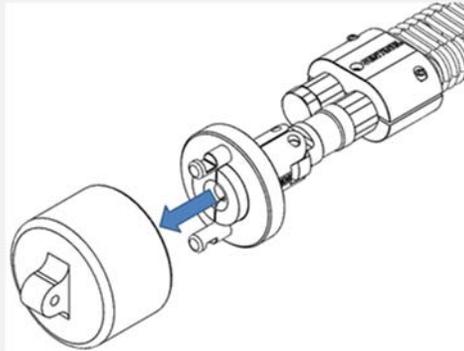
STEP 1 (Exposures)

Prepare the remote controls for use

1. Before using the controls, ensure they have been inspected per Section 3.4 of this manual.
2. Lay out the control housings as straight as possible. Each bend radius, if present, must be approximately 3 feet (1 meter) or more.
3. Avoid any risk of damage to the control housings by falling objects, moving vehicles, closing doors, hot surfaces, etc.
4. The control crank mechanism (operator's hand-crank) should be placed as far away from the source focal position as possible (preferably behind shielding).

STEP 1 Continued (Exposures)

5. Remove the protective rubber end-cap from the 661 safety connector.



CAUTION

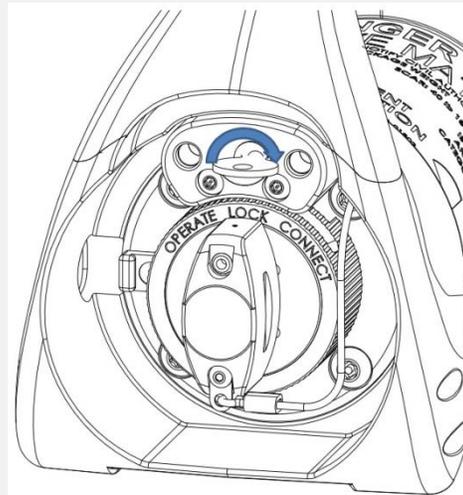
The control cable connector is made from hardened steel and should never be left unprotected. Do not force the control cable connector into source assembly connector. This could damage the connectors over time leading to possible breakage during use.

ALWAYS use the protective end-cap when the remote controls are not connected to the exposure device.

STEP 2 (Exposures)

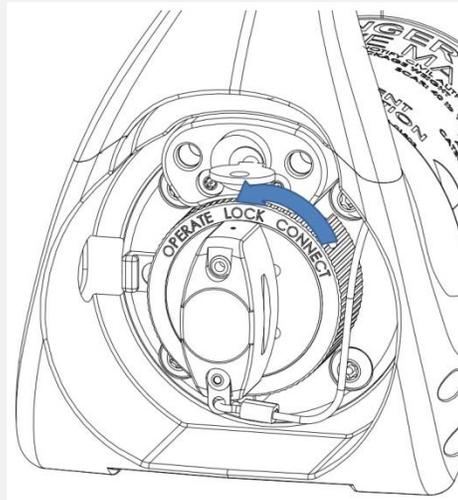
Connect the remote controls to the gamma-ray source projector

1. Visually inspect the controls before attaching them to the device per Section 3.4 of this manual.
2. Unlock the spring loaded plunger lock with the key. Turn the key clockwise to unlock.

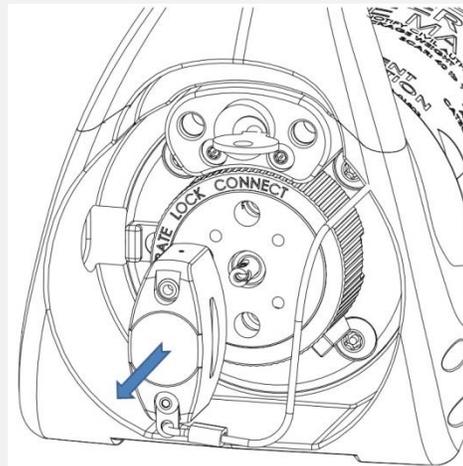


STEP 2 Continued (Exposures)

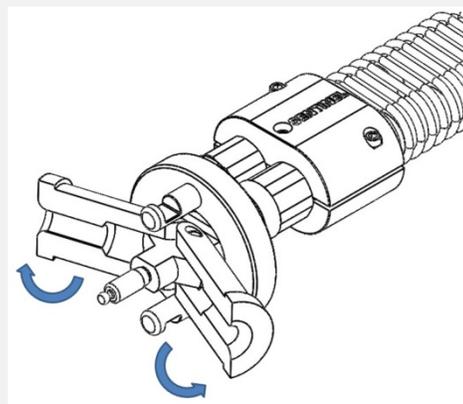
3. Turn the selector ring from LOCK to CONNECT.



4. The protective cover will disengage from the exposure device.



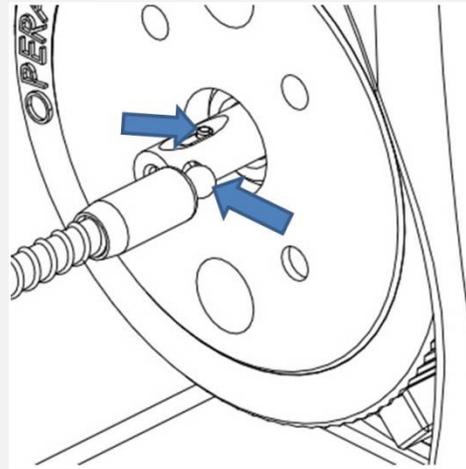
5. Slide the 661 safety connector collar back to open the jaws to access the control cable connector.



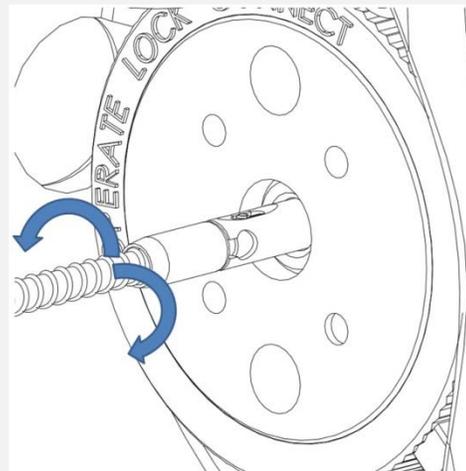
STEP 2 Continued (Exposures)

6. Slide your thumb-nail along the groove in the source connector pushing the spring pin until the internal sleeve slides back enough to allow the ball end of the control connector to enter the key slot of the source connector.
7. Release the spring pin of the source connector. Check that the sleeve has returned and captures the ball feature of the control connector making a secure connection.

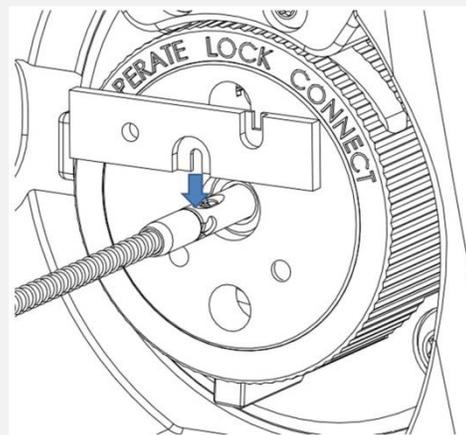
NOTE: ALWAYS manually move the sleeve in the source connector to the OPEN position when attaching and removing the control cable connector.



8. Check for a proper connection by lightly flexing (wagging) the control cable up and down and side to side, especially in low-light working conditions.



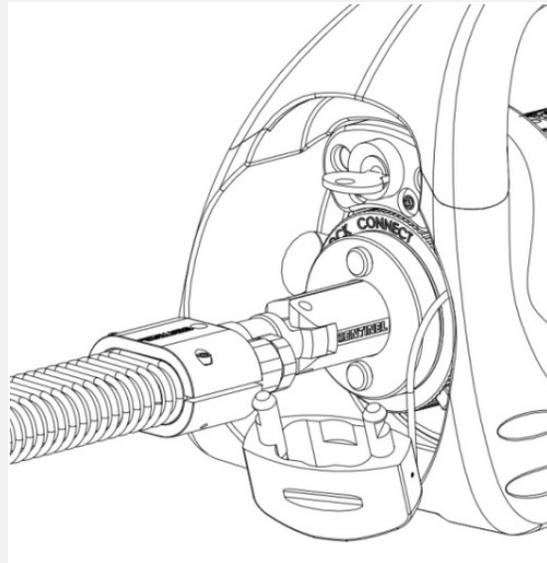
9. Use the NO-GO gauge to check the gap between the joined connectors.
10. The gage should not fit in the gap between the connectors for a proper connection.



STEP 2 Continued (Exposures)

11. Close the pivoting jaws of the 661 safety connector over the joined connectors.
12. Slide the 661 safety connector color over the pivoting jaws.

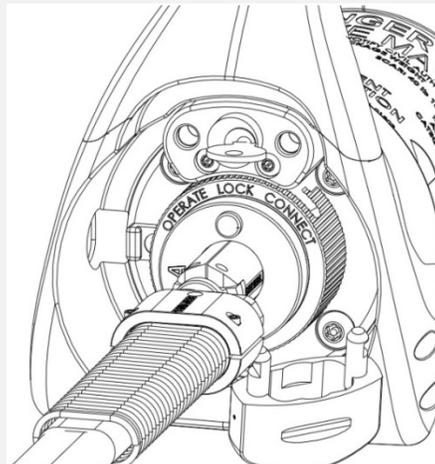
NOTE: When the selector ring is in the CONNECT position and the 661 safety connector is properly installed, the anti-rotation lugs inside the Posilok are pushed in to allow the selector ring to be rotated to the LOCK position and when required, to the OPERATE position.



CAUTION

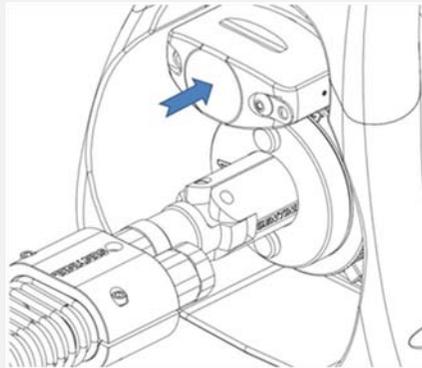
Ensure the exposure device is on stable footing and use some means to prevent the device from moving when attaching the 661 safety connector. Failure to do this may allow the device to slide away or fall causing potential damage to the control cable or connections.

13. Push and hold the 661 safety connector collar flush up against the exposure device's locking mechanism and rotate the selector ring from CONNECT to LOCK.
14. Engage the plunger lock until ready to make the first exposure.
15. The remote control 661 safety connector is now secured to the exposure device locking mechanism.



STEP 2 Continued (Exposures)

16. Insert the protective cover into the lock housing.



WARNING



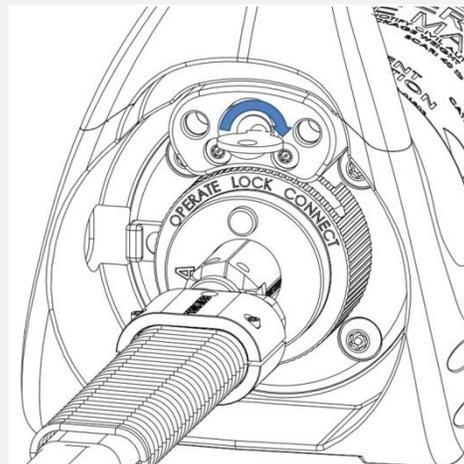
Perform the following checks **BEFORE** exposing the source.

- ✓ Attach the source guide tubes to the outlet port of the front plate when used in the projection mode.
- ✓ Attach the controls to the locking mechanism of the rear plate.
- ✓ Remove all personnel from the restricted area of exposure room.
- ✓ Post the proper signs and activate required warnings.

STEP 3 (Exposures)

Unlocking the source assembly before exposures

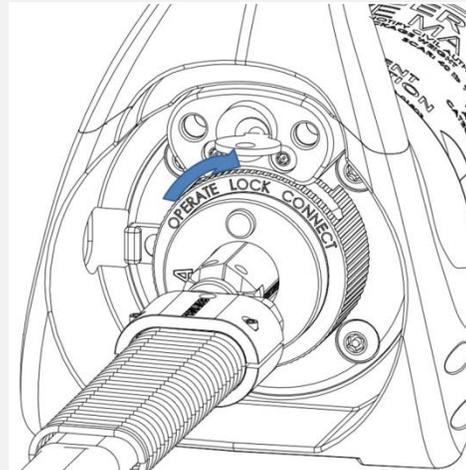
1. Remove the protective lock cover, if in place.
2. Unlock the brass plunger lock with the key.



STEP 3 Continued (Exposures)

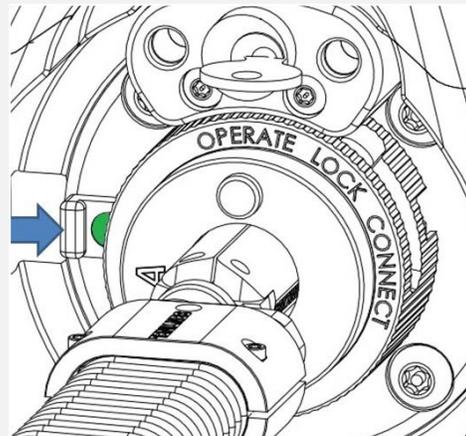
3. Turn the selector ring from LOCK to OPERATE.

4. Ensure the control crank is not pushing or pulling the control drive cable. The crank should be in a neutral tension (no force) condition.



5. When the **GREEN** mark appears on the lock slide, the source is in its secured and shielded position within the exposure device.

6. Push the lock slide, shown with **GREEN** mark, to the right towards the selector ring until the **RED** mark appears on the right side of the selector ring.



7. In low noise work areas, a click will be heard when the lock slide is pushed into the expose position.

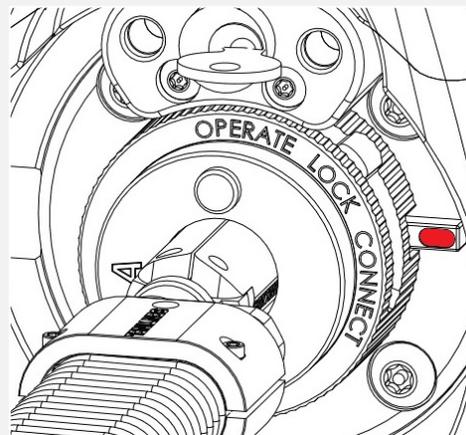
8. When the **RED** mark appears, the source is now free to be projected from the shielded position. The source can now be exposed into the guide tube and/or collimator.

9. Ensure all personnel are removed from the immediate area before projecting the source.

10. For protection, always operate the remote control crank from a safe position distance away from the exposed source and device.

11. If the controls are fitted with an odometer, then adjust the reset knob to read zero.

12. The source is ready to be projected.



CAUTION

When retracting the source into the device to the secured position, (**GREEN** dot in view on lock slide) confirm the source is secure by applying a light force to the control crank handle in the expose direction. The crank handle should not move in either direction. Do not continue to force the control crank handle after the lock slide has tripped and source is secured.

When approaching projector always have meter in hand to confirm source has been secured in the stored position.

Leave the control crank and the control cable in a neutral tension position.

Do not apply the control crank brake after source retraction.

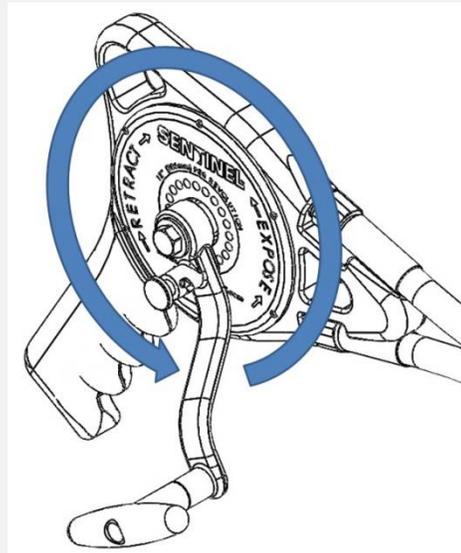
If the source cannot be secured when retracted after several attempts to expose and retract the source, determine if the source is exposed or shielded using a survey meter.

If the source is still exposed when it should be secured based on high survey readings and cannot be retracted into a shielded position, treat the situation as an emergency where the device or system may have been potentially damaged or malfunctioned. Contact your Radiation Safety Officer (RSO).

STEP 4 (Exposures)

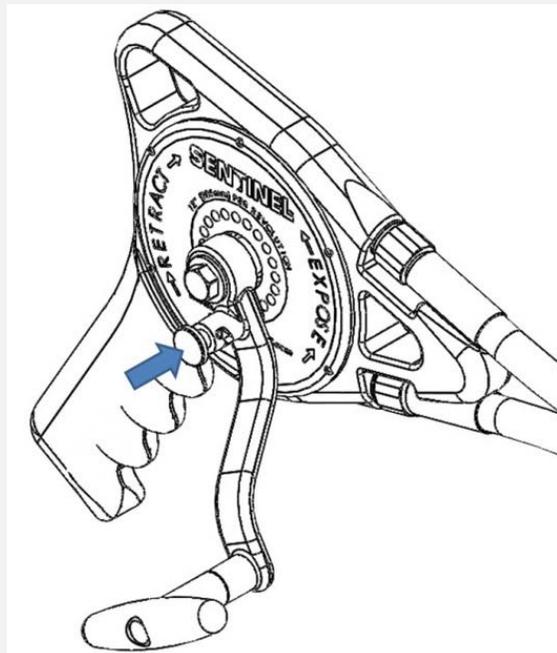
Projecting the source assembly

1. At the controls, rotate the control crank rapidly in the EXPOSE direction. The label on the crank housing indicates the EXPOSE direction. This moves the source from the exposure device to the radiographic exposure location in the guide tube, source stop or collimator.
2. When the device is used in the projector mode, the survey meter readings during source projection should increase quickly from background levels to a high level as the source exits from the exposure device into the source guide tubes. The readings should fall as the source moves towards the exposure location, fall sharply as the source enters a collimator (if used) and remain steady throughout the exposure. Use the brake if exposing uphill or to prevent source movement if needed.



STEP 4 Continued (Exposures)

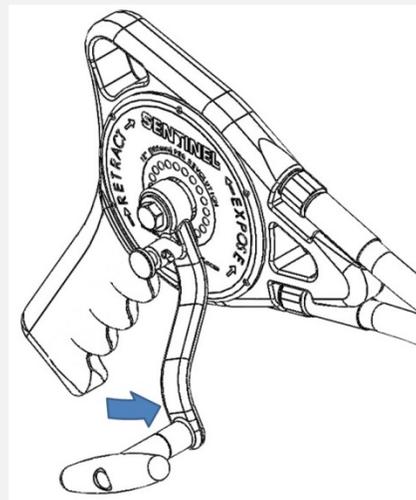
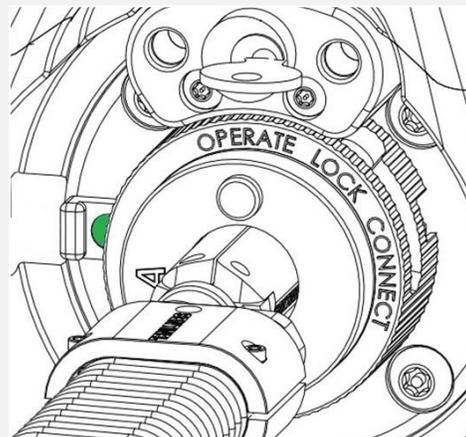
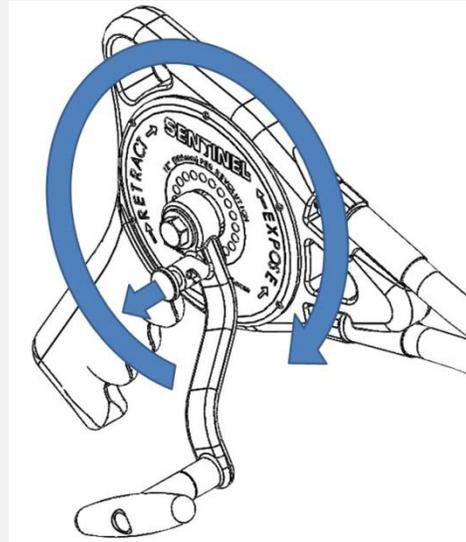
3. When used in the SCAR mode, the survey meter readings during source projection should not increase except in the direction of the collimator beam port.
4. Actual survey meter readings will depend on the source activity, distance, collimators and shielding. The sequence of changes should be observed and the readings noted.
5. An abrupt stop will be felt in the crank when the source reaches its destination in the source stop/collimator. DO NOT use excessive force on the crank.
6. The odometer (if fitted) will indicate the approximate total distance traveled. Each standard guide tube section is 7 feet (2.1 meters) plus some travel within the device.
7. With the source at the radiographic exposure location, the brake can be set to prevent movement of the source assembly during the radiographic exposure.
8. Start timing the radiographic exposure from the moment the source assembly reaches the exposure location.
9. 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.
10. Once exposure time has lapsed, retract the source back to the exposure device by following the sequence as described in the next section.



STEP 5 (Exposures)

Retracting the source assembly after exposures

1. At the end of the required exposure time, unset the brake if used and rapidly turn the crank handle in the RETRACT direction until it stops. Again the label on the crank housing indicates the RETRACT direction.
2. The survey meter should increase as the source assembly is retracted back into the device and drop to background levels when the source assembly is secured back in the device.
3. When the source assembly engages the automatic locking mechanism, you may hear the lock slide 'click' back into its lock position depending on the ambient noise levels at the job site.
4. From the control crank you may be able to see the **GREEN** marking on the lock slide.
5. Slowly turn the crank handle as if to expose the source. This checks to ensure the source is secured by the automatic locking mechanism. The source should not be projected out of the device. If the source can be projected out when it should be secured, then consider the device as potentially damaged equipment and contact your RSO.
6. Release the crank handle to allow the control cable to return to a neutral (no force) position. At this point the source cannot be moved out of the stored position



NOTE: Any residual force on the control cable from the crank when the source is locked could cause the source to move slightly after unlocking the lock slide for the next exposure.



WARNING



Always approach device with survey meter in hand to confirm source position.

If the lock slide does not return completely to the stored (**GREEN** showing) position, and the source cannot be exposed using the crank assembly, manually push lock slide into position from **RED** side or push back into **RED** operate and retract source again. Retracting too slowly is the likely cause.

If the condition persists, a weak or damaged return spring may be the cause. Perform annual maintenance on plate assembly after source is removed.

In the unlikely event the lock slide will not trip or trips prematurely with source still exposed or partially exposed, make additional attempts with control cranks to secure the source within the projector.

If survey meter reading is low indicating the source is shielded but not yet secured, push tripped lock slide back to red and attempt to retract again with control crank.

If lock slide is not tripped attempt to push slide manually from the **RED** side to the **GREEN** side while applying some retract pressure on the control crank.

If source cannot be secured or radiation readings are high indicating source is not shielded, one must suspect an accident condition in which the source assembly may have become disconnected or stuck outside the exposure device - giving rise to a very high radiation field.

Treat this situation as an **EMERGENCY** and notify the site radiation safety officer.

STEP 6 (Exposures)

Confirmatory Survey

1. Approach the exposure device while observing the survey meter.
2. Visually confirm the **GREEN** marking on the lock slide is shown while the exposure device is surveyed. The survey meter should indicate the same radiation level as observed before the exposure. Be particularly aware of the outlet port reading.
3. Survey the entire length of source guide tube (and collimator or J-tube if used). If the meter shows a sharp increase, the source assembly is not completely shielded.
4. If the source is still unshielded and the lock slide **RED** mark still appears, attempt to store the source by cranking the source a short distance towards the exposure head and retracting it, repeating if necessary.



DANGER



Special confirmatory surveys must be performed whenever using a low-activity isotope source.

After performing radiography and with the source locked in the device, carefully and deliberately conduct the confirmatory survey on the following:

- All surfaces of the exposure device,
- Along the entire length of source guide tube and
- On exposure head/collimator or SCAR collimator.

STEP 7 (Exposures)

Locking the Gamma-ray source projector (exposure device)

1. With the source assembly properly stored in the exposure device, rotate the selector ring from the OPERATE position to the LOCK position.
2. Push in the brass plunger lock to secure the device.
3. Remove and safeguard the key.
4. See Section 2.6 for instructions to dismantle and store the equipment.



WARNING



If after several attempts to return the source assembly, the selector ring cannot be rotated to the lock position (do not use excessive force) or the lock slide is not actuated, one must suspect an accident in which the source assembly may have become disconnected or stuck outside the projector, giving rise to a very high radiation field. Treat the situation as an EMERGENCY.

2.6 Disassembly & Storage

STEP 1 (Disassembly & Storage)

Remote control unit

1. Unlock the exposure device and then rotate the selector ring counter-clockwise from LOCK to CONNECT. The remote control 661 connecting collar will disengage from the exposure device's locking mechanism.
2. Completely disengage the remote controls from the exposure device by disconnecting the control cable connector from the source assembly connector.
3. Place the protective cover over the 661 safety connector assembly to protect the connector pins and control cable connector from damage and dirt.
4. Roll up the remote control housings loosely for easier handling and transport.
5. Reinstall the locking mechanism's protective cover, hold in place and rotate the selector ring clockwise to the LOCK position.
6. Push in the plunger lock and remove the key to secure the exposure device.

STEP 2 (Disassembly & Storage)

Source Guide Tubes

1. Remove the source guide tube attached to the exposure device outlet port by:
 - Grip and pull the spring-loaded interlock knob. While pulling the knob, rotate it 1/8 turn clockwise and then release or push the knob in until seated.
 - Rotate the outlet port knob counter-clockwise until it stops at about the 9 o'clock position.
 - Grip the source guide tube fitting and rotate it 1/4 quarter turn clockwise. Remove the source guide tube from the outlet port.
 - Grip and pull the outlet port knob slightly. Rotate the knob into the closed position and release. The port knob should now cover the front plate outlet port.
2. Replace protective covers where provided back onto the source guide tube fittings. Thread together extension fittings to protect the swaged fitting threads and keep dirt out.
3. Source guide tubes should be rolled up loosely for easier handling and transport.

STEP 3 (Disassembly & Storage)

Surveying

1. With all covers in place on the device, survey the entire surface of the device with the survey meter to ensure the source is fully shielded and properly secured.
2. The survey should not measure more than 2 mSv/hr (200 mR/hr) on any surface of the device and should indicate the same measurement as the initial survey.

STEP 4 (Disassembly & Storage)

Storage

1. Lock the exposure device.
2. Perform a storage survey on the surface of the exposure device to verify the dose rate is less than 2mSv/hr (200mR/hr) and record.
3. Place the locked device in the shipping case for protection when not in use.
4. Store and secure the case in a clean dry storage area where it cannot be tampered with or removed by unauthorized personnel.
5. A radioactive material warning notice must be posted on the door or entrance of the storage area.
6. The door or entrance must be locked to prevent access by unauthorized personnel. Activate security alarm requirements per national regulations.

Whenever unattended by qualified radiographers, the gamma-ray source projector must be kept physically secured in a designated storage area to prevent tampering or removal by unauthorized personnel. Additionally, the storage area must be secured such that no unauthorized personnel are allowed access. The gamma-ray source projector must be locked (key removed) and stored in a clean and environmentally protected (dry) storage area that also provides the considerations to minimize the potential dangers from fire or explosion. Perform a storage survey on the surface of the gamma-ray source projector to verify the dose rate is less than 2 mSv/hr (200 mR/hr) and record.

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. As required by most regulatory jurisdictions, security devices must be activated to detect any unauthorized intrusion into the radioactive materials storage area.

3. DAILY INSPECTION INSTRUCTIONS.

3.1 Introduction

The USNRC and international regulations require routine inspections to ensure that industrial radiography equipment is operating safely and properly. Design of the SENTINEL 1075 SCAR*Pro* device includes inherent safety features and quality construction to ensure the highest degree of quality, safety, reliability and durability.

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

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

 *DANGER* 

The sealed source in the source assembly contains radioactive material and must not be handled outside of the exposure device under any circumstances.

An unshielded source at close proximity can cause serious injury, sickness, or death to anyone exposed to it even for a short duration.

Suspected exposure to high radiation dose should be treated immediately as effects may not be readily apparent yet still be deadly.

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 and from the job-site. If damaged equipment is 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 to include the date, the name of the inspector and the specific equipment 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 replaced or repaired before reuse in radiographic operations. The radiographic exposure device and transport case, remote controls and source guide tubes must all be inspected in addition to accessories such as lab stands, collimators, J-tubes, magnetic lab-stands and pipe-clamping apparatus.

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.

3.2 Daily Inspection of the Gamma-ray source projector

- a. Survey the surface of the gamma-ray source projector 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 gamma-ray source projector 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 gamma-ray source projector. In some regulatory jurisdictions, a legible label that provides the owner's name (company name), address and telephone number must also be affixed onto the gamma-ray source projector.

- c. Inspect the gamma-ray source projector's locking mechanism to ensure the protective covers are installed over the source assembly connector. Inspect the plunger lock to ensure the lock will engage when the plunger is depressed and the key is removed. Grasp the entire locking mechanism with one hand and try to move the lock to determine that the screws have not loosened due to vibration. Unlock the plunger lock, rotate the selector ring, and remove the protective dust cover to check for functionality. Re-install the protective dust cover back, rotate the selector ring, and engage the plunger lock to protect the source assembly connector until the unit is needed for radiography.
- d. When in projector mode, inspect the outlet port for damage and for smooth operation by operating the outlet port cover. Verify that the outlet port cover rotates smoothly and that the mechanism is not clogged with dirt, grease or sludge.
- e. Ensure the outlet port mechanism plate (or collimator assembly plate) is secured to the gamma-ray source projector housing with the required hardware (see Section 2.2).

3.3 Daily Inspection of the Source Guide Tube(s) – Projector Mode

- a. Remove the protective covers from the swaged fittings on the source guide tubes. Inspect both swage fittings to ensure the threads are not stripped or clogged with dirt, grease or sludge. Inspect the ears on the bayonet fitting to ensure they are not bent, broken or excessively worn. Inspect the swivel bayonet nut to ensure the threads are not stripped or clogged with material and that it rotates freely.
- b. Inspect each length of source guide tube(s) that will be used for cuts, inward dents and heat damage. The inspection is primarily a visual one, but it should include the radiographer using his hands to feel for the inward dents. This is necessary due to the fact the outer material of the source guide tube is a flexible waterproof material that can mask dents. During a visual-only inspection, a dent in the source guide tube may retain a circular appearance on the

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exterior, while having an inward dent in the metallic conduit directly below the waterproof material. This type of masked dent can be felt by the radiographer's hands. Dents in the source guide tubes are the major cause of source hang-ups.

- c. Inspect the source stop (exposure head) to ensure there is no excessive wear, perforations, bends and inward dents. Perform this visual inspection with the collimator removed from the source stop.



Figure 13 – Source Stop Examples

Inspect the collimator and the attachment of the collimator to the source stop (exposure head) if used during radiography. Verify the original equipment brass thumb-screw is being used. The use of generic set-screws other than original equipment may damage the source stop. Typical damage may include; scoring as a result of rotating the collimator around the source stop during radiographic set-ups and inward dents on as a result of over tightened steel set-screws.

- d. Inspect the attachment of the collimator to the source stop (exposure head) if used during radiography. If collimator utilizes a thumb-screw to affix the collimator to the source stop, be certain to hand tighten only. The use of tools may damage the source stop.

