

PANHANDLE EASTERN PIPE LINE COMPANY  
OPERATING & EMERGENCY PROCEDURES  
FOR HANDLING OF BYPRODUCT MATERIAL

1.0 RADIATION SAFETY OFFICER

The Radiation Safety Officer is directly responsible for the radiation protection program of Panhandle Eastern Pipe Line Company. He is responsible for the use of byproduct material, for performing Industrial Radiography, the Recording Surveillance and Enforcement of all phases of radiation safety. The Radiation Safety Officer is the only one with authority to issue or change Operating Procedures or Instructions.

The Assistant Radiation Safety Officer is responsible for the above, as directed by the Radiation Safety Officer, or in the absence of the Radiation Safety Officer.

2.0 EQUIPMENT OPERATION

Each radiographic exposure device and its method of operation is described in the following paragraphs:

2.1 Gamma Industries, Model "Gamma Century" - Capacity - 100 curies - Iridium 192 EXHIBIT H

This is a special lightweight unit using depleted uranium for shielding material.

This unit consists of three (3) parts (storage safe, control cables, and guide tube).

Size: 5-1/2" diameter, 8" high

Weight: 32 pounds

Guide Tube: Up to 23 ft. long

Control Cable: 25 ft. long

Operation:

- (a) Remove the protector cap from the lock box, thereby exposing the pigtail connector.
- (b) Crank the control cable to a length of approximately six inches (6"), and connect to the pigtail.
- (c) Crank control cable in so that male connecting thread can be screwed into lock box.

## 2.0 EQUIPMENT OPERATION - Cont'd

### 2.1 Gamma Industries, Model "Gamma Century" - Capacity - 100 curies - Iridium 192 EXHIBIT H - Cont'd

#### Operation:

- (d) Remove safety plug from protruding nipple approximately, one inch (1") from top of unit and connect the guide tube.
- (f) Place free end of guide tube in desired position, trying to keep it in a straight line without kinks.
- (g) Stretch control cable away from exposure device in as straight a line as possible.
- (h) Crank source out as smoothly as possible. When you feel that source is approaching the end of guide tube, slow turning speed so that pigtail does not bank into end of guide tube.
- (i) At end of exposure, retract source into the exposure device by reversing the cranking action.
- (j) Survey the exposure device and guide tube carefully to be sure that source has returned to safe position.
- (k) Additional exposures may be made in accordance with the above instructions, but the exposure device must be locked during the interval between exposures.
- (l) Depress plunger lock.
- (m) Disconnect source tube and insert safety plug.
- (n) Disconnect control cables and replace protector cap.

The source replacement and storage is done in accordance with manufacturer's instructions.

### 2.2 Technical Operations, Model 660 - Capacity - 100 curies - Iridium 192 EXHIBIT Q

This unit has a lightweight portable storage safe using depleted uranium for shielding material. The control unit, which includes control cables and guide tubes, is removable from the exposure device.



## 2.0 EQUIPMENT OPERATION - Cont'd

### 2.2 Technical Operations, Model 660 - Capacity - 100 curies - Iridium 192 EXHIBIT Q - Cont'd

Size: 9-1/2" high x 4-3/4" wide x 12-3/4" long

Weight: 44 pounds

Guide Tube: 21 ft. long (three 7 ft sections)

Control Cable: 25 ft. long

#### Operation:

- (a) Remove the storage plug from the projector connector.
- (b) Lay out the guide tubes as straight as possible, directing them toward the projector and connect.
- (c) Lay out the control cable as straight as possible, directing it toward the projector.
- (d) Unlock the projector with the key provided and rotate the selector ring to the "Connect" position.
- (e) Attach the control cable to the projector by sliding the control cable collar back and open the jaws of the cable connector.
- (f) Engage the male and female portions of the swivel connector.
- (g) Close the jaws of the control cable.
- (h) Slide the control cable over the connector jaws.
- (i) Hold the control cable collar flush against the projector connector and rotate the selector ring from the "Connect" position to the "Lock" position.
- (j) Unlock the projector connector and rotate the selector ring to the "Operate" position.
- (k) At the control, rapidly rotate the hand crank in the "Expose" direction. Continue to rotate the hand crank until the source reaches the snout, which serves as a mechanical stop for the source.
- (l) After exposure time has elapsed, rapidly turn the hand crank in the "Retract" direction.

## 2.0 EQUIPMENT OPERATION - Cont'd

### 2.2 Technical Operations, Model 660 - Capacity - 100 curies - Iridium 192 - EXHIBIT Q - Cont'd

#### Operation:

- (m) After exposure, conduct a physical radiation survey of the guide tube and the exposure device subsequent to each radiographic exposure during a radiographic operation to determine that the sealed source has returned to its safe shielded position.
- (n) At the projector, rotate the connector selector from the "Operate" position to the "Lock" position.
- (o) Additional exposures may be made in accordance with the above instructions, but exposure device must be locked during the interval between exposures.
- (p) To disconnect, unscrew the guide tube sections. Insert storage plug into position and tighten.
- (q) Unlock the projector using the supplied key.
- (r) Rotate the connector selector ring from the "Lock" position to the "Connect" position.
- (s) Slide the control cable connector collar over the jaws away from the projector.
- (t) Open the connector jaws and disconnect the swivel-type connector.
- (u) Replace the storage cover in the projector connector and rotate the selector ring to the "Lock" position. Remove the key and engage the lock to secure the projector.

The source replacement and storage is done in accordance with manufacturer's instructions.

### 2.3 Technical Operations, Model 900 - Capacity - 100 curies - Iridium 192 - EXHIBIT R

This gamma radiography system is used as a radiographic exposure device and Type B shipping container. The exposure device serves as the storage and transport device for the radioactive source assembly. The exposure device consists of a steel housing which contains a depleted uranium shield. The control unit, which includes control cables and guide tubes, is removable from the exposure device.

## 2.0 EQUIPMENT OPERATION - Cont'd

### 2.3 Technical Operations, Model 900 - Capacity - 100 curies - Iridium 192 EXHIBIT R

Size:	12.25" Long x 5.25" Wide x 7.75" High
Mass:	44 lbs (20kg)
Shielding: (Depleted Uranium)	28 lbs (13kg)
Source Assembly:	Model 90003
Type B Identification:	USA/9141/B(U)
Control Unit Model	693
Type:	Piston Grip
Standard Control Length	25 ft (7.6m)
Odometer:	Yes
Weight (Standard)	19 lbs (8.6kg)

#### Operation:

- (a) Remove the storage plug from the projector connector.
- (b) Lay out the guide tubes as straight as possible, directing them toward the projector and connect. Source guide tube will connect them with no sharp turns or bends. The bend radius of the guide tube should never be less than twenty inches. Shorter bend radii can restrict source movement in the source guide tube.
- (c) Lay out the control cable as straight as possible, directing it toward the projector.
- (d) Unlock the projector, with the key provided, and rotate the selector ring to the "Connect" position.
- (e) Attach the control cable to the projector by sliding the control cable collar back and open the jaws of the cable connector.
- (f) Engage the male and female portions of the swivel connector.

## 2.0 EQUIPMENT OPERATION - Cont'd

### 2.3 Technical Operations, Model 900 - Capacity - 100 curies - Iridium 192 EXHIBIT R - Cont'd

#### Operation:

##### Drive Cable Connector

##### WARNING

Assure that the source assembly is properly locked in the source changer when connecting, disconnecting or testing for proper connection.

##### To Engage Connector

##### To Disengage Connector

1. Using a fingernail, move the connector pin forward (toward stored position of source) to move the connector sleeve away from the keyway in the female connector.
  2. Slide the drive cable connector into the female connector and release the pin. Assure that the connector sleeve has returned to its original position closing the keyway.
  3. Test the connection by pulling between the source and the drive cable. (Note WARNING)
1. Using a fingernail, move the connector pin forward (toward stored position of source) to move the connector sleeve away from the keyway in the female connector.
  2. Slide the drive cable connector out of the female connector and release the pin.

##### CAUTION

Move connector sideways only. Do not bend or twist.

- (g) Close the jaws of the control cable.
- (h) Slide the control cable over the connector jaws.
- (i) Hold the control cable collar flush against the projector connector and rotate the selector ring from the "Connect" position to the "Lock" position.
- (j) Unlock the projector connector and rotate the selector ring to the "Operate" position. Lift the indicator knob up until the indicator slide locks in place. The source is now free to move.

## 2.0 EQUIPMENT OPERATION - Cont'd

### 2.3 Technical Operations, Model 900 - Capacity - 100 curies - Iridium 192 EXHIBIT R - Cont'd

#### Operation:

- (k) At the control, rapidly rotate the hand crank in the "Expose" direction. Continue to rotate the hand crank until the source reaches the snout, which serves as a mechanical stop for the source.
- (l) After exposure time has elapsed, rapidly turn the hand crank in the "Retract" direction.
- (m) After exposure, approach the exposure device with the survey meter. Make a physical radiation survey of the exposure device on all sides and survey the guide tube subsequent to each radiographic exposure during a radiographic operation to determine that the sealed source has returned to its safe shielded position.
- (n) At the projector, rotate the connector selector from the "Operator position to the "Lock" position.
- (o) Additional exposures may be made in accordance with the above instructions, but exposure device must be locked during the interval between exposures.
- (p) To disconnect unscrew the guide tube sections. Insert storage plug into position and tighten.
- (q) Unlock the projector using the supplied key.
- (r) Rotate the connector selector ring from the "Lock" position to the "Connect" position.
- (s) Slide the control cable connector collar over the jaws away from the projector.
- (t) Open the connector jaws and disconnect the swivel-type connector.
- (u) Replace the storage cover in the projector connector and rotate the selector ring to the "Lock" position. Remove the key and engage the lock to secure the projector.

The source replacement and storage is done in accordance with manufacturer's instructions. EXHIBIT Q

### 3.0 CHANGING SOURCES

- 3.1 Source changing for the Gamma Industries Model "Gamma Century" will be accomplished by the use of Gamma Industries Model C-4 or Model C-10 Source Changer. Manufacturer's instructions will be followed. See source changing instructions for C-4 shipping container and source changing instructions for C-10 shipping container attached as a part of this Operating and Emergency Procedure. (EXHIBIT C and EXHIBIT D)
- 3.2 Source changing or replacement for the Technical Operations Exposure Device Model 660, Iridium 192 will be accomplished by using the Technical Operations Source Changer Model 414 or 650. Instructions contained in the Operations Manual for this unit will be followed. See Operations Manual for Model 414 Source Changer and Operating Instructions for Source Changer Model 650 attached as a part of this Operating and Emergency Procedure. (EXHIBIT A and EXHIBIT B)
- 3.3 Source changing or replacement for the Technical Operations Exposure Device Model 900, Iridium 192 will be accomplished by using the Technical Operations Source Changer Model 850. Instructions contained in the Operations Manual for this unit will be followed. See Operating Instructions for Source Changer Model 850 attached as part of this Operating and Emergency Procedure. (EXHIBIT S)

### 4.0 SHIPPING INSTRUCTIONS

- 4.1 Use only Gamma Industries Model C-4 or Model C-10 Source Changers when returning old source which was used in a Gamma Century exposure device to Gamma Industries, Inc.
- 4.2 Use only Technical Operations Model 414 or Model 650 Source Changers when returning old source which was used in Technical Operations Model 660 exposure device to Technical Operations, Inc.
- 4.3 Use only Technical Operations Model 850 Source Changer when returning old source which was used in Technical Operations Model 900 exposure device to Technical Operations, Inc.
- 4.4 The step-by-step instructions issued by the manufacturer of the container must be followed in detail and in the sequence presented. These step-by-step instructions are included as a part of this Operating and Emergency Procedure.
- 4.5 Check to confirm that source is securely locked in the fully shielded position by carefully performed and recorded radiation surveys. These surveys shall be taken at the surface of the shipping container and at one (1) meter and recorded on the Shipper's Certification for Radioactive Materials. (EXHIBIT E)



#### 4.0 SHIPPING INSTRUCTIONS - Cont'd

- 4.6 No source changer with radiation levels in excess of 200 milliroentgens per hour at the surface of the source changer OR 10 milliroentgens per hour at one (1) meter shall be released for shipment, as specified in Department of Transportation Regulations.
- 4.7 Check package labeling and accompanying shipping papers to confirm that they are complete.

#### 5.0 RECEIVING INSTRUCTIONS

- 5.1 When receiving Byproduct Material, make arrangements to receive the material when it is offered for delivery by the carrier.
- 5.2 When receiving material from a carrier terminal, arrangements will be made to pick up material expeditiously upon receipt of notification from the carrier.
- 5.3 Upon receipt of material, materials shall be monitored on the external surfaces of the package for radioactive contamination.
- 5.4 No package shall be in excess of 200 millirems per hour on the surface OR in excess of 10 millirems at three (3) feet from external surface.

#### 6.0 INSPECTION AND MAINTENANCE PROCEDURE

Visually inspect all of the exposure equipment before each day's work. Correct any damage or malfunction before using the equipment. Report inspection on "Radiation Report" and "Description of Inspection and Maintenance" forms. This Inspection and Maintenance will be as follows: (EXHIBIT G)

##### Inspection:

- (a) Inspect cables for cuts, breaks, and broken fittings.
- (b) Inspect source tubes for cuts, crushing and broken fittings.
- (c) Survey for excessive radiation levels.
- (d) Inspect exposure device for damage to fittings, lock, fasteners, and labels.
- (e) Inspect crank for damage and loose hardware.
- (f) Check operation of cable connections.
- (g) Check operation of control for freedom of source movement.

## 6.0 INSPECTION AND MAINTENANCE PROCEDURE - Cont'd

### Maintenance

- (a) Perform complete inspection and maintenance each three (3) months according to manufacturer's procedures. For Gamma Century exposure device, use Gamma Industries Inspection and Maintenance Procedure. (EXHIBIT H)
- (b) Perform complete inspection and maintenance each three (3) months according to manufacturer's procedures. For Technical Operations Model 900 exposure device, follow Section VII "Maintenance" located in Instruction Manual. (EXHIBIT R)
- (c) Perform complete inspection and maintenance each three (3) months according to manufacturer's procedures. For Technical Operations Model 660 exposure device, use Inspection and Maintenance Procedure No. 71-129. (EXHIBIT F)
- (d) Report inspection on "Description of Inspection and Maintenance" forms. (EXHIBIT I)

## 7.0 RADIATION SURVEY INSTRUMENTS AND METHODS

- 7.1 A calibrated and operable radiation survey instrument must be used by Radiographer to make the necessary physical radiation surveys. Each instrument shall be calibrated at intervals not to exceed three (3) months. These instruments shall have a range to measure two (2) milliroentgens per hour through one (1) roentgen per hour.
- 7.2 No testing operation shall be conducted unless a calibrated and operable survey instrument is available and used at each site where radiographic exposures are made. Survey instrument must have been calibrated within the last three (3) months.
- 7.3 Each vehicle shall be equipped with a minimum of one (1) radiation survey instrument that has been calibrated and certified in the past three (3) months. Description of radiation detection instruments:
  - Victoreen Model 592-B
  - Eberline Model E510G or E120G SKI
  - Victoreen Radactor Model 500G
  - Eberline Model E130G SKI or equivalent
- 7.4 Instrument calibration will be done by one of the following:
  - Panhandle Eastern Pipe Line Company (EXHIBIT O)
  - Victoreen Instrument Corporation, Cleveland, Ohio
  - Eberline Instrument Corporation, Santa Fe, New Mexico
  - Technical Operations, Radiation Products, Burlington, Mass.

## 7.0 RADIATION SURVEY INSTRUMENTS AND METHODS - Cont'd

- 7.5 A physical radiation survey shall be made after each radiographic exposure during a testing operation to determine that the sealed source has been returned to its safe, shielded position.
- 7.6 Before locking the radiographic exposure device, make a physical radiation survey to determine that each sealed source is in its shielded position. Keep a record of this survey and maintain it for inspection by the Nuclear Regulatory Commission. (EXHIBIT J)
- 7.7 Each exposure set-up must be roped off (where applicable), barricaded, and posted with four (4) "CAUTION RADIATION AREA" signs designating the radiation area. The high radiation area will be posted at the perimeter with "CAUTION HIGH RADIATION AREA" signs. The use of the survey meter will determine the radiation area to be barricaded and the high radiation area shall be determined by calculations 100 mr/hr level. This is to avoid unnecessary exposure to the Radiographer. Restrict the radiation at the perimeter of the radiation area to 2 mr/hr or less and the high radiation area to 100 mr/hr. The Radiographer in charge must remain in a position to permit continuous surveillance of the radiation area. He will be prepared to secure source if anyone attempts to enter the radiation area.

## 8.0 SECURITY OF SOURCES IN STORAGE AND TRANSPORT TO FIELD LOCATIONS

- 8.1 The Gamma Century, the Technical Operations Model 660 and the Technical Operations Model 900 exposure devices shall have no radiation level in excess of 50 mr/hr at six inches (6") from any exterior surface of the device. Source Changers Technical Operations Model 414, Model 650 and Model 850, and Gamma Industries Model C-4 and Model C-10 shall have no radiation level in excess of 200 mr/hr at any exterior surface and shall not exceed 10 mr/hr at one meter from any exterior surface.
- 8.2 Each radiographic exposure device and storage container shall be provided with a lock or outer container designed to prevent unauthorized or accidental removal or exposure of a sealed source. They shall be kept in a locked condition at all times except when in use and under surveillance of a Radiographer or Radiographer's Assistant.
- 8.3 When the radiographic exposure device is not in use, the radiographer shall lock the storage container, in which sealed sources are stored, in the compartment on the truck which is designed for this purpose. Secure the compartment from entry by unauthorized personnel by locking. The storage compartment shall be locked at all times except when attended.

8.0 SECURITY OF SOURCES IN STORAGE AND TRANSPORTED TO FIELD LOCATIONS -  
Cont'd

8.4 Before leaving the vehicle, Radiographer in charge will:

- (a) Lock the exposure device.
- (b) Lock the exposure device in the truck compartment.
- (c) Lock the vehicle in which the device is stored.

9.0 TRANSPORTING SEALED SOURCES

- 9.1 When an exposure unit containing a source is transported to a field location, it must be securely fastened in the transporting vehicle as far from the driver as possible. The transporting vehicle must bear a placard stating "CAUTION RADIOACTIVE MATERIAL". (EXHIBIT K)
- 9.2 Add additional shielding, when necessary, to restrict the radiation level reaching the driver of the vehicle to less than one (1) mr/hr and to restrict the level of radiation emanating from any portion of the vehicle to less than two (2) mr/hr. These levels of radiation shall be determined by careful surveys and reading recorded on the daily report. (EXHIBIT J)

10.0 PERSONNEL MONITORING EQUIPMENT

- 10.1 Each Radiographer or Radiographer's Assistant shall wear a film badge and a pocket dosimeter. The pocket dosimeter must be capable of measuring doses from zero to at least 200 milliroentgens. A film badge and dosimeter shall be assigned to and worn by only one (1) person. Pocket dosimeters shall be recharged before each work day and doses recorded at the end of each work day. Pocket dosimeters must be read frequently throughout the working day so the Radiographer or Radiographer's Assistant will be aware of the radiation dose he is receiving. Radiographers and Radiographer's Assistants must keep assigned dosimeter and film badge in their possession to avoid theft, tampering, or exposure by other Radiographers. The film badge shall be returned for processing each month.
- 10.2 If at any time the Radiographer or Radiographer's Assistant finds that his pocket dosimeter has gone off scale, the individual shall immediately shut down operation of the work site, clear the area, secure equipment, and immediately notify the Radiation Safety Officer. At such time, the individual's film badge shall be processed immediately.
- 10.3 Dosimeter calibration will be done by one of the following:

Panhandle Eastern Pipe Line Company (EXHIBIT N)  
Victoreen Instrument Corporation, Cleveland, Ohio  
Eberline Instrument Corporation, Santa Fe, New Mexico  
Technical Operations, Radiation Products, Burlington, Mass.

## 10.0 PERSONNEL MONITORING EQUIPMENT - Cont'd

10.4 Film badges will be supplied and processed monthly by:

R. S. Landauer Jr. & Co.  
Science Road  
Glenwood, Illinois 60425

10.5 Each Radiographer will wear a pocket dosimeter and film badge. Daily records will be kept of the dosimeter readings and film badges will be processed monthly. Pocket dosimeters will be supplied by either:

Victoreen Instrument Corporation  
Model 541A pocket dosimeter

Bendix Corporation  
Model 06-862 pocket chamber

Landsverk Electro Mater Company  
Model U-750

## 11.0 EMERGENCY PROCEDURES

11.1 In case of a road accident involving a vehicle, or any type of accident containing byproduct material, the radiographer must immediately conduct a radiation survey to determine if the source container or exposure device has been damaged. If damage has occurred, the same precautions used for a temporary exposure area must be put into effect; i.e., barrier ropes, signs, and continuous surveillance until a safe recovery can be affected. The Radiographer must remain at the scene of the restricted area after all precautions have been set up.

11.2 In the event the Radiographer is injured in such an accident and is unable to physically perform the required surveys and area restrictions, he should assist the civil authorities by direction, if possible.

## 12.0 NOTIFICATION OF ACCIDENTS

12.1 The Radiographer, his Assistant, or whomever may be available shall report to K. F. L. Dohrman or S. R. Griffin, as soon as possible by telephone. Mr. Dohrman will notify the cognizant authorities, and if practical, effect the safe return of the byproduct material to a suitable vault or shield.

K. F. L. Dohrman - Office: 913/341-1400 Overland Park, Kansas  
- Home: 913/782-3544 Olathe, Kansas

S. R. Griffin - Office: 316/624-7241 Liberal, Kansas  
- Home: 316/624-5446 Liberal, Kansas



## 12.0 NOTIFICATION OF ACCIDENTS - Cont'd

- 12.2 In the event of any type of accident causing damage to the isotope camera or storage container that may result in exposure to personnel (unit dropped, cable sheared, camera drive jammed, etc.) the same emergency procedures and notifications described in Sections 11.0 and 12.1 are to be followed. Mr. K. F. L. Dohrman or Mr. S. R. Griffin will notify the regional Nuclear Regulatory Commission Office, if emergency warrants.

## 13.0 UTILIZATION LOGS

- 13.1 The Radiographer must complete a "Radiation Report" daily. If radiography is performed at different locations, use additional forms, one for each location. He will forward the original to the Overland Park Office weekly and retain a copy. (EXHIBIT J)
- 13.2 The information required by the "Radiation Report" shall be kept available for inspection by the Nuclear Regulatory Commission.

## 14.0 LEAK TESTING OF SEALED SOURCES

- 14.1 Leak testing of sealed sources for use in radiography shall be conducted at intervals not exceeding six (6) months, or more often if reasonable cause exists, by the procedure capable of detecting the presence of .005 microcuries of removal contamination on the exposure device, storage container or sealed source. Records of leak test results shall be kept in units of microcuries and maintained for inspection by the Nuclear Regulatory Commission, in the Overland Park Office, 10890 Benson Drive, Building 24, Suite 360, Overland Park, Kansas 66212.
- 14.2 Radioactive sources not returned to the manufacturer (within six months) shall be leak tested in the following manner using Tracerlab Model LT-2 Leak Test Kit or Technical Operations Model 518 Leak Test Kit: (EXHIBIT M)
- (a) Use survey meter to be sure the source is fully retracted into the exposure device.
  - (b) Remove the guide tube or shipping plug from the face of the shield.
  - (c) Wet the swab with Alconox solution, shake off the excess, and insert the swab in the hole in the shield. Wipe the interior of the hole thoroughly (as near the source as possible) by rotating the swab holder.
  - (d) Withdraw the swab and place into the plastic envelope.
  - (e) The swab should now be monitored by the survey meter set on its most sensitive range. Place the meter in a low background area and move the swab in its plastic envelope to the meter - NOT the meter to the swab.



#### 14.0 LEAK TESTING OF SEALED SOURCES - Cont'd

- (f) Each qualified Radiographer will be responsible for performing the function of swabbing for leak testing.
- (g) If there is no indication on the meter, or if the indication is no more than 0.2 mr/hr above background, put the plastic envelope with the swab into the mailing box supplied. Mail to the appropriate vendor for processing.

NOTE: Be sure to fill out and return the Leak Test Record supplied. (EXHIBIT L)

- (h) If the swab shows more than 0.2 mr/hr, do not mail. Do NOT use the unit for radiography. Replace all storage locks and notify K. F. L. Dohrman or S. R. Griffin for specific instructions.

- 14.3 Leak testing of all sources or instruments will be accomplished by outside agencies approved or qualified to perform such testing. Radiographers are authorized to swab equipment and follow directions of the agency which will perform tests. Agencies to perform such tests are:

Technical Operations, Inc., Burlington, Massachusetts  
Use of their Model 518 Leak Test Kit

Tracerlab Model LT-2 Kit

#### 15.0 POCKET DOSIMETER CALIBRATION

##### 15.1 General Requirements

- (a) Pocket dosimeters shall be calibrated at intervals not to exceed one (1) year.
- (b) Each qualifying Radiographer will be responsible for performing the function of calibrating instruments.
- (c) Pocket dosimeter calibration shall be accomplished using the Tech/Ops Model 773 Instrument Calibration Device (EXHIBIT P).
- (d) Pocket dosimeters shall be calibrated by measuring the response to a known exposure. The dosimeter's response should be checked at 25%, 50% and 75% of the full scale reading (0 to 200 mr dosimeters should be checked at 50 mr, 100 mr, and 150 mr). A dosimeter will be considered in satisfactory calibration if its response is within + 30% of the known exposure. Additionally, dosimeters shall be checked for leakage. If the dosimeter drifts more than 2% of full scale in 24 hours, it shall be considered unsatisfactory.

## 15.0 POCKET DOSIMETER CALIBRATION - Cont'd

### 15.2 Procedure for Calibrating Pocket Dosimeters

- (a) Determine the points to be checked for the dosimeter to be calibrated. Determine the exposure time necessary to obtain the required exposure.
- (b) Initially charge the dosimeter and note the initial reading. Place the dosimeter in the calibrator and expose for the required time.
- (c) Read the dosimeter and record the net reading on the Dosimeter Calibration Record Sheet (EXHIBIT N). Repeat this procedure for the remaining points.
- (d) Recharge the dosimeter and note the reading. Place the dosimeter in a low background area for at least 24 hours and record the leakage rate on the Dosimeter Calibration Record Sheet.
- (e) If the dosimeter is in satisfactory calibration, attach a calibration decal to the dosimeter indicating the date of calibration and the calibration due date. If the dosimeter is not in a satisfactory calibration, return the dosimeter to the Radiation Safety Officer with the Dosimeter Calibration Record Sheet.

## 16.0 CALIBRATION OF SURVEY METERS

The calibration device and its operation is described in the following paragraphs:

### TECH/OPS MODEL 773 INSTRUMENT (EXHIBIT P)

#### 16.1 General

The Model 773 is a portable survey instrument calibration device. The unit consists of a 150 millicurie Cesium<sup>137</sup> source permanently attached to a movable source rod which is installed in a lead shield casing. The source is exposed by raising the source rod which positions the source in a 36° x 20° collimated beam port.

Size:	5 in (12.7cm) wide, 5 in (12.7cm) deep, 8.5 in (21.6cm) high
Weight:	(with attenuators) 52 lbs (24 kg) (without attenuators) 45 lbs (20 kg)
Source:	Model 77302, Cesium <sup>137</sup> , 150 millicuries
Transport Status:	DOT Specification 7A Type A package
Shielding Material:	Lead. Approximately 29 lbs. (13 kg)

## 16.0 CALIBRATION OF SURVEY METERS - Cont'd

- 16.3 All personnel operating the equipment will use a calibrated and operable survey instrument and wear appropriate personnel monitoring devices. Place the source shield in a restricted area so that the directional port is aimed horizontally. To minimize the effects of scattered radiation, the unit should be 16 feet from any wall in the direction of the primary beam.

Restrict access to the area where the radiation level is in excess of 2 milliroentgens per hour.

- 16.4 To properly calibrate a survey instrument it is necessary to check the instrument's response at two (2) points on each of the instrument's ranges. These points must be separated by at least 50% of the full scale reading. The instrument reading should agree with the actual radiation intensity within 10% to be in proper calibration.

The following procedure is designed for a survey instrument with three (3) scales and a range of 0-1000 mr/hr. For instruments with different ranges, the procedure will be similar but the points will differ.

### Procedure to Calibrate and Use

- (a) Turn on the survey meter and allow it to "warm up" for approximately 10 minutes.
- (b) Determine the activity of the source on the date of calibration from the decay chart provided with the source.
- (c) Calculate the distance from the source at which the radiation intensity would be 800 mr/hr.
- (d) Using the tape measure attached to the Model 773, place the survey meter such that the axis of the detector is located at the proper distance from the source as determined above.

NOTE: The survey meter should be located so that the center of the detector is at the correct distance and centered on the center line of the radiation beam. The axis of the detector should be perpendicular to the centerline of the radiation beam.

- (e) Unlock the handle of the Model 773. Remove the shipping plate. Remove all the attenuators from the radiation beam.
- (f) Standing away from the radiation beam, expose the source by manually raising the source rod. Movement of the source rod should be accomplished as expeditiously as practicable. Note and record the survey meter reading and return the source to the stored position.

CAUTION: Do not enter the area of the radiation beam while the source is exposed.

## 16.0 CALIBRATION OF SURVEY METERS Cont'd

### 16.4 Procedure to Calibrate and Use - Cont'd

- (g) Place the 0.25 attenuator in the radiation beam. Repeat Step (f). The actual intensity is 200 mr/hr.
- (h) Remove the 0.25 attenuator from the radiation beam and place a 0.10 attenuator in the radiation beam. Repeat Step (f). The actual intensity is 80 mr/hr.
- (i) Place the 0.25 attenuator in the radiation beam. Repeat Step (f). The actual intensity is 20 mr/hr.
- (j) Remove the 0.25 attenuator from the radiation beam and place the other 0.10 attenuator in the radiation beam. Repeat Step (f). The actual intensity is 8 mr/hr.
- (k) Place the 0.25 attenuator in the radiation beam. Repeat Step (f). The actual intensity is 2 mr/hr.

At the end of calibration operation, use survey meter to insure that source rod is in place. Replace the lock on handle and secure. Remove key.

Calibration Unit will be sent to vendor for source replacement in accordance with manufacturer's instructions.

### 16.5 Records

After each instrument has been calibrated or servicing has been done, a record will be filled out and placed on file (EXHIBIT O). A decal shall be placed on instrument indicating the calibration date and calibration due date.

Each qualifying Radiographer will be responsible for performing the function of calibrating instruments.

### 16.6 Procedure for Leak Testing

The Tech/Ops Model 773 Meter Calibration Kit contains a Cesium<sup>137</sup> source which must be leak tested at intervals not to exceed six (6) months. This may be accomplished using the Tech/Ops Model 518 Leak Test Kit or Tracer Lab Model LT-2.

- (a) Place the Model 773 calibrator in a restricted area.
- (b) Remove the lock and rotate the handle from the top of the source rod. Remove the shipping cover.
- (c) Moisten leak test seal with EDTA solution. Blot off excess.
- (d) Wipe around the top of the source rod.

## 16.0 CALIBRATION OF SURVEY METERS Cont'd

### 16.6 Procedure for Leak Testing - Cont'd

- (e) Standing away from the beam port, raise the source rod to the open position and wipe the exposed source rod thoroughly.
- (f) Place the leak test swab into the plastic envelope.
- (g) Set the survey meter on its most sensitive range and place the meter in a low background area. Move the swab, in its plastic envelope, to the meter, NOT the meter to the swab.
- (h) If there is no indication on the meter, or if the indication is no more than 0.2 mr/hr above background, put the plastic envelope, with the swab, into the mailing box supplied. Mail to the below listed address:

Panhandle Eastern Pipe Line Company  
10890 Benson Drive  
P. O. Box 12330  
Overland Park, Kansas 66212

ATTENTION: K. F. L. Dohrman

NOTE: Be sure to fill out and return the Leak Test Record supplied. (EXHIBIT L)

- (i) If the swab shows more than 0.2 mr/hr, do NOT mail. Do NOT use the unit. Replace all storage locks and notify K. F. L. Dohrman or S. R. Griffin for instructions.

## 17.0 SECURITY AND STORAGE OF CALIBRATION UNITS

- 17.1 The Tech/Ops Model 773 calibration device shall have no radiation level that exceeds more than 200 mr/hr at the surface and less than 10 mr/hr at three (3) feet from the surface.
- 17.2 The calibration unit shall be provided with a lock or outer locked container designed to prevent unauthorized or accidental removal or exposure of a sealed source. It shall be kept in a locked condition at all times, except when in use and under surveillance of a Radiographer or Radiographer's Assistant.
- 17.3 The calibration device unit shall also be placed in container made of at least 1/8" steel plate and lined with a shielding material so there is no radiation level to exceed 2 mr/hr at surface. Container shall have a lock to prevent tampering or removal of unit by unauthorized personnel.



## 18.0 PERMISSIBLE DOSE LEVELS

- 18.1 Limits on radiation dosage per calendar quarter (13 week period) are:
- (a) Whole body, head and trunk, active blood forming organs, lens of the eyes, or gonads ----- 1.25 roentgens
  - (b) Hands and forearms, feet and ankles -- 18.75 roentgens
  - (c) Skin of the whole body ----- 7.50 roentgens
- 18.2 Radiographers will receive no more than 1.25 roentgens whole body dosage per calendar quarter.
- 18.3 Company considers all radiation dosage to be whole body.

## 19.0 INTERNAL INSPECTION SYSTEM OR OTHER MANAGEMENT CONTROL

- 19.1 Periodic inspections will be conducted by K. F. L. Dohrman, Radiation Safety Officer, and in his absence, by S. R. Griffin, Assistant Radiation Safety Officer. These inspections will be quarterly and unannounced. Inspections will cover the following:
- (a) The actual operations
  - (b) Inspecting Radiographers and Radiographer's Assistants to see if they are following the guidelines set forth in the Operating and Emergency Procedures
  - (c) Auditing all procedures of receiving and shipping of sources
  - (d) Auditing and inspecting quarterly maintenance
  - (e) Inspections and inventory of sources and equipment
  - (f) Maintaining and reviewing the utilization logs, personnel monitoring results and surveys
- 19.2 The Radiation Safety Officer will assume control in instituting corrective action of all Radiographers and Assistant Radiographers as set forth in all phases of the Operating and Emergency Procedures and U. S. N. R. C. License.
- 19.3 The Radiation Safety Officer will maintain and keep all records pertaining to the Nuclear Regulatory Commission Licenses.

Attached is the list of Management Personnel who may at any time audit or inspect all the files and records kept and maintained by the Radiation Safety Officer. This shall be done on an annual basis.



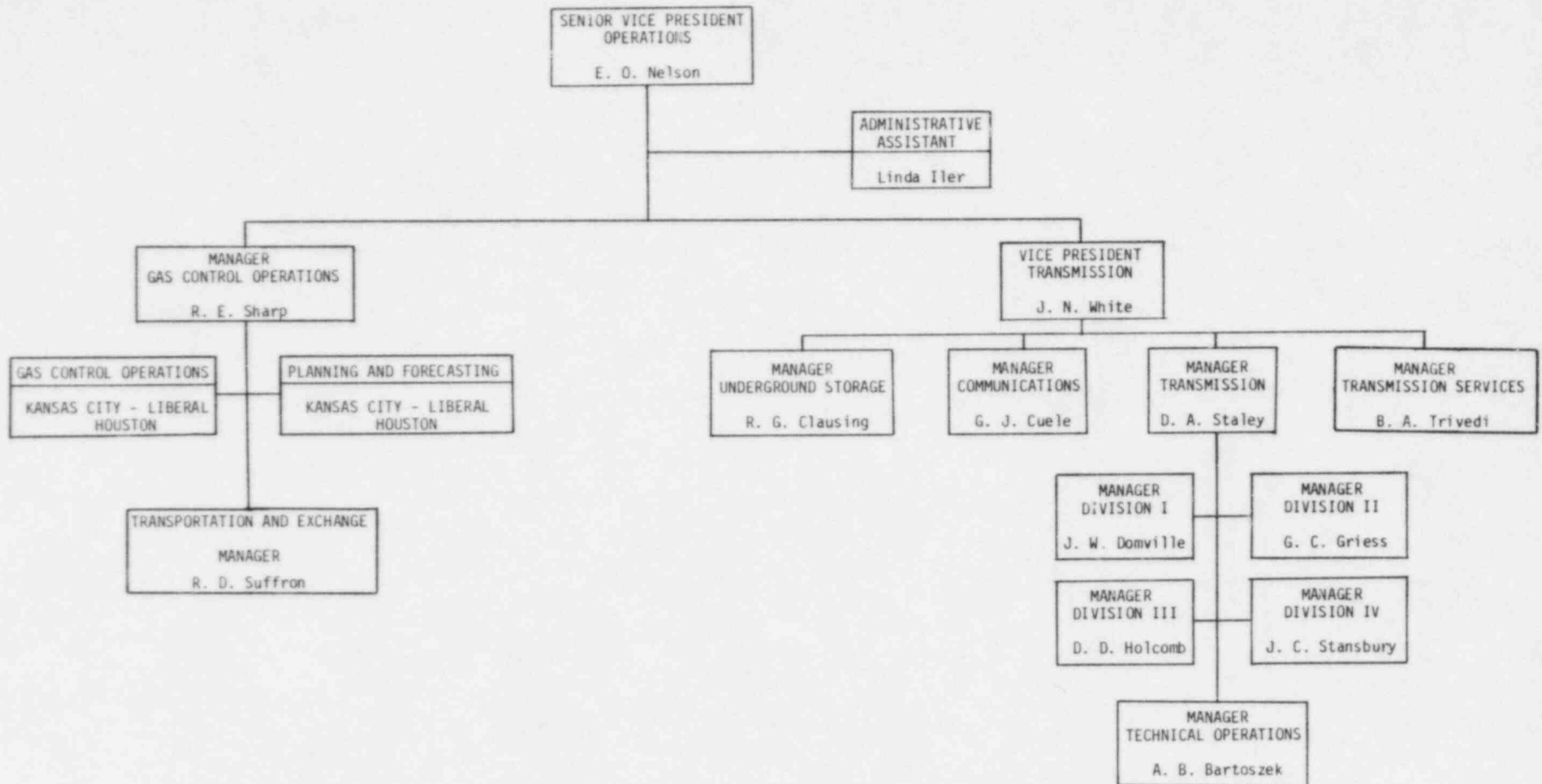
PANHANDLE EASTERN CORPORATION  
DIRECTORS

<u>Name</u>	<u>Address</u>
Robert J. Allison, Jr.	5618 Green Springs, Houston, TX 77066
M. O. Boring, Jr.	P.O. Box 3427, Odessa, TX 79760
Harry E. Ekblom	350 Highland Avenue, Ridgewood, NJ 07450
Harold S. Hook	2204 Troon Road, Houston, TX 77019
Robert D. Hunsucker	11946 S. Durette, Houston, TX 77024
Max R. Lents	3260 Chevy Chase, Houston, TX 77019
John A. Morgan	Big Owl Road, Allenspark, CO 80510
William M. Osborne, Jr.	1 Pepper Ridge Road, Pepper Pike, OH 44124
Richard L. O'Shields	10 South Briar Hollow Lane, #95, Houston, TX 77027
James B. Pearson	1642 30th Street, NW Washington, D.C. 20007
Thomas Rodd	Byram Lake Road, Mount Kisco, NY 10549
Gerald C. Smith	2425 Tracy Place, NW Washington, D.C. 20008

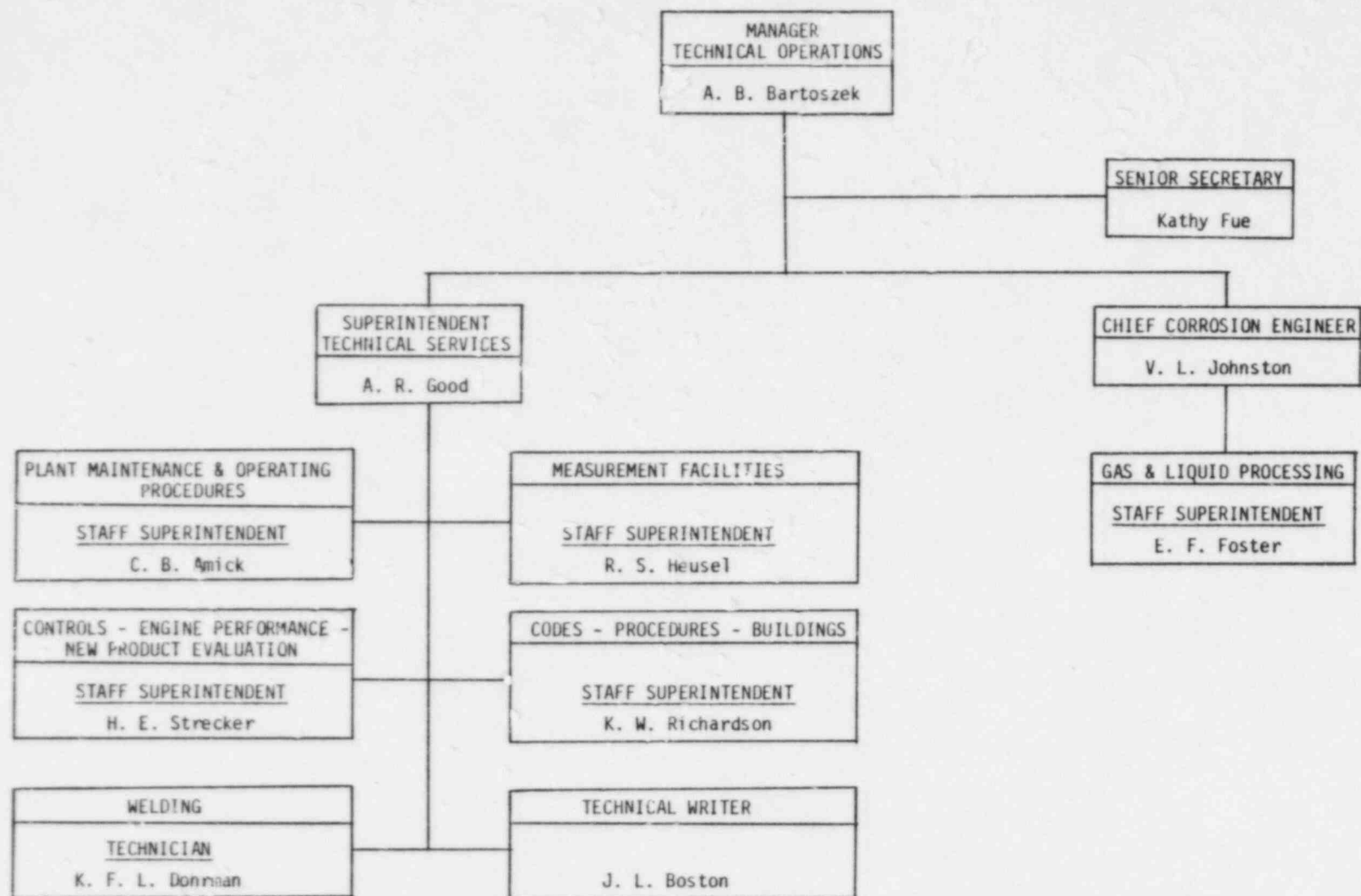
PANHANDLE EASTERN PIPE LINE COMPANY  
OFFICERS

Name	Title	Address
Richard L. O'Shields	Chairman of the Board	10 South Briar Hollow Lane, #95 Houston, Texas 77027
Robert. D. Hunsucker	President and Chief Executive Officer	11946 South Durrette Houston, Texas 77024
Robert J. Allison, Jr.	Group Vice President	5618 Green Springs Houston, Texas 77066
W. P. Anderson	Group Vice President	239 Tamerlaine Houston, Texas 77024
Kenneth E. Kalen	Group Vice President	8001 El Monte Prairie Village, Kansas 66208
G. J. Kurk	Group Vice President	10 South Briar Hollow Lane, #18 Houston, Texas 77027
T. B. Irwin	Senior Vice President, Finance	8018 Candle Lane Houston, Texas 77071
Vernon D. Rigdon	Senior Vice President and Treasurer	10035 North Charlotte Kansas City, Missouri 64155
Harry S. Welch	Senior Vice President and General Counsel	10611 Twelve Oaks Houston, Texas 77024
Cyril J. Smith	Vice President and Secretary	7534 Del Monte Drive Houston, Texas 77063
H. R. Newsom	Vice President	5631 Inwood Drive Houston, Texas 77056
J. F. Schomaker	Vice President	1902 Augusta Drive, #34 Houston, Texas 77057
H. E. Schulze, Jr.	Vice President	510 Winter Oaks Houston, Texas 77079
S. A. Wallace	Vice President	355 Tealwood Houston, Texas 77024
Vernon D. Rigdon	Assistant Secretary and Assistant Controller	10035 North Charlotte Kansas City, Missouri 64155
E. B. Dawson	Assistant Treasurer and Assistant Secretary	6127 Lynbrook Houston, Texas 77057

PANHANDLE EASTERN PIPE LINE COMPANY  
TRUNKLINE GAS COMPANY  
TRANSMISSION DEPARTMENT



ORGANIZATION CHART

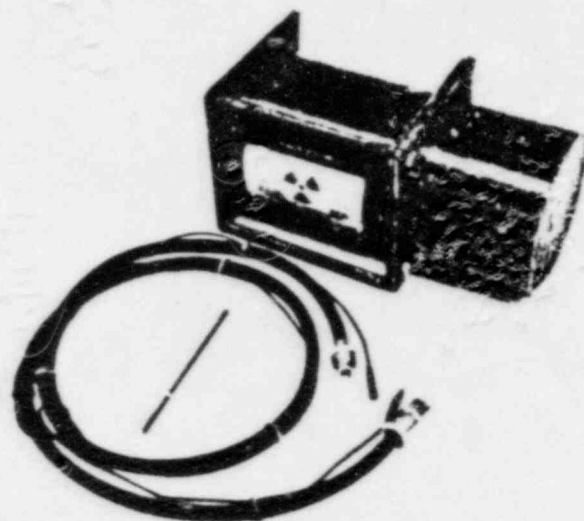


ORGANIZATION CHART

## INDEX OF EXHIBITS

EXHIBIT A	Model 414 Source Changer - Operation Manual
EXHIBIT B	Model 650 Source Changer - Operating Instructions
EXHIBIT C	Model C-4 Shipping Container - Source Changing Instructions
EXHIBIT D	Model C-10 Shipping Container - Source Changing Instructions
EXHIBIT E	Panhandle Eastern Pipe Line Company Shipping Certification for Radioactive Materials
EXHIBIT F	Inspection and Maintenance Procedures NO. 71-129
EXHIBIT G	Technical Operations Gamma Ray Projector Daily Checklist
EXHIBIT H	Gamma Industries Model Gamma Century S and SA
EXHIBIT I	Inspection and Maintenance Record
EXHIBIT J	Panhandle Eastern Pipe Line Company Radiation Report NO. PE-125
EXHIBIT K	Typical X-Ray Unit
EXHIBIT L	Leak Test Record
EXHIBIT M	Tech/Ops, Inc. Leak Test Kit Model 518
EXHIBIT N	Dosimeter Calibration Certificate
EXHIBIT O	Meter Calibration Certificate
EXHIBIT P	Technical Operations Model 773 Instrument Calibration Device Operation Manual
EXHIBIT Q	Model 660 Series Exposure Device - Operation and Maintenance Manual
EXHIBIT R	Model 900 Exposure Device - Technical Operations Manual
EXHIBIT S	Model 850 Source Changer - Operating Instructions

# OPERATION MANUAL



**Model 414**

IRIDIUM 192

**Source Changer**



TECHNICAL OPERATIONS INC. BURLINGTON, MASSACHUSETTS

EXHIBIT A



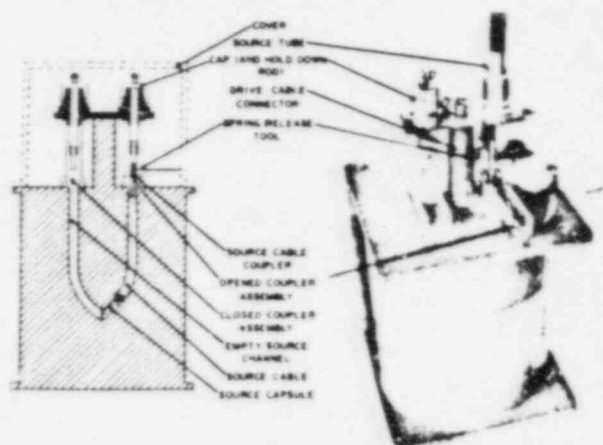
## DESCRIPTION GENERAL PURPOSE

The Technical Operations Model 414 Iridium Source Changer is a shielded shipping and storage container designed to permit field exchange of old for new sources without exposure to the operator to unsafe radiation levels.

## SPECIFICATIONS

1. New weight: 175 lbs.
2. Maximum safe contents: 100 curies Iridium
3. Surface radiation: Less than 2 milli-roentgens per hour per curie
4. Built in accordance with I.C.C. SPEC 55.

## PARTS AND THEIR TERMINOLOGY



### PLEASE NOTE

The Atomic Energy Commission forbids the use of this equipment and the exchange of sources unless the user is specifically authorized by the terms of his license.

If you are not authorized to make source changes contact the Picker X-Ray Corporation. They have

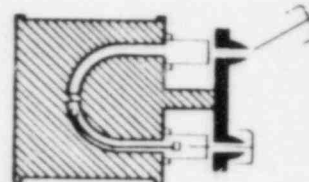
licensed personnel who can perform this operation. If you wish to be licensed to perform source changes, application should be made to the Atomic Energy Commission, Division of Licensing and Regulation, Washington 25, D. C. Your application, in letter form, should specify by whom and under what conditions source exchanges are to be made. Refer to this Instruction Manual for detailed procedures. Additional copies of this manual may be obtained for incorporation in your operating procedures manual.

Packed with each Source Changer you will find,

1. Source decay chart and leak test certification. Keep for your records.
2. Source identification plate. Fasten to your projector.
3. Return shipping labels.
4. Tamperproof seals.
5. Instruction manual.

## OPERATING INSTRUCTIONS

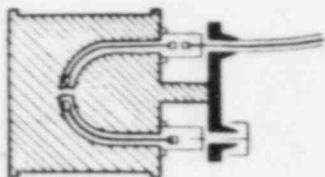
### REMOVING THE OLD SOURCE FROM YOUR PROJECTOR



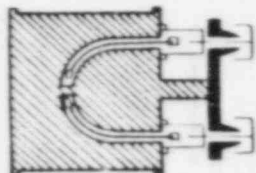
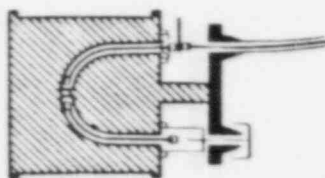
1. Position the source changer and projector where the source may be exposed safely. Locate the source changer so that one section of source tube reaches between the fittings on the changer and projector. Remove

source changer cover. Fasten the source tube to the projector and to the EMPTY channel of the source changer. Note radiation level at source changer. It should not be higher than 2 MR/HR per curie contained.

2. Crank the source from the projector into the source changer. Monitor this operation with your survey meter, and be sure the source is propelled into the source changer as far as it will go. The radiation levels at the source changer should not be higher than 2 MR/HR per curie now contained.

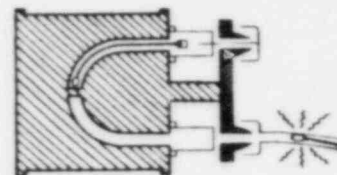
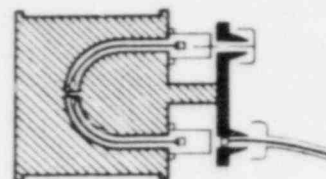
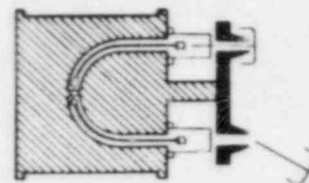


3. Open the source guides and disconnect the source assembly from the drive cable. See FIGURE 1. The locking sleeve must be retracted by moving the actuating pin in the direction shown. The thumbnail, a coin or key may be used. This permits the drive cable terminal to be moved sideways out of the hole, freeing it from the connector.



4. Remove source tube from the source changer. Close source guides and replace cap and hold down rod.

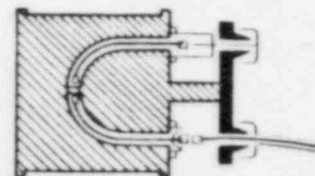
↓



1. Remove cap and hold down rod from the channel containing the new source. Open source guides. Fasten the source tube to this channel and engage drive cable terminal to connector of new source by retracting the locking sleeve and inserting the terminal. Release the locking sleeve and allow it to come forward.

The connector should now appear as in FIGURE 2.

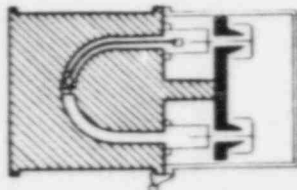
2. Close the source guides. Crank the control to retract the new source into the projector. Monitor this operation and be sure the source is fully retracted. Radiation levels at the projector should now be comparable with normal operation.



3. Remove the old source identification plate from the projector and affix it with seal wire to the source changer channel containing the old source.

↓

4. Affix the new source identification plate to the projector.
5. Replace the source changer cover. Tighten bolts and seal with tamperproof seal provided. Apply labels provided and return to Technical Operations, Inc. Containers not returned to Technical Operations, Inc. are subject to rental fees.



Upon receipt of your returned source, Technical Operations, Inc. will mail you an acknowledgment of receipt. Keep this receipt for your records.

#### SAFETY

During the process of transferring sources to observe the same precautions with respect to monitoring activity and restricting personnel as you employ in making radiographic exposures.

#### WARRANTY

Technical Operations, Inc. guarantees the equipment to be free of defects for a period of one year from the date the equipment is received.

Technical Operations does not assume responsibility or liability for the misuse of radioactive material.

February 1963

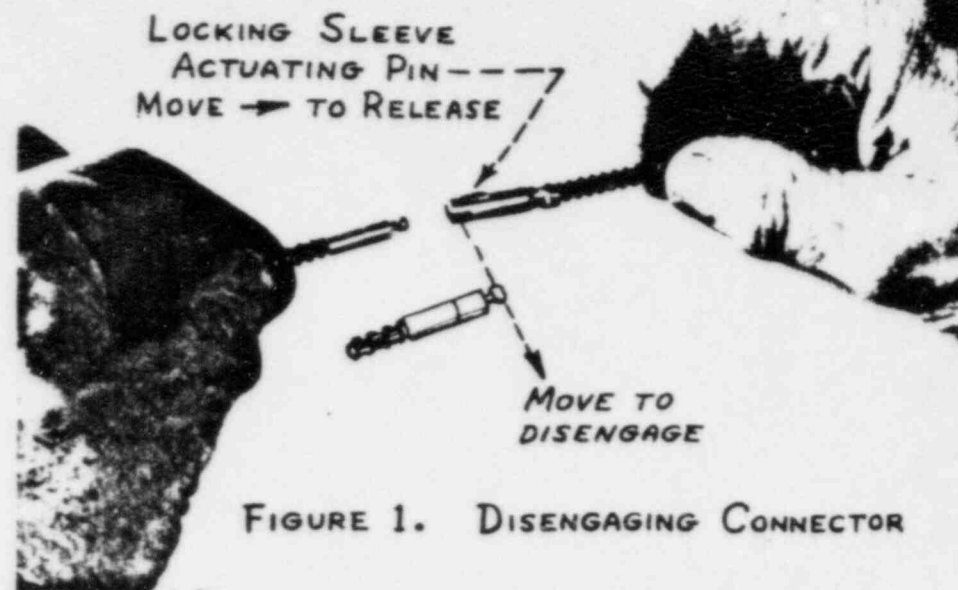


FIGURE 1. DISENGAGING CONNECTOR

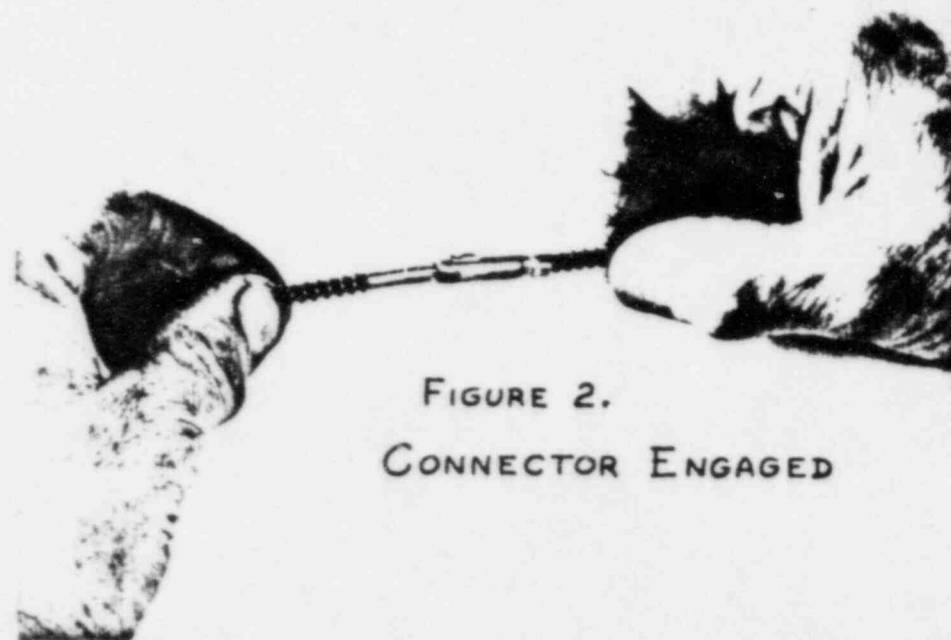


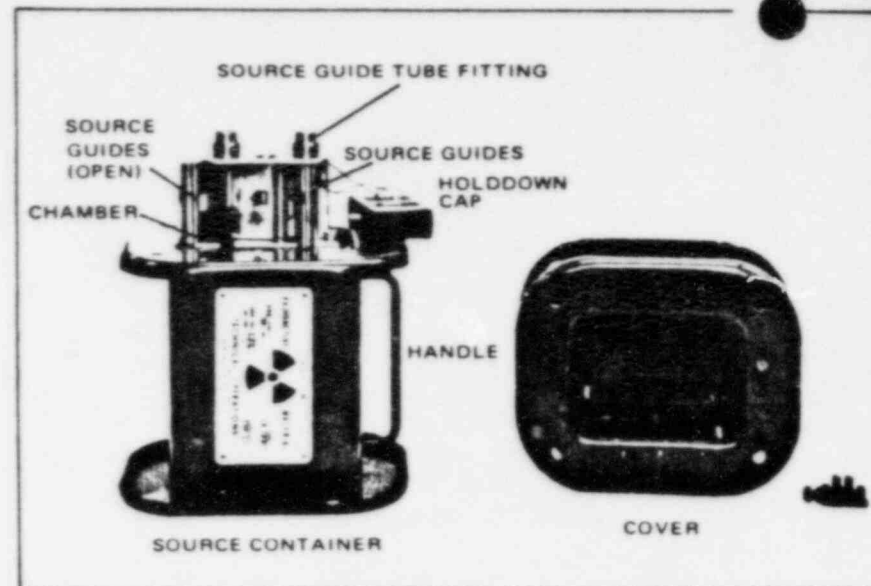
FIGURE 2.  
CONNECTOR ENGAGED

# OPERATING INSTRUCTIONS

## SOURCE CHANGER Model 650



TECH/OPS, INC.  
Radiation Products Division  
Burlington, MA 01803



Model 650 Source Changer  
(Source in a chamber - Parts Identification)

### NOTICE

This container is for shipping only licensed sources of Tech/Ops, Inc. No attempt to use the equipment should be made unless the user is thoroughly familiar with the instructions in this manual.

### USER WAIVER AGREEMENT

The user agrees that Tech/Ops, Inc. is not liable for any claims alleged to be due to use of the product.

The NRC forbids the use of this equipment and the exchange of sources unless the user is specifically authorized by the terms of his license.

If user is not authorized to make source changes, contact Tech/Ops, Inc. It has licensed personnel that can perform this operation. If user wishes to be licensed to perform source changes, application should be made to the Materials Branch, Office of Nuclear Safety and Safeguards, U.S. Nuclear Regulatory Commission, Washington, D.C. 20555. The application, in letter form, should specify by whom and under what conditions source exchanges are to be made. Refer to this instruction manual for detailed procedures. Additional copies may be obtained for incorporation in your operating procedures manual.

Prior to the first use of this source changer, the user, in addition, should register as such with the Transportation Branch, Office of Nuclear Safety and Security, U.S. Nuclear Regulatory Commission. The user should have in his possession a copy of Certificate of Compliance No. 9032 issued for this source changer.

## GENERAL DESCRIPTION

The Source Changer Model 650 is a portable, shielded container for transferring encapsulated radioisotope sources into radiography projectors. The changer is designed to safely contain the radiographic sources during shipment and to permit field exchange of old for new sources without exposing the operator to unsafe radiation levels. The source changer has depleted uranium for shielding.

## QUICK REFERENCE DATA

Source Types	Sealed sources (Tech/Ops sources only) Isotope: Iridium-192 Radiation: Gamma rays
Container capacity	Iridium-192: 200 Curies + 20%
Shielding	Depleted Uranium (U238), weight 35 lbs.
Housing	Steel
Design	Type B Radioactive Material Shipping Container (USNRC Certificate of Compliance No. 9032 and IAEA Certificate of Competent Authority No. USA/9032/B(U)T
Effective radiation shielding	Well below regulatory mR/hr limits prescribed in 10CFR34.21 and 49CFR-173.393(i)
Dimensions	13¼ in. H X 10 in. L X 8¼ in. W
Shipping weight	66 lbs.

## SHIPMENT DATA

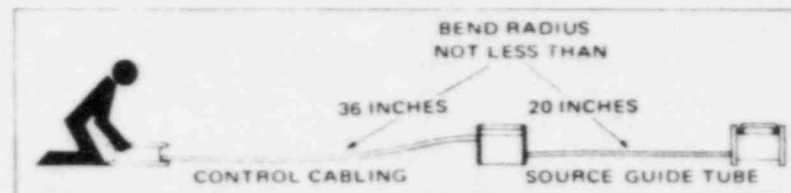
1. Source decay chart and leak test certification. Keep for user's records.
2. Source identification (ID) plate. Affix to user's projector.
3. Return shipping labels.
4. Tamperproof seals.
5. Instruction manual.

## OPERATION

**NOTE:** All the precautions used when making radiographic exposures must be followed.

Wear personnel monitoring devices during all source changing operations. Monitor all operations with a calibrated, operable survey meter.

1. Upon receipt of the source changer, survey the source changer to ensure that the source is in the proper storage position.
2. Locate the source changer and projector in a restricted area. Locate the devices so as to avoid sharp bends in the guide tube or control housing.

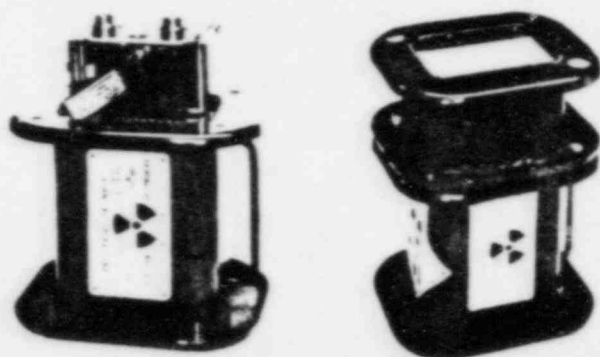


Typical Source-exchange Arrangement

3. Set the projector as for an exposure.
  4. Remove the cover from the source changer by breaking the seal wire and removing the bolts.
  5. Remove the source holddown cap by breaking the seal wire and unbolting.
- CAUTION:** When the source holddown cap is removed, the source connector is exposed. Care must be taken to ensure the source is not dislodged when handling the changer.
6. Connect one end of a guide tube extension to the projector and the other end to the fitting above the empty chamber in the source changer.
  7. Close and latch the source guides.
  8. At the projector controls, crank the source from the projector to the source changer.
  9. Approach the projector with the survey meter. Survey the projector on all sides, survey the guide tube and survey the source changer on all sides to ensure the source has been properly transferred. The maximum radiation level at the source changer should be less than 200 milliroentgens per hour at contact.






10. Open source guides. Disconnect the drive cable from the source assembly by moving the lock pin down and sliding the drive cable connector out through the keyway.
11. Disconnect the guide tube from the source changer. Connect the guide tube to the fitting above the chamber containing the new source.
12. Couple the drive cable to the source by depressing the lock pin, sliding the drive cable connector into the keyway, and releasing the lock pin. Test for proper engagement.
13. Close and latch the source guides.
14. At the projector controls, crank the source from the source changer to its storage position in the projector.
15. Approach the projector with the survey meter. Survey the projector on all sides, survey the guide tube, and survey the source changer on all sides to ensure the source has been properly transferred.
16. Lock the projector.
17. Disconnect the source guide tube from the source changer.
18. Affix the identification plate of the new source to the projector and attach the identification plate of the old source to the source holddown cap.
19. Bolt the source holddown cap in place and seal wire.
20. Bolt the source changer cover in place and seal wire.
21. Survey all exterior surfaces of the source changer to ensure that the radiation level does not exceed 200 milliroentgens per hour at contact.



Preparing Source Changer for Shipment

22. Measure the radiation level three feet from all exterior surfaces of the source changer and ensure that the radiation level is less than 10 milliroentgens per hour. The maximum radiation level measured three feet from any exterior surface is the Transport Index. (Example: With a maximum radiation level of 2.2 milliroentgens per hour, the Transport Index is 2.2.)
23. Select the proper shipping labels (Radioactive II or Radioactive III) according to the radiation levels at the surface and at 3 feet from the container. Complete the labels listing the radioisotope contained (Iridium-192). Indicate the activity as the number of Curies. Record the Transport Index as determined above.

	MAXIMUM RADIATION LEVELS	
	Surface	3 Feet
<b>RADIOACTIVE WHITE I</b> 	0.5mR/hr	None
<b>RADIOACTIVE YELLOW II</b> 	50mR/hr	1.0mR/hr
<b>RADIOACTIVE YELLOW III</b> 	200mR/hr	10mR/hr

24. If a shipping container is packaged inside a crate or other packaging, mark the outside package "Inside package complies with prescribed specifications USA/9032/B(U) Type B".
25. Apply the shipping labels, properly completed, to two opposite sides of the container.

26. Properly complete the shipping papers (see samples on following pages) indicating:

Radioactive Material, Special Form, n.o.s. NA 9182

Iridium-192 (X) \_\_\_\_\_ curies, and

Radioactive Device, n.o.s. UN 2911

Uranium-238, Solid Metal, 0.005 curies

Radioactive (X) \_\_\_\_\_ Labels

Transport Index (X) \_\_\_\_\_

Package Identification Number USA/9032/B(U)

All (X) marks must be completed by the shipper.

And the Shippers 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."

- Notes: 1. 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, packed, marked and labeled and are in proper condition for carriage by air according to applicable national governmental regulations".

2. 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"**

27. Return the container to Tech/Ops, Inc. according to proper procedures from transporting radioactive material as established in Title 49 Code of Federal Regulations, Parts 172-178.

28. See following page(s) for sample forms.

Complete the Shipping Certificate and Bill of Lading and fill in the necessary information in blocks marked (X).

## NOTE

Please return container promptly. Rental charges will be made for containers held beyond normal transportation time.



Connecting/Disconnecting



Testing Connection

## WARNING

Do not move source assembly more than 1/2 inch from its stored position when connecting/disconnecting or when testing for proper connection.

### TO ENGAGE CONNECTORS

1. With fingernail move lock pin back from keyway. (Pressure on pin is downward toward stored position of source.)
2. Slide drive-cable connector into keyed sleeve and release pin.
3. Test connection by pulling between source and drive cable. (Note WARNING.)

### TO DISENGAGE CONNECTORS

1. With fingernail move lock pin back from keyway.
2. Slide drive-cable connector out through keyway and release pin.

### CAUTION

Move connector sideways only. Do not bend or twist.

Figure A. Procedure for engaging and disengaging the Model 550 source assembly connector. Testing for proper connection must be performed.

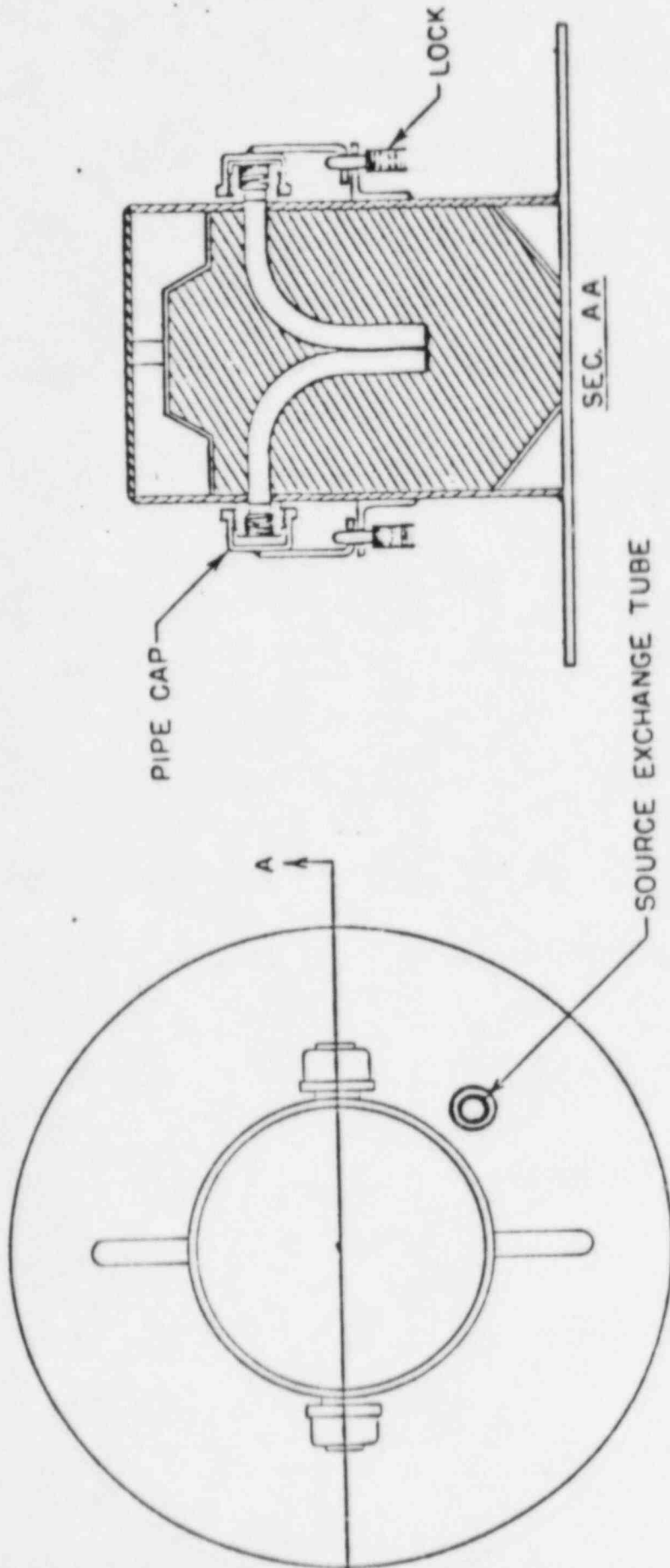
EXHIBIT C

SOURCE CHANGING INSTRUCTIONS  
FOR C-4 SHIPPING CONTAINER

Enclosed herewith is a cross sectional view of the shipping container used for transporting your pigtail source. As you can see, the container consists of two tubes - one which is labelled "New Source" immediately above the opening in the side wall of the container. The second tube is empty and is for your decayed source which is to be shipped to Gamma Industries, Inc.

The following procedure should be followed in the source changing operation:  
ALWAYS HAVE PROPERLY OPERATING SURVEY METER AT HAND WHEN CHANGING SOURCES.

1. Survey container with meter. Surface reading should not exceed 200 mr/hr.
2. Connect the short exposure cable provided to the old source hole with the other end attached to your camera.
3. Connect your control cable to the pigtail.
4. Crank source from your camera into shipping container.
5. Survey.
6. Disconnect source tube from shipping container.
7. Disconnect pigtail from the control cable.
8. Swing hasp cover over hole and lock.
9. Unlock new source side.
10. Connect control cable to pigtail.
11. Screw exposure cable into coupling of container.
12. Standing as far away as possible, retract control cable which will pull source out of shipping container and into your camera.
13. Survey.
14. Disconnect control cable from pigtail.
15. Unscrew the exposure cable from your camera and from the shipping container.
16. Lock camera and shipping container.
17. Survey shipping container and do not ship if surface radiation levels exceed 200 mr/hr, or 10 mr/hr at 1 meter.



GAMMA INDUSTRIES B.R., LA.

SCALE: NONE

APPROVED BY:

DRAWN BY KJR

DATE: 11-22-77

REVISED

CATALOG DWG. FOR C-4 SHIPPING CONTAINER

DRAWING NUMBER

607-7001-006

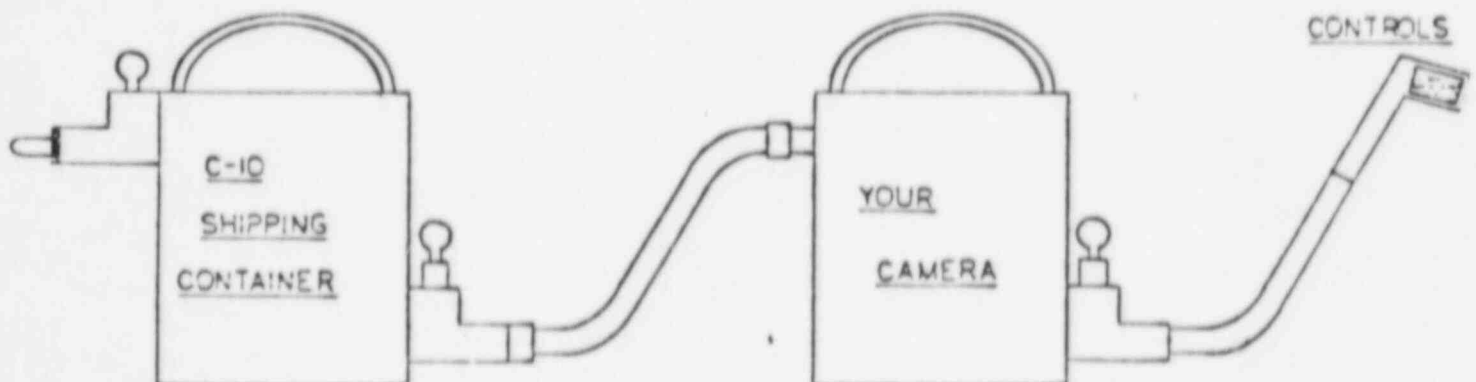
IMPORTANT - READ CAREFULLY BEFORE CHANGING SOURCESOURCE CHANGING INSTRUCTIONS  
FOR C-10 SHIPPING CONTAINER  
Revised 4/22/74

Attached is a cross-sectional view of the shipping container used for transporting your pigtail source. The container has two lock boxes-- one on each side. The upper lock box is labelled "NEW SOURCE" and the upper tube contains the new source. The lower lock box and tube contain a safety plug when shipped to you. The lower tube will be used to return the decayed source to Gamma Industries.

The following procedure should always be followed in the source changing operation:

ALWAYS HAVE A PROPERLY OPERATING SURVEY METER AT HAND  
WHEN CHANGING SOURCES!

1. Survey the C-10 shipping container with meter. The radiation intensity should not exceed 10 mr/hr at 1 meter from any surface of the C-10.
2. Open the lower lock of the C-10 shipping container. Remove the safety plug.
3. Connect one end of short exchange tube (provided in the shipping barrel) to the lower lock box of the C-10 shipping container. Attach the other end of the short exchange tube to your camera.

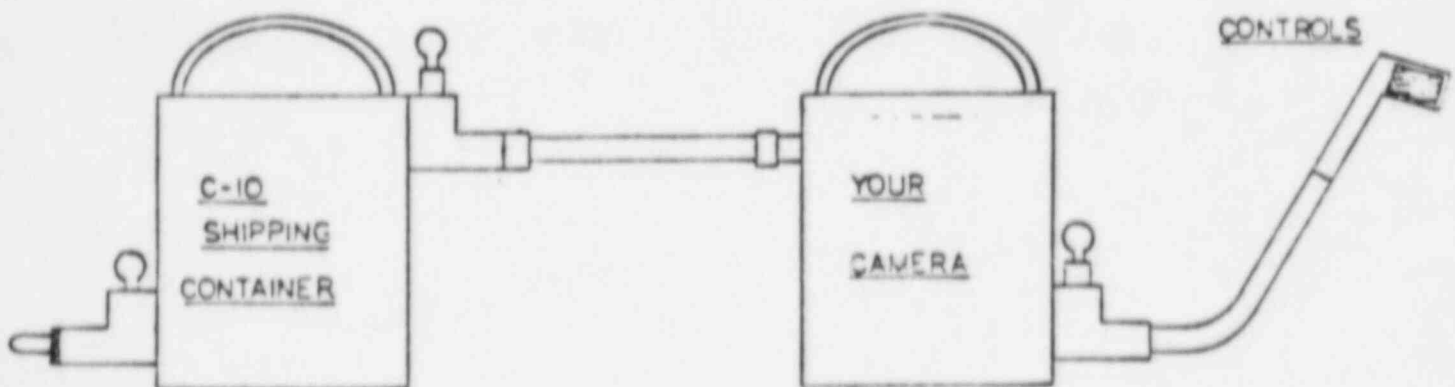


4. Crank your old source into the C-10 shipping container until it reaches a definite stop.

EXHIBIT D

SOURCE CHANGING INSTRUCTIONS FOR C-10 SHIPPING CONTAINER Continued

5. Survey to assure that the old source has reached a safe position.
6. Lock the lower lock of the C-10 shipping container onto the old pigtail locking ball. You must be aware that the source could be removed from the open end of the lock box if the lower lock is not locked.
7. Remove the short exchange tube from the C-10 shipping container. Disconnect the control cable from the old pigtail. (Attempt to move the pigtail into and out of the C-10 shipping container to assure the lock is depressed upon the pigtail locking ball. If the pigtail can be moved, then open the lower lock, carefully move the pigtail, and lock the lock upon the pigtail locking ball. This will assure that the old source will remain properly locked and shielded during the return shipment.)
8. Remove the source protector cap from the upper lock box and attach the source protector cap over the old source pigtail in the lower lock box.
9. Attach the control cable to the new pigtail which is in the upper lock box.
10. Attach short exchange tube to the C-10 shipping container upper lock box.



11. Unlock the upper lock from the new source.
12. Standing as far away as possible, crank the new source from the C-10 shipping container into your camera.



SOURCE CHANGING INSTRUCTIONS FOR C-10 SHIPPING CONTAINER Continued

13. Survey.
14. Lock your camera lock.
15. Remove the short exchange tube from your camera. Remove the short exchange tube from the C-10 shipping container.
16. Insert the safety plug into the upper tube of the C-10 shipping container. Lock the upper lock of the C-10 shipping container.
17. Survey.
18. Place the C-10 into the barrel in the same orientation which it was received. Place the short exchange tube into the barrel. Place the top on the barrel and secure with the locking ring.
19. Insert a safety seal into the barrel locking ring.
20. Survey. (The radiation intensity should not exceed 200 mr/hr at any barrel surface or 10 mr/hr at one meter from any barrel surface.)

END OF SOURCE INTERCHANGE INSTRUCTIONS

Be sure that you:

1. Attach two "Radioactive Yellow-III" labels to the barrel.
2. Measure and write the transport index upon the affixed labels.
3. Properly fill out all shipping documents.

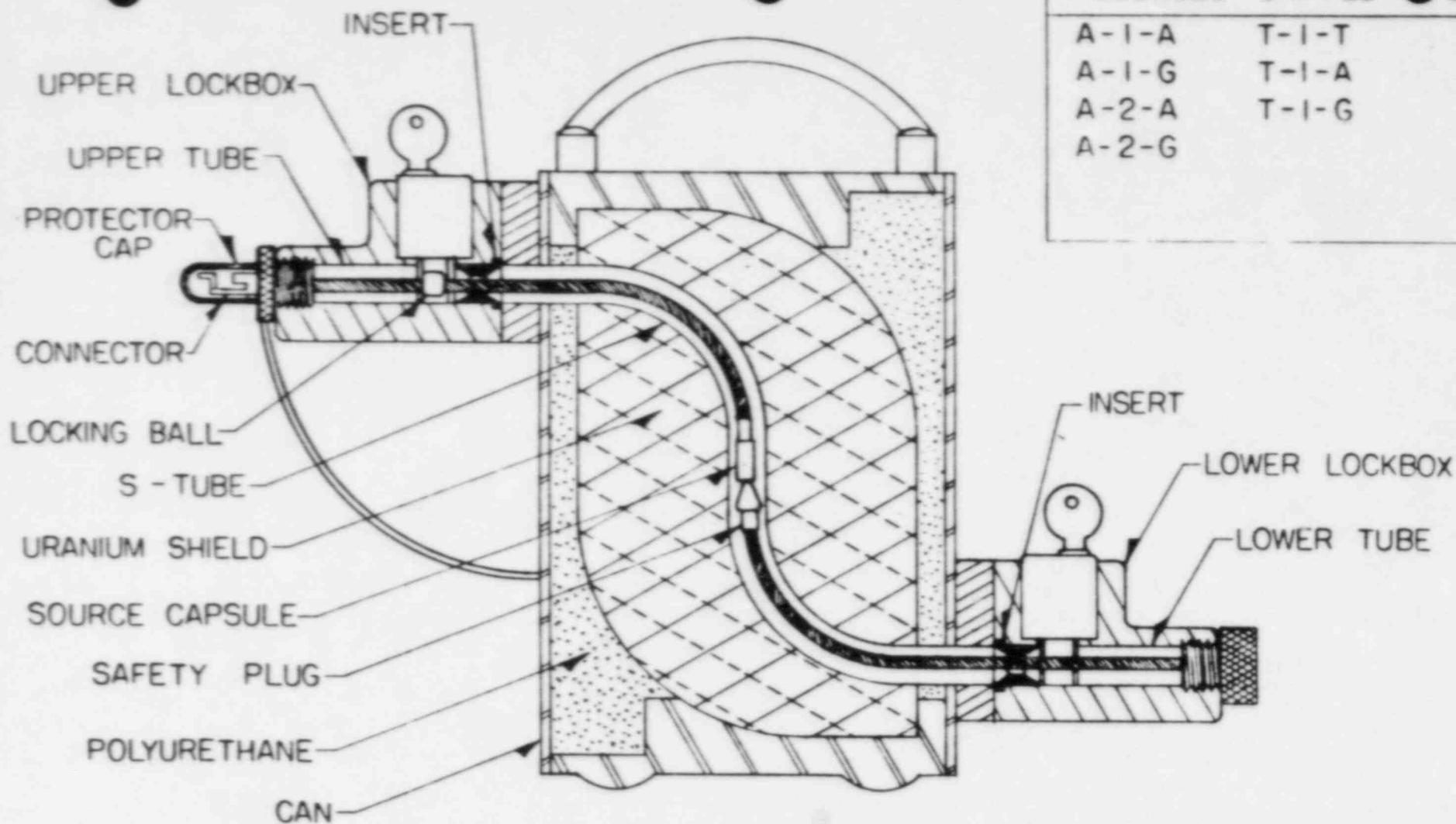


EXHIBIT D

GAMMA INDUSTRIES, B. R., LA.

SCALE: NONE

APPROVED BY:

DRAWN BY WDL

DATE: 9-20-74

REVISED

C-10 SHIPPING CONTAINER

REVISIONS TO DRAWING NO. 323

DRAWING NUMBER

323-02

## EXHIBIT E

PANHANDLE EASTERN PIPE LINE COMPANY  
 Transmission Department  
 10890 Benson, Suite 360  
 Overland Park, Kansas 66212  
 913/341-1400

SHIPPER'S CERTIFICATION FOR RADIOACTIVE MATERIALS  
 To Be Completed in Triplicate

This is to certify that the contents of this consignment are properly described by name and are packed, marked and labelled, and are in proper condition for carriage by air according to all applicable carrier and governmental regulations, and to the IATA Restricted Articles Regulations. This consignment is within the limitations prescribed for passenger carrying aircraft.

NAME AND ADDRESS OF SHIPPER

Panhandle Eastern Pipe Line Company  
 Transmission Department  
 10890 Benson, Suite 360  
 Overland Park, Kansas 66212

By: \_\_\_\_\_

Radiographer

Date: \_\_\_\_\_ 19 \_\_\_\_\_

Source Changer Serial # \_\_\_\_\_

Source Changer Model # \_\_\_\_\_

Iridium 192 - Curies \_\_\_\_\_

Model #424-1 Source # \_\_\_\_\_

NATURE AND QUANTITY OF CONTENT				PACKAGE		
Radionuclide	Group	Form	Activity	Category	Transport Index	Type
Name of Principal Radioactive Content	Group Numbers of Groups I to VII	Either Chemical form plus gas/liquid/solid or Special Form	Number of curies or millicuries	I-White II-Yellow III-Yellow Label	For yellow label categories	Type A or Type B
	---	Special Form				Type
C   A   R   G   O - O   N   L   Y				A   T   R   C   R   A   F   T		

ADDITIONAL INFORMATION REQUIRED FOR FISSILE MATERIAL ONLY

Exempted from the additional requirements for Fissile Materials	Not Exempted
N/A	Fissile Class I
	Fissile Class II
	Fissile Class III

NAMES, PLUS QUANTITY IN GRAMS, OR CONCENTRATION OR ENRICHMENT IN U235

Additional Certificates Obtained by the Shipper When Necessary  
 Special Form Encapsulation Certificate(s)  
 Type 'B' Packaging Certificate(s)  
 Certificate(s) for Fissile Material  
 Certificate(s) for Large Radioactive Source  
 Government Approvals/Permits

INSPECTION AND MAINTENANCE PROCEDURES  
NO. 71-129

INSPECTION

To insure safety in use and to avoid malfunctions that could impair the productivity of this equipment, it is strongly recommended that daily and periodic inspections be made. Missing or defective components must be replaced or repaired if the equipment is to function as designed.

PERIODIC INSPECTION AND MAINTENANCE

It is recommended that a periodic inspection and maintenance be performed after each three (3) months of service, or after prolonged storage. Under severe operating conditions, it may be advisable to perform a periodic inspection and maintenance on a more frequent basis.

This service is available at Technical Operations, Inc., Burlington, Massachusetts.

Machines returned for periodic inspection and maintenance will be given a complete disassembly, cleaning, and inspection for wear and damage. Missing or servicable parts will be replaced, the machine reassembled, and given a final inspection. A nominal charge for this will be made, plus the cost of parts required. This work can be performed promptly to minimize downtime.

If you prefer to perform this periodic inspection and maintenance, we recommend the following procedure:

Equipment and Material

Source Changer

Wrenches, Screwdrivers, and Allen Keys

Basin - approximately 12" diameter

Two (2) Quarts Solvent (perchloroethylene)

Syringe

Lubricant - 2 oz. Texaco "Unitemp" grease

Dummy Source Assembly

Procedure

Remove the source from the unit and store it in the source changer. Follow the instructions for the use of the source changer.

PERIODIC INSPECTION AND MAINTENANCE ContinuedControl

Detach from shield, eject and coil source drive cable by cranking control to EXPOSE direction. Examine cable for kinks, fraying, broken wires, or rust. Minor bends in the cable may be straightened by hand. Do not use pliers. A cable with frayed or broken wires must be replaced. Light rust may be removed by hand wire brushing. Do NOT use a powered brush or abrasives. Heavy rust that has penetrated into the cable will cause unsatisfactory operation or complete failure. Replace cable.

Clean the cable by immersing the coil in solvent. A heavy accumulation of dirt laden lubricant may require more than one washing.

Examine the connector. Use the Tech Ops Model 550 Connector Gage to check for wear. Replace if connector fails at any gaged dimension. Examine cable attachment to connector for straightness and evidence of looseness. A loose attachment or bend at this point must be repaired. Do not attempt to fabricate a replacement connector or to fasten it to the cable. The connector is a special heat treated steel made to exacting tolerances and under strict metallurgical control. The attachment is swaged with special tools and proof tested. Order a replacement from Technical Operations.

Lubricate the cable with Texaco "Unitemp" grease. This is the most satisfactory lubricant for this purpose. Common greases can cause gumming and unsatisfactory operation. Take care in handling the cable to avoid picking up dirt or grit.

Control Crank

Remove control cable housings by undoing fitting nuts. Remove crank unit from reel, remove crank and disassemble. Wash parts in solvent. Check inside of housing for evidence of galling and wear. A deeply scored (more than .020 deep) line where the cable contacts the inner wall of the housing indicates the need for replacement.

Check clearance between the hubs of the wheel and the bushings. More than .005 clearance indicated replacement.

Examine teeth of wheel for damage. A bent tooth may be filed off. Two (2) or more bent teeth will require replacement of the wheel.

Lubricate bushings with Texaco "Unitemp" grease and reassemble.

PERIODIC INSPECTION AND MAINTENANCE

Continued

Control Cable Housings

Examine carefully for internal damage by flexing the housings by hand. Internal damage to the reinforcing braid or flexible metallic tube will be evidenced by a crunch feeling when the cable housing is flexed. Cut, flattened, or burnt cable housings should be replaced. Superficial cuts or burns may be sealed and reinforced with tape. Clean housings by syringing a few ounces of solvent into bore and blow out with low pressure air (not more than 20 p.s.i.). Do not allow solvent to remain. Do not soak in solvent. Check end fittings for secure attachment.

Source Guide Tubes

Check for cuts, burns, or crushed tubes. Check fittings for secure attachment. Examine and test screw threads for function. Clean bore of tube with water or solvent and drain out properly. Do not soak in solvent. Check for free passage of source by holding tube vertical and dropping dummy source assembly through tube. The dummy source assembly should fall through freely.

Shield Assembly

Check exterior for loose or missing hardware. Replace or tighten as required. Examine source exit fitting. Nut should rotate freely without excessive shake. Look into exit port and check concentricity of source tube with nut. Misalignment, if found, indicates a damaged housing or shifting of the shield within the housing. This is best repaired by Technical Operations. We do not recommend disassembly of the shield assembly. Pour an ounce of solvent through the source tube from the cable connector end. Drain.

Examine the shield assembly for complete labels and warning symbol. Replace obliterated or illegible marking. Adhesive backed replacements are available from Technical Operations.

Final Inspection

Reassemble system, connect control cables and source guide tubes to shield and install dummy source. Operate machine several times to be sure of proper function. Check operation of the source position indicator system. Refer to the electrical schematic for guidance in locating faults. A volt-ohmmeter may be used for measuring voltages and checking circuit continuity.



PERIODIC INSPECTION AND MAINTENANCE

Continued

Final Inspection Continued

Return live source to shield and make a gamma ray survey. Radiation levels must not exceed the following:

At One Meter (39-3/8 inches)  
Not more than 0.066 mr per curie

At Six Inches (6") from the Surface  
Not more than 0.33 mr per curie

Technical Operations is prepared to demonstrate these inspection and maintenance procedures at its Burlington, Massachusetts facility. We welcome the opportunity to assist you.

TECH/OPS GAMMA RAY PROJECTOR

DAILY CHECKLIST

1. Inspect cables for cuts, breaks, and broken fittings.
2. Inspect source tubes for cuts, crushing, and broken fittings.
3. Survey for excessive radiation levels.
4. Inspect shield for damage to fittings, lock, fasteners, and labels.
5. Inspect crank for damage and loose hardware.
6. Check operation of cable connection.
7. Check operation of control for freedom of source movement.

NOTE

DEFECTIVE EQUIPMENT MUST BE CORRECTED PRIOR TO USE

DON'T COMPROMISE ON SAFETY

RECORD INSPECTION IN LOG BOOK

EXHIBIT H

PERIODIC INSPECTION AND MAINTENANCE FOR  
GAMMA CENTURY, GAMMA "35", SA MODELS, GAMMATRONS AND UTILITY TWINS

Periodic inspection of exposure devices should be performed at intervals not to exceed 90 days or whenever operation of the device appears to be impaired through abuse or wear. However, it should be emphasized that this applies only to the device. DO NOTHING TO THE SOURCE. If the source appears worn or faulty in any way, contact Gamma Industries. In order to perform device inspection and maintenance, proceed as follows:

1. Remove safety cap in lock box and inspect source connector. The holding pin should still have a true 90 degree elbow; it should be straight and parallel with axis of source connector and the key on apex of elbow should not be worn excessively. Check flexible cable at connector for straightness.

Maintenance: If the elbow is not bent out of line, the mating connector should then be connected to the source and tested by pulling straight back on cable applying about 30 to 40 pounds of pressure.

2. The lock plunger should be inspected and checked for ease of operation. Foreign matter may at times foul the plunger and make it inoperative. The lock plunger may not retract to its fullest extent which is 1/2 inch. This would prevent free travel of the source in and out of the lock box.

Maintenance: The lock plunger may be removed by removing the two 8-32 set screws in the lock box. Wash lock in solvent to remove dirt or other foreign matter. Lock may also be cleaned and lubricated by spraying a lubricant (such as WD-40) into the lock.

3. Inspect the source outlet nipple by first removing safety plug. The outlet nipple should be round and smooth so that it will match with the I.D. of the source tube.

Maintenance: If the outlet nipple should be out-of-round it can sometimes be straightened by using a punch or round bar on the inside of the outlet. If it cannot be straightened or if the nipple has been broken by dropping the unit, it must be replaced. This replacement can be done in the field shop, or returned to Gamma Industries.

4. Inspect labeling on exposure device. The warning signs and source identification tags should be distinct and legible.

EXHIBIT H

PERIODIC INSPECTION AND MAINTENANCE FOR GAMMA CENTURY, GAMMA "35", SA MODELS,  
GAMMATRONS AND UTILITY TWINS Continued

5. Inspect source tubes for damage such as crimps, foreign matter, ease of connecting, and disconnecting from exposure device.

Maintenance: Crimps, kinks, and other damaged places may be cut out, and connectors placed on ends so that tube is not shortened excessively. The quick disconnect coupling that connects to outlet nipple of exposure device may be removed with heat and replaced. Foreign matter may be washed from tube with solvent and blown with compressed air.

6. Inspect source connector on drive cable. The hole should be 7/64 inch in diameter when new. This hole should show some wear after much use, but should not be out-of-round to the extent that it will disconnect from the mating piece other than in the correct position. It should not be loose on the drive cable. The portion of the connector with the connector hole should not be bent, but should be straight and parallel with body of connector.

Maintenance: This worn connector may be replaced by one of two methods:

1. Send back to Gamma Industries to have new connector replaced by swedging on new replacement.
  2. Order new core with connector attached.
7. Inspect remainder of drive cable for wear, rusty sections, causing cable to become stiff and non-flexing, kinks, or other damaging conditions that would prevent cable from running on gear in the gear box housing.

Maintenance: The drive cable should be cleaned with a solvent such as varsol, diesel fuel or some other solvent that will not dry out. This is done to remove sand, dust, and other foreign matter that will cause abrasions in the exposure device and gear box drive mechanism. Drive cable that has become rusty and non-flexible should be replaced. Failure to replace cable may cause controls to become stiff, hard to operate, wear excessively, and possible break. The cable would usually break when the source is exposed. Lubrication of the drive cable is important. In areas where there is a problem with sand or other abrasive material, dry powdered graphite is excellent. Graphite should not be packed continually since it will tend to pack in the gear box and cause excessive wear to the gear housing and to the gear. Where the control cables can be kept reasonably clean, a light oil will be adequate.

EXHIBIT H

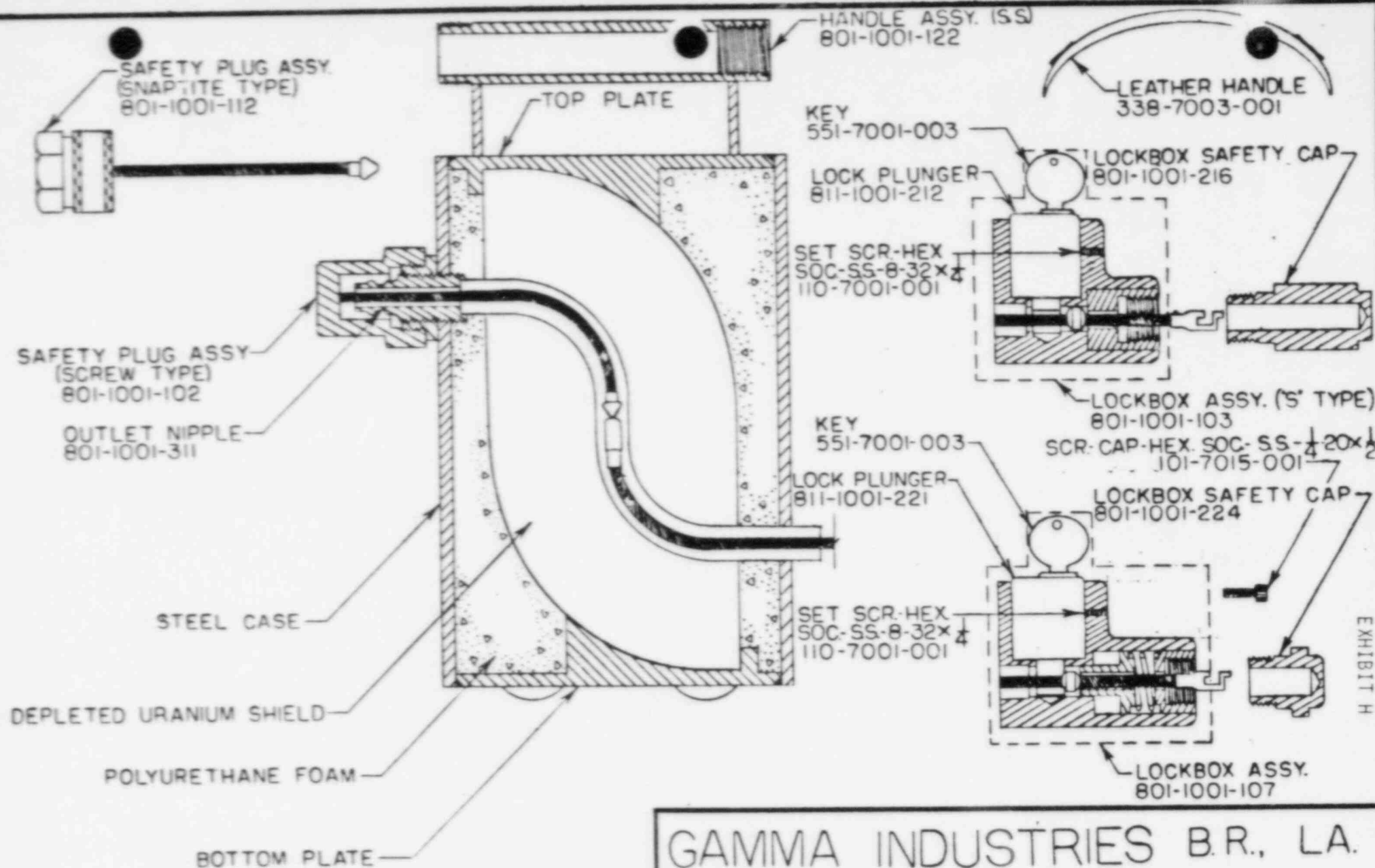
PERIODIC INSPECTION AND MAINTENANCE FOR GAMMA CENTURY, GAMMA "35", SA MODELS,  
GAMMATROWS AND UTILITY TWINS Continued

8. Inspect the control assembly. This assembly consists of the gear box assembly and the crank handle. The bronze bushings in the gear housing and the plate are the most likely places to find wear. When these bushings are worn, they tend to permit the gear to wobble and eventually wear out. Usually (due to some build-up on the drive cable or the gear teeth) there will be some wear around the inner circumference of the housing. This will permit the drive cable to slip on the gear and prevent source from moving properly through the exposure device.

Maintenance: It is suggested that if powdered graphite is used as a lubricant the gear box be cleaned with compressed air occasionally so as to remove any packed graphite in the gear mechanism. The application of some type light oil on bronze bushings will help prevent excessive wear.

9. Inspect drive cable housing or conduit. This conduit can be damaged by dropping it across a hot weld, severe kinking, or by dropping some object on the conduit. Any of these can prevent the drive cable from moving freely. The conduit at the end connections may become damaged from excessive flexing while being assembled or disassembled.

Maintenance: In any case where the inner liner has been damaged, the conduit must be replaced. When the outer covering has been damaged, waterproof tape should be wrapped around the break to prevent the entrance of water or other corrosive substances. If the extreme ends of the conduit are damaged, they tend to permit the gear to wobble and eventually wear out.



NOTE: PARTS WITH AJJOINING NUMBERS  
CAN BE PURCHASED FROM  
GAMMA INDUSTRIES

GAMMA INDUSTRIES B.R., LA.

SCALE: NONE

APPROVED BY:

DRAWN BY KJR

DATE: 11-1-77

REVISED

CATALOG DWG. FOR CENTURY 'S', 'SA' & 35 'S', 'SA'

DRAWING NUMBER

607-7001-001





# PANHANDLE EASTERN PIPE LINE COMPANY

X-RAY UNIT

## RADIATION REPORT

REPORT#

NO. E-\_\_\_\_\_

DATE \_\_\_\_\_

LOCATION \_\_\_\_\_

PROJECT \_\_\_\_\_

MODEL AND SERIAL NO. OF  
GAMMA RAY EXPOSURE DEVICE \_\_\_\_\_MODEL AND SERIAL NO.  
OF SURVEY INSTRUMENT \_\_\_\_\_TYPE AND NO.  
OF SOURCE \_\_\_\_\_ACTIVITY  
OF SOURCE \_\_\_\_\_MODEL AND SERIAL NO.  
OF X-RAY MACHINE \_\_\_\_\_

KV \_\_\_\_\_

RESULT OF  
PHYSICAL SURVEY \_\_\_\_\_BARRICADE  
EQUIPMENT \_\_\_\_\_RECORD OF PHYSICAL SURVEY MADE TO DETERMINE  
SOURCE IS IN SHIELDED POSITION PRIOR TO  
SECURING EXPOSURE DEVICE

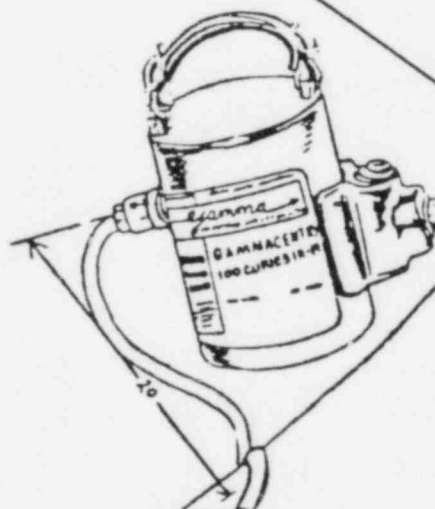
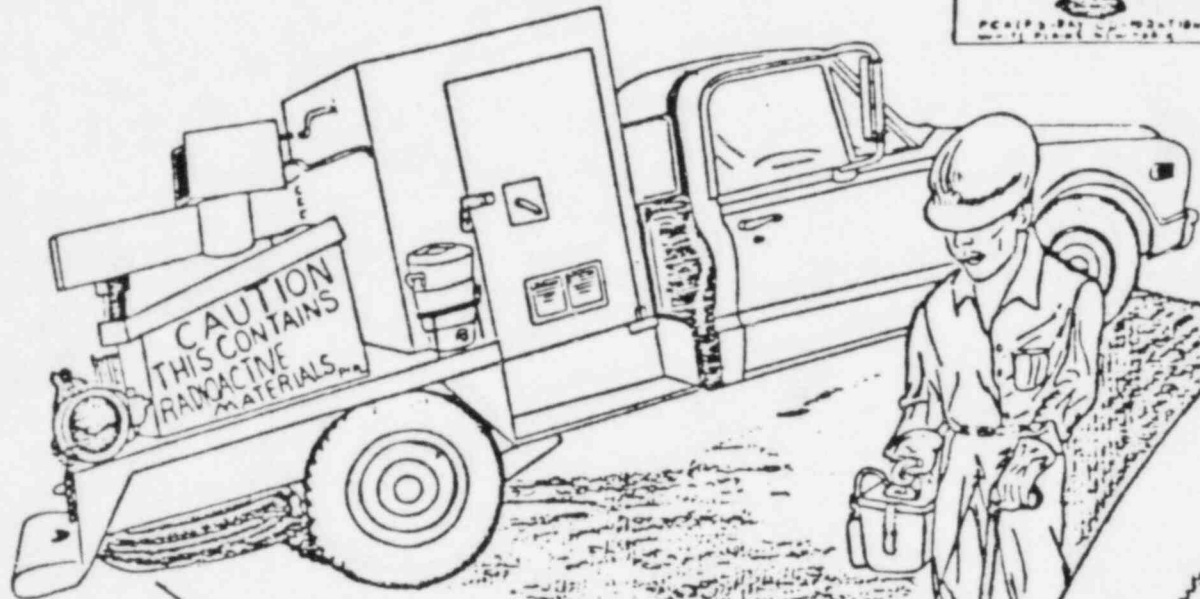
RADIOGRAPHER \_\_\_\_\_

RADIOGRAPHER'S  
ASSISTANT \_\_\_\_\_SERIAL NO.  
OF DOSIMETER \_\_\_\_\_DOSIMETER  
READING \_\_\_\_\_FILM BADGE  
AND SERIAL NO. \_\_\_\_\_

SURVEY OF TRANSPORTING VEHICLE \_\_\_\_\_

MRNR  
@ DRIVER \_\_\_\_\_MRNR @  
OUTSIDE SURFACE \_\_\_\_\_MRNR @  
1 FT FROM SURFACE \_\_\_\_\_

REMARKS \_\_\_\_\_



## LEAK TEST RECORD

Company Name \_\_\_\_\_  
P.O. Box No. \_\_\_\_\_  
Street \_\_\_\_\_  
State \_\_\_\_\_ Zip \_\_\_\_\_  
NRC or \_\_\_\_\_  
State License No. \_\_\_\_\_  
Projector  
Model No. \_\_\_\_\_ Serial No. \_\_\_\_\_  
Source  
Model No. \_\_\_\_\_ Serial No. \_\_\_\_\_ Curies \_\_\_\_\_  
IR-192 \_\_\_\_\_ CO-60 \_\_\_\_\_ CS137 \_\_\_\_\_ Other \_\_\_\_\_  
Wipe Test  
Performed by \_\_\_\_\_ Date \_\_\_\_\_

The United States Nuclear Regulatory Commission requires that radiographic sources be tested for evidence of leaking at the time of manufacture and thereafter at not more than six-month intervals.

The amount of removable contamination must not exceed 0.005 microcuries. If the test shows more than 0.005 microcurie of removable contamination, the source and equipment must be immediately taken out of service and be repaired or be disposed of. Please note that this source must be tested again on or before \_\_\_\_\_

## VENDOR USE ONLY

Processed By \_\_\_\_\_  
Radio Assay \_\_\_\_\_ Microcurie  
Test  
Performed by \_\_\_\_\_  
Next Leak  
Test Due \_\_\_\_\_

**TECH/OPS, INC.  
LEAK TEST KIT MODEL 518**

EXHIBIT M

**INSTRUCTIONS FOR USE**

This kit is designed for use on Tech/Ops Gamma Ray Projectors. It provides a convenient and safe method of performing leak tests of radiographic sources in accordance with NRC regulations, which require such tests at intervals of not more than 6 months.

**CONTENTS**

Flexible swab holder with swab  
Vial of EDTA solution  
Plastic Envelope  
Mailing Box  
Identification Sheet

**PROCEED IN THIS MANNER:**

1. Be sure source is fully retracted and secured in the projector. (Use a survey meter to be sure that radiation levels are normal.)
2. Remove source guide tube from front of projector or remove shipping plug.
3. Wet the swab with EDTA solution. Shake off excess and insert the swab into the hole in the shield. Wipe the interior of the hole thoroughly by rotating swab holder.
4. Withdraw swab and place in plastic envelope.
5. The swab should now be monitored by turning the survey meter to its most sensitive range. Place the meter in a low background area and move the swab in its plastic envelope to the meter, not the meter to the swab.
6. If there is no indication on the meter, or if the indication is no more than 0.2 mR per hour above background, put the plastic envelope with the swab in the mailing box and mail to Tech/Ops, Incorporated, 40 North Ave., Burlington, Massachusetts 01803. Be sure to fill out and return the identification sheet.
7. If the swab should show more than 0.2 mR per hour, do not mail. Contact Tech/Ops, Inc., for specific instructions.

NOTE: If the survey meter available does not have the capability of detecting as little as 0.2 mR per hour, ship the wipe-test swab to Tech/Ops, Inc., via express. Do not ship if the radiation from the swab exceeds 2 mR per hour and contact Tech/Ops, Inc., for specific instructions. The wipe-test swab will be subjected to a precise radio-assay when received by Tech/Ops, and a leak-test certificate will be mailed promptly. The NRC requires that this certificate be kept with your records and that it be available for inspection (10 CFR 34.25(c)).

**NOTICE**

In order to use this Model 518 Leak Test Kit, the user must be specifically licensed to do so in accordance with Title 10, Code of Federal Regulations, Part 34, Paragraph 34.11 (f). If your license does not authorize the use of this leak test kit, an application for a license amendment should be filed on Form NRC-313R with the Materials Licensing Branch, Division of Fuel Cycle and Material Safety, Office of Nuclear Material Safety and Safeguards, U. S. Nuclear Regulatory Commission, Washington, DC 20555.

Use of this kit without specific authorization constitutes a violation of U. S. Nuclear Regulatory Commission regulations.

**Tech/Ops, Inc.  
Burlington, MA**

7-276-1 12/82

## PANHANDLE EASTERN PIPE LINE COMPANY

SUITE 360 10890 BENSON

P.O. BOX 12330

OVERLAND PARK, KANSAS 66212

(913) 341-1400

## DOSIMETER CALIBRATION CERTIFICATE

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MODEL NO. \_\_\_\_\_ SERIAL NO. \_\_\_\_\_

CALIBRATION DATE \_\_\_\_\_

DATE CALIBRATION DUE \_\_\_\_\_

TRUE FIELD      RESPONSE      % ERROR

---

ASSIGNED TO: \_\_\_\_\_ DATE \_\_\_\_\_

REASSIGNED TO: \_\_\_\_\_ DATE \_\_\_\_\_

THE ABOVE INSTRUMENT WAS CALIBRATED WITH A CESIUM 137 SOURCE.  
U.S. NRC REGULATIONS REQUIRE THAT IT BE RECALIBRATED WITHIN ONE (1) YEAR.

WITHIN NORMAL LIMITS

BY: \_\_\_\_\_

PANHANDLE EASTERN PIPE LINE COMPANY

ORIGINAL: Radiation Safety Officer

COPY: Radiographer

COPY: File



7-275 3/83

## PANHANDLE EASTERN PIPE LINE COMPANY

SUITE 360 10890 BENSON  
P.O. BOX 12330  
OVERLAND PARK, KANSAS 66212  
(913) 341-1400

## METER CALIBRATION CERTIFICATE

\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_

MODEL NO. \_\_\_\_\_ SERIAL NO. \_\_\_\_\_

CALIBRATION DATE \_\_\_\_\_

DATE CALIBRATION DUE \_\_\_\_\_

	TRUE FIELD	RESPONSE	% ERROR
RANGE _____	_____	_____	_____
	_____	_____	_____
RANGE _____	_____	_____	_____
	_____	_____	_____
RANGE _____	_____	_____	_____
	_____	_____	_____

THE ABOVE INSTRUMENT WAS CALIBRATED WITH A CESIUM 137 SOURCE. U. S. NRC  
REGULATIONS REQUIRE THAT IT BE RECALIBRATED WITHIN THREE (3) MONTHS.

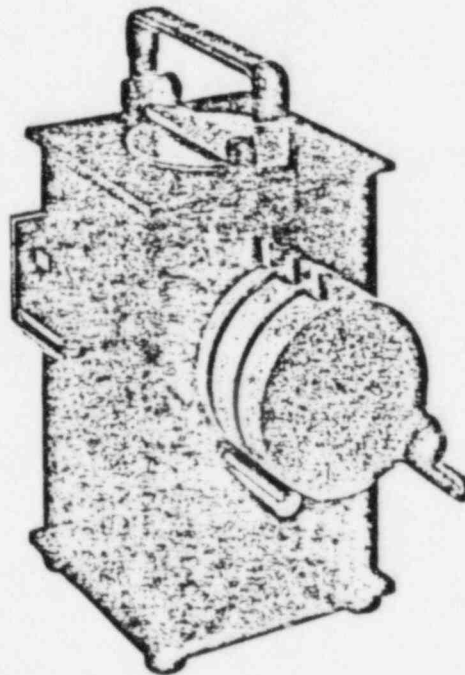
WITHIN NORMAL LIMITS

BY: \_\_\_\_\_ ASSIGNED TO: \_\_\_\_\_  
PANHANDLE EASTERN PIPE LINE COMPANY

DATE: \_\_\_\_\_



# Tech/Ops Model 773 Instrument Calibration Device Operation Manual



TECHNICAL OPERATIONS, INC.  
Radiation Products Division  
Burlington, Mass. 01803  
Phone (800) 225-1383 (toll free)  
[in Mass. call (617) 272-2000]

WARRANTY  
AND  
LIMITATION OF LIABILITY

Technical Operations, Incorporated (hereinafter referred to as *the manufacturer*) warrants its product which it manufactures and sells to be free of defects in material and workmanship for a period of 1 year from 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 operations, 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 it transportation prepaid; or, at its option, to returning the purchase price thereof.

The warranty on other manufacturers' 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.

Technical Operations, Incorporated assumes no liability or responsibility for the usage of any radioactive material used in connection with this product.

All other warranties, except those warranties expressly stated herein, including warranties of merchantability or otherwise, are expressly excluded.

## Technical Data

Size:	5 in (12.7 cm) wide, 5 in (12.7 cm) deep, 8.5 in (21.6 cm) high
Weight:	(with attenuators) 52 lbs. (24 kg) (without attenuators) 45 lbs. (20 kg)
Source:	Model 77302, $^{137}\text{Cesium}$ , 150 millicuries
Transport Status:	DOT Specification 7A Type A Package
Shielding Material:	Lead Approx. 29 lbs. (13 kg)

## General

The Model 773 is a small, portable radiation survey instrument calibration device. The unit consists of a 150 millicurie  $^{137}\text{Cesium}$  source permanently attached to a movable source rod which is installed in a lead shield casting. The source is exposed by raising the source rod which positions the source in a  $36^\circ \times 20^\circ$  collimated beam port.

The unit is equipped with three attenuators (Transmission of 0.25, 0.10 and 0.10) to allow a survey instrument with three ranges to be calibrated at 20% and 80% of each range without changing the position of the survey instrument. The Model 773 can be used to calibrate survey instruments with ranges up to 2000 milliroentgens per hour.

The unit is equipped with a carrying handle which also serves as a source locking bar to prevent unauthorized use of the calibrator. A shipping cover is also attached to provide and additional means of securing the source.

## Receiving

Survey the device for excessive radiation levels. The device should have radiation levels less than 200 mR/hr at the surface and less than 10 mR/hr at three feet from the surface. Inspect the device for shipping damage and insure that the device is locked.

## Safety Precautions

The Model 773 Meter Calibration Device contains a 150 millicurie  $^{137}\text{Cesium}$  source that

emits gamma radiation which can cause injury if improperly used. Disassembly of the device or removal of the source requires special equipment. We recommend that any service requiring disassembly of the device or removal of the source be performed by the manufacturer.

## Instrument Devices

Although the device has radiation levels which are well below the maximum radiation level permitted on storage containers, personnel should not stay close to the device any longer than necessary.

Precautions should be taken to store the instrument calibration device in an area that meets the requirements of Title 10 Code of Federal Regulations 20.202(b) (2), 20.203(b) and 20.203(e).

It is recommended that personnel operating the equipment use a calibrated and operable survey instrument and wear appropriate personnel monitoring devices. The radiation level at the source rod when the source is in the "operate" position is approximately 50 milliroentgens per hour.

Movement of the source rod should be accomplished as expeditiously as practicable. An alternative method of raising the source rod would be the use of a string and pulley arrangement.

In no case should anyone enter the area of the radiation beam or expose any part of his body to the radiation beam.

## Preparation for Use

Place the source shield in a restricted area so that the directional port is aimed horizontally. To minimize the effects of scattered radiation, the unit should be 16 feet from any wall in the direction of the primary beam.

Position a support horizontally from the Model 773 Instrument Calibration Device as shown in Figures 1 and 2.

Restrict access to the area where the radiation level is in excess of 2 milliroentgens per hour. (See Figure 4).

## Operation

**Note:** To properly calibrate a survey instrument it is necessary to check the instruments response at two points on each of the instruments ranges. These points must be separated by at least 50% of the full scale reading. The instruments reading should agree with the actual radiation intensity within 10% to be in proper calibration.

The following procedure is designed for a survey instrument with three scales and a range of 0-1000 mr/hr. For instruments with different ranges, the procedure will be similar but the points will differ.

1. Turn on the survey meter and allow it to "warm up" for approximately 10 minutes.
2. Determine the activity of the source on the date of calibration from the decay chart provided with the source.
3. Determine the distance from the source at which the radiation intensity would be 800 mr/hr (use Figure 3).
4. Using the tape measure attached to the Model 773, place the survey meter such that the axis of the detector is located at the proper distance from the source as determined above.

### Note:

The survey meter should be located so that the center of the detector is at the correct distance and centered on the center line of the radiation beam. The axis of the detector should be perpendicular to the centerline of the radiation beam. Depending upon the physical size of your survey instrument, it may be necessary to mount it somewhat higher than the bench surface. When the proper geometry for your instrument has been established, use the same physical arrangement consistently in future calibration operations.

At short distances, using survey instruments with large detector volumes, the radiation intensity will not be uniform across the detector. Consideration should be given to this effect when determining the radiation intensities to be checked.

5. Unlock the handle of the Model 773. Re-

move the shipping plate. Remove all the attenuators from the radiation beam.

6. Standing away from the radiation beam, expose the source by manually raising the source rod. Note and record the survey meter reading, return the source to the stored position. The actual intensity is 800 mr/hr. If the reading is within  $\pm 10\%$  of the actual intensity, continue checking the instrument. If the instrument reading is not within  $\pm 10\%$  of the actual intensity, the instrument must be adjusted and recalibrated.

**CAUTION:** Do not enter the area of the radiation beam while the source is exposed.

7. Place the 0.25 attenuator in the beam. Repeat step 6; the actual intensity is 200 mr/hr.
8. Remove the 0.25 attenuator from the beam and place a 0.10 attenuator in the beam. Repeat step 6; the actual intensity is 80 mr/hr.
9. Place the 0.25 attenuator in the beam. Repeat step 6; the actual intensity is 20 mr/hr.
10. Remove the 0.25 attenuator from the beam and place the other 0.10 attenuator in the beam. Repeat step 6; the actual intensity is 8 mr/hr.
11. Place the 0.25 attenuator in the beam. Repeat step 6; the actual intensity is 2 mr/hr.

## Leak Testing

The Tech/Ops Model 773 Meter Calibration Kit contains a  $^{137}\text{Cesium}$  source which must be leak tested at intervals not to exceed six months. This may be accomplished using the Tech/Ops Model 518 leak test kit.

1. Place the Model 773 calibrator in a restricted area.
2. Remove the lock and rotate the handle from the top of the source rod. Remove the shipping cover.
3. Moisten the leak test swab with EDTA solution. Blot off the excess.
4. Wipe around the top of the source rod.
5. Standing away from the beam port, raise the source rod to the open position and

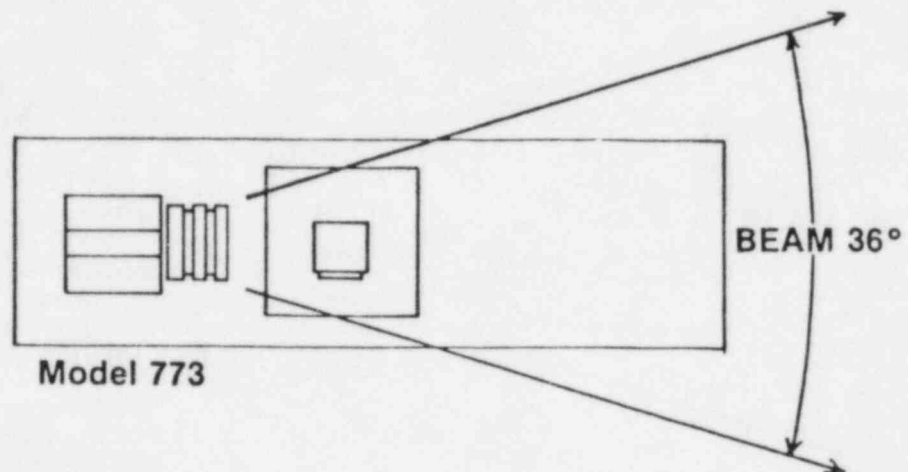


FIGURE 1

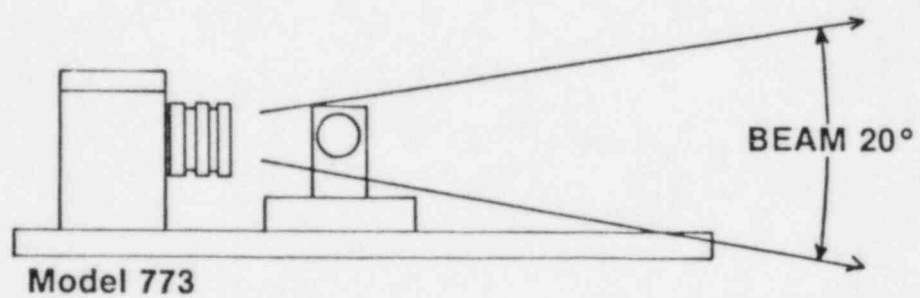


FIGURE 2



- wipe the exposed source rod thoroughly.
6. Place the leak test swab in the plastic envelope.
  7. Set the survey meter on its most sensitive range and place the meter in a low background area. Move the swab, in its plastic envelope, to the meter, not the meter to the swab.
  8. If the meter indication is less than 0.2 mr/hr above background, place the plastic envelope with the swab into the mailing box and mail to Technical Operations, Inc., Burlington, Massachusetts. BE SURE TO FILL OUT AND RETURN

#### THE IDENTIFICATION SHEET.

9. If the swab should show more than 0.2 mr/hr. DO NOT MAIL. Contact Technical Operations, Inc. for specific instructions.

#### Note:

The wipe test swab will be subjected to a precise radioassay when received by Tech/Ops and a leak test certificate will be mailed promptly. This certificate must be kept with your records as it is subject to N.R.C. inspection.

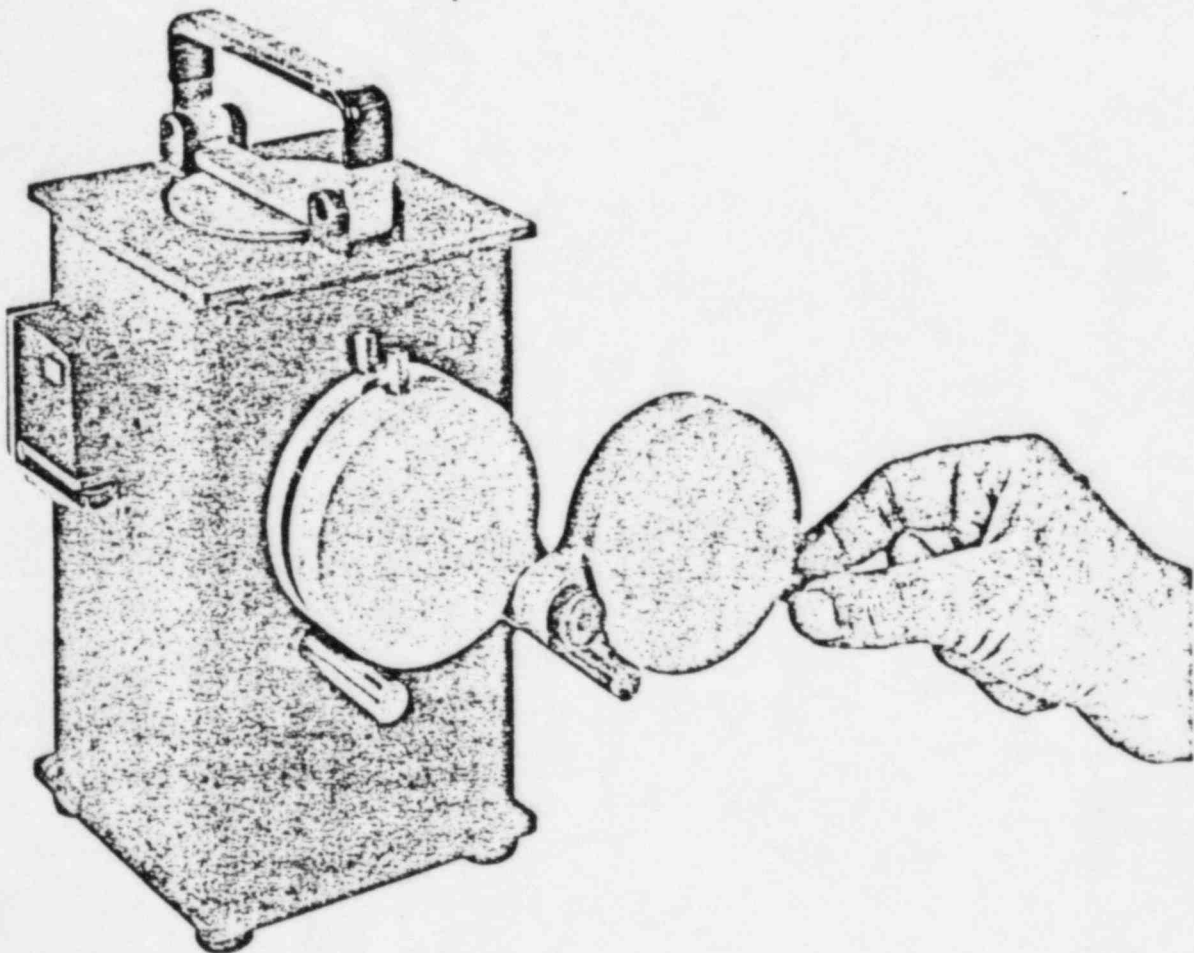
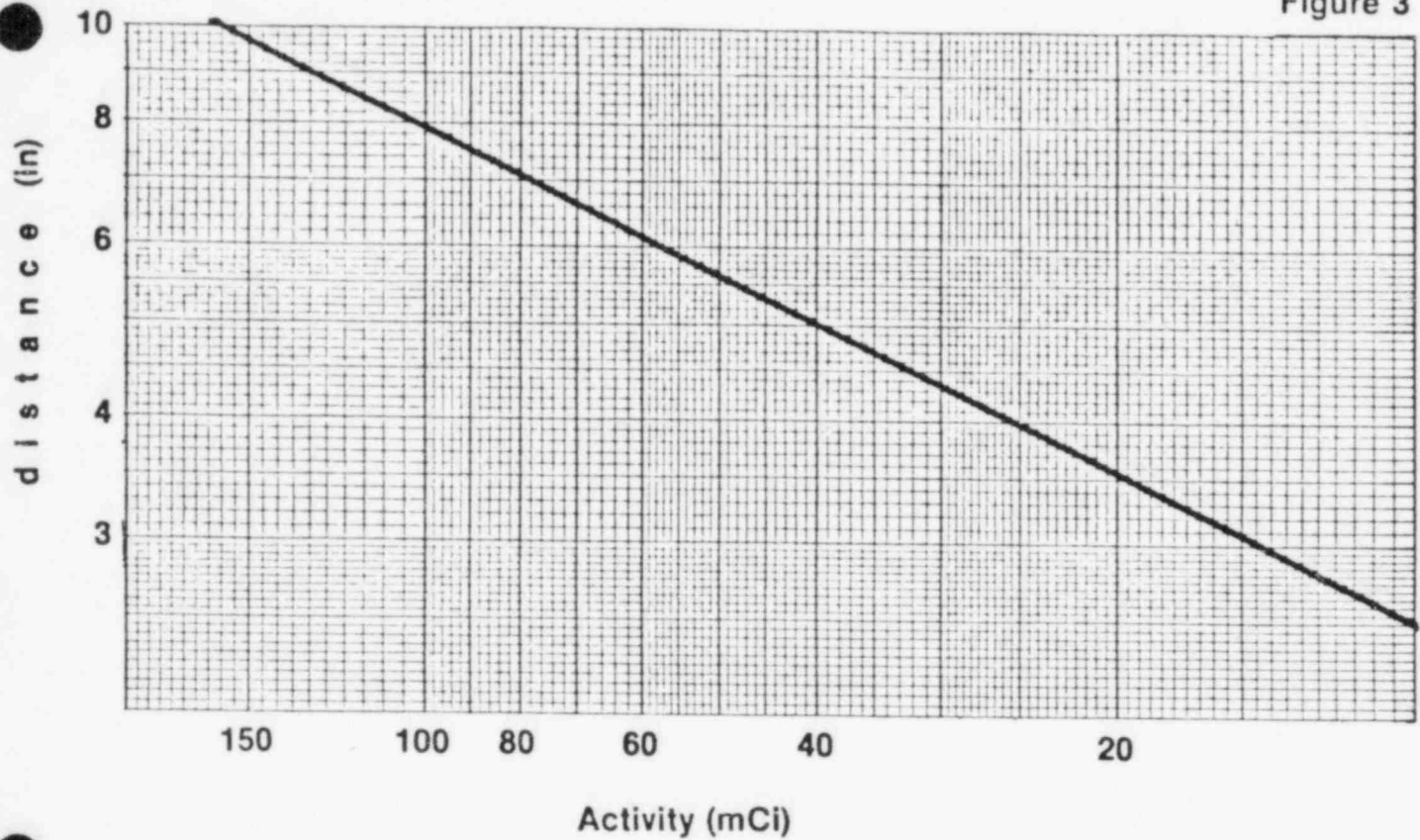
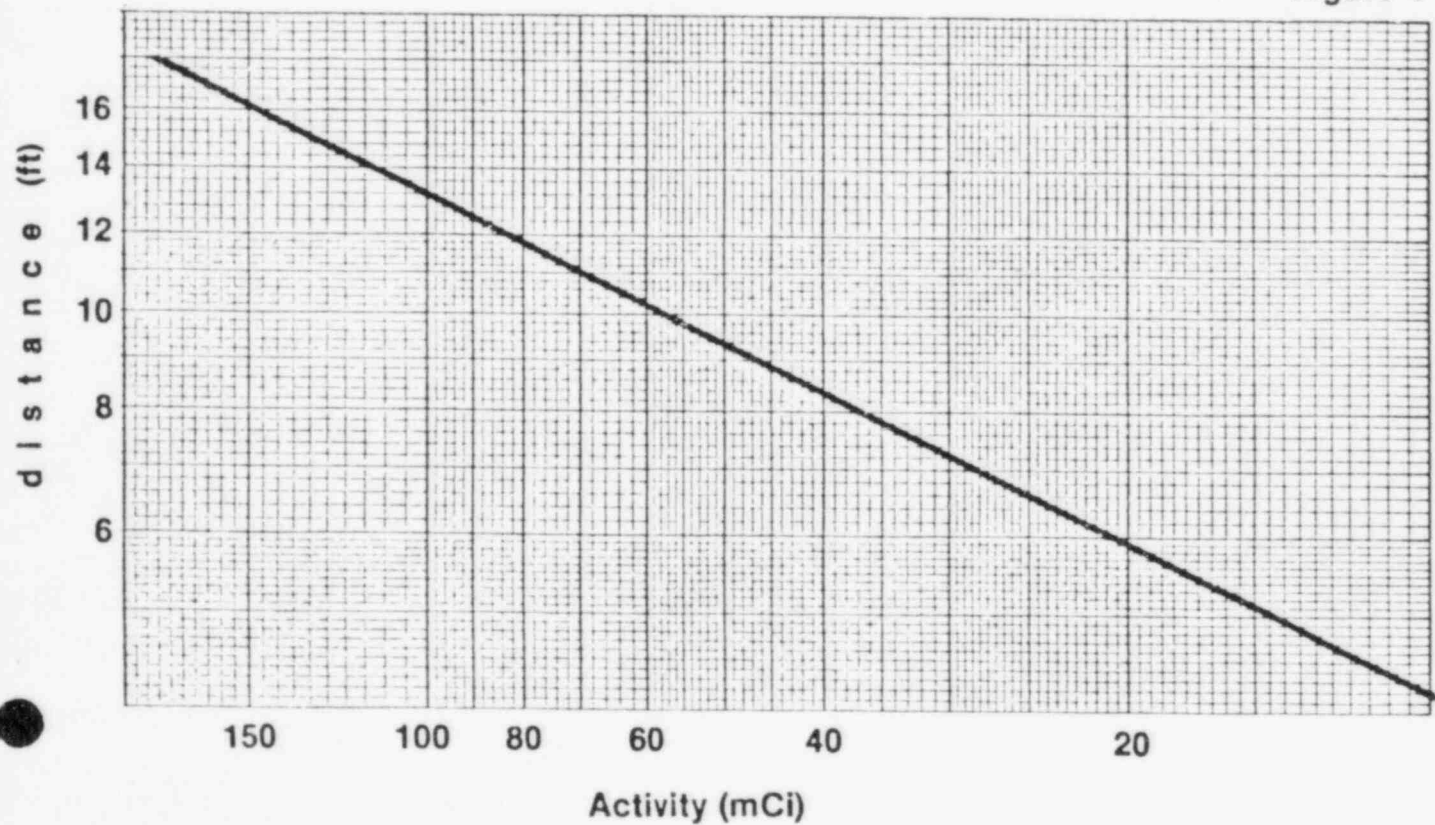


Figure 3



Distance to 800mR/hr isodose line as a Function of Activity

Figure 4



Distance to 2mR/hr isodose line as a Function of Activity



RADIATION PRODUCTS DIVISION

# Operation and Maintenance Manual

EXHIBIT Q to Panhandle Eastern

Pipe Line Company - Operating  
and Emergency Procedures

## Model 660 Series Gamma Radiography Systems

**Tech/Ops**



Tech/Ops, Inc.  
Radiation Products Division  
40 North Avenue  
Burlington, Mass. 01803

## NOTