Operating and Maintenance Manual

Cobalt-60 Source Projector
Models 680-OP and 741-OP
DANGER - IMPORTANT WARNINGS

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

Gamma radiography systems emit high levels of highly penetrating radiation during use. An unshielded radiation source at close range can cause injury, sickness or death to anyone who is exposed to it even for a short period of time.

A radiation source (or an unshielded source assembly) 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, direct reading pocket dosimeters and audible alarm ratemeters must be worn during all radiographic operations.

During use of this radiography system, never assume the position of the radiation source. Always conduct a thorough confirmatory survey using a calibrated and operable survey meter to verify the location of the radiation source. Be reminded that a multitude of overexposure incidents which include injuries are directly attributed to a failure of the radiographer to perform or supervise an adequate confirmatory survey.

It is imperative that the users of this transport container perform adequate radiation surveys of the transport container and exposure devices. Surveys must be performed using a calibrated survey instrument before, during and after source exchanges and before transport to determine if the source assembly is properly shielded within the transport 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 and international 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
When possible, always apply the use of effective shielding between you and the radiation source.

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

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

Do not use any components that are not approved for use with the radiography system or after-market components that may compromise the safety features designed into the system.
SECTION 1 - TECHNICAL SPECIFICATIONS

Exposure Device Description
The Model 680-OP and Model 741-OP are mobile industrial radiography exposure devices and are identical except for capacity and size. They consist of a Model 680 or a 741 gamma ray projector contained within a protective carbon steel container of welded construction with dimensions of approximately 32" in length, 19" in width, and 18.5" in height. Together, the gamma ray projector and the steel container constitute the Type B(U)–96 transport package.

Refer to the Type B certifications and applicable drawings as needed for licensing purposes and packaging for transportation. A copy of all package certifications is available from Sentinel customer service, 800-225-1383 in the USA. See back page for contact information outside the USA.

The ends of the carbon steel containers have easy access sliding doors that permit attachment of the controls and source guide tubes to the gamma ray projector within the steel container when used at locations other than a fixed permanent installation. The sliding doors permit use of the gamma ray projector within the protective steel container.

The ‘S’ tube design exposure device consists of a cast depleted Uranium (DU) shield encased in a steel housing and fixed in position by retaining bar assemblies. The exposure device housing is fabricated from a steel shell and two side plates. The internal void space of the steel housing is filled with polyurethane foam to prevent the ingress of water or foreign material, but is open to atmospheric pressure.

The devices are equipped with locking mechanisms to prevent motion of the source assembly when in the locked position. The lock mechanism also prevents the source from being inadvertently retracted through the back of the device. The device is operated with a flexible cable that moves the source from the shielded position to the end of the source guide tube, and returns the source to the shielded position upon completion of the exposure. The source is fastened to the flexible cable with a stainless steel connector.

The Model 680-OP and 741-OP Posilok exposure devices and applicable sources are designed, tested and manufactured to meet the requirements of ANSI N432-1980, International Atomic Energy Agency IAEA TS-R-1 (1996), USNRC 10CFR34, 10CFR71 and 49CFR173 requirements. Additionally, the exposure devices are designed, manufactured and serviced under a ISO 9001 QA program and a USNRC 10CFR71, Subpart H QA program. The QA program also includes the reporting requirements of USNRC 10CFR21 for suppliers of source and byproduct materials. Only Posilok (A and B versions with automatic securing locks) devices contained in the 680-OP and the 741-OP are authorized for use in Canada and the USA.

Applications
The Models 680-OP series and 741-OP series devices are used for industrial applications of gamma radiography with Cobalt–60 to inspect materials and structures. Used for industrial gamma radiography of various materials in the following approximate thickness range:

- Steel from 2 to 8 inches (50–200mm)
- Light alloy from 1.5 to 7.5 inches (40 to 190mm)
- Concrete from 10 to 40 inches (200 to 1000mm)

Standard source assembly
Compacted metallic Cobalt–60 pellets are doubly encapsulated in welded stainless steel or titanium capsules. The sealed source assemblies are designed and tested to achieve an ISO/ANSI minimum classification of 77C64515. The source meets the IAEA and USDOT requirements for 'Special Form' radioactive material.
SECTION 1 - TECHNICAL SPECIFICATIONS

The sealed source is swaged to one end of a source holder consisting of a flexible steel cable which has the female half of a connector at the other end, used for coupling to a control cable connector.

The source assembly also has a stainless steel stop-ball swaged onto it slightly forward from the source holder's connector. The purpose of the stop-ball is to provide mechanical positioning of the source assembly within the exposure device's shielding and to provide a means of securing the source assembly in the exposure device's locking mechanism.

Model 680-OP Authorized Contents

<table>
<thead>
<tr>
<th>Isotope</th>
<th>Assembly Model Number</th>
<th>Gamma Energy Range</th>
<th>Approximate Half Life</th>
<th>Device/Source Steel Working Thickness</th>
<th>Maximum Capacity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cobalt-60</td>
<td>A424-14</td>
<td>1.17-1.33MeV</td>
<td>5.27 Years</td>
<td>50-200 mm</td>
<td>4.1 TBq (110 Ci)</td>
</tr>
</tbody>
</table>

Model 741-OP Authorized Contents

<table>
<thead>
<tr>
<th>Isotope</th>
<th>Assembly Model Number</th>
<th>Gamma Energy Range</th>
<th>Approximate Half Life</th>
<th>Device/Source Steel Working Thickness</th>
<th>Maximum Capacity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cobalt-60</td>
<td>A424-18</td>
<td>1.17-1.33MeV</td>
<td>5.27 Years</td>
<td>50-200 mm</td>
<td>1.2 TBq (33 Ci)</td>
</tr>
</tbody>
</table>

Source Output

<table>
<thead>
<tr>
<th>Isotope</th>
<th>At 1 m per 37 GBq (1 Ci)</th>
<th>At 1 ft per 37 GBq (1 Ci)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cobalt-60</td>
<td>13.0 mSv/hr (1.30 R/hr)</td>
<td>140 mSv/hr (14.0 R/hr/Ci)</td>
</tr>
</tbody>
</table>
SECTION 1 - TECHNICAL SPECIFICATIONS

Operating Distance
The distance between the remote control and the exposure head is determined by summing the length of the remote control conduits plus the total length of source guide tubes used, and normally should not exceed 47 ft (14.2 m) with standard 25 ft. controls.

Standard Remote Controls
25 ft (7.6 m), 35 ft (10.7 m), 50 ft (15 m)

Standard Source Guide Tubes (Projection Sheaths)
7 ft (2.1 m) set of three source guide tubes: 21 ft total (6.3 m)

Note:
The total length of source guide tubes utilized must be shorter in length than the remote controls to ensure the source assembly will project into the working position.

e.g. When using 25 ft (7.6 m) remote controls, a maximum of three 7 ft (2.1 m) source guide tubes can be used with a combined length of 21 ft (6.4 m).

When using 35 ft (10.7 m) remote controls, a maximum of four 7 ft (2.1 m) source guide tubes can be utilized.

When using 50 ft (15 m) remote controls, a maximum of six 7 ft (2.1 m) source guide tubes can be utilized. This limitation is due to the weight and friction of remote control cable length.

Control Specifications

<table>
<thead>
<tr>
<th>Complete Remote Control Assemblies</th>
</tr>
</thead>
<tbody>
<tr>
<td>Product Code</td>
</tr>
<tr>
<td>---------------</td>
</tr>
<tr>
<td>TAN66425</td>
</tr>
<tr>
<td>TAN66435</td>
</tr>
<tr>
<td>TAN66450</td>
</tr>
<tr>
<td>TAN69325</td>
</tr>
<tr>
<td>TAN69335</td>
</tr>
<tr>
<td>TAN69350</td>
</tr>
<tr>
<td>TAN69225</td>
</tr>
<tr>
<td>TAN69235</td>
</tr>
<tr>
<td>TAN69250</td>
</tr>
</tbody>
</table>

Model 664 Control Storage Reel Unit Size

<table>
<thead>
<tr>
<th>Length</th>
<th>21 in (533 mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Width</td>
<td>12 in (305 mm)</td>
</tr>
<tr>
<td>Height</td>
<td>6.6 in (168 mm)</td>
</tr>
</tbody>
</table>

Source Guide Tube (With Source Stop)

<table>
<thead>
<tr>
<th>Product Code</th>
<th>Model Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>TAN48906</td>
<td>48906 7 ft (2.1 m) Male 1-18 threaded fitting</td>
</tr>
<tr>
<td>48906-X</td>
<td>48906-X Customer specified length</td>
</tr>
<tr>
<td>95020</td>
<td>95020 7 ft (2.1 m) Male 1-18 threaded fitting, Extreme Condition</td>
</tr>
<tr>
<td>95020-X</td>
<td>95020-X Customer specified length, Extreme Condition</td>
</tr>
</tbody>
</table>
SECTION 1 - TECHNICAL SPECIFICATIONS
Source Guide Tube Extension

<table>
<thead>
<tr>
<th>Product Code</th>
<th>Model Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>TAN48907</td>
<td>48907 7 ft (2.1 m) Male/Female 1-18 threaded fitting</td>
</tr>
<tr>
<td>95021</td>
<td>95021 7 ft (2.1 m) Male/Female 1-18 threaded fitting, Extreme Condition</td>
</tr>
<tr>
<td>95021-X</td>
<td>95021-X Customer specified length, Extreme Condition</td>
</tr>
</tbody>
</table>

NOTE:
X indicates customer can order lengths other than the standard length.
The Model 664 reel and 693 pistol-grip controls are equipped with odometers.
The Model 692 pistol-grip controls are not equipped with an odometer.

Optional Device/Overpack Cart

<table>
<thead>
<tr>
<th>Product Code</th>
<th>Model Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>974</td>
<td>974 Cart that includes a four-point lifting frame is provided for mobility</td>
</tr>
</tbody>
</table>

Exposure Device Specifications

Manufacturer
SENTINEL™ - QSA Global, Inc.
40 North Avenue, Burlington, Massachusetts, USA 01803

Primary Application
Industrial gamma radiography

Model Numbers
Model 741-OP: Containing device model numbers; 741, 741E, 741A, 741AE, 741B, 741BE

Length
32 inches (81.3 cm) both models

Width
19 inches (48.3 cm) both models

Height
18-1/2 inches (47.0 cm) both models

Weight of exposure device
680-OP 615 lbs. (280 kg), 741-OP 510 lbs. (232 kg)

Weight of depleted Uranium shield
680-OP 302 lbs. (137 kg), 741-OP 225 lb (102.1 Kg)

Approximate activity of depleted Uranium shield
680-OP 1,809.3 MBq (48.9 mCi), 741-OP 1,357 MBq (36.6 mCi)
SECTION 1 - TECHNICAL SPECIFICATIONS

Certification
Type B(U)-96 package.
680-OP Certification Number USA/9035/B(U)-96
741-OP Certification Number USA/9027/B(U)-96

Construction
A depleted Uranium (DU) shield is encased within a steel housing and fixed in position by retaining bar assemblies and polyurethane foam in the interior void space. The exposure device is contained within a protective carbon steel container of welded construction.

Materials
The primary materials used in the 680-OP and 741-OP are a titanium or zircalloy ‘S’ tube, depleted uranium shield, polyurethane foam, wood (transport container), copper separators, steel body and steel fasteners.

Maximum Capacities
Model 680-OP 4.1 TBq (110 Ci) of Co-60, Model 741-OP 1.2 TBq (33 Ci) of Co-60

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.

Device Operating Temperature Range
-40°F to 300°F (-40°C to 149°C)

Source Assembly
Model 680-OP Model Number: A424-14 source assembly with a doubly encapsulated Co-60 source
Model 741-OP Model number: A424-18 source assembly with doubly encapsulated Co-60 source

The IAEA/USDOT Special Form Certificate number is USA/0377/S for Co-60

NOTICE
These industrial radiography systems are used as an exposure device and a Type B(U)-96 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 Model 680-OP and 741-OP gamma radiography systems. The user must be thoroughly familiar with this instruction manual before attempting operation and use of this equipment.
SECTION 1 - TECHNICAL SPECIFICATIONS
The following instructions are samples for the transport or this radiographic exposure device and source 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 Air Transport Association, ‘Dangerous Goods Regulations’.
- U.S. Department of Transportation, Title 49 Code of Federal Regulations Parts 171 through 178.
- Transport in the United Kingdom: Refer to the regulations as listed on the ADR approval Certificate.
SECTION 1 - TECHNICAL SPECIFICATIONS

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 or equivalent Agreement State or permitted by any regulation of the U.S. Nuclear Regulatory Commission or State Regulation may constitute a violation of such license terms.

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

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

QSA Global, Inc. has received equipment approvals for the Model 680-OP and Model 741-OP systems from the Commonwealth of Massachusetts, the USNRC Transportation Branch, the U.S. Department of Transportation, and the Canadian Nuclear Safety Commission. This requires use of Agreement State or USNRC registered and approved remote controls, control cables, projection sheaths, sealed source assemblies, remote control cranks used in conjunction with the Model 680-OP and Model 741-OP. For additional information on compliance with Type B(U)-96 certifications, USNRC 10CFR34 and ANSI N432-1980 please contact QSA Global, Inc.

SENTINEL™, QSA Global, Inc. shall not be liable for any errors or omissions contained herein and the provision by SENTINEL™, QSA Global, Inc. of the information set out in this manual does not in itself constitute acceptance of any liability on the part of SENTINEL™, QSA Global, Inc.
SECTION 2 – OPERATING INSTRUCTIONS

Job site safety precautions

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

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

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

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

Shielding
Whenever possible, situate the radiographic exposure area in a room with suitably thick walls, floor, ceiling and doors. 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.
SECTION 2 – OPERATING INSTRUCTIONS

Model 680-OP and 741-OP System Set-Up Procedure
This section provides instructions and the recommended hook-up sequence for operation of the QSA Global, Inc. cobalt radiography projector systems.

Note
The gamma ray projector must be within the protective steel container, which must be used during all modes of transportation. Additionally, the gamma ray projector must be used while inside the steel container at temporary job sites, except as noted below. An optional Model 974 cart that includes a four-point lifting frame is provided for mobility of the gamma ray projector and the steel container.

If the projector is used as a fixed exposure device within a permanent radiographic installation, the steel container is not required.

Under certain limited conditions, the device may be used outside of the container at temporary job sites. These conditions include:

1) When the device must pass through a portal of insufficient size to allow the container and/or cart access into the work area to perform radiography.
2) When the work platform or scaffolding is limited such that it may not support the weight and/or size of the device when used in the container.
3) Any other physical restrictions in the work environment that can not accommodate the size and/or weight of the device in the container, and where use of the device within the container may compromise safety.

The following additional operational controls must be followed when the device is used outside the protective container:

1) The device can not be used at a height greater than four feet (1.2 m) above the working surface/platform.
2) The lock assembly end of the device must be facing upward when lifting.
3) Redundant safety slings must be used.
4) The shipping plate must be installed over the lock assembly when lifting.

STEP 1
Exposure Device Survey
Protection against radiation incidents begins with proper use of the survey meter. Operators must inspect the survey instrument to verify that it is operating properly in accordance with 10CFR34.31 and applicable company specific operating procedures.

Check the operation of the survey meter by measuring the radiation level at the surface of the 680-OP or 741-OP. The radiation level measurement should not exceed 2 mSv/hr (200 mR/hr) on any surface of the exposure device. Use this measurement for verification surveys (reference survey) of the source assembly's return to fully shielded/secured position within the exposure device after each radiographic exposure.

(Perform a daily inspection of all equipment used according to the daily inspection section.)
SECTION 2 – OPERATING INSTRUCTIONS

STEP 2
Source Guide Tube (Projection Sheath) Layout
Ensure all source guide tubes that will be utilized have received a daily inspection according to the daily inspection section of this manual. Position and secure the source stop (exposure head) of the terminating source guide tube at the radiographic focal position using a tripod stand and swivel clamps or some other secure and suitable means.

Ensure that a source stop (end stop) is in place on the terminating source guide tube.

Use a collimator (beam limiter) to limit the primary beam in unwanted directions.

Determine where the exposure device will be positioned and lay out the source guide tubes as straight as possible, with no bend radius less than 20 in (0.5 m) to avoid restricting the movement of the source assembly.

Make sure that the source guide tubes do not contact any heated surface greater than 140°F (60°C). Contact QSA Global, Inc. for high temperature resistant source guide tubes.

Avoid any risk of crushing the source guide tube(s) by falling objects, vehicles or doorways during set-up and during radiographic exposure.

Do not connect the source guide tube to the projector at this time.

Preparation for Equipment Hook-Up
If required, unlock the two padlocks and open the container lid.

Open sliding doors on both ends of the container.

Remove the blocking materials to obtain access to the locking mechanism and the outlet port as required.

Remove the locking mechanism cover plate (shipping plate).

Source Guide Tube Connection

1. Remove the shipping plug by holding the female outlet port fitting (front nut) stationary while rotating the shipping plug counterclockwise and unthread until the plug detaches from the outlet port. Store the shipping plug in a safe place.
SECTION 2 – OPERATING INSTRUCTIONS

2. Connect the source guide tube(s) to the exposure device outlet port. Connection is secured by inserting the male guide tube fitting into the female outlet port fitting (front nut) and thread together by rotating the front nut counterclockwise until the guide tube fitting is securely seated in the outlet port fitting.

WARNING

Ensure that the available length of the control cable is greater than the total length of the source guide tubes. See the technical specifications section for details.

If the remote control conduits are shorter than the total length of the source guide tubes:

1) 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.
2) The source assembly may not reach a collimator; therefore, restricted area dose rates may be higher than expected.
3) The control cable end may be cranked beyond the drive wheel of the remote controls if the drive cable is not be fitted with a safety retaining spring. This scenario must be treated as an EMERGENCY.

STEP 3
Remote control conduit layout
Lay out the remote control conduits as straight as possible, with no bend radii less than about 36 in (approximately 1 m).

Avoid any risk of crushing the remote control conduits by falling objects, moving vehicles or closing doors, etc.

The remote control crank mechanism (operator's hand-crank) should be placed as far away from the source focal position as possible (preferably behind shielding).
SECTION 2 – OPERATING INSTRUCTIONS

Connecting the remote control cable
Connect the control cable to the source projector as follows:

Note:  Pictures illustrate Posilok style device. Non-Posilok devices operate identically for connection of the control cable.

1. Unlock the plunger lock with the key.

2. Turn the selector ring counter-clockwise from LOCK to CONNECT.

3. The protective cover will disengage from the projector.

Check the control cable and source assembly connectors using the NO GO gauge according to the daily inspection section. (See 3-d, page 3-8 for use of NO GO gauges.)
SECTION 2 – OPERATING INSTRUCTIONS

4. Remove the protective rubber cap from the remote control connector.

5. Slide the remote control connector assembly's collar back and open the jaws to expose the male portion of the control cable connector (i.e. the ball-end on the control cable connector).

6. Press back the spring-loaded locking pin of the source assembly connector with a thumbnail and engage the male and female portions of the connectors.

Release the locking pin of the source assembly connector and check that the connection is secure.

IMPORTANT NOTE
When operating a manually securing lock mechanism device (Model Number 680, 680E, 741, or 741E), and the selector ring is rotated from the LOCK position to the OPERATE position, the source assembly is no longer secured and is ready for projection from the exposure device.
SECTION 2 – OPERATING INSTRUCTIONS

Use the NO GO gauge to check the gap between the joined connectors during the daily inspection.

Connecting the remote control cable

7. Close the jaws of the control cable connector over the joined connectors.
   Slide the remote control connector assembly collar over the connector jaws.

CAUTION:
When using a Non-Posilok (manually locking) device, rotation of the selector ring to the “OPERATE” position frees the source to move from the stored position.

NOTE:
The control cable connector, when properly installed with the selector ring in the CONNECT position, displaces anti-rotation lugs which allows the selector ring to be rotated to the LOCK position and when required, through to the OPERATE position.

8. Push and hold the remote control connector assembly collar flush against the exposure device’s locking mechanism and rotate the selector ring clockwise from CONNECT to LOCK. The selector ring can be secured in this position by engaging the plunger lock.

   Do not rotate past LOCK.

   The remote control cable connector is now secured into the exposure device's locking mechanism. Keep the exposure device in the LOCK position until ready to start the exposure.

   Replace blocking material above and around the device, close lid and secure the padlocks.
SECTION 2 – OPERATING INSTRUCTIONS

Checks Before Exposure of the Source
Verify that the source guide tubes are attached to the outlet port.

Verify that the remote control connector assembly is correctly connected to the exposure device’s locking mechanism.

Ensure that no personnel are inside the Restricted Area or exposure room.
Ensure that the proper signs are posted and required warnings are in operation.

NOTE
If the remote control is fitted with an additional lock, release this lock and apply a forward motion to the control crank handle, as if exposing the source, until a resistance is felt. Release the control crank handle and proceed with the next step.

CAUTION
Do not apply excessive force to the control crank handle in the expose direction as this could cause the source assembly to move forward out of the stored position when the lock slide is released. Do not retract the control cable and apply the control crank brake. Leave the control crank and the control cable in a neutral tension position.

STEP 4
Projecting and retracting the source assembly

Unlocking
1. If engaged, unlock the exposure device's plunger lock with the key.

2. Rotate the selector ring clockwise to the OPERATE position.
Ensure there is no tension/force in either direction on the control cable

IMPORTANT NOTE
When operating a manually securing lock mechanism device (Model Number 680, 680E, 741, or 741E), and the selector ring is rotated from the LOCK position to the OPERATE position, the source assembly is no longer secured and is ready for projection from the exposure device.
SECTION 2 – OPERATING INSTRUCTIONS

Projecting and retracting the source assembly

3. Push the lock slide, with the **GREEN MARKING**, laterally from left to right (as viewed from behind the projector) until the lock slide snaps into the expose position. The operator may feel or hear the sleeve snap into the lock slide indicating the slide is fully engaged in the expose position.

   When the **GREEN MARKING** is visible, the source assembly is locked into the secured position within the exposure device.

![Image 1](image1.png)  ![Image 2](image2.png)

4. When the **RED MARKING** on the lock slide is visible, the source assembly is free to be projected from, and retracted to, the projector. Verify the lockslide is fully engaged by attempting to push the lockslide (push laterally from right to left) into the secured position. Notice: Operation of the exposure device without full engagement of the lockslide may create problems during source retraction. (See the “Retracting” section for further information.)

   Ensure all personnel leave the immediate area.

   Go to the remote control crank.

   If an odometer is fitted, adjust the reset knob to read zero.

   The source assembly can now be projected.
SECTION 2 – OPERATING INSTRUCTIONS

**Projecting**
Rapidly rotate the control crank handle in the EXPOSE direction (counter-clockwise) to move the source assembly out of the exposure device to the radiographic focal position. The control crank handle will stop turning when the source reaches the source stop.

Do not use excessive force.

The odometer (if applicable) will indicate the approximate total distance traveled, 7 ft (2.1 m) for each guide tube section, plus approximately 12 inches from the stored position to the exit port.

Set the brake to ON to prevent movement of the source assembly during the radiographic exposure.

Start timing the radiographic exposure from the moment the source assembly reaches the exposure head (source stop).

Survey meter readings observed during the projection operation should increase rapidly from background to a high level as the source emerges from the projector. Then readings should fall as the source moves out towards the focal point, fall sharply as the source enters a collimator (if used) and remain steady throughout the exposure.

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.

During retraction of the source assembly from the exposure head to the exposure device, the sequence will reverse. The survey meter should indicate a continually increasing radiation level as the source assembly is retracted, then drop to background when the source assembly is stored in the exposure device.

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.

**Retracting**
At the end of the required exposure time, set the brake to OFF and rapidly turn the crank handle in the RETRACT (clockwise) direction until it no longer moves. When using a Posilok device, you may hear the lock slide ‘click’ back into its original position depending on the ambient noise level at the job site. From the control crank you may be able to observe the GREEN MARKING on the slide bar.

To ensure that the source has returned properly and the positive locking mechanism has actuated and secured the source in the stored position, apply a slight amount of forward pressure on the crank handle in the EXPOSE direction (counter-clockwise) as if to expose the source. The source assembly should not be able to move forward out of the stored position.

Allow the crank handle to return to a neutral position, thereby relieving any tension (force) on the control cable that would cause source movement when unlocking the projector. At this point, the source cannot be moved out of the stored position.

**Important Note**
When operating a manually securing lock mechanism device (Model Number 680, 680E, 741, or 741E), set the brake to OFF and rapidly turn the crank handle in the RETRACT (clockwise) direction until it no longer moves. Apply slight RETRACT pressure on crank handle and set the brake to the ON position. After conducting a confirmatory survey, the source is secured in the device by rotating the selector ring from the OPERATE position to the LOCK position. Engaging the plunger lock and removing the key puts the exposure device in the locked mode.
SECTION 2 – OPERATING INSTRUCTIONS

Retracting
In the unlikely event for a Posilok device the lock slide moves toward the lock position before the source is fully stored in the exposure device, turn the crank handle in the RETRACT (clockwise) direction until it stops turning. (The lock slide is designed to lock on the stop ball, not the control cable). Do not use excessive force. The source assembly will be in the exposure device but not in the fully shielded position. Approach the exposure device, from the rear, with a survey meter. The survey meter will measure approximately 400 μSv/hr (40 mR/hr) at the rear plate of the exposure device when a 3.7 TBq (100 Ci) Co-60 source is in use in a 680-OP or a 1.1 TBq (30 Ci) source in a 741-OP.

CAUTION
Remain clear of the front of the exposure device (outlet port side) to minimize personal exposure. Reset the lock slide to the open position. Return to the control crank and turn the crank handle in the RETRACT (clockwise) direction and store the source assembly in the normal manner. Apply a slight amount of forward pressure on the crank handle to ensure the source is properly stored.

The odometer (if supplied) should read approximately zero when the source assembly has returned to the projector.

Confirmatory Survey
Approach the exposure device while observing the survey meter - observe the GREEN MARKING on the lock slide for Posilok devices and survey the exposure device (when used outside the protective container). The survey meter should indicate the same radiation level as observed before the exposure. Note particularly the outlet port reading.

Survey the entire length of source guide tube with the survey meter. If the meter shows a sharp increase, the source is exposed or incompletely shielded.

If the source is still exposed, attempt to store it properly by cranking the source a short distance toward the exposure head and retracting it, repeating if necessary.

Locking the exposure device
When the source assembly is properly stored in the projector, rotate the selector ring from the OPERATE position to the LOCK position and secure it with the plunger lock.

Remove and safeguard key.

⚠️ 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.
SECTION 2 – OPERATING INSTRUCTIONS

STEP 5
Dismantling Equipment

Remote Control Unit

Note:
When the device is used in the protective container, you may open the lid to allow easy access to the locking mechanism and source guide tube connection for dismantling. When accessing through the lid, and after dismantling, always make sure to install the shipping plate, replace the blocking material, close the lid and lock the container.

Unlock the exposure device and then rotate the selector ring counter-clockwise from LOCK to CONNECT. The remote control connector will partially disengage from the exposure device's locking mechanism.

Completely disengage the remote controls from the exposure device by disengaging the control cable connector from the source assembly connector. Place the protective cover over the remote control's connecting plug assembly to exclude dirt and protect the control cable connector from damage. Roll the remote control conduits loosely for easier handling and transport.

Reinstall the locking mechanism's protective cover, hold in place and rotate the selector ring clockwise to the LOCK position. Push in the plunger lock and remove the key to lock the exposure device.

Source Guide Tubes

Remove the source guide tube attached to the exposure device outlet port by:
1) Unthreading the guide tube fitting from the female outlet port fitting until it disconnects.
2) Install the shipping plug into the female outlet port fitting (front nut) by holding the outlet port fitting stationary while threading the male shipping plug fitting clockwise until it is securely seated in the outlet port fitting.
3) Place the protective covers on the fittings of each source guide tube used to exclude dirt and protect the swaged fittings. Source guide tubes should be rolled up loosely for easier handling and transport.

Surveying

After installing the locking mechanism’s protective cover and the outlet port cover, survey the entire circumference of the exposure device with the survey meter to ensure the source is fully shielded and properly secured. The survey should not measure more than 2 mSv/hr (200 mR/hr) on any surface of the exposure device and should indicate the same measurement as the initial survey.

Storage

Lock the exposure device and secure it in a clean dry storage area where it cannot be tampered with or removed by unauthorized personnel. Perform a storage survey on the surface of the exposure device 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.
SECTION 3 - DAILY INSPECTION INSTRUCTIONS

Introduction
The USNRC and international regulations require routine inspections to ensure that industrial radiography equipment is operating safely and properly. Design of the Models 680-OP and 741-OP 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 lack of inspection and maintenance.

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

Operational Features

1) Source Assembly

A sealed source containing the radioactive material is swaged (crimped) to one end of a flexible steel leader, commonly referred to as the source holder or pigtail. A stainless steel stop-ball and a stainless steel connector are swaged to the opposite end of the source holder. The stop-ball provides the means to secure the source assembly within the exposure device's locking mechanism. The source assembly connector provides the means to attach the control cable connector to enable remote projection and retraction of the source assembly. The source assembly connector and projector locking mechanism are designed so that the sealed source cannot be projected from the exposure device unless it has been properly coupled to the control cable connector and the remote control. (See figure 3.1)

⚠️ DANGER - IMPORTANT WARNING

The source assembly while in an unshielded position and the sealed source containing the radioactive material must NOT be handled under any circumstances. The unshielded source at close proximity can cause serious injury, sickness or death to anyone exposed to it even for a short duration.

All specific model number source assemblies used in the Model 680-OP and 741-OP are designed and tested for use in accordance to ISO/ANSI and USNRC requirements.

![Figure 3.1 Source assembly and remote control cable connectors](image)
SECTION 3 - DAILY INSPECTION INSTRUCTIONS

2) Exposure Device

The source assembly is shown in the stored position in a titanium or zircalloy ‘S’ tube at the center of the depleted Uranium shield of the exposure device. (See figure 3.2)

A remote control unit is shown with its control cable connector coupled to the source assembly.

High density depleted Uranium shielding is used in the exposure device to provide good radiological protection with minimal weight.

The outlet port of the device has a threaded fitting that secures the shipping plug during transport and facilitates attachment of the source guide tube(s) during operation.

The exposure device locking mechanism on Posilok (auto locking) devices provides three main safety features for the radiographer during radiographic operations.

- First, the locking mechanism requires a deliberate action to enable exposure of the source assembly. This is accomplished by coupling the control cable connector to the source assembly connector, coupling the remote control connector to the exposure device locking mechanism and then pushing a lock slide from the SECURED position into the EXPOSE position. The lock slide must be manually pushed into the EXPOSE position prior to each radiographic exposure to enable operation of the remote control.

- Second, during termination of a radiographic exposure, the remote controls are used to retract the source back into the exposure device. When the source assembly is returned to the fully shielded position within the exposure device, the locking mechanism automatically secures the source assembly, preventing the source from being inadvertently exposed from the fully shielded position. The automatic securing mechanism allows movement of the exposure device with the remote controls attached at the job site while preventing inadvertent exposure of the source assembly.

- For the third feature, the controls cannot be removed from the exposure device locking mechanism unless the source assembly has been returned to the fully shielded position within the exposure device.

Manual locking device Models 680, 680E, 741 and 741E locking mechanism provide two main safety features for the radiographer during radiographic operations. First, the remote controls cannot be removed from the device unless the source assembly has been returned to the fully shielded position within the exposure device. Second, a source assembly cannot be exposed from the device without a secure connection between the remote control cable and source assembly connector.

The complete radiography system consists of the radiographic exposure device containing the source assembly, the remote controls, source guide tubes and collimators (beam limiters) whenever possible.
SECTION 3 - DAILY INSPECTION INSTRUCTIONS

The use of multiple source guide tubes must be a combined length shorter than the length of the remote controls, e.g. if the remote controls are 25 ft (7.6 m) long, only 3 source guide tubes can be utilized for a combined length of 21 ft (6.4 m). This consideration ensures the source assembly will be fully projected to the source stop (exposure head).

The source assembly must never be projected until the equipment is properly connected and all personnel have exited the restricted area.

Transit Mode
Rotating the handle of the remote control crank in the EXPOSE direction (counter-clockwise) moves the source assembly out of the shielded position in the exposure device and into the source guide tubes (projection sheaths). (See figure 3.3)

The source assembly is under positive mechanical control using the remote control crank. The remote controls may be fitted with an odometer to provide an indication of the sealed source’s position. The odometer reading should never be a substitute for the requirement and proper use of a radiation survey meter.
SECTION 3 - DAILY INSPECTION INSTRUCTIONS

Exposure Mode
When the source assembly reaches the exposure head at the radiographic working position, the odometer will indicate (in feet and tenths of a foot) the approximate distance the sealed source has traveled. (See figure 3.4)

To return the source assembly to the exposure device the crank handle is rotated in the RETRACT direction (clockwise). When the source assembly is returned to the fully shielded position within the exposure device, the locking mechanism automatically secures the source assembly. The automatic securing mechanism will not permit exposure of the source assembly unless the radiographer pushes the lock slide into the expose position.

The remote controls cannot be disconnected from the source assembly unless the source assembly is fully retracted into the shielded position in the exposure device. The system is designed for safe and reliable operation provided the system is properly used and maintained.

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

The results of a daily inspection should be recorded and include the date, the name of the inspector and what specific equipment was inspected. If any defective or damaged components are discovered during the daily inspection, the component must be removed from service and identified with a status indicator (tag, label, or tape) to prevent inadvertent use by other radiography personnel. Defective or damaged components must be repaired or replaced before reuse in radiographic operations. The three main components of the radiography system consisting of the radiographic exposure device and transport case, remote controls and source guide tubes must be inspected in addition to accessories such as lab stands, collimators, J-tubes, magnetic lab-stands and pipe-clamping apparatus.

Figure 3.4 Sealed source in the exposure mode
SECTION 3 - DAILY INSPECTION INSTRUCTIONS

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.

Daily Inspection of the Exposure Device and Transport Case
1) Survey the surface of the exposure device or device in the transport case to ensure the radiation level is less than 2 mSv/hr (200 mR/hr), even when containing a source assembly with the maximum allowable activity. This survey provides a function check of the survey instrument, that it is responding to radiation, in addition to providing the radiographer with a reference measurement that can be compared to confirmatory surveys after terminating each radiographic exposure.

2) Inspect the labels on the exposure device or the transport case to ensure they are legible and securely attached to the unit. The warning label containing the trefoil should be legible from a distance of at least 3 ft (approximately 1 m). This label warns the individuals in the immediate vicinity of the presence of radioactive materials and permits them to take measures to minimize their exposure to radiation. The printed verbiage and the radiation symbol must be legible. The trefoil symbol becomes the warning for those individuals who cannot read or understand the written warning, ‘Caution or Danger, Radioactive Material’. Inspect the legibility and attachment of the source identification tag that describes the radioactive source contained within the exposure device.

3) Inspect the exposure device’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 and remove the protective cover.

4) Inspect the outlet port for damage. Verify that the outlet port fitting rotates smoothly and that the threads are not stripped or clogged with dirt, grease or sludge.

5) Inspect the transport case for damage that could prevent proper assembly prior to shipment or could allow for package failure during transport (e.g. faulty lock clasps, missing pieces, broken hinges, etc.)

Daily Inspection of the Source Guide Tube(s)
1) 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.

2) 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 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.

3) Inspect the attachment of the collimator to the source stop (exposure head) if used during radiography.
SECTION 3 - DAILY INSPECTION INSTRUCTIONS

Daily Inspection of the Remote Controls

The remote control consists of a control crank, a control 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 exposure device. The control crank is equipped with a lever brake that retains the source assembly while in the exposure head. Beneath the control crank is a label that indicates the direction for EXPOSE and RETRACT during use in addition to ON and OFF positions for the brake. 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.

Two remote control conduits (sheaths, housings) are attached to the control crank. One conduit contains the working side of the control cable that drives the source assembly out of the exposure device and through the source guide tubes. The second conduit is the reserve 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 exposure device. The connecting plug assembly and the control cable connector are designed with minimal tolerances. 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 exposure device. 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 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 exposure device 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.
SECTION 3 - DAILY INSPECTION INSTRUCTIONS

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 an unknown origin (non-traceable) must not be used and must be removed from service.

1) Remote Control Inspection:
   a) Uncoil the remote controls at the site. Inspect the control crank to assure all screws 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 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 instructions it is conceivable a radiographer could become confused as to which direction the crank handle must be turned to retract or expose the source.

   c) Ensure the brake is operational. Resistance should be felt while rotating the crank handle with the brake in the ON position. Inspect the control conduit fittings to verify they are secured to the control crank.

2) 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 PVC 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 PVC 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 or bent. Check the control sheath swage fittings to verify they are not loose where they are joined to the connecting plug assembly.
SECTION 3 - DAILY INSPECTION INSTRUCTIONS

3) Control 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 that the stem and ball of the connector are not bent or cracked.

   Using hand pressure, attempt to twist the control cable connector from the control cable. If the control cable connector can be twisted 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 between the outer spiral windings. Also check for flattened areas and wear.
   - Bend the connector section of control cable back towards itself 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, approved by QSA Global, Inc., 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 3.5):

   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.
SECTION 3 - DAILY INSPECTION INSTRUCTIONS

IMPORTANT REMINDER
Do not compromise on safety. Always perform a daily inspection of the exposure device, 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 3.5 No-Go gauge diagram
SECTION 4 - MAINTENANCE INSTRUCTIONS

Quarterly (Routine) and Annual (Complete) Maintenance Requirements

Radiographic exposure devices and associated equipment must be maintained regularly by trained and qualified personnel to ensure consistent and safe operation of the radiographic system. The routine inspection and maintenance also ensures that the integrity of the Type B(U)-96 transport packages are maintained in compliance with the package certification numbers USA/9035/B(U)-96 and USA/9027/B(U)-96 for the Models 680-OP and 741-OP, respectively.

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 exposure device 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.

Routine (quarterly) Maintenance Requirements

1) 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.
SECTION 4 - MAINTENANCE INSTRUCTIONS

2) Source Guide Tubes
Clean and inspect the source guide tubes in accordance to the “Quarterly and 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.

3) Radiographic Exposure Device and Transport Container
Clean and inspect the exposure device and container for wear and obvious damage. Record any defects that might affect safe operation of the exposure device or contribute to unsafe transport of the device in the container. If deficiencies are found during this maintenance, the exposure device and/or container 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 using a ‘satisfactory’ or ‘deficient’ criteria:

1. Survey the surface of the container to ensure the measurable dose/rate is less than 2 mSv/hr (200 mR/hr) and 100 μSv/hr (10 mR/hr). Remove the device from service if the dose/rate exceeds these limits. Contact QSA Global, Inc. for guidance.

2. Ensure the metal identification tags for the radioisotope is legible and securely fastened to the exposure device. Do not cover the tag with any other labels.

3. Ensure the label containing the device model number, serial number, Type B certification number 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.

4. Visually inspect the outer container to verify the following:
The inserts are installed properly and secured within the container.
The sides, top and bottom of the foam and wood inserts have no significant damage, and there are no missing pieces.
Replace any missing or significantly damaged pieces.
The outer container and lid are in good physical condition with no excessive rust, cracked welds, major dents or holes. DO NOT use the container if it is not in good condition.
The latches are not broken and can be properly installed and secured.
The two padlocks are in good working order and the keys fit and work in the locks.
The container feet are in good condition.

5. Check all fasteners on the exposure device to ensure they are in place and securely fastened.

6. Check that the outlet port shipping plug is in place and that the screw and nut turn freely, but are not loose.

7. 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.
SECTION 4 - MAINTENANCE INSTRUCTIONS

8. Assure the shipping plate is in place and properly secured.

9. Use the Model 550 NO GO gauge to check for wear on the remote control cable connector and the source assembly connector. Replace components that fail any of these tests.

10. Operationally check the locking 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 locking mechanism and the entire system operates smoothly and freely. If operation is faulty, remove the exposure device from service and perform the complete annual maintenance.

Misconnect Test
After performing the quarterly maintenance, the complete radiography system must be tested by the maintenance program administrator or Radiation Safety Officer. A misconnect test on the exposure device 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 identify any excess wear on the control cable connector, device locking mechanism and sealed source connectors simultaneously.

Note: Component wear occurs to both the control assemblies and the device lock assemblies over time, therefore, to ensure acceptable equipment operation, the misconnect test must be performed on each device lock assembly and control assembly combination that could be used in the field. For example, if controls are used interchangeably with more than one specific exposure device, then each control must be checked with each device to ensure the failsafe system for all control assembly/device combinations are compliant.

⚠️ The test should only be performed by personnel that are formally trained, authorized and thoroughly familiar with quarterly 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.

⚠️️ WARNING
Ensure the shipping plug is installed in the outlet port before performing a misconnect test.

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.
SECTION 4 - MAINTENANCE INSTRUCTIONS

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 EXPOSURE mode.

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

Routine (Quarterly) Maintenance Records

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

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

Annual Maintenance Requirements

Radiographic exposure devices 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 detect deficiencies and to prevent corrosion and wear related problems.

The complete maintenance of the exposure device requires the disassembly of the exposure device to enable a detailed inspection of all major components. Therefore, the inspection and maintenance requires transfer of the source assembly from the exposure device 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 exposure device into a source changer:

1) Perform a survey of the exposure device to ensure measurable dose rates are less than 2 mSv/hr (200 mR/hr) and 100 μSv/hr (10 mR/hr) 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.

2) Perform a daily inspection of the remote controls, source guide tube and exposure device 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.
SECTION 4 - MAINTENANCE INSTRUCTIONS

3) 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 exposure device, source guide tube and source changer to confirm that the sealed source is properly secured. Engage the lock on the source changer to lock the sealed source within the source changer. Remove the source identification tag from the exposure device and fasten it to the source changer.

Attach a Model 550 connector gauge (jumper) to the end of the remote control cable connector found inside of the protective cover of the locking mechanism. The jumper will allow removal of the remote controls from the locking mechanism of the device after the remote control cable connector is returned to the exposure device lock.

Leak Testing

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 μCi). To perform a wipe of the radioactive sealed source, perform the following steps:

1) Survey the entire exterior surface of the exposure device to ensure the dose/rates are less than 2 mSv/hr (200 mR/hr).

2) 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.

3) Remove the shipping plug from the outlet port.

4) Fully insert the wipe test swab into the s-tube and move back and forth to obtain the sample.

5) 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.

6) Install the shipping plug into the outlet port.

7) In a low background (non-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 1 μSv/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 a laboratory for radio-assay. The laboratory will send a leak test certificate after performing the radio-assay. Retain this certificate in your records.
SECTION 4 - MAINTENANCE INSTRUCTIONS

In the event you are informed by the radio-assay laboratory that your leak test results indicate greater than >185 Bq (0.005 μCi), you must immediately remove from service the radioactive sealed source, the exposure device 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.

Leak test for depleted Uranium (DU)

Some regulatory jurisdictions require periodic leak tests every twelve months of all projection-type exposure devices that utilize DU for shielding. The purpose of the leak test is to detect the long-term wear through of the device's source tube that may consequently expose the DU shielding. A wipe-test wand that is both flexible and long enough to reach a bend radius or a wear point is required to perform a leak test. The wand enables direct contact with the DU where the device's source tube has worn through. A direct wipe of the DU is required due to the low specific activity of depleted uranium. The wipe test for DU is obtained in the same fashion as a leak test of a sealed source utilizing the same radiation safety procedures. The analysis performed on the wipe test must be capable of detecting the presence of 0.005 μCi (185 Bq) of radioactive material on the test sample. If the test sample reveals 185 Bq (0.005 μCi) or more of removable DU contamination, the exposure device must be removed from service until an evaluation of the wear on the 'S' tube has been made. Should the evaluation reveal that the source tube is worn through, the exposure device may not be used again.

DU shielded devices do not have to be tested for DU contamination while in storage and not in use. Before using or transferring a device that has been in storage for more than 12 months, the exposure device must be leak tested for DU contamination prior to use or transfer.

Please contact a QSA Global, Inc. service center if you require leak test kits, radio-assay services or assistance in the disposal of worn through exposure devices.

Annual maintenance for the Models 680-OP and 741-OP exposure devices

Tools required for complete maintenance

• 5/32" Allen wrench for the 10-32 socket head lock and selector-ring screws.
• 3/32" Allen wrench for the lock's socket head screw.
• #30 Drill bit and pop-rivet gun for removal and installation of 1/8" s/s rivets.
• Tamperproof tool bit for locking mechanism plate screws.
• Calibrated torque wrench (inch/pound). Calibrated foot-pound wrench required for the device side frames.
• Small slot screwdriver for source identification tag 4-40 screws.
• U-tool (part # SK1761) for functional checks of lock mechanism.
• Mock source assembly and short length control cable for lock mechanism operational tests after servicing.
• Safety wire pliers
SECTION 4 - MAINTENANCE INSTRUCTIONS

Materials required for complete maintenance of exposure devices:

- Mil-spec grease MIL-G-23827B (or C), MIL-PRF-23827C, (or equivalent radiation resistant grease authorized by QSA Global, Inc.).
- Temporary Lock-tite™ or Vibra-tite™ thread sealant for 10-32 X 1 ¼” lock mechanism socket-head screws.
- Recommended solvents for cleaning and degreasing operations: clean mineral spirits (Follow manufacturers safety precautions for use, handling, storage and disposal).
- Clean lint-free rags.
- 12-gauge gun patches or any lint-free cloth for cleaning the S-tube.
- Large pan for use in cleaning and degreasing the remote drive cable and mechanical parts.
- Stainless steel, brass or synthetic bristle brush to be used during degreasing and cleaning of parts.
- Light viscosity oil, such as 3-in-1™ oil to lubricate plunger lock.
- Device label if required and 1/8” stainless steel rivets.
- Number 4 Scott-drive fasteners for Co-60 device labels.
- Replacement springs (Qty 1 - compression spring part # SPR006, Qty 1 - compression spring, part number SPR005, Qty 2 – compression spring part # SPR004) for the lock mechanism.
- Source guide tube for operational tests of the outlet port.
- 0.032” Stainless steel safety wire

Model 680-OP and 741-OP annual maintenance requirements

Model 680-OP and 741-OP exposure devices must receive inspection and maintenance at least once a year.

The exposure device must be removed from the protective container and the locking mechanism and outlet port mechanism must be removed from the exposure device and disassembled for proper cleaning, inspection and lubrication of components that are critical to safety.

These procedures can only be performed on an empty exposure device, which requires transfer of the radioactive source assembly into an approved storage container.

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.

Trained and qualified personnel who wish to perform this work should use the following procedure. Refer to Figure 4.1 for Posilok style lock assemblies. Refer to Figure 4.2 for Non-Posilok style lock assemblies:

1) 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. The exposure device must be empty for the following steps.

2) Remove the shipping plate.

3) Remove safety wire; then remove the four tamperproof screws holding the locking mechanism mounting plate onto the device shell using the tamperproof tool bit mounted in a ratchet.
SECTION 4 - MAINTENANCE INSTRUCTIONS

4) Remove the four 10-32 x 1-3/8 in. socket head screws that secure the locking mechanism to the rear mounting plate.

5) Disassemble the locking mechanism assembly, taking care not to lose the spring loaded parts. Place the disassembled locking mechanism components into a pan filled with fresh, clean solvent. Clean all parts using a brush to dislodge any dirt or grease. Remove cleaned parts from the solvent bath, dry and place on a clean surface. Inspect all parts for wear. Replace worn parts as necessary. Discard all used locking mechanism springs and replace with new springs. All compression springs located within the selector ring mechanism must be replaced at 12-month intervals to ensure smooth and consistent operation of the mechanism.

When ordering spare parts, quote the model and serial number of the exposure device as well as the part number to ensure correct replacement.

Remove the two 10-32 x 5/8 in. flat head screws that secure the lock retainer to the rear mounting plate. Remove the plunger lock from the lock retainer by removing the lock retaining flat head screw. Clean the lock plunger, lock retainer and springs in a solvent bath. Ensure the lock plunger is thoroughly rinsed to remove all dust from the key tumblers. Removed the cleaned parts from the solvent bath and dry thoroughly, using compressed air to dry the lock tumbler. Inspect all parts for wear. Replace worn parts as necessary. Lubricate the plunger lock barrel and tumbler using two drops of a light viscosity oil. Apply Vibratite™ thread sealant to the lock set screw and install. Check the plunger lock for proper function by using the key to engage and unlock. Apply Vibratite™ to the lock retainer’s 10-32 x 5/8 in screws, then mount the lock retainer to the rear mounting plate. Hand-tighten the screws using an #2 Philips head screwdriver.

Selector Mechanism Re-Assembly/Testing

Apply a light coating of lubrication to the inside surfaces of the selector body, selector ring and selector ring retainer using MIL-G-23827B (or C), MIL-PRF-23827C, (or equivalent radiation resistant grease authorized by QSA Global, Inc.). Do not lubricate the lock slide and sleeve. Note that some types of greases may undergo chemical changes and form tars when exposed to radiation.

Note: Instructions for maintenance of Posilok and Non-Posilok (Manual locking) selector mechanisms are described in sections 6 and 7 and 6a and 7a, respectively.

6) Begin assembly of the Posilok locking mechanism by lightly coating all components with MIL-G-23827B (or C), MIL-PRF-23827C, (or equivalent radiation resistant grease authorized by QSA Global, Inc.). Treat all screw thread ends with Vibratite™ or Locktite™ thread sealant.

Hold the rear mounting plate horizontally; face up with the lock in the 12 o’clock position. (Note: Carefully mount the mounting plate in a vise or fixture so hands are free for the assembly procedure and no damage to the mounting plate will occur.)
SECTION 4 - MAINTENANCE INSTRUCTIONS

The narrow end of the lock slide slot must be located at the 3 o'clock position. Locate the lock slide and return spring into the mating slot of the selector body.

Place the selector ring with the word “CONNECT” at the 12 o'clock position, over the selector body. Push the lock slide inward during placement of the selector ring for clearance. Doing so will allow the selector ring to rest flush on the selector body. Insert the anti-rotation lug springs at the top and bottom of the selector body. Place the anti-rotation lugs over the springs.

Place the steel sleeve with the large diameter facing downward, on the center of the lock slide.

Place the compression spring over the sleeve.

Install the selector ring retainer into the selector ring. Verify that the three non-threaded holes line up under the word CONNECT located on the selector ring. Depress the selector ring retainer into the selector ring until it is flush with the top of the selector ring.

Hold the selector ring retainer firmly against the mounting plate until the 10-32 x 1-3/8in screws are installed.

While firmly holding the locking mechanism against the mounting plate, turn the plate over to expose the back side of the mounting plate. Install the four 10-32 x 1-3/8 in socket head screws to secure the mechanism to the mounting plate. Torque the socket head screws to 30 in/lb (3.39 Nm) ± 5 in/lb (0.57 Nm) using a calibrated torque wrench.

6a) Begin assembly of the Non-Posilok locking mechanism by lightly coating all components with MIL-G-23827B (or C), MIL-PRF-23827C, (or equivalent radiation resistant grease authorized by QSA Global, Inc.). Treat all screw thread ends with Vibratite™ or Locktite™ thread sealant.

Begin selector re-assembly by inserting the two shorter compression springs (8) and locking pins (7) into the holes on the edge of the selector body.

Insert the steel sleeve into the center of the selector body with its larger end facing up.

Hold the selector body so that the hub is pointing down and the knob is in the 4-5 o’clock position.

Fit the selector ring over the selector body making sure that the locking pins (7) ride on the inner ring of the selector and that the word “OPERATE” is in the 12 o’clock position facing up.

Insert the large compression spring on top of the sleeve.

Fit the selector ring retainer into the selector ring, flat face up. Ensure that the three non-threaded holes line up under the word OPERATE located on the selector ring.

Turn the sub-assembly over and insert the two anti-rotation lugs holding the longer compression springs into the two large holes in the selector body with the springs uppermost.

Place the rear mounting plate on this assembly over the selector body hub.
SECTION 4 - MAINTENANCE INSTRUCTIONS

Hold the selector ring firmly against the mounting plate until the four 10-32 x 1-1/4in socket head screws are installed. Torque the socket head screws to 30 in/lb (3.39 Nm) ± 5 in/lb (0.57 Nm) using a calibrated torque wrench.

7) Perform functional safety testing of the Posilok locking mechanism by the following:
Mount the mounting plate vertically in a vise or mounting fixture with the plunger lock at the 12 o'clock position.

Insert the 'U-tool' into the top and bottom holes of the selector assembly and rotate the selector ring toward the OPERATE position. Push the lock slide until the sleeve snaps into place.

While in the OPERATE position, wind out a short length of control cable and pass it through the front of the selector assembly. Attach a mock source assembly or the test jumper connector to the control cable connector and withdraw it into the selector assembly.

Pull on the section of control cable and confirm that the lock slide automatically secures the connector. The lock slide must snap shut in a fast and smooth motion when triggered.

Verify the securement action of selector mechanism by attempting to both push and pull the mock source assembly out of the selector mechanism while in the EXPOSE, LOCK and CONNECT positions.

Rotate the selector mechanism back to the OPERATE position and push in the lock slide to ensure smooth operation and positive engagement. Attempt to push the lock slide towards the SECURED position to test for a positive engagement of the sleeve in the lock slide. If a smooth operation is not attained and/or the lock slide can be forced into the secured position by testing for positive engagement, disassemble and thoroughly re-inspect for faulty components.

Thoroughly inspect all components for rough edges or burrs, etc. which could cause jamming or irregular operation. Replace parts as necessary, re-lubricate and reassemble the selector assembly. Repeat the functional safety testing to verify smooth and safe operation of the selector mechanism.

Install the serviced rear locking mechanism mounting plate back onto the device using the four ¼-20 tamperproof button-head screws. Torque the tamperproof screws in an opposing cross-pattern to 70 in/lb (7.909 Nm), ± 5 in/lb (0.57 Nm).

Install 0.032” stainless steel safety wire (lock-wire) to the four mounting plate screws.

7a) Perform functional safety testing of the Non-Posilok locking mechanism by the following:
Mount the mounting plate vertically in a vise or mounting fixture with the plunger lock at the 12 o'clock position.

While still in the OPERATE position, wind out a short length of control cable and pass it through the front of the selector assembly.

Attach a mock source assembly or the test jumper connector to the control cable connector and withdraw it into the selector assembly.
SECTION 4 - MAINTENANCE INSTRUCTIONS

Run through the normal operations of the lock and selector mechanism.

If a smooth operation is not attained disassemble and thoroughly re-inspect for faulty components. Thoroughly inspect all components for rough edges or burrs, etc. which could cause jamming or irregular operation. Replace parts as necessary, re-lubricate and reassemble the selector assembly. Repeat the functional safety testing to verify smooth and safe operation of the selector mechanism.

Install the serviced rear locking mechanism mounting plate back onto the device using the four ¼-20 tamperproof button-head screws. Torque the tamperproof screws in an opposing cross-pattern to 70 in/lb (7.909 Nm), ± 5 in/lb (0.57 Nm).

Install 0.032” stainless steel safety wire (lock-wire) to the four mounting plate screws.

8) Remove the outlet port front mounting plate by removing the safety wires, then remove the four 1/4-20 x 3/4 in Hex head screws holding the front mounting plate to the device shell.

Remove the guide tube connector nut and retaining ring and clean with solvent and dry.

After removing the outlet port mechanism, clean the ‘S’ tube of the exposure device by pushing cloth swabs wetted with solvent through the ‘S’ tube until they come out clean. Use a dry cloth swab to remove any residual solvent from the ‘S’ tube after cleaning.

Reinstall the guide tube connector nut and retaining ring.

Reinstall the outlet port front mounting plate by installing the four 1/4-20 x 3/4 in Hex head screws holding the front mounting plate to the device shell. Torque the screws in an opposing cross-pattern to 70 in/lb (7.909 Nm), ± 5 in/lb (0.57 Nm).

Install 0.032” stainless steel safety wire (lock-wire) to the four mounting plate screws.

Ensure that all of the information contained on the device labels is legible. The trefoil and the warning, ‘Caution or Danger, Radioactive Material’, must be legible at a distance of 3 ft (approximately 1 m). The model number and serial number on the container must also be legible.

Operationally test the function of the entire system using a source guide tube, the remote controls and a mock source assembly.

Attachment of the source guide tube fitting must be smooth and without resistance until it is fully threaded and seated in the connector nut.

Connect the (serviced) remote controls to mock source assembly connector and the device locking mechanism.

For Posilok devices, push the lock slide into the EXPOSE position and crank the control cable into the exposure mode.
SECTION 4 - MAINTENANCE INSTRUCTIONS

For non-Posilok devices simply rotate the selector to the OPERATE position and crank the cable into the exposure mode.

While cranking the mock source assembly from the exposure device, carefully feel for resistance or snags. During retraction of the mock source assembly back into the exposure device, carefully feel for any resistance or snags during movement. Conclude the test by verifying the lock slide automatically secures the mock source assembly (Posilok only). Action of the lock slide should be smooth with an audible ‘snap’ during automatic securing. After automatic securing, attempt to expose the mock source assembly from the exposure device to confirm a positive capture. Repeat this testing several times.

If resistance, snags or sluggish movement of the lock slide is discovered during this testing, remove the outlet port and locking mechanism mounting plates to determine the cause.

Repeat all safety function tests if any additional servicing is required.

Clean the Model 550 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 and insert back into the spring clip of the locking mechanism's protective cover.

Annual maintenance for the remote controls (Reference Figures 4.3 and 4.4)

Tools required for complete maintenance of Models 692, 693, 664 remote controls:
• 11/16 in open-end wrench for the control conduit swage fittings.
• ½ 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.
• 0.050 in Allen wrench for the 4-40 set screw 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.
• X7 magnification glass for control cable inspection if required.
• Micrometer for measurement of control cable diameter.

Materials required for complete maintenance of 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, approved by QSA Global, Inc.) 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.
SECTION 4 - MAINTENANCE INSTRUCTIONS

Remote Control Maintenance Requirements
1) Disconnect the remote control unit from the exposure device.
2) 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.
3) 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.
4) Pull the remaining control cable through the 661 safety connector and secure.
5) Using the 11/16 in open-end wrench, remove both remote control conduits from the 661 safety connector and the control crank.
6) 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.
7) Perform the following inspections of the control cable:
   a. 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.
   b. 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.
SECTION 4 - MAINTENANCE INSTRUCTIONS

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.

8) Lightly lubricate the control cable using MIL-G-23827B (or C), MIL-PRF-23827C, or equivalent grease, approved by QSA Global, Inc. Apply additional grease to the first 3 ft (approximately 1 m) of control cable (male connector end).

9) 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.

10) 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.**
SECTION 4 - MAINTENANCE INSTRUCTIONS

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.

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.
SECTION 4 - MAINTENANCE INSTRUCTIONS

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.

11) 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, loose or damaged 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.

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.

Quarterly and Annual Maintenance for Source Guide Tubes

Tools required for maintenance of source guide tubes:
- A424-9XL mock source assembly to perform function tests after cleaning and inspection.
- Length of clean control cable to push A424-9 XL 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.
SECTION 4 - MAINTENANCE INSTRUCTIONS

Materials required for maintenance of source guide tubes:

- **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, approved by QSA Global, Inc.)**: 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.

**Source Guide Tube Maintenance**

1) Clean the exterior of all the source guide tubes thoroughly using clean cloths and a detergent. Remove all of dirt, grease and grime from the polyvinyl source guide tubes and the swage fittings.

2) 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 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.

3) 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 A424-9XL) 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 is suitable for use.

4) 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 1 in-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. If any damage is found, 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, Inc. 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.
SECTION 4 - MAINTENANCE INSTRUCTIONS

Misconnect Test after Reloading Sealed Source into the Exposure Device

After performing the annual maintenance, the complete radiography system must be tested by the maintenance program administrator or Radiation Safety Officer. A misconnect test on the exposure device including the radioactive source assembly and wind-out controls effectively tests the integrity of the entire locking system. This procedure detects long-term wear (or damage) of the interrelated failsafe system including identify any excess wear on the control cable connector, device locking mechanism and sealed source connectors simultaneously.

Note: Component wear occurs to both the control assemblies and the device lock assemblies over time, therefore, to ensure acceptable equipment operation, the misconnect test must be performed on each device lock assembly and control assembly combination that could be used in the field. For example, if controls are used interchangeably with more than one specific exposure device, then each control must be checked with each device to ensure the failsafe system for all control assembly/device combinations are compliant.

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.

⚠️ WARNING

Ensure the shipping plug is installed in the outlet port before performing a misconnect test on non-Posilok (manual locking) devices.

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 EXPOSURE mode.

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

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.
- name of the qualified individual performing the required inspections.
- problems found and maintenance or repairs performed.
- model number and serial number of the exposure device.
- associated equipment that was inspected and maintained.
- part numbers and associated lot numbers or serial numbers of replacement parts installed.
SECTION 4 - MAINTENANCE INSTRUCTIONS

Model 680-OP and 741-OP Safety Class A Components

Safety Class A Designation Items
Items that comprise the Model 680-OP and 741-OP radiographic exposure device 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.

Considerations of Safety Class A Items
Users of the Model 680-OP and 741-OP exposure devices and associated equipment must recognize their responsibilities of maintaining the integrity of the Type B(U)-96 package and the control of Safety Class A items and components by:

• maintaining traceability of Class A replacement items or components to a specific exposure device or an associated component.

• use of manufacturer specified items to maintain the integrity of the exposure device/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 notifying 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.
## SECTION 4 - MAINTENANCE INSTRUCTIONS

### Figure 4.1

**SENTINEL Cobalt-60 GAMMA RAY PROJECTOR (Posilok)**

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SECTION 4 - MAINTENANCE INSTRUCTIONS

Figure 4.2

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## SECTION 4 - MAINTENANCE INSTRUCTIONS

### Figure 4.3

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<td>Washer</td>
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<td>35 ft (10.7 m) Housing</td>
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<td>50 ft (15.2 m) Housing</td>
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<td>70 ft (21.3 m) Control Cable</td>
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* TABLE APPLIES TO FIGURES 4.3 AND 4.4
SECTION 4 - MAINTENANCE INSTRUCTIONS

Figure 4.4
SECTION 5 – SAMPLE TRANSPORTATION INSTRUCTIONS

The following instructions are samples for the transport or this radiographic source changer and source 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 Air Transport Association, ‘Dangerous Goods Regulations’.
- U.S. Department of Transportation, Title 49 Code of Federal Regulations Parts 171 through 178.
- Transport in the United Kingdom: Refer to the regulations as listed on the ADR approval Certificate.

Transport Package

The Model 680-OP and 741-OP are approved as radiographic exposure devices and Type B(U)-96 transport packages under the certification number USA/9035/B(U)-96 and USA/9027/B(U)-96 respectively.

The Model 680-OP and 741-OP may only be transported in the metal protective container. As a shipper of radioactive material, you must perform a pre-shipment inspection to verify conformance to the Type B(U)-96 certification 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.
- Visually inspect the side frame bolts on the 680 (or 741). Ensure they are fully threaded into the housing. Inspect the 680 (or 741) housing frame and side frames for signs of damage. Ensure visible welds are intact and that the side frames have no significant damage and are secured flush to the side of the device.
- Assure the shipping plate assembly and the locking plate assemblies are securely attached to the projector housing using the hardware specified on the certificate reference drawings. Assure all screws are present and secured.
- Assure the front port is properly secured and that the shipping plug threads fully and securely into the shipping plate assembly.
- Assure the seal wire is properly installed, if used.
- Ensure the dust cover installs properly onto the lock assembly and that the cover plate can be secured over the lock assembly using the hardware specified on the certificate reference drawings.
- Verify that the outer container inserts are properly installed and secured within the container, the sides, top and bottom of the foam and wood inserts have no significant damage and there are no missing pieces. Replace any missing or significantly damaged pieces.
- Confirm that the outer container and lid are in good physical condition with no excessive rust, cracked welds, major dents or holes. Assure the container feet are in good condition. Ensure the latches, including the sliding doors, are not broken and can be properly installed and secured.
SECTION 5 – SAMPLE TRANSPORTATION INSTRUCTIONS

• Ensure the two padlocks are in good working order and that the keys fit and work in the locks.
• 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 label is legible (the warnings and trefoil, the model number and serial number and the Type B certification number).
• Assure all the conditions of the Certificate of Compliance are met and the transport package has all the required markings.
• Wipe test the transport package over an area of 300cm² and assure the level of removable contamination is less than 0.0001 μCi per cm².

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

Receipt of Radioactive Material

NOTE
1) A radioactive material package must be accepted from the carrier at the time it is delivered. [10CFR20.1906(a)(1)]

2) 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), Reg. Guide 7.3-5]

3) 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]

3.a Upon receipt of a package of radioactive material, the package shall be placed in a restricted area. Assure appropriate personnel are notified.

3.b 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]
SECTION 5 – SAMPLE TRANSPORTATION INSTRUCTIONS

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.

4) 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 individual's name making the record, transport package model number, mass or activity of the depleted uranium and the package serial number. [10CFR34.63]

5) 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]

6) 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)]

Shipment of Radioactive Material

1) Prior to shipment of a Type B package within the USA, assure that you are a registered user of the radioactive material package you wish to ship. Also, assure that you have appropriate quality assurance procedures for Type B packages. [10CFR71.12, 10CFR34.31(b)]

2) 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 material to which employees may be exposed in the workplace
  - 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
  - Security Awareness Training (49CFR172.800, 10CFR30)
- 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
SECTION 5 – SAMPLE TRANSPORTATION INSTRUCTIONS

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

3) Prior to shipment maintain copies on file of the most current Type B 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 or required shipping plugs are properly installed and seal wired where required.
- All conditions of the Type B(U)-96 Certificate of Compliance are met. [10CFR71.87]

Note: Quantities of special form radioactive material equal to or greater than 0.4 TBq (10.8 Ci) of Co-60 must be shipped in Type B packages.

4) 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 B(U) certification.

5) As applicable, attach a security seal with an identification mark to the package closure that serves as a tamper indicator. [49CFR173.412(a)]

6) 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]

7) 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 a Type B container inside an overpack or convenience box in the back of a vehicle, survey and label both the inner Type B package and the overpack. Placarding the vehicle is dependent on the category of label applied to the overpack if used. [49CFR173.448]
### SECTION 5 – SAMPLE TRANSPORTATION INSTRUCTIONS

#### Table 1

<table>
<thead>
<tr>
<th></th>
<th>Maximum Radiation Level at Surface</th>
<th>Maximum Radiation Level at 1 Meter</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Radioactive White I</strong></td>
<td>0.5 mRem/hr (0.005 mSv/hr)</td>
<td>0 mRem/hr (0.00 mSv/hr)</td>
</tr>
<tr>
<td><strong>Radioactive Yellow II</strong></td>
<td>50 mRem/hr (0.5 mSv/hr)</td>
<td>1.0 mRem/hr (0.01 mSv/hr)</td>
</tr>
<tr>
<td><strong>Radioactive Yellow III</strong></td>
<td>200 mRem/hr (2 mSv/hr)</td>
<td>10 mRem/hr (0.1 mSv/hr)</td>
</tr>
</tbody>
</table>

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

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

8) Properly complete two shipping labels indicating the contents (Cobalt-60), the activity of the source (in Becquerels or multiples of Becquerels, e.g. GigaBecquerels (GBq)) and the transport index. The transport index is used only on Yellow II and Yellow III labels and is defined as the maximum radiation level in mRem/hr at 1 m from the package surface (see Table 1). [49CFR172.403(g)]
SECTION 5 – SAMPLE TRANSPORTATION INSTRUCTIONS

9) 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)]

10) 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.

11) Mark the outside of the package with the proper shipping name and identification number (Radioactive Material, Type B(U) Package, UN2916) if not already marked. Place the letters RQ (stands for Reportable Quantity) next to the proper shipping name when shipping more than 370 GBq (10 Ci) of Co-60. [49CFR172.300]

12) If the shipping package is inside a crate or other outer packaging, mark the outside package ‘Inside package complies with prescribed specifications’ and list the appropriate USNRC Type B number and the words ‘Type B(U)’ in letters a minimum of ½ in (13 mm) high. [49CFR172.310; 49CFR173.471; 49CFR173.25]

13) Assure that the levels of removable radioactive contamination on the outside surface of the outer package do not exceed 0.37Bq (10^-5 μCi) per cm². [49CFR173.443]

14) If the package gross weight exceeds 110 lb, mark the outside of the package with the gross weight. [49CFR172.310]

15) Properly complete the shipping papers indicating:
   a. Proper shipping name, United Nations Class Number ‘7’, and identification number (i.e. Radioactive Material, Type B(U) Package, Class 7, UN2916).
   b. The letters RQ must appear next to the proper shipping name when shipping more than 370 GBq (10 Ci) of Co-60.
   c. Name of the radionuclide (Cobalt-60).
   d. Physical and chemical form (Special Form).
   e. 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).
   f. Category of label applied (i.e. Radioactive Yellow II).
   g. Transport Index.
   h. USNRC identification number (i.e. USA/9035/B(U)-96).
   i. For export shipments, the IAEA identification number (i.e. USA/9035/B(U)-96).
      For Canadian shipments, include the Canadian Endorsement Number for the package.
   j. Shipper’s certification: ‘This is to certify that the above-named materials are properly classified, described, packaged, marked and labeled and are in proper condition for transport according to the applicable regulations of the Department of Transportation.’ [49 CFR 172.204(a)]
SECTION 5 – SAMPLE TRANSPORTATION INSTRUCTIONS

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

k. 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.

16) 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 15 of this part, the following information needs to be specified:

a. 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.)

b. 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’.

c. Airport of departure: Enter the full name of the airport of city of departure, which may be amended by the carrier.

d. Airport of destination: Enter the full name of the airport or city of destination, which may be amended by the carrier.

e. Shipment type: Specify the shipment type as ‘Radioactive’.

f. Under nature and quantity 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’ 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 multiples of meters.

g. The 24-hour emergency number required by Step 15 of this part, must appear in the ‘Additional Handling Information’ section of the Declaration for Dangerous Goods.

h. For shipment of special form radioactive material, the Special Form Certificate of Competent Authority for the radioactive source must be included. (e.g. USA/0377/S).

i. The shipper's certification must be as follows:

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

The information on the Declaration for Dangerous Goods must be entered strictly in accordance with the order specified in the latest edition of the International Air Transport Association, Dangerous Goods Regulations. Questions regarding completion of a Shipper's Declaration for Dangerous Goods should be directed to the Radiation Safety Officer.
SECTION 5 – SAMPLE TRANSPORTATION INSTRUCTIONS

Shipment of Empty Uranium Shielded Containers

1) Assure that the package does not contain a radioactive source. Perform the following procedure to confirm there are no unauthorized source assemblies within the container:
   - Transfer the authorized source assembly from the exposure device in accordance with the source changer operation manual
   - After removing and disconnecting the source assembly, attach the jumper (dummy connector without a serial number) to the male connector of the control cable.
   - Retract the control cable and jumper, and disconnect the controls from the locking mechanism.
   - Insert the protective cover into the locking mechanism, rotate the selector ring into the lock position, engage the plunger lock and remove key. Insert the shipping plug.
   - Remove the source identification tag from the exposure device and place it with the source assembly.
   - In some regulatory jurisdictions, ‘empty’ labels or tags must be attached to the empty Model 680-OP or 741-OP.

2) If the shipping package is to be placed inside a crate or other outer packaging, the outer packaging must be strong enough to withstand the normal conditions of transport and must not reduce the safety of the package. The shipping package must be placed within the outer package with sufficient blocking to prevent shifting during transportation. [49CFR173.25]

3) Assure that the levels of removable radioactive contamination on the outside surface of the outer package does not exceed 0.4 Bq \(10^{-5} \mu \text{Ci}\) per cm\(^2\) based on wiping an area of at least 300 cm\(^2\). [49CFR173.443]

4) Survey the package at the surface and at 1m from the surface to determine the proper shipping labels to be applied to the package.

Note: If the surface radiation level does not exceed 5 \(\mu\text{Sv/hr}\) (0.5 mRem/hr) and there is no measurable radiation level at 1m from the surface, continue with the instructions in Step 5 below and skip Step 6. If either of these levels are exceeded, skip Step 5 and continue with the instructions in Step 6.
SECTION 5 – SAMPLE TRANSPORTATION INSTRUCTIONS

5) If the surface radiation level does not exceed 5 μSv/hr (0.5 mRem/hr) and there is no measurable radiation level at 1 m from the surface, no label is required.

a. The outside of the inner packaging or, if there is no inner packaging, the outside of the packaging itself bears the marking ‘Radioactive’.

b. The outside of the package must be marked with UN2909.

c. When shipping by air, excepted packages are exempt from the requirement for use of Dangerous Goods Declaration.

i. For air shipments [IATA 10.8.8.3], the ‘Nature and Quantity of Goods’ box must read:

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

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

   ![Radioactive Material, Excepted Package Label](image)
SECTION 5 – SAMPLE TRANSPORTATION INSTRUCTIONS

6) If the surface radiation level exceeds 5 μSv/hr (0.5 mRem/hr), or if there is a measurable radiation level at 1 m from the surface, use the criteria of Table 1 to determine the proper shipping labels to be applied to the package.

a. Mark the outside of the outer shipping package with the proper shipping name and identification number (Radioactive Material, Low Specific Activity (LSA-I) UN2912. If the container is packaged inside a crate or other outer packaging, mark the outer package with the word ‘Overpack’.

b. Properly complete the shipping papers, indicating:
   i. Proper shipping name, identification number and class (i.e. Radioactive Material, Low Specific Activity (LSA-I), Class 7, UN2912).
   ii. Name of the radionuclide (i.e. depleted Uranium-238).
   iii. Physical and chemical form (i.e. Solid Metal).
   iv. Activity of the uranium in Becquerels or other appropriate multiples of Becquerels.

   NOTE: Number of Curies × 37,000 = number of MegaBecquerels (MBq). The activity in milliCuries for U-238 equals 0.16 x the shield weight in pounds (i.e. for a Model 680 with a 302 lb shield, the approximate activity is 0.16 x 302 lb = 48.3 mCi).

   v. Category of label applied (i.e. Radioactive Yellow II).
   vi. Transport Index.
   vii. USNRC identification number or DOT specification number, i.e. Model 680-OP cert: USA/9035/B(U)-96).
   viii. Shipper's certification:

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

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

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

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

   ix. For air shipments, the package must be labeled with a ‘Cargo aircraft only’ label and the shipping papers must state: ‘This shipment is within the limitations prescribed for cargo only aircraft’.

   x. Your company's 24-hour emergency telephone number.

   xi. The weight of the package including the unit of measurement of the hazardous material covered by the description (e.g. 100 lb). (Note: For air shipments, the weight must be in multiples of kilograms.)
SECTION 5 – SAMPLE TRANSPORTATION INSTRUCTIONS

c. For air shipments, the shipping papers must meet the requirements specified in IATA for a Shipper's Declaration for Dangerous Goods. In addition to the information listed in this Section, the following information needs to be specified:

   i. 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.)
   ii. 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’.
   iii. Airport of departure: Enter the full name of the airport of city of departure, which may be amended by the carrier.
   iv. Airport of destination: Enter the full name of the airport or city of destination, which may be amended by the carrier.
   v. Specify contents (isotope) on the DOT hazard labels as LSA-I.
   vi. Shipment Type: Specify the shipment type as ‘Radioactive’.
   vii. Under Nature and Quantity of Dangerous Goods, specify the number of packages (of same type and content), their type of packaging and activity in Becquerels or multiples thereof (units used must be clearly indicated) in each package, including packages in overpacks and LSA-I.

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

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

   The information on the Declaration for Dangerous Goods must be entered strictly in accordance with the order specified in the latest edition of the International Air Transport Association, Dangerous Goods Regulations. Questions regarding completion of a Shipper's Declaration for Dangerous Goods should be directed to the Radiation Safety Officer.

Carriage of Radioactive Material

1) 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.

2) 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.

3) Place the transport package in the vehicle. Properly brace and secure the package against movement in the vehicle. [49CFR177.842(d)]
SECTION 5 – SAMPLE TRANSPORTATION INSTRUCTIONS

4) 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)]

5) 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.

6) Complete the Radioactive Material Transport Checklist (see attached example). Forward a completed copy to the Radiation Safety Officer upon completion of the carriage.

7) 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.

8) 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.

9) 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.

10) 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.

11) If the vehicle is going to be used for storage of radioactive material at a temporary job site:
   a. The vehicle's storage access entrance must be posted with ‘Caution Radioactive Material’ signs.
   b. The vehicle must be secured/locked so that there is no unauthorized access.
   c. Radiation levels must be below 20 μSv/hr (2 mR/hr) outside the vehicle to meet unrestricted area requirements.

12) In the event of a transport emergency or accident involving this package, follow the guidance contained in “2004 Emergency Response Guidebook: A Guidebook for First Responders During the Initial Phase of a Dangerous Goods/Hazardous Materials Incident”, or equivalent guidance documentation.
SECTION 5 – SAMPLE TRANSPORTATION INSTRUCTIONS

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

(Record highest reading) Vehicle (18in from surface) _________ mRem/hr

Packages properly marked and labeled (including transport index) ______________________

Packages secured in vehicle __________ Vehicle placarded __________________________

Shipping papers properly completed _______________________________________________

Remarks: _______________________________________________________________________
________________________________________________________________________________
________________________________________________________________________________
________________________________________________________________________________

Operator’s signature ____________________________
SECTION 6 - DEFINITIONS AND TERMS

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

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

Apparatus for Industrial Gamma Radiography
Apparatus including an exposure device, 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 exposure device 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 exposure device 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 exposure device and providing physical protection to the control cable. The control cable sheath includes the necessary connections for attachment to the radiographic exposure device and to the remote control. Also known as: control cable housing, conduit.
SECTION 6 - DEFINITIONS AND TERMS

Exposure Device (container)
Radiographic exposure devices 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 exposure device 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 exposure device or a transport container.

Plunger Lock
A mechanical device with a key used to lock or unlock the radiographic exposure device or transport container.

Projection Sheath
A flexible or rigid tube for guiding the source assembly from the radiographic exposure device to the working position, having the necessary connections for attachment to the radiographic exposure device 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 be moved to and from a working position by operation from a distance away from the radiographic exposure device. 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.
SECTION 6 - DEFINITIONS AND TERMS

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 exposure device and source assembly, when the sealed source is fully shielded and restricted to this position within the radiographic exposure device.

Note: When in the secured position during radiographic operations, the radiographic exposure device 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 ‘pigtails’. 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 exposure device (category I apparatus - an exposure device in which the source assembly is not removed for exposure).
- fitted at the end of the control cable (category II apparatus - an exposure device 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.
SECTION 6 - DEFINITIONS AND TERMS

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.
SECTION 7 - EMERGENCIES AND PERSONNEL SAFETY

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 exposure device, radiographers are required to perform a confirmatory survey of the exposure device, 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 exposure device. If the radiographer measures any radiation level that indicates the sealed source is not fully shielded while performing the confirmatory survey, the radiographer must first recognize that problem exists and then follow his company’s emergency procedures. Emergency conditions are those problems in which the source assembly cannot be returned to the shielded position by normal means, specifically the remote control crank mechanism. The majority of problems experienced by radiographers are where the source assembly becomes disconnected or when the source assembly becomes jammed in the projection sheath while in an exposed position. The important safety points for radiographers to follow are:

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

The radiography crew is limited to the following basic steps and must be adhered to under regulation:

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

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

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

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.
SECTION 7 - EMERGENCIES AND PERSONNEL SAFETY

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.

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.

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 μSv (5 mRem) could be received in any one hour.

‘Restricted Area’ must be identified and posted where a dose of 20 μSv (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 μSv (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 μSv (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’.
SECTION 7 - EMERGENCIES AND PERSONNEL SAFETY

EU Regulations
A ‘Controlled Area’ must be marked with a barrier at a distance where the radiation intensity will not exceed 7.5 μSv/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 μSv/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’.

Personnel Monitoring
All personnel who enter a ‘Restricted’ or ‘Controlled’ area or are present during radiographic operations are required to wear the appropriate personnel monitoring devices as required by the regulatory jurisdiction. These devices can include; film badges; thermoluminescent dosimeters (TLD); optically stimulated luminescence badges; direct reading pocket dosimeters; electronic pocket dosimeters; alarm ratemeters; and audible alarms. Calibrated and operable survey meters must be used to determine radiation levels when conducting radiographic operations.
SECTION 8 - INSTRUCTIONS FOR DISPOSAL

By international regulations, radioactive materials that are no longer required must be transferred to a licensed recipient for final disposition. Cobalt-60 source assemblies that have depleted beyond their useful working life may be returned to authorized recipients using a source changer authorized for the specific model source assembly.

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

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

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

Contact QSA Global, Inc. for assistance in the transfer of DU shielded exposure device for final disposition.
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