3.4 Daily Inspection of the Remote Controls

The remote control consists of a control crank, a control drive cable with a connector swaged at one end, two control cable conduits and a connector plug assembly.

The control crank contains a diagonally cut, geared drive wheel that matches the outer helical winding of the control cable. This worm-gear arrangement of the control crank drive wheel and the control cable provides the radiographer with a reliable means to project and retract the source assembly from and to the gamma-ray source projector.

The Model 692, 693 and 664 control cranks are equipped with a lever brake that prevents movement of the source assembly while in the exposure head.

The Model 882 and 885 control cranks are equipped with a spring-loaded brake plunger that engages into one of the spaced indents of the crank cover plate.

Directly below the control crank handle is a label that indicates the direction for EXPOSE and RETRACT during use.

The label also indicates the ON and OFF position for the lever brake. The brake plunger knob is rotated to engage the plunger and simultaneously pulled and rotated to disengage the plunger.

Some control cranks are available with an odometer to provide the radiographer with the approximate travel distance of the source assembly. The travel distance is indicated in increments of feet and tenths of a foot. Radiographers can count the number of rotations of the crank handle when using control cranks that are not equipped with odometers to obtain an approximation of the travel distance. One full revolution of the crank handle is equal to approximately 10 in (25.4 cm) of travel on Model 692, 693 and 664 control cranks. One full revolution of the Model 882 and 885 control cranks is equal to approximately 12 inches (30.5 cm) of travel.

Two remote control conduits (sheaths, housings) are attached to the control crank. One conduit contains the working side (also called "live side") of the control cable that drives the source assembly out of the gamma-ray source projector and through the source guide tubes. The second conduit is the reserve (storage side) conduit containing the length of the control cable necessary for projection of the source assembly. The remote control conduits provide a degree of protection of the control cable against the elements common to the working environments that industrial radiography is performed.

Attached to the opposite end of the remote control conduits is a connecting plug assembly that is used for attachment of the remote controls to the locking mechanism of the gamma-ray source projector. The connecting plug assembly and the control cable connector are designed with minimal tolerances for safety. A connection of the source assembly connector to the control cable connector must be completed before the remote control connecting plug assembly can be attached to the locking mechanism of the gamma-ray source projector. A protective end-cover must be installed after use of the remote controls. The protective cover provides protection to the connecting plug assembly and the control cable connector and prevents the ingress of water, mud, sand or other foreign matter.



IMPORTANT WARNING



The control cable connector is a made from hardened steel and should never be left unprotected or forced into connection with the source assembly as this could damage the connector over time leading to possible breakage during use. Always use the protective end-cover when remote controls are not connected to the gamma-ray source projector and always manually move the sleeve of the female connector of the source assembly to the OPEN position when connecting and disconnecting the control cable from the source assembly.

The control cable (drive cable) is a flexible, steel cable with an outer helical winding. The length of control cable is approximately twice the length of the remote controls. Attached to one end of the control cable is a male connector. The control cable when used in conjunction with the remote control as a system provides a positive mechanical control of the source assembly at a distance. The control cable is a critical link for safe operation and is the radiographer's only means of control over the source assembly. Therefore, the control cable's storage, use, daily inspection and quarterly maintenance are critical elements to the prevention of a control cable failure. In almost all cases, repairs for a control cable are not possible, with the exception of replacing the control cable's Model 550 male connector every five years. Damaged, defective or control cables with unknown origin (non-traceable) must not be used and must be removed from service.

3.4.1 Remote Control Inspection:

- a. Uncoil the remote controls at the site. Inspect the control crank to assure all fastening hardware are present and tightened and that the crank handle is properly secured. If the control crank is equipped with an odometer, zero the odometer while the control cable is fully retracted. Verify the odometer, if equipped, is fully functional.
- b. Ensure the instructions on the control crank's label are legible. These instructions are important to safety, especially when assistants are being trained or during an emergency. Without the written instructions, it's conceivable that a radiographer could become confused as to which direction the crank handle must be rotated to retract or expose the source assembly.
- c. Ensure the lever brake is operational if equipped. Resistance should be felt while rotating the crank handle with the brake in the ON position. If the extreme controls are being used, set the brake plunger knob to the ON position (engaged into one the drive gear cover plate indents) and attempt to turn the handle using moderate pressure to ensure security. Then, test the brake plunger to ensure that it disengages easily before use. Inspect the remote control conduit fittings to verify they are secured to the control crank. This can be accomplished by trying to rotate the nut that mounts to the control crank assembly.

3.4.2 Remote Control Conduit Inspection:

- a. Inspect the control conduit where it is swaged onto the fittings that mount on the control crank. There should be no evidence of cracks or breaks in the waterproof sheath. Also, look for bulges in that area that result from repeated flexing.
- b. Visually inspect the entire length of both control conduits looking for dents, cuts and thermally damaged areas. During this inspection, the radiographer should use his hands to feel for inward dents. Cuts and melted areas found on the control conduits should be sealed with PVC tape to prevent against the ingress of water.
- c. Inspect the control conduits where they are swaged to the swage fittings that are mounted to the connecting plug assembly. There should be no evidence of cracks, breaks or bulges in the waterproof sheath.
- d. Remove the protective cover from the connecting plug assembly. Inspect the connecting plug assembly to verify the movable jaws are not excessively loose and the connecting collar pins are not excessively loose, have rotated or are bent. Check the control sheath swage fittings to verify they are not loose where they are joined to the connecting plug assembly.

3.4.3 Remote Control Drive Cable Inspection:

- a. Inspect the control cable connector as it protrudes out of the connecting plug assembly. The control cable connector should not be bent or at an angle exceeding 15 degrees relative to the control cable centerline. If a control cable connector is repeatedly bent at an angle greater than 15 degrees, damage to the control cable may be introduced by straightening the bend.

Inspect the control cable (male) connector to verify the shank and the ball of the connector are not bent or cracked.

Using moderate hand pressure, attempt to twist the control cable connector from the control cable. If the control cable connector can be twisted (moved) using hand pressure or appears bent or cracked, remove from service and label as defective.

- b. Pull approximately 12 in (30.5 cm) of control cable out of the connecting plug assembly and inspect for the following anomalies directly behind the connector:
- Cuts, breaks, nicks or fraying of the spiral windings of the control cable.
 - Areas with kinks or permanent bends.
 - Rust (a red oxide) on the inner core of the control cable.
 - Uniformity of the spacing (elongations or compressions) between the outer spiral windings. Also check for flattened areas and wear.
 - Bend the connector section of control cable back towards itself (forming a “U”) and release the cable to test for flexibility or ‘spring’ of the control cable. A cable that has been subjected to the flexibility test and remains in the bent position after the test provides an indication of internal corrosion and **must be removed from service**.
 - Verify that a light coating of mil-spec grease is present on the control cable. The light coating of grease is necessary to prevent the penetration of water and chemicals that can oxidize and permanently damage the control cable.
- c. Check for freedom of movement of the control cable within the remote controls by moving the control crank handle back and forth approximately one-quarter turn. During this test, take care to avoid cranking the control cable onto the ground exposing it to dirt and sand. If any resistance is felt during this check, re-inspect the control conduits for dents or depressions. If dents are not present on the remote control conduits, the control cable may be rusted stiff somewhere within the control conduits. Do not use remote controls that do not function properly or exhibit defects described above.
- d. A final check of the control cable connector and source assembly connector is accomplished by use of a Model 550 NO GO gauge to check for significant wear on the connectors that would affect safety. Without using excessive force, check the following four positions (see Figure 14):
- 1 Ball at the end of the control cable connector must NOT GO into the hole of the gauge.
 - 2 The shank or stem of the control cable connector must NOT GO into the smaller of the two notches located on the side of the gauge.
 - 3 The width of the gauge must NOT GO into the female slot of the source assembly connector.
 - 4 After a positive connection between the control cable and source assembly connectors has been accomplished, verify that the larger notch located on the side of the gauge will NOT GO in the gap between the joined connectors.

Replace any components that fail any of the NO GO gauge tests, because a failure indicates significant wear that could allow safety features of the design to be defeated.

IMPORTANT REMINDER

Do not compromise on safety. Always perform a daily inspection of the gamma-ray source projector, projection sheaths and remote controls prior to use. Defective equipment that is discovered during the daily inspection must be removed from service until repaired or replaced.

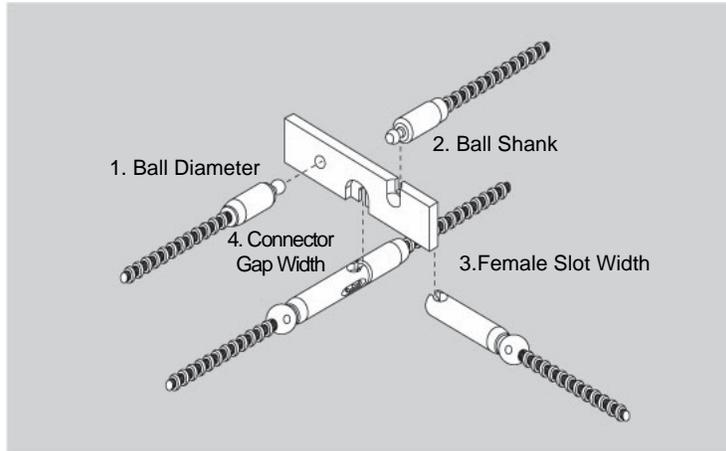


Figure 14 - No-Go gauge tests

Position	Test
1	Ball at the end of the control cable connector must NOT GO into the hole of the gage.
2	The shank or stem of the control cable connector must NOT GO into the smaller of the two notches located on the side of the gage.
3	The width of the gage must NOT GO into the female slot of the source assembly connector.
4	After a positive connection between the control cable and source assembly connectors has been accomplished, verify that the larger notch located on the side of the gage will NOT GO in the gap between the joined connectors.
<p>Do not use and replace any component that fails a NO-GO gage test. A failure indicates significant wear could allow designed-in safety features to be defeated.</p>	

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 package is 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 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 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.

CAUTION

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 environments and conditions. Extreme or severe environments and 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, 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.

Subjected to more than 10,000 exposures in a 3-month period.

4.1 Routine (Quarterly) Maintenance Requirements

4.1.1 Tools and Materials for Maintenance

Tables 5 and 6 list the tools and materials needed to perform maintenance on the exposure device, remote controls, and source guide tubes. Additional materials/tools are listed in later subsections.



WARNING



Personal safety equipment must be worn to prevent injury while performing equipment maintenance.

At a minimum, safety glasses and gloves must be worn for protection.

Ensure safety by following the manufacturer instructions of the tools and materials in the tables below.

Table 5 - Maintenance Tool List

TOOL #	TOOL NAME	TOOL NUMBER OR SIZE	QUANTITY
MT1	Torque Wrench, Calibrated	IN-LB	1
MT2	SENTINEL U-Tool	SK1761	1
MT3	Mock Source Assembly, Inactive	A425-1XL	1
MT3	Allen Wrench	0.05-Inch	1
MT4	Allen Wrench	1/16-Inch	1
MT5	Allen Wrench	3/32-Inch	1
MT6	Allen Wrench	7/64-Inch	1
MT7	Allen Wrench	1/8-Inch	1
MT8	Allen Wrench	5/32-Inch	1
MT9	Allen Wrench	3/16-Inch	1
MT10	Allen Wrench	1/4-Inch	1
MT11	Nut Driver	1/4-Inch	1
MT12	Driver Bit, Tamper-Resistant TORX	T10, 1/4-Inch Hex Shank	1
MT13	Driver Bit, Tamper-Resistant TORX	T25, 1/4-Inch Hex Shank	1
MT14	Driver Bit, Tamper-Resistant TORX	T40, 1/4-Inch Hex Shank	1
MT15	Small Screwdriver, Slotted	1/4-Inch Tip Width	1
MT16	Open-end Wrench	11/16-Inch	1
MT17	Open-end Wrench	1/2-Inch	1
MT18	Open-end Wrench	3/8-Inch	1
MT19	Magnification Glass	X7	1
MT20	Micrometer	6-Inch	1
MT21	Tap & Die Set	1-18 UNS Thread	1
MT22	Control Cable, 7-Foot	55000-7	1

Table 6 - Maintenance Materials List			
MAT #	MATERIAL NAME	MATERIAL NUMBER	QUANTITY
MM1	Grease	MIL-G-23827B (or C) or MIL-PRF-23827C	AR (As Required)
MM2	Thread locker	LOCTITE 242	AR
MM3	Thread locker	LOCTITE 222	AR
MM4	Thread lubricant	PERMATEX ANTI-SEIZE	AR
MM5	Cleaning Solvent	Mineral Spirits	AR
MM6	Clean Lint-Free Rags	MCMASTER-CARR# 7366T28 or similar	AR
MM7	Cotton Wipes, 3X3 Inch	MCMASTER-CARR# 7492T3 or similar	AR
MM8	Large Pan	MCMASTER-CARR# 4204T4 or similar	1
MM9	Bristle Brush	MCMASTER-CARR# 63015T23 or similar	1
MM10	Polyvinyl Tape	Yellow or black	AR

4.1.2 Remote Controls

Disassemble, clean, inspect and maintain the remote control crank, control conduits and control cable according to the complete service section. Record the results of the inspection and any repairs that are performed. Any components found to be deficient during the inspection must be removed from service until repaired or replaced. Deficient components must be labeled with a status indicator to prevent inadvertent use.

4.1.3 Source Guide Tubes

Clean and inspect the source guide tubes in accordance to the “Annual maintenance for source guide tubes” section of this manual. Record the results of the inspection and any repairs that are performed. All source guide tubes found to be deficient during this inspection must be removed from service and sent to a service center for repairs. Deficient components must be tagged with a status indicator to prevent inadvertent use.

4.1.4 Radiographic Gamma-ray source projector

Clean and inspect the gamma-ray source projector/transport container for wear and obvious damage. Record any defects that might affect safe operation of the gamma-ray source projector or contribute to unsafe transport of the device in the container. If deficiencies are found during this maintenance, the gamma-ray source projector must be removed from service until repairs are accomplished and the results of subsequent operational tests and inspection are satisfactory. Inspect the radiography system for the following details using a ‘satisfactory’ or ‘deficient’ criteria:

- a. Survey the surface of the container to ensure the measurable dose/rate is less than 2 mSv/hr (200 mR/hr) and less than 50 µSv/hr (5 mR/hr) at 1 meter (to comply with ANSI/ISO requirements). Remove the device from service if the measured dose/rate exceeds these limits. Contact QSA Global, Inc. for guidance.
- b. Ensure the metal identification tag for the radioisotope is legible and securely fastened to the gamma-ray source projector. Do not cover the tag with any other labels.

- c. Ensure the label containing the device model number, serial number, Type A specification identification, and the trefoil with the warning 'Caution or Danger, Radioactive Material' is legible from a distance of 3 ft (approximately 1 m) and securely fastened to the container. Do not cover the required warnings with any other labels. Ensure the labels applied for transportation are legible. As required, ensure the label that provides the owner's name (company name), address and telephone number is legible and affixed to the gamma-ray source projector.
- d. Ensure the plastic jacket handle, base surfaces and sides are intact. If any substantial wear and tear is found, replace it at a QSA Global service center.
- e. Check the device structure for weld failure (cracks, etc.) at the outlet port end behind the front plate or collimator. The collimator or front plate will need to be removed to check the weld. Check all fasteners to ensure they are tight. Without removing the rear plate attachment screws, examine the screws for any signs of damage or fatigue cracking. Examine the front plate and collimator assembly attachment screws for signs of damage including thread damage. The fasteners must be replaced if they are no longer fit for use (e.g., threads stripped, unable to fully thread, signs of cracking, etc.). Check the function of the rear plate locking mechanism. If the device is loaded with a source do not test the lock slide function. If the assembly does not function properly, then perform complete maintenance on the device per Section 4.2.5. If any deficiencies are found during this inspection, repairs can be accomplished at a QSA Global service center.
- f. Check the front plate for proper function by attaching and removing a source guide tube equipped with the appropriate bayonet connector. The operation should be smooth and resistance free. If there is any resistance or 'crunchy' feeling noticed during attachment or removal of the source guide tube or during movement of the outlet port cover, this indicates excessive amounts of sand or dirt within the outlet port mechanism. The outlet port mechanism must be removed, cleaned, inspected and lubricated according to the complete service instructions.
- g. Check the locking mechanism and plunger lock to verify attachment and operation. Grasp the entire mechanism with one hand and attempt to shift the mechanism. Retaining screws that have been loosened from excessive vibration or improper maintenance will allow the movement of the locking mechanism during this check. Loose screws must be tightened according to the annual maintenance requirements prior to use or transport.
- h. Use the Model 550 NO GO gauge to check for wear on the remote control cable connector and the source assembly connector as described in Section 3.4.3.d. Replace all components of the "locking system" that fail any of these tests.
- i. Operationally check the automatic securing mechanism and then the function of the entire system during the first radiographic exposure of the work shift while within a restricted area. Operation of the radiographic system verifies both the automatic securing mechanism and entire system operates smoothly and freely. If operation is faulty, remove the gamma-ray source projector from service and perform the complete annual maintenance.

4.1.5 Mismatch Test

After performing the quarterly or annual maintenance, the complete radiography system must be tested by the maintenance program administrator or Radiation Safety Officer. A mismatch test on the gamma-ray source projector including the radioactive source assembly and remote controls effectively tests the integrity of the entire locking system. This procedure detects long-term wear (or damage) of the interrelated failsafe system including identification of any excess

wear on the control cable connector, the gamma-ray source projector's automatic securing mechanism and sealed source connectors simultaneously.

Note: Component wear occurs to both the control assemblies and the device locking mechanisms over time, therefore, to ensure acceptable equipment operation, the misconnect test must be performed on each device lock assembly and control assembly that will be used for radiographic operations. All remote controls must be tested using a QSA Global, Inc. manufactured automatic securing mechanism equipped with a QSA Global, Inc. manufactured source assembly, 550 jumper or a mock source assembly (A425-6XL) to ensure the effectiveness of the misconnect test.



WARNING



The test should only be performed by personnel that are formally trained, authorized and thoroughly familiar with annual maintenance procedures. This test is performed by engaging the remote control connecting plug assembly into the exposure device's locking mechanism **WITHOUT** first engaging the control cable connector within the source assembly connector.

The ability to then rotate the locking mechanism from the CONNECT position towards the LOCK position indicates critical dimensions of the locking system are excessively worn to an unsafe condition. **Extreme care should be exercised to prevent rotating the locking mechanism's selector ring beyond the LOCK position (see WARNING above).** If the locking mechanism and remote controls fail a misconnect test the equipment must be removed from radiographic operations. The equipment must not be used until repairs are performed and misconnect test results are satisfactory.

During the performance of the misconnect test there is a **risk of losing control of the radioactive source assembly if:**

- the components are excessively worn or damaged
- the person performing the test intentionally or inadvertently rotates the selector ring from the CONNECT position to the OPERATE position
- the person performing the test intentionally or inadvertently pushes the lock slide into the open (**RED**) position.

Contact a QSA Global, Inc. service center if you have questions regarding the misconnect test.

4.1.6 Routine (Quarterly) Maintenance Records

Records of all equipment inspected and maintained during the routine maintenance must be recorded. The 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.

These inspection and maintenance records must be retained according to the record keeping requirements of the applicable regulatory jurisdiction.

4.2 Routine (Annual) Maintenance Requirements

Radiographic gamma-ray source projectors used under normal environmental conditions should only require complete maintenance once a year. Complete maintenance on the associated equipment including the remote controls and source guide tubes should be performed every three months to prevent corrosion, detect any damage and any deficiencies related to the long-term wear of components that could compromise safety.

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 into a source changer performed inside of a restricted area. The annual inspection and maintenance must be performed by individuals specifically trained, qualified and authorized for this work.

Perform the following steps to transfer the sealed source from the gamma-ray source projector into a source changer:

- a. Perform a survey of the gamma-ray source projector to ensure measurable dose rates are less than 200 mR/hr (2 mSv/hr) and less than 5 mR/hr (50 μ Sv/hr) at 1 meter (to comply with ANSI/ISO requirements) when loaded to maximum capacity. Perform a radiation survey and an inspection of the source changer to be used according to the source changer's operating instructions manual.
- b. Perform a daily inspection of the remote controls, source guide tube and gamma-ray source projector according to the daily inspection section of this manual. If the source assembly connector fails the NO GO gauge test, do not proceed with transfer of the source assembly. Contact a QSA Global, Inc. service center for advice on disposition of the source assembly.

Use the Model 550 NO GO gauge to check the remote control cable connector before and after a connection to the source assembly connector. For complete instructions to use the NO GO gauge and points tested, review the daily inspection instructions.

Do not use remote controls that do not meet the inspection criteria described in the daily inspection.

- c. Set up the equipment within a restricted area before transferring the source assembly into the source changer according to the instructions supplied with the source changer. The transfer must be performed by properly trained and licensed personnel. Use a survey meter to perform confirmatory surveys of the gamma-ray source projector, source guide tube and source changer to confirm that the sealed source is properly secured. Engage the lock on the source changer to lock and secure the sealed source within the source changer.

Remove the source identification tag from the gamma-ray source projector and fasten it to the source changer.

Attach a Model 550 connector gauge (jumper) to the end of the remote control cable connector. The jumper gauge will allow removal of the remote controls from the locking mechanism of the device after the remote control cable connector and jumper gauge is fully returned to the gamma-ray source projector lock automatic securing mechanism.

4.2.1 Leak Test 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. If necessary, remove the collimator assembly and attachment of the projector assembly as described in Section 2.2.
- c. 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.
- d. Install the plastic service bayonet fitting into the outlet port and rotate the cover to allow the wipe test wand to enter the 'S' tube.



DANGER



High radiation emits from the open outlet port when the knob is turned to the 11 o'clock position and the shutter is in the open position.

Perform the wipe test without delay to minimize dose to the hand.

- e. Fully insert the wipe test swab into the 'S' tube and move back and forth to obtain the sample.
- f. 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.
- g. Remove the service bayonet fitting from the outlet port and rotate the outlet port cover into the closed position.
- h. 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.

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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.

4.3 Annual Maintenance for the SENTINEL 1075 SCARPro Gamma-Ray Source Projector

4.3.1 General SENTINEL 1075 SCARPro Annual Maintenance Requirements

This gamma-ray source projector must receive inspection and maintenance at least once a year.

The locking mechanism and outlet port mechanism must be removed from the gamma-ray source projector and disassembled for proper cleaning, inspection and lubrication of components that are critical to safety.

The inspection and maintenance procedures must be performed by personnel specifically trained and qualified for this work. QSA Global, Inc. service engineers will service these systems at one of their service centers or in the field upon request.

Inspection & Maintenance classes are offered and held several times per year for companies wishing to perform maintenance in house. See the QSA training course schedule for class dates and locations. Trained and qualified personnel who wish to perform this work should use the procedure in this section.

Perform a daily inspection of the system and transfer the radioactive source assembly into an approved storage container. Disengage remote controls and source guide tubes.



DANGER



The gamma-ray source projector must be empty for the following steps. Do not perform complete maintenance on the exposure device with a radioactive source assembly in the device.

The radioactive source assembly must be transferred to an approved source changer before complete maintenance can be performed on the device.

Cleaning solvents can be flammable. Precautions must be taken to follow the solvent manufacturer instructions.



WARNING



Personal safety equipment must be worn to prevent injury while performing equipment maintenance.

Safety glasses must be worn for protection.

Rubber gloves are recommended when handling solvents, lubrications, etc.

4.3.2 Replacement Parts – Complete Maintenance

When ordering replacement or spare parts, quote the model and serial number of the exposure device as well as the part number to ensure correct replacement. See Section 4.7 regarding considerations related to Safety Class A components on the SENTINEL 1075 SCAR*Pro*.

4.3.3 Source Transfer Instructions

The source transfer can only be done with the front plate assembly and source guide tube extensions attached. This may require removal of the collimator assembly and attachment of the projector plate assembly as described in Section 2.2. The source transfer must only be performed by properly trained and licensed personnel.

- a. Survey the device with a calibrated meter. Dose rates must not exceed 2 mSv/hr (200 mR/hr) on the surface and 20 μ Sv/hr (2 mR/hr) at 1 meter.
- b. Survey the loaded storage container to check the local dose rates and location of the source.
- c. Inspect the controls and source guide tubes used for the source transfer. Do not use equipment that fails the inspection. Connect an extension guide tube from the outlet port to an open hole in the changer/container.
- d. Connect the controls to the device after checking the source connectors with the Model 550 NO GO gage. If the connection fails the gage, then do not proceed with the transfer and contact a QSA Global, Inc. service center for further instructions.
- e. Follow the instructions in the source changer manual for source transfer from the device to the changer.
- f. Survey the device, changer and source guide tubes to confirm the source is in the changer.
- g. Lock the source in the changer and disconnect the control cable from the source.
- h. Remove the source identification tag on the device and place it on the source changer.
- i. Use a dummy connector from the tool kit and attach it to the control cable connector. The dummy connector will trip the lock slide in the Posilok rear plate assembly when the drive cable is retracted. This will enable the controls to be removed from the device for servicing.

4.3.4 Projector Body Maintenance

- a. Make sure the source assembly has been transferred to an approved source changer in accordance with Section 4.3.3 of this manual. Confirm the projector is empty by using a survey meter to verify no radioactive source is contained in the projector.

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- b. Disconnect and remove the remote controls and source guide tubes from the gamma-ray source projector.
- c. Remove the front plate assembly from the device and perform maintenance on the assembly according to Section 4.3.5.
- d. If necessary, remove the collimator assembly from the device and perform maintenance on the assembly according to Section 4.3.6.
- e. Remove the rear plate assembly from the device and perform maintenance on the assembly according to Section 4.3.7.
- f. Clean the exterior of the device using a mild detergent spray solution and rags to remove all dirt and grime.
- g. Visually inspect the device looking for damage and/or foreign material that may cause the device to malfunction. Contact a QSA Global service center for guidance on the approved damage repair procedure if damage is found.
- h. Visually inspect the plastic jacket for cracks, ensure the handle and mounting points are intact, and the bottom contact surfaces are not excessively worn. Contact a QSA Global service center for guidance on replacing a damaged or worn jacket.
- i. Visually inspect the device label or nameplate to ensure all information is legible. The trefoil and the warning, 'Caution or Danger, Radioactive Material', must be legible at a distance of 3-feet (approximately 1-meter).
- j. Replace the label/nameplate if the information is not legible or likely not to be legible in the next twelve months.
- k. Re-attach the front plate assembly.
- l. Perform a front plate functional test according to Section 4.3.8.
- m. Perform a rear plate functional test according to Section 4.3.9.
- n. Re-attach the rear plate assembly (not already attached).
- o. Perform a complete gamma-ray source projector functional test according to Section 4.3.10.

4.3.5 Front Plate Assembly Maintenance

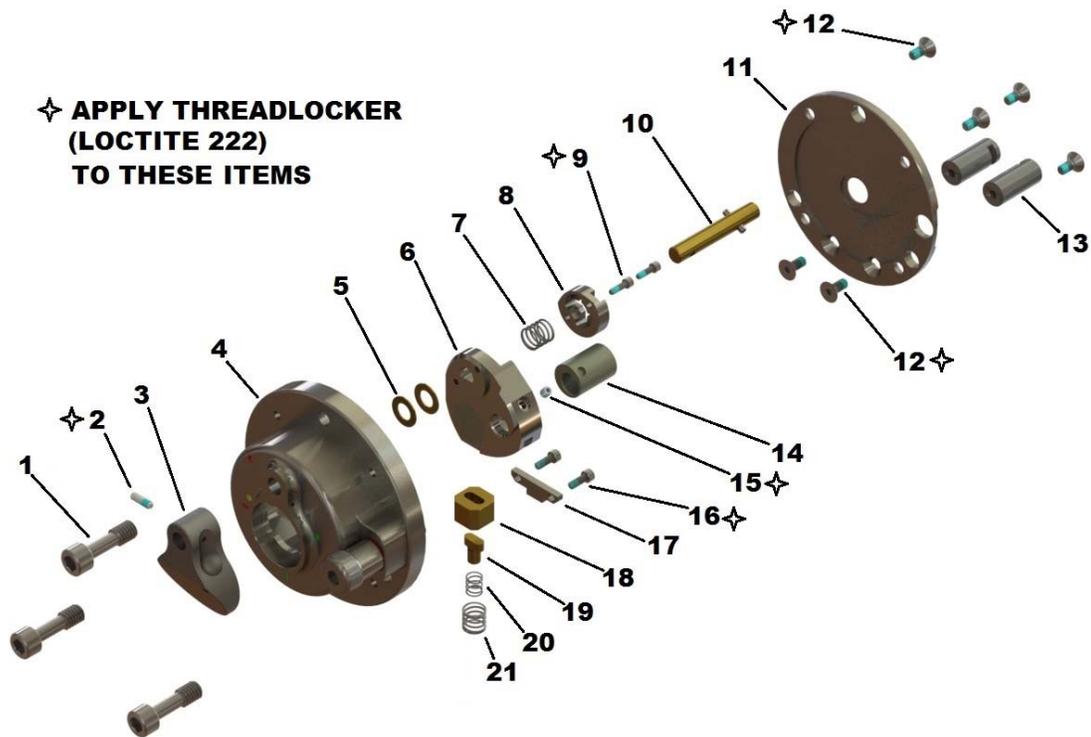


Figure 15 – Front Plate Assembly Component Exploded View

Table 7 – Front Plate Assembly Parts List

ITEM #	PART NAME	PART NUMBER	QUANTITY
1	Screw, Front Plate	107530-13	3
2	Set Screw, Knob	SCR251	1
3	Knob	88033	1
4	Front Plate	107530-01	1
5	Washer	88036	2
6	Rotor Assembly	107530-09	1
7	Spring, Rotor	SPR033	1
8	Pivot Disc	107530-05	1
9	Screw, Pivot Disc	SCR160	2
10	Shaft Assembly	107530-14	1
11	Front Cover	107530-08	1
12	Screw, Front Cover	SCR392	6
13	Pin, Shutter Interlock	107550-01	2
14	Front Plate Sleeve	107530-07	1

ITEM #	PART NAME	PART NUMBER	QUANTITY
15	Set Screw, Sleeve	SCR017	1
16	Screw, Slider Cap	SCR210	2
17	Slider Cap	107530-10	1
18	Slider	107530-02	1
19	Slider Insert	107530-15	1
20	Spring, Slider Insert	SPR004	1
21	Spring, Slider	SPR033	1

- a. If necessary, remove the front plate assembly from the device by unthreading the three captive screws and interlock knob on the front plate. Shutter interlock mechanism must be closed to remove the front plate.
- b. Place the front plate assembly with the port knob down on a clean surface. With the inside of the front plate facing up, remove the four inside cover screws holding the front cover to the plate assembly.
- c. Remove the front cover. The two shutter interlock pins should remain attached to the cover.
- d. Flip the front plate over with knob facing up. Remove the set screw in the knob. Remove the knob from the shaft assembly.
- e. Flip the front plate over again to access the internal mechanism.
- f. Pull out the rotor and shaft assembly. Remove and inspect the bronze shaft for wear. Check the roll pin for looseness or damage, replace shaft assembly if needed.
- g. Pull out the slider and slider insert together with their springs. Remove and discard the springs from the slider and slider insert.
- h. Unscrew the two screws holding the pivot disc to the rotor. Remove and discard the spring from the pivot disc.
- i. Wipe down all the parts using a brush and solvent if needed to remove all dust and dirt.
- j. Lightly lubricate shaft, slider parts, and rotor slot. Do not lubricate these if the device is used in an environment where sand and grit is present.
- k. Inspect all parts for wear, damage, and burrs.
- l. Inspect the rotor shield disc remains securely positioned. Shield rotation is normal.
- m. Apply a small drop of low strength thread locker onto the last two threads of all small screws.
- n. Assemble the rotor with the new pivot disk spring and lightly install screws.
- o. Install the shaft into the pivot disc. Use the shaft to align and center the pivot disc before securing screws.
- p. Install two brass washers.

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- q. Assemble the slider insert into the slider slot. Place the slider insert spring onto the slider pocket. Place the slider spring over insert spring and into the slider pocket.
- r. Insert the slider assembly with springs first into pocket with the insert tab aligned with the slot in the rotor. Use a finger inserted through the outlet port to compress and hold the assembly while inserting the rotor assembly.
- s. Install the rotor assembly into the front plate while ensuring the two washers remain in place on the shaft. Ensure the slider assembly and springs are positioned and oriented correctly.
- t. Install the knob onto the rotor shaft and secure with set screw.
- u. Install the cover plate with four flat head screws. Tighten the four cover plate screws.
- v. A partial function test can be performed using a leak test fitting or bayonet fitting to check the outlet port function.
 - 1 Hold the assembly with the large pins horizontally at the top.
 - 2 Open the knob to the 3 o'clock position and insert the leak test/bayonet fitting.
 - 3 Rotate the fitting ¼ turn counterclockwise and rotate the knob to the 5 o'clock position.
 - 4 The assembly should operate smoothly with a slight drag when moving the knob to the open position.
 - 5 Reverse steps 2 and 3 to remove the fitting.
 - 6 The Interlock can only be checked while installed on device.

4.3.6 Collimator Assembly Maintenance

✦ **APPLY THREADLOCKER
(LOCTITE 242)
TO THESE ITEMS**

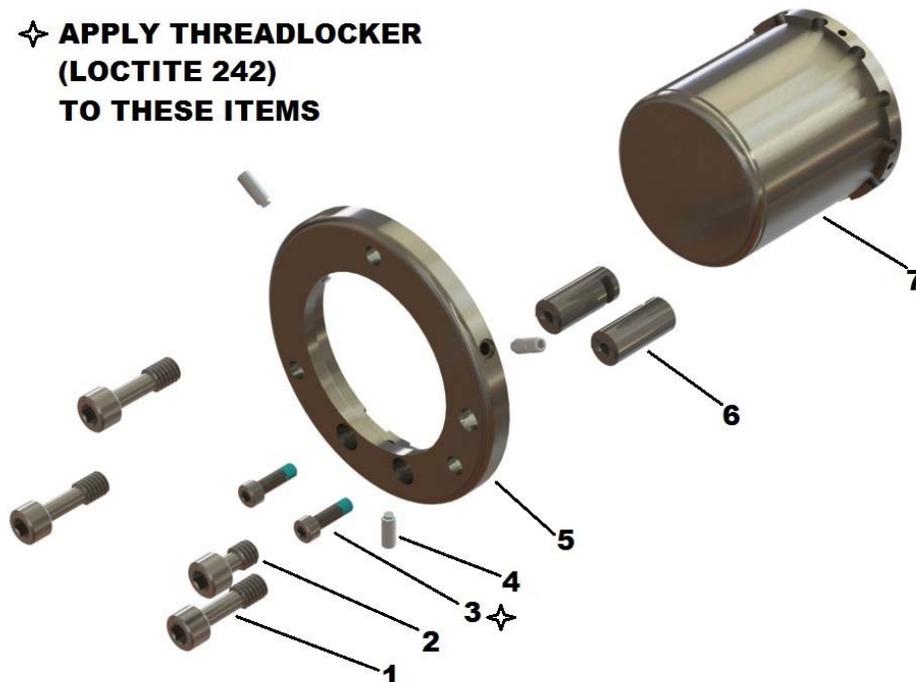


Figure 16 – Collimator Assembly Component Exploded View

Table 8 – Front Plate Assembly Parts List

ITEM #	PART NAME	PART NUMBER	QUANTITY
1	Screw, Captive	107530-13	3
2	Screw, Collimator Lock	107560-03	1
3	Screw, Shutter Interlock	SCR015-07	2
4	Set Screw, Beam Port Adjustment	SCR395	3
5	Collimator Ring	107560-04	1
6	Pin, Shutter Interlock	107550-01	2
7	Collimator Housing	107560-02	1

- a. If necessary, remove the collimator from the device by unthreading the captive lock screw and the three other captive screws.
- b. Unscrew and remove the three set screws from the collimator.
- c. Slide the collimator housing away from the collimator ring. The two shutter interlock pins can remain attached to the ring.
- d. Wipe down all parts with rag lightly wetted with cleaning solvent. Use a soft brush to remove the dirt and dust.
- e. Thoroughly dry all solvent cleaned parts.
- f. Inspect all parts for damage or heavy wear.
- g. Install collimator ring over collimator housing.
- h. Install the three set screws into the collimator ring almost flush.
- i. Adjust collimator housing beam port for desired orientation. (Typically down towards pin retaining screws) and secure screws.
- j. Install all large captive screws into collimator ring.

ITEM #	PART NAME	PART NUMBER	QUANTITY
11	Spring, Lock Slide	SPR006	1
12	Spring, Anti-Rotate Lug	SPR004	2
13	Anti-Rotate Lug	66001-6	2
14	Sleeve	88025	1
15	Spring, Sleeve	SPR005	1
16	Selector Ring	107540-09	1
17	Selector Ring Retainer	85701-5	1
18	Lock Cover Assembly	107545	1
-	Rear Plate Attachment 5/16-18 Tamper Resistant Screws (not shown)	SCR400	4

- a. Remove rear plate assembly by removing the four large 5/16-18 attachment screws. Use the largest supplied TORX bit to engage the tamper-resistant screws. The TORX bit can be mounted in a socket for easy on, off, and torquing.
- b. Unscrew and remove the two plunger lock mount screws holding the plunger lock mount to the rear plate. Use the smaller tamper-resistant TORX bit.
- c. Remove and inspect the four rubber sleeves from the plunger lock mount. Replace if worn or degraded.
- d. Unscrew and remove the plunger lock extension using a large flat blade screwdriver.
- e. Remove and inspect the plunger lock (conical shaped) spring. Replace if needed.
- f. Unscrew and remove the four screws from the back of the rear plate holding the selector ring retainer.
- g. Disassemble the remainder of the locking mechanism assembly. **Take care not to lose the spring loaded parts.**
- h. Remove the lanyard from the lock cover assembly. Replace if worn or damaged.
- i. Remove and discard the four springs of the lock assembly.
- j. Place the unassembled parts, except the lanyard, into a pan filled with fresh cleaning solvent. Clean all parts using a soft bristle brush to remove any dirt or grease.
- k. Remove cleaned parts from the solvent bath, dry and place on a clean surface.
- l. Ensure the plunger lock is thoroughly rinsed to remove all dirt and grit from the key tumblers. Use compressed air to dry the plunger lock cylinder.
- m. Lubricate the plunger lock barrel and tumbler using two drops of light viscosity oil.
- n. Inspect all parts for wear. Replace worn parts as necessary.
- o. Apply medium strength thread locker to all screws pictured. The four large tamper proof screws (SCR400 not pictured) will receive thread lubricant before rear plate installation.
- p. Install the conical spring, wide end first. Push plunger lock into lock mount until secured by lock pin when correctly oriented. Secure with plunger lock extension screw. Do not over-tighten.

- q. Check the plunger lock for proper function in the lock mount by using the key to unlock and engage several times. Ensure key inserts and turns easily in the lock cylinder.
- r. Prepare the selector ring by applying a light coating of GRE002 to the inner most opposing surfaces of the selector ring only. The remaining parts including the lock slide and sleeve are installed dry.
- s. Place the rear (base) plate horizontally on bench with the two mounting holes for the plunger lock housing aligned at the 12 o'clock position.
- t. With the narrow end of the lock slide slot located at the 3 o'clock position, install the new small spring and lock slide with the **RED** painted slot facing right.
- u. Insert new springs for the anti-rotation lugs into the rear plate spring pockets. Place the anti-rotation lugs over the springs.
- v. Position the selector ring onto the center of the rear plate aligning the "OPERATE" at the 12 o'clock position. At this position, the anti-rotation lugs will be pushed down by the inner ring. Use a finger to guide the spring loaded lugs into the pockets and hold the lugs down using the selector ring. Maintain pressure on the ring until secured with the first screw in step bb.
- w. Push the lock slide inward slightly during placement of the selector ring. This will allow the selector ring to rest flush on the selector body.
- x. Place the sleeve with the large diameter step facing downward in the center of the rear plate on the lock slide. Lock slide is in neutral position.
- y. Place the new large spring over the sleeve.
- z. Install the selector ring retainer with large three holes aligned vertically.
- aa. Allow the sleeve spring to insert into the larger center bore of the retainer and press the retainer down into the selector ring until flush. Holding pressure can now be transferred to the retainer.
- bb. Hold the assembly firmly together until one of four retaining screws can be installed. Spring compression must be maintained during assembly to keep the lugs properly seated within the pockets. Check basic operation before installing the remaining screws. The selector ring will have slight clearance wiggle when assembled correctly.
- cc. Install the remaining screws and torque the screws to 30-in/lb (3.39-Nm) \pm 5-in/lb (0.57-Nm) using a calibrated torque wrench.
- dd. Insert the four (two stacks of two) rubber sleeves back into the plunger lock mount pockets.
- ee. Position the fully assembled plunger lock mount into place so the sleeve will not fall out and install the two lock mount screws.
- ff. Tighten the screws using the TORX style tamper-resistant driver bit.

4.3.8 Front Plate Assembly Functional Test

- a. Install the front plate assembly back onto the device and secure the retaining screws. The rear plate must be installed at this time to test interlock function.
- b. Perform the following functional test three times using a guide tube with integrated bayonet fitting. Always position the port shutter in the closed position during this functional test. Check for smooth operation of the adjusting screw.
 - 1 Pull the port cover knob and rotate clockwise 90 degrees to open the outlet port. The knob movement should be smooth and limited to a clockwise 90 degree turn with tungsten port shield visible in opening.

- 2 Insert a bayonet fitting into the outlet port and rotate the fitting 90 degrees in a counter-clockwise direction. The fitting insertion and rotation should be smooth and limited to a 90 degree turn.
- 3 Rotate the port cover knob from the 9 o'clock position to the 11 o'clock position. This opens the source path at the outlet port – which would allow a source to travel in and out. The knob should hold its position and not fall back from gravity to the 6 o'clock position.
- 4 Check the interlock knob function by pulling the knob out and rotating it 1/8 turn counterclockwise. Then release the knob into its seating position. The outlet knob must be fully open to pull out the interlock knob. With the interlock knob now in the unlocked position, the outlet port is now prevented from moving to the closed position thus preventing removal of the guide tube.
- 5 Pull and turn to return the interlock knob back to the locked position (all the way in) and check to ensure the lock slide cannot be moved to the operate (red showing) position.
- 6 Return the outlet knob to 9 o'clock position to disengage the bayonet fitting. Close the outlet port. If operation does not perform as described, then determine the cause and make corrections.
- 7 Safety interlocks are designed into the device to help prevent unintended accidental overexposures to individuals when the equipment is used improperly. Attempting to bypass or circumvent interlocks is a violation of these operating procedures and can result in loss of time, expense, employment, injury or worse. Always operate the equipment in a safe manner using the appropriate safety equipment at all times. Poorly maintained equipment will eventually result in an operational failure.

4.3.9 Rear Plate Assembly Functional Test

- a. Hold the rear plate assembly in one hand and unlock the plunger lock using the key. Rotate the selector ring to the connect position. A click or clicks can be heard and will lock the selector ring from further movement.
- b. Insert the 'U- tool' into the two outer holes in the selector ring retainer to depress the lugs and rotate the selector ring to the OPERATE position.
- c. Push the lock slide (**GREEN** side) in until the spring-loaded sleeve snaps into place. The green mark is now hidden to indicate the source can now be exposed. The **RED** mark on the lock slide is now visible on the right side.
- d. The lock slide is now positioned to align the source path and the large portion of the key hole in the lock slide. Attempt to trip the lock slide using a mock or dummy source wire assembly with a short length of control cable or jumper wire attached. Insert the cable end into the back end of the rear plate assembly.
- e. Pull the dummy source wire assembly through the plate until the lock slide is tripped. The **GREEN** lock slide mark should be visible with a distinct click. The U-tool hook on one leg can also be used to trip the slide by retracting the sleeve away from the slide through the center hole.
- f. Repeat steps c. through e. in this section several times while observing the action of the mechanism. The action should be quick and smooth.
- g. If the assembly does not operate smoothly as designed, determine malfunction and make correction.
- h. When satisfied with the rear plate operation, attach the plate back onto the device.
- i. Apply thread lubricant to the four mounting screws and torque the screws to 110 in-lbs (12.43 Nm), ± 5 in-lbs (0.57 Nm) in an opposing cross pattern.

- j. After attaching the rear plate back onto the device, again perform the functional test to ensure the dummy source assembly moves smoothly in and out of the device and will lock securely. A standard dummy source assembly can be used for this test. The shutter will need to be in the open position to install the dummy source assembly and expose the dummy source using the control crank.

4.3.10 Gamma-Ray Source Projector Functional Test

- a. Install the dummy source connector into the rear plate assembly using a jumper wire or control assembly.
- b. Connect all cleaned and serviced guide tubes to the device.
- c. Connect the cleaned and serviced remote controls to the dummy source connector and device.
- d. Pull and turn the interlock knob 1/8 turn counter clockwise and release.
- e. Unlock the device and place the selector ring in the "OPERATE" position.
- f. Push the lock slide to the EXPOSE (RED mark) position.
- g. Crank the dummy source connector from the device into the guide tubes a short distance while carefully feeling for resistance and/or snags.
- h. Crank the dummy source connector back into the device again checking for resistance until secured in the lock assembly.
- i. Check to ensure the lock slide automatically secures the dummy source connector.
- j. The lock slide trip movement should be quick and smooth. An audible 'snap' or "click" should be heard when the lock slide is tripped to the secured position.
- k. Confirm the source is secure by attempting to crank the dummy source connector from the device with the lock slide GREEN mark showing. A secured source will not exit the device.
- l. Repeat this testing several times.
- m. If resistance or snags are felt and/or the lock slide movement is sluggish, inspect the entire system to determine the cause.
- n. Repeat all functional tests if any additional servicing is performed or additional controls or guide tubes are tested.
- o. If the Model 550 jumper gauge was used during the servicing, clean the jumper gauge in solvent. Lubricate the inner sleeve with light oil while moving the sleeve back and forth. Apply a light coat of oil over the entire jumper before storage.
- p. After performing the full servicing of the system, reload the gamma-ray source projector by performing a source transfer. After performing the source exchange from the source changer into the gamma-ray source projector, conduct radiation surveys of the gamma-ray source projector, source guide tube and source changer to confirm the sealed source is fully shielded and secured within the gamma-ray source projector. Survey the surface of the gamma-ray source projector to ensure the measureable dose/rate is less than 2 mSv/hr (200 mR/hr) on the surface and less than 50 µSv/hr (5 mR/hr) at 1 meter (to comply with ANSI/ISO requirements).
- q. If previously removed for the servicing of the gamma-ray source projector, install the source identification tag to the gamma-ray source projector.
- r. Conduct the misconnect test on the serviced gamma-ray source projector and remote controls as described in Section 4.1.5.

4.4 Annual Maintenance for Models 692, 693, 664 Remote Controls



Figure 18 – 692/693 Control Styles



Figure 19 – 664 Reel Control

4.4.1 Maintenance Tools for Models 692, 693, 664 remote controls

- 11/16 in open-end wrench for the control conduit swage fittings.
- 1/2 in open-end wrench for the 5/16 in control crank handle bolt.
- Slot screwdriver for the 10-32 remote control crank screws.
- 3/8 in wrench for the 10-32 control crank stop nuts.
- 0.08 in Allen wrench for the 4-40 set screw (SCR242) on the odometer knob on the Model 693 and Model 664 remote control units.
- Control cable run-off prevention (stop) spring removal tool if required.
- Model 550 connector NO GO gauge for wear check of the control cable connector.
- X4 to X7 magnification glass for control cable inspection if required.
- Micrometer for measurement of control cable diameter.

4.4.2 Maintenance Materials required for Models 692, 693, 664 remote controls

- Clean solvent: fresh mineral spirits recommended for cleaning and degreasing remote control mechanism, control cable and cleaning the control conduits internally. (Follow manufacturer's safety precautions for use, handling, storage and disposal.)
- Large pan for cleaning and degreasing the control crank assembly and control cable.
- Clean lint-free rags and detergent to clean the exterior of the control conduits.
- Mil-spec grease, MIL-G-23827B (or C), MIL-PRF-23827C (or equivalent radiation resistant grease) for lubricating the control cable and control crank mechanism.
- Stainless steel, brass or synthetic bristle brush to clean control crank parts and the control cable.
- Compressed air source and hand nozzle to blow dry the control cable internal Teflon™ liner of the remote control conduits after cleaning.
- 3M™ yellow polyvinyl tape (or black polyvinyl electrical tape) for repair of cuts in remote control conduits.
- Safety glasses.

4.4.3 Remote Control Maintenance Requirements

- a. Disconnect the remote control unit from the gamma-ray source projector.
- b. Straighten out the remote control housings on a work surface, then remove the control cable from the remote control conduits (661 safety connector side) until it stops (a stop spring on the end of the control cable). Rubber gloves are recommended for this operation. Do not use excessive force during removal of the control cable. During removal of the control cable, it should be coiled in loops no less than a 12 in (305 mm) diameter and secure.
- c. Disconnect the remote control conduit fitting from the control crank using the 11/16 in open-end wrench. Remove the stop spring from the end of the control cable and pass the control cable through the crank gear to completely disengage. Label the remote control conduits for proper assembly after the servicing.
- d. Pull the remaining control cable through the 661 safety connector and secure.
- e. Using the 11/16 in open-end wrench, remove both remote control conduits from the 661 safety connector and the control crank.
- f. Thoroughly clean the control cable using a brush in a degreaser bath. Use compressed air to blow off residual solvent after the degreasing operation. Be sure to follow the solvent manufacturer's safety recommendations.
- g. Perform the following inspections of the control cable:
 - 1 Use the Model 550 NO GO gauge to inspect the control cable connector for wear. Closely inspect the connector for bends or cracks in the neck (shank) area and dented areas on the ball of the connector. Remove the control cable from service if any cracks or bends in the shank or dents in the ball of the male connector are found during this inspection. The male connector should not be bent at an angle greater than 15 degrees from the axis of the control cable in the area where it is crimped. Using your hands, attempt to twist or rotate the male connector off the control cable. If any movement is possible during this test, the control cable must be removed from service and the male connector must be replaced.
 - 2 Carefully inspect the control cable directly behind the remote control cable connector and approximately 12 in (305 mm) beyond the male connector looking for the following anomalies:
 - Cuts, breaks, nicks or fraying in the spiral windings of the cable.
 - Kinks or permanent bends.
 - Rust (red oxide) on the inner and outer core of the cable.
 - Uniformity of the spacing between the outer helical windings of the cable. Check for flattened areas and excessive wear that reduces the cable's outer diameter less than 0.183 in (4.7 mm).
 - Perform a flexibility (spring) test of the cable by bending the connector end of the cable into a 'U' shape and then releasing it. A cable that is bent/released and does not spring back into an essentially straight shape is indicative of internal corrosion of the cable. The cable must be removed from service.
 - Carefully examine the cable in the area of the control crank assembly looking for cuts, breaks, fraying, rust, unusual stiffness and uniformity of the spacing between the outer spiral windings.
 - Examine the entire length of cable looking for defects described above.

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If a control cable is deemed as defective during this inspection, remove it from service and tag it with a label to prevent inadvertent use.

The control cable (Model 550 male) connector must be replaced at intervals **not to exceed five (5) years**. Maintenance program administrators must maintain traceability records for replacement of all 'Safety Class A' designated components.

- h. Lightly lubricate the control cable using MIL-G-23827B (or C), MIL-PRF-23827C, or equivalent grease. Apply additional grease to the first 3 ft (approximately 1m) of control cable (male connector end).
- i. Clean the exterior of the remote control conduits using clean rags and a detergent. Remove all dirt and grease from the polyvinyl conduits and swaged fittings. Carefully inspect the entire length of remote control conduits for cuts and melted areas. Repairs to cut or melted areas can be accomplished by taping the area with 3M™ yellow polyvinyl tape (or black polyvinyl electrical tape). The tape will prevent the ingress of water and other liquid that would cause corrosion of the remote control conduit's inner braids and the remote control cable. Look and feel for dents and depressions in the remote control conduits. Minor dents can be rounded out by gently tapping the area with a small hammer.

Examine the control conduits where they protrude from the swage fittings, looking for bulges or cracks in the polyvinyl. Remote control conduits with large dented areas or cracks/ bulges near the swage fittings should be sent to the manufacturer for repairs.

Clean the interior of both remote control conduits by pouring 4-5 oz (100 ml) of clean solvent into one end. Use compressed air to blow the solvent through the entire length of conduits into a clean white cloth attached to the opposite end. Repeat this cleaning process until the solvent blown through the conduit comes out clean. Use the compressed air to thoroughly dry the interior of the conduit. Residual solvent left in the remote control conduit will dilute the lubrication applied to the remote control cable diminishing the protective qualities.

Check the swage fittings to ensure the threads are not stripped and are clean. Using your hands, attempt to twist or rotate the swage fittings off the control conduits. If any movement is possible, the control conduit must be removed from service and new swage fittings must be installed.

- j. Remove the crank arm from the control crank assembly by removing the 5/16 in hex bolt and washer.

While wearing safety glasses, carefully remove the control crank assembly from the handle or frame by unscrewing the four bind head screws from the stop nuts.

Separate the two halves of the control crank housing.



CAUTION



Ensure the cable adapters stay in the bottom control crank housing during separation. Care should be taken to avoid losing control of the tensioned wear strip that may fly out during separation of the control crank housing. **This is the reason why safety glasses must be worn.**

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Disassemble and degrease the drive wheel, wear strip, the two cable adapters, the two brake jaws, the two halves of the control crank housing and brake bearing. The wheel bearings may be left in the control crank housing during cleaning, but care should be taken not to lose the spacer rings that fit between the wheel bearings and the drive wheel as applicable. Clean and inspect all parts for damage or wear and replace as necessary.

If applicable, remove the reset knob of the odometer by loosening the two Allen set screws, then remove the odometer cover by removing the two bind head screws that fasten it to the mounting plate. Do not disassemble the odometer.

Clean the helical gear of the odometer with solvent using a brush to dislodge any material between the gear teeth. Check the odometer for proper operation: turning the gear should turn the odometer but the odometer shaft should still be able to turn when the gear is held fixed (for zeroing the odometer).

Clean the drive wheel in solvent using a brush to dislodge any dirt between gear teeth. Inspect the drive wheel's gear teeth looking for broken or bent teeth. If the drive wheel has broken or bent teeth, use a file to grind the tooth flush with the drive wheel. Up to three consecutive teeth can be missing from the drive wheel before a replacement is required.

Light rust may be removed from the wear strip using fine sandpaper and machine oil.

Lightly grease the drive wheel hub, wheel bearings and the wear strip before reassembling.

Place one of the cable adapters in the lower control crank housing. Place one end of the wear strip against the cable adapter then fit the rest in the track of the housing. Fit the other cable adapter in place to retain the wear strip.



CAUTION



Wear safety glasses when inserting the wear strip. It will be under tension and could suddenly fly out during assembly.

Place the drive wheel in the lower half of the control crank housing making sure the spacer rings are between it and the wheel bearings if applicable.

Assemble the two brake jaws, brake bearing and brake arm. The angled sides of the brake jaws should be facing the retract side of the control crank housing.

Place the upper control crank housing over the assembly while keeping them level and press them together.

Check that the control crank mechanism is properly assembled by turning the shaft. It should spin freely.

Check the operation of the friction brake while holding both halves of the control crank housing together tightly. If it does not function correctly, check for faulty assembly or excessively worn brake jaws.

As applicable, mount the control crank housing on the frame or handle with the four bind head screws and stop nuts. Secure the crank arm to the shaft using the 5/16 in washer and hex bolt.

For reel type controls, secure the odometer cover to the mounting plate with two bind head screws. Secure the odometer's reset knob to the shaft by tightening the two Allen head screws, leaving clearance between the knob and the cover.

After assembly, perform a check to ensure the control crank will turn freely. Set the brake lever to the ON position and attempt to turn the handle using moderate pressure. Do not apply excessive force. Run a section of the control cable through the control crank to ensure the control crank operates easily without snags or resistance.

If applicable, make sure the odometer turns when the crank handle is turned. If the odometer does not function during this test, check for improper assembly or damaged parts.

- k. Clean the 661 safety connector assembly using a brush and solvent. Ensure the movable jaws of the safety connector are not excessively loose or worn where they swivel in the clevis pins. Examine the connector collar for bent or loose connecting pins and excessive wear on the inner-mating surface. Examine the face of the connector body where the control cable protrudes and verify that long-term usage has not chamfered the area.

4.4.4 Re-assembly of the Remote Control Unit:

Reattach the remote control conduits to the safety connector assembly. Attach the EXPOSE sheath to the EXPOSE side of the control crank assembly.

Lay the remote control conduits out in a straight line or a wide loop. Feed the end of the control cable into the conduit as far as it will go. As the control cable is being fed into the remote control conduits, feel for any resistance that indicates damage of the remote control conduit.

Turn the control crank handle in the RETRACT direction until the end of the control cable is protruding. Screw the safety stop spring onto the end of the control cable approximately 2 in (50 mm) from the end.

Connect the RETRACT control housing to the control crank housing. Retract the control cable fully, watching for any binding that may indicate damage to the control housing.

If applicable, reset the odometer to zero with the control cable fully retracted.

Replace the protective rubber cap over the end of the safety connector assembly.

4.5 Annual Maintenance for Extreme Condition Remote Controls



Figure 20 – 882 Control Styles



Figure 21 – 885 Reel Control

4.5.1 Maintenance Tools required for Models 882 and 885 extreme remote controls:

- 11/16 inch open-end wrench for the control conduit swage fittings.
- 1/2 inch open-end wrench for the 5/16 inch control crank handle bolt.
- 1/8 inch Allen wrench for the 6-32 socket-head remote control crank screws (SCR-252).
- 1/8 inch drill, #21 drill bit.
- Control cable run-off prevention (stop) spring removal tool if required.
- Model 550 connector NO GO gauge for wear check of the control cable connector.
- X4 to X7 magnification glass for control cable inspection if required.
- Micrometer for measurement of control cable diameter.

4.5.2 Materials required for complete maintenance of Models 882 and 885 remote controls:

- Clean solvent: fresh mineral spirits recommended for cleaning and degreasing remote control mechanism, control cable and cleaning the control conduits internally. (Follow manufacturer's safety precautions for use, handling, storage and disposal.)
- Large pan for cleaning and degreasing the control crank assembly and control cable.
- Clean lint-free rags and detergent to clean the exterior of the control conduits.
- Mil-spec grease, MIL-G-23827B (or C), MIL-PRF-23827C (or equivalent radiation resistant grease) for lubricating the control cable and control crank mechanism.
- Stainless steel, brass or synthetic bristle brush to clean control crank parts and the control cable.
- Compressed air source and hand nozzle to blow dry the control cable internal Teflon™ liner of the remote control conduits after cleaning.
- 3M™ yellow polyvinyl tape (or black polyvinyl electrical tape) for repair of cuts in remote control conduits.
- Loctite™ 242 temporary thread sealant or equivalent.

4.5.3 Remote Control Maintenance Requirements

- a. The remote control unit must be disconnected from the gamma-ray source projector for inspection and maintenance. A "misconnect test" can be performed before servicing to verify if unsafe wear is present.
- b. Straighten out the remote control housings on a work surface, then check for freedom of movement of the control cable within the remote controls by moving the control crank handle back and forth approximately one-quarter turn. During this test, take care to avoid cranking the control cable onto the ground exposing it to dirt and sand. If any resistance is felt during this check, inspect the control conduits for dents or depressions. If dents or depressions are not present on the remote control conduits, the control cable may be rusted stiff somewhere within the control conduits or the control crank internal housing may contain dirt or debris. After the operational check, remove the control cable from the remote control conduits (661 safety connector side) until it stops (a stop spring on the end of the control cable). Rubber gloves are recommended for this operation. Do not use excessive force during removal of the control cable. During removal of the control cable, it should be coiled in loops no less than a 12 in (305 mm) diameter.
- c. Disconnect the remote control conduit fitting from the control crank using the 11/16 in open-end wrench. Remove the stop spring from the end of the control cable and pass the control cable through the crank gear to completely disengage. Label the remote control conduits (hand crank end / safety plug assembly end) for proper assembly after the servicing.

- d. Pull the remaining control cable through the 661 safety connector and secure using tie wraps or equivalent.
- e. Using the 11/16 in open-end wrench, remove both remote control conduits from the 661 safety connector and the control crank.
- f. Thoroughly clean the control cable using a brush in a degreaser bath. Use compressed air to blow off residual solvent after the degreasing and cleaning operation.



CAUTION



Be sure to follow the solvent manufacturer's safety instructions and Material Safety Data Sheet recommendations.

- g. Perform the following inspections of the control cable:
 - 1 Use the Model 550 NO GO gauge to inspect the control cable connector for wear. Closely inspect the connector for bends or cracks in the neck (shank) area and dented areas on the ball of the connector. Remove the control cable from service if any cracks or bends in the shank or dents in the ball of the male connector are found during this inspection. The male connector should not be bent at an angle greater than 15 degrees from the axis of the control cable in the area where it is crimped. Using your hands, attempt to twist or rotate the male connector off the control cable. If any movement is possible during this test, the control cable must be removed from service and the male connector must be replaced.
 - 2 Carefully inspect the control cable directly behind the remote control cable connector and approximately 12 in (305 mm) beyond the male connector looking for the following anomalies:
 - Cuts, breaks, nicks or fraying in the spiral windings of the cable.
 - Kinks or permanent bends.
 - Rust (red oxide) on the inner and outer core of the cable.
 - Uniformity of the spacing between the outer helical windings of the cable. Check for flattened areas and excessive wear that reduces the cable's outer diameter less than 0.183 in (4.7 mm).
 - Perform a flexibility (spring) test of the cable by bending the connector end of the cable into a 'U' shape and then releasing it. A cable that is bent / released and does not spring back into an essentially straight shape is indicative of internal corrosion of the cable. A 'crunching' feeling and stiffness when bending the cable into the "U" shape is another confirmation of the problem. The drive cable must be removed from service.
 - Carefully examine the drive cable in the area of the control crank assembly looking for cuts, breaks of the inner and outer spiral metal windings, fraying, rust, unusual stiffness and uniformity of the spacing between the outer spiral windings.
 - Examine the entire length of cable looking for defects described above.

If a control cable is deemed as defective during this inspection, remove it from service and tag it with a label to prevent inadvertent use.

The control cable (Model 550 male) connector must be replaced at intervals **not to exceed five (5) years**. Maintenance program administrators must maintain traceability records (lot numbers) for replacement of all “Safety Class A” designated components.

- h. Lightly lubricate the control cable using MIL-G-23827B (or C), MIL-PRF-23827C, or equivalent grease. Apply additional grease to the first 3 ft (approximately 1m) of control cable (male connector end).
- i. Clean the exterior of the remote control conduits using clean rags and a detergent. Remove all dirt and grease from the polyvinyl conduits and swaged fittings. Carefully inspect the entire length of remote control conduits for cuts and melted areas. Repairs to cut or melted areas can be accomplished by taping the area with 3M™ yellow polyvinyl tape (or black polyvinyl electrical tape). The tape will prevent the ingress of water and other liquid that would cause corrosion of the remote control drive cable. Visually inspect and feel for dents and inward depressions on the remote control conduits. The extreme control conduits are dent resistant, but may have flattened areas or cuts due to impacts.

Remove the spring duplex strain relief assembly and examine the control conduits where they protrude from the swage fittings, looking for bulges or cracks in the polyvinyl. Remote control conduits with large dented areas or cracks/ bulges near the swage fittings must be sent to the manufacturer or authorized service center for repairs.

Clean the interior of both remote control conduits by pouring 4-5 oz (100 ml) of clean solvent into one end. Use compressed air to blow the solvent through the entire length of conduits into a clean white cloth attached to the opposite end. Repeat this cleaning process until the solvent blown through the conduit comes out clean. Use the compressed air to thoroughly dry the interior of the conduit. Residual solvent left in the remote control conduit will dilute the lubrication applied to the remote control cable diminishing the protective qualities.

Check the swage fittings to ensure the threads and hex nuts are not stripped and are clean. Using your hands, attempt to twist or rotate the swage fittings off the control conduits. If any movement is possible, the control conduit must be removed from service and new swage fittings must be installed.

- j. Remove the crank arm assembly with brake from the control crank assembly by removing the 5/16 inch hex bolt and washer. Check the hand crank knob (tee-handle) pin (part number 95010) for looseness or excessive wear. Replace worn knob pin by removing roll-pin (part number PIN024), replace knob pin (part number 95010) and then insert a new roll pin (part number PIN024). Check brake assembly for proper on and off operation and verify the spring tension is adequate to maintain the set position. Compare the crank arm assembly to a new crank arm assembly for conformity to shape. If required, a bent crank arm can be mounted into a vise and bent back into its original shape.

Disassemble the control crank assembly by unscrewing the six socket-head screws (part number SCR252) using a 1/8 inch Allen wrench.

Separate the drive gear cover (steel plate, part number 95002-6) from the molded grip handle body of the control crank. Inspect the drive gear cover plate label (part number 95007-01 or 95006-01) to ensure the “expose” and “retract” and arrows indicating the direction of travel is legible. Replace the operator instruction label if damaged or illegible.

Inspect the molded grip handle body (part number 95003) to ensure the tubular spacers (part number 95003-6) are all present. The tubular spacers prevent over-compression and distortion of the black molded grip handle when the six socket-head screws are tightened. Inspect the black plastic handle body for cracks near the conduit fittings and the ball bearing housing. Inspect the black plastic handle body for its general condition to ensure it's not

deformed as the result from exposure to high temperature and there are no cracks or perforations in the plastic housing that could allow the ingress of foreign materials such as water, sand, mud or fly ash.

Disassemble, clean and degrease the drive gear (part number 95005), interior surface of the molded grip handle and drive gear cover (part number 95002-6), the two conduit fittings and the external surfaces of the ball bearings (part number BBS032). Inspect the ball bearings to ensure the rubber seals are not cracked or worn through. Check the ball bearings for smooth and free movement by holding the inner hub stationary and rotating the outer hub. These are sealed ball bearings and do not require additional lubrication.

Inspect the two rubber seals, 15mm seal (part number RIN024) and the large O-ring seal (part number RIN026) for cracks, cuts or abrasion that would warrant replacement. If the rubber seals are deemed satisfactory after this inspection, apply a light coating of grease to these seals.

Clean the drive gear in solvent using a brush to dislodge any dirt between drive gear's teeth. Inspect the drive wheel's gear teeth looking for broken or bent teeth. If the drive wheel has broken or bent teeth, use a file to grind the tooth flush with the drive wheel. Up to three consecutive teeth can be missing from the drive wheel before a replacement is required.

Light rust may be removed from the wear strip using fine sandpaper and machine oil.

Lightly grease the wear strip before reassembling.

4.5.4 Reassembly of the remote control handle assembly:

Install the ball bearing (part number BBS032) into the steel insert of the molded grip handle. Insert the drive gear in the ball bearing already placed in the crank housing. Rotate the drive gear (part number 95005) to ensure free movement and proper seating. Install the second ball bearing (BBS032) onto drive gear shaft and rotate to ensure proper seating of the installed components. Install the lubricated large diameter O-ring seal onto the back side of the drive gear cover plate and seat into the molded grip handle body. The serial number of the drive gear cover plate should be positioned at the five o'clock position relative to the hand grip at the six o'clock position. Install the lubricated 15 mm rubber seal onto the drive gear shaft while making sure it's seated within the drive gear cover plate.

Apply Loctite 242 (GLU031) onto the first four threads of socket head screws (part number SCR252). **Ensure the tubular spacers (part number 95003-6) are all present. The tubular spacers prevent over-compression and distortion of the black molded grip handle when the six socket-head screws are tightened.** Install and hand tighten the six socket head screws (part number SCR252) and flat washers (part number WSH047) into the back of the molded grip handle body using the 1/8 inch Allen wrench. Install the crank arm assembly onto the drive gear shaft at the 9 o'clock position relative to the 6 o'clock position of the hand grip. Apply temporary Loctite 242 (GLU031) to the first four threads of the 5/16 inch bolt. Install the 5/16 inch hex-head bolt (part number SCR219-03) and washer (WSH045) and hand tighten using a 1/2 inch open-end wrench.

After assembly, verify the control crank mechanism is properly assembled by turning the crank arm. It should spin freely. Check the operation of the brake's plunger knob.

For reel type controls, apply Loctite 242 (GLU031) to the first four threads of the flat socket head screws. Mount the control crank housing on the reel type frame with the two flat socket head screws (part number SCR350) and 2 thrust plates (part number 95063).

After assembly, perform a check to ensure the control crank will turn freely. Set the brake plunger knob to the ON position (engaged on the drive gear cover plate) and attempt to turn the handle using moderate pressure. Do not apply excessive force. Run a section of the control cable through the control crank to ensure the control crank operates easily without snags or resistance.

Clean the 661 safety connector assembly using a brush and solvent. Ensure the movable jaws of the safety connector are not excessively loose or worn where they swivel in the Spirol pins (part number PIN016). Attempt to push the pins out using the back end of a 1/8 inch drill bit or a drift punch. If they can be moved by pushing, replace the pins. Visually look for cracked Spirol pins from both sides of the safety connector. Replace the Spirol pins if there is any evidence of cracked or broken pins. Examine the connector collar for bent or loose connecting pins and excessive wear on the inner-mating surface. Examine the face of the connector body where the control cable protrudes and verify that long-term usage has not chamfered the area.

4.5.5 Re-assembly of the Remote Control Unit:

If required, install the spring duplex strain relief assembly on the opposite end of the remote control conduits from which it was removed. This will promote even wear of the remote control conduits. Reposition the spring strain relief assembly by sliding it down the entire length of conduits to the opposite end. Apply heavy-duty shrink wrap or wrap PVC tape, near the end the spring to prevent chafing of the conduits. Reattach the remote control conduits to the safety connector assembly. Attach the EXPOSE sheath (yellow side of the joined conduits) to the EXPOSE side of the control crank assembly.



Lay the remote control conduits out in a straight line or a wide loop. Feed the end of the control drive cable into the conduit as far as it will go. As the control cable is being fed into the remote control conduits, feel for any resistance that indicates damage of the remote control conduit.

Turn the control crank handle in the RETRACT direction until the end of the control cable is protruding. Screw the safety stop spring onto the end of the control cable a minimum of two full outer helical wraps from the end. This minimum distance is 0.250 in (6.3mm). The safety stop spring prevents the drive cable from disengagement from the drive gear causing a loss of control to expose or retract.

Connect the RETRACT control housing (black side of the joined conduits) to the control crank housing. Fully retract the remote control drive cable while feeling for any binding that may indicate damage to the control housings. Perform a freedom of movement test as described part two of this section.



Perform a “misconnect test” (see Sections 4.1.4 and 4.6.4) of the serviced remote controls on a QSA Global Inc. gamma-ray source projector locking mechanism to confirm the remote control assembly is free from long term wear or damage could cause a failure of the interrelated failsafe system that includes the control drive cable connector, safety plug assembly, device locking mechanism and sealed source connector.

Replace the protective rubber cap over the end of the safety connector assembly.

Record all inspections conducted, all maintenance performed and components that were replaced on the remote controls. Identify the remote controls with the serial number that is etched on the stainless steel drive gear cover. See “Annual Maintenance Records” section.

Extreme controls descriptive: The lightweight, extreme controls were designed for operation in -40°C to 100°C temperatures while providing users with a rugged, water-resistant, crush-resistant weld-joined control housings matched to an ergonomically designed hand crank. The extreme remote controls are compatible with all QSA Global, Inc. crank-out radiographic gamma-ray source projectors.

4.6 Annual Maintenance for Source Guide Tubes

4.6.1 Maintenance Tools

- A424-13XL or A424-14XL mock source assembly to perform function tests after cleaning and inspection.
- Length of clean control cable to push A424-13XL (or A424-14XL) through a 7 ft (2.1 m) source guide tube.
- 1 in-18 tap and 1 in-18 die for male and female threads of the source guide tubes, if required.

4.6.2 Maintenance Materials

- Solvent: Clean mineral spirits to clean the source guide tubes internally.
- Clean lint-free cloths and detergent to clean the exterior of the source guide tubes.
- Mil-spec grease MIL-G-23827B (or C), MIL-PRF-23827C (or equivalent radiation resistant grease) to lubricate the swage fittings on the source guide tubes.
- Source of compressed air and hand nozzle to blow dry the internal conduit of the source guide tubes.
- 3M™ yellow polyvinyl tape (or black polyvinyl electrical tape) for repair of cuts in the source guide tubes.
- Loctite™ 242 (GLU031) temporary thread sealant or equivalent for bayonet adaptor threads.

4.6.3 Source Guide Tube Maintenance

- a. Clean the exterior of all the source guide tubes thoroughly using clean cloths and a detergent. Remove all dirt, grease and grime from the yellow polyvinyl source guide tubes and the swage fittings.
- b. **(Use of Safety Glasses is recommended for this step.)** Clean the interior of each source guide tube by pouring 4-5 oz (100 ml) of clean solvent into one end. Manipulate the source guide tube back and forth to cause the solvent to wash the interior of the entire length of source guide tube. Pour the solvent into a used solvent container. Refill the source guide tube with clean solvent and repeat the cleaning operation. Repeat this cleaning process until the solvent poured out of the source guide tube into the used solvent container is clean. Use a compressed-air hose to blow out any residual solvent from the source guide tubes. Use of a

clean white cloth attached to one end of the source guide tube will trap any debris or residual solvent when blowing out the source guide tubes. Repeat the cleaning process until the cloth 'trap' indicates dirt is not present within the source guide tubes.

- c. Carefully inspect the entire length of each source guide tube for cuts and melted areas. Repairs to cut or melted areas can be accomplished by taping the area with 3M™ yellow polyvinyl tape (or black polyvinyl electrical tape). Taping the damaged area of the polyvinyl sheath will prevent the ingress of water and other liquid that would cause corrosion to the remote control cable. Carefully look and feel for dents and depressions in the source guide tubes. Even a small inward dent in the source guide tube could cause a seized source assembly resulting in emergency operations. A 'mock' (Model A424-13XL or A424-14XL) source assembly attached to a section of control cable that is pushed through the entire length of source guide tube provides additional confirmation the source guide tube suitable for use.
- d. Inspect the swage fittings of each source guide tube to ensure the threads are not stripped or galled. If the threads are damaged, the use of a 1inch-18 tap or die and oil can be used to clean the damaged area. Using moderate pressure, attempt to twist the swage fitting off the source guide tube. If any movement is possible, remove from service and replace the swage fitting. Inspect the source guide tube near the swage fitting for breaks and bulging, remove from service and send to a service center for repairs. Inspect the exposure head (source stop) for excessive wear or perforations on the end-stop and the side where the collimator (beam limiter) is mounted. Damaged fittings or exposure heads on source guide tubes can be replaced at a QSA Global service center. If the swage fittings are not damaged and are securely attached to the source guide tube, apply a light coat of grease to the threads and install the protective covers over the fittings.
- e. Thoroughly clean the bayonets (86062-110 or 86062-330) in clean solvent and thoroughly dry. No disassembly is required for servicing these swaged bayonet adaptors. Inspect the ears on the bayonet fitting to ensure they are not bent, broken or excessively worn. Inspect the swivel bayonet nut to ensure the threads are not stripped, clogged with material and that it rotates freely. Inspect the bayonet to verify the separation gap is not excessively wide or loose. Verify the identification marking (110 or 330) on the bayonet is legible for easy identification. After cleaning, screw the bayonet onto a source guide tube to verify the threads of the bayonet nut properly engage to the threads of the source guide tube. Test the bayonet on the outlet port of the gamma-ray source projector as described in Section 4.3.3.e.

4.6.4 Annual Maintenance Records

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

- The date of the inspection and maintenance.
- The name of the qualified individual performing the required inspections.
- Record problems found and maintenance or repairs performed. Include results of misconnect tests on all remote controls and gamma-ray source projectors by manufacturer, model number and serial number.
- The model number and serial number of the gamma-ray source projector.
- The associated equipment including the model number of remote controls (serial number if serialized) and source guide tubes that were inspected and maintained.
- The part numbers and associated lot numbers or serial numbers of replacement parts installed.

These inspection and maintenance records must be retained according to the record keeping requirements of the applicable regulatory jurisdiction.

4.7 SENTINEL 1075 SCARPro Safety Class A Components

4.7.1 Safety Class A Designation Items

Items that comprise the SENTINEL 1075 SCARPro gamma-ray source projector and associated equipment that are critical for safe radiological operation are classified as Class A items or components. 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. This would include extreme conditions such as the loss of primary containment with a subsequent release of radioactive material and or a loss of shielding creating a substantial safety hazard. Replacement parts that are sent to you with a safety Class A designation are clearly marked with lot numbers and contain instructions to maintain traceability.

4.7.2 Considerations of Safety Class A Items

Users of the SENTINEL 1075 SCARPro gamma-ray source projector and associated equipment must recognize their responsibilities of maintaining the integrity of the radiography device and Type A package and the control of Safety Class A items and components by:

- maintaining traceability of Class A replacement items or components to a specific gamma-ray source projector or an associated component.
- use of manufacturer specified items to maintain the integrity of the gamma-ray source projector/transport package 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 Class A items are not excessively worn from long term use or have been damaged from accidents.
- use and handling of the system consistent with its design and intended application.
- promptly notify the manufacturer in the event a Safety 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.

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CONTROL ASSEMBLIES

Model Numbers 692, 693 and 664 Series



SOURCE GUIDE TUBES

Model Numbers 48906, 48907,
48930, 48931, 95020 and 95021
Series



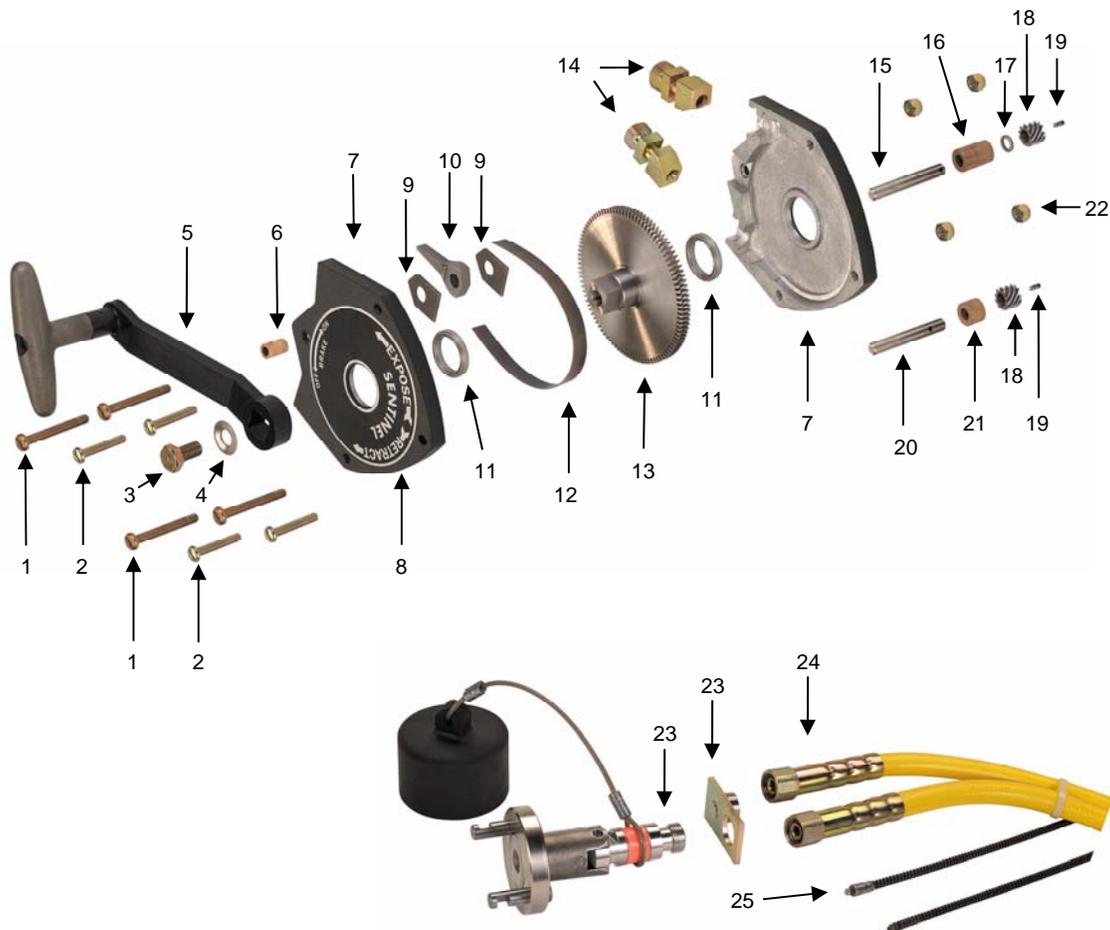
REMOTE CONTROL HAND CRANK ASSEMBLIES

Model numbers: 692, 693 and 664

ITEM	PART NO.	QTY.	DESCRIPTION
1	SCR125	4	1 5/8 IN BIND HEAD SCREW ●
2	SCR008	4	1 1/4 IN BIND HEAD SCREW ○
3	BLT008	1	HEXAGONAL BOLT
4	WSH019	1	WASHER
5	68901	1	CRANK ARM
6	BBS-004	1	BRAKE BUSH
7	81800-10	2	CONTROL CRANK HOUSING
8	68900-8	1	CRANK DECAL
9	68900-4	2	BRAKE JAW
10	68900-3	1	BRAKE ARM
11	BBS-001	2	BALL BEARING ASSEMBLY
12	68900-7	1	WEAR STRIP
13	81800-1	1	DRIVE WHEEL
14	68900-2	2	CABLE ADAPTER
15	69302-1	1	GEAR SHAFT ●
16	BBS-007	1	OILITE BEARING ●
17	PIC-003	1	WASHER ●

ITEM	PART NO.	QTY.	DESCRIPTION
18	GEA-002	1	HELICAL GEAR
19	PIN008	1	ROLL PIN
20	66404-1	1	GEAR SHAFT ○
21	BBS-005	1	OILITE BEARING ○
22	NUT025	4	STOP NUT
23	66103	1	SAFETY CONNECTOR
	66101-4	1	CABLE PLUG
24	59125	2	25 FT (7.6 M) HOUSING
	59135	2	35 FT (10.7 M) HOUSING
	59150	2	50 FT (15.2 M) HOUSING
25	55005	1	50 FT (15.2 M) CONTROL CABLE
	55010	1	70 FT (21.3 M) CONTROL CABLE
	55009	1	100 FT (30.5 M) CONTROL CABLE
26	69303-	1	ODOMETER ASSEMBLY ●
27	69201-3	1	HANDLE ●
28	66410	1	FRAME ○
29	66403-	1	ODOMETER ASSEMBLY ○

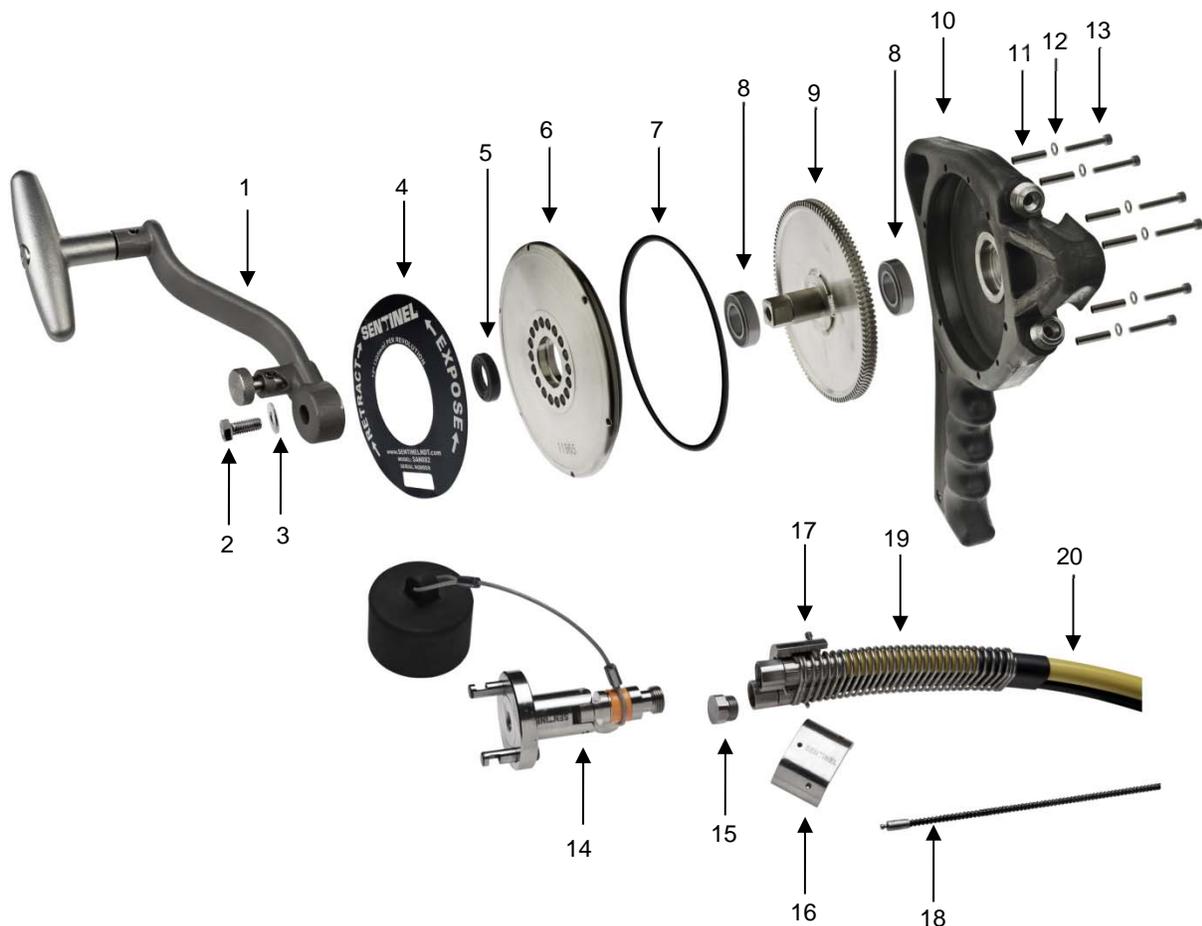
● PISTOL GRIP MODEL ○ REEL TYPE MODEL



REMOTE CONTROL HAND CRANK ASSEMBLIES

Model Numbers: 882 and 885 series

Item	Part No.	Qty.	Description	Item	Part No.	Qty.	Description
1	95008	1	Crank Arm Assembly	11	95003-6	6	Tubular Spacer
2	SCR219-03	1	5/16-18 UNC x 3/4 Hex Head Screw	12	WSH047	6	Flat Washer
3	WSH045	1	0.75 OD x 0.313 ID x 0.051-.080 Thick SST Flat Washer	13	SCR252	6	6/32 x 7/8 SST Socket Head Screw
4	95006-01	1	SAN882 Label	14	66103	1	Connecting Plug Assembly
5	RIN024	1	15mm Seal	15	95039	1	Plug Conduit End
6	95002-6	1	Drive Gear Cover	16	95037-2	1	Clamp, Bottom Half
7	RIN026	1	3 x 96 mm ID O-Ring	17	95037-1	1	Clamp, Top Half
8	BBS032	2	15 x 28 x 7 mm Ball Bearing	18	55005 55010 55009	1	50 FT (15.2 M) CONTROL CABLE 70 FT (21.3 M) CONTROL CABLE 100 FT (30.5 M) CONTROL CABLE
9	95005	1	Drive Gear Weldment	19	95038	1	Spring Duplex Strain Relief
10	95003	1	Molded Grip Handle Body	20	95035-XX	1	Conduit Assembly, Extreme Control, XX = 25, 35, 50 Feet Long

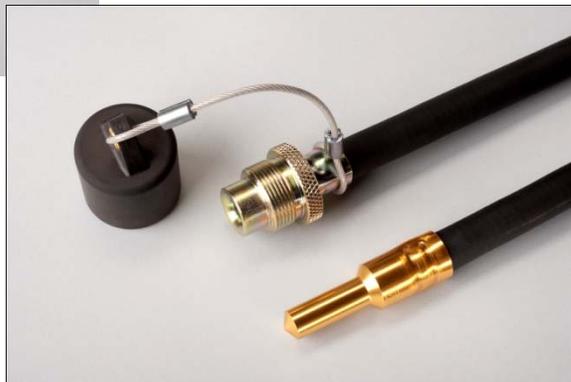


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REMOTE CONTROL ASSEMBLIES Model numbers: 882 and 885 series

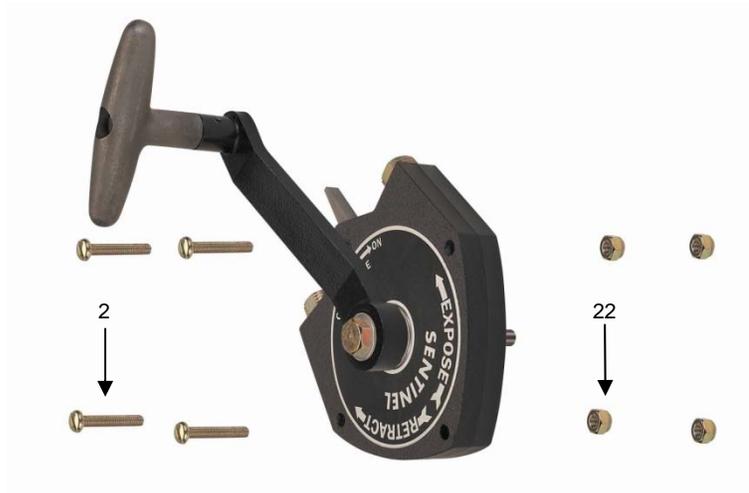


SOURCE GUIDE TUBES Model numbers: 95020 and 95021



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COMPONENTS FOR: Model 664 reel, odometer for Model 664 reel, Model 692 hand crank, Model 693 hand crank



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 1075 SCAR*Pro* is approved as a component of a Type A transport package (Model 1075A). As a shipper of radioactive material, you must perform a pre-shipment inspection to verify conformance to the Type A package requirements 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.
- If attached to the device, 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).
- Assure all the conditions of the Type A approval are met and the transport package is assembled as required by the Type A approval.
- Survey the exterior surfaces to assure the radiation levels do not exceed the maximum allowable of 200 mR/hr (2 mSv/hr) on the surface or the maximum allowable required by ANSI/ISO equipment standards of 5 mR/hr (50 μ Sv/hr) at one meter from the surface. Wipe test the transport package over an area of 300 cm² and assure the level of removable contamination is less than 0.0001 μ Ci per cm².

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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 transport requirements.

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.

- 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)]

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- 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 the shipment involves the use of a Declaration of Dangerous Good form, all personnel involved with the shipment must be trained in IATA/ICAO/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.

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 certification and Special Form certifications, and assure the package and its contents meet the following requirements:
- The contents 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 certification for the package and special form certifications on file.

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- 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 under the “Transport Package” requirements and verify the package is assembled as described in the Type A approval.
- e. Attach a padlock to the package closure that serves as a tamper indicator. [49CFR173.412(a)]
- f. 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]
- g. 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 Type A package and the overpack. Placarding the vehicle is dependent on the category of label applied to the overpack if used. [49CFR173.448]

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.

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The TI is the maximum radiation level measured in mRem/hr at a distance of 1m 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.)

- h. Properly complete two shipping labels indicating the contents (e.g. Se-75), 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 1m from the package surface (see Table 1). [49CFR172.403(g)]
- i. 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)]
- j. 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.
- k. Mark the outside of the package with the proper shipping name and identification number (e.g., 'Radioactive Material, Type A Package, Special Form, UN3332' for a Type A shipment) 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. [49CFR172.300]
- l. 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]
- m. 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]
- n. Properly complete the shipping papers indicating:
 - 1 Identification number, proper shipping name, hazard class (e.g. 'UN 3332, Radioactive Material, Type A Package, Special Form, Class 7').
 - 2 The letters RQ must appear before the identification number or after the hazard class when shipping more than 10 Ci (370 GBq) of Se-75.
 - 3 Name of the radionuclide (e.g., Se-75).
 - 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 Ci x 37 = number of GigaBecquerels (GBq).
 - 6 Category of label applied (i.e. Radioactive Yellow II).
 - 7 Transport Index.
 - 8 DOT Type A Specification 7A.

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- 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, 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.
- o. 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(o) 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.

- p. The 24-hour emergency number required by Step 5.3(n) 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."

- q. For shipment of special form radioactive material, the Special Form Certificate of Competent Authority for the radioactive source must be included. (e.g. USA/0335/S-96).
- r. 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.'

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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.

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. [10 CFR 20.2207 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 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 $\mu\text{Sv/hr}$ (2 mR/hr) outside the vehicle to meet unrestricted area requirements.
 - Vehicle must meet new security requirements where applicable.
- l. 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 and 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.

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- 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.

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 5mSv/hr (500mR/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 assembly is fully shielded and restricted to this position within the radiographic gamma-ray source projector. The SENTINEL 1075 SCAR*Pro* is equipped with automatic securing mechanisms that are actuated whenever the source assembly is fully retracted into the gamma-ray source projector's fully shielded position.

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

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. Never assume!
- 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 and must be adhered to under regulation:

- 1 Immediately leave the area and maintain continuous surveillance of the 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.

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 and inspection & maintenance 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 (OSL) badges; direct reading pocket dosimeters; electronic pocket dosimeters; alarm ratemeters; and audible alarms. Calibrated and operable survey meters must be used to determine and verify 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. Selenium-75 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.

If the gamma-ray source projector is impaired or damaged, the gamma-ray source projector must be transported without radioactive source assemblies. Contact QSA Global, Inc. for assistance in the evaluation and disposition of an impaired or damaged SENTINEL 1075SCARPro gamma-ray source projector and or SENTINEL 1075A Type A package for final disposition.

9. CONTACT INFORMATION.

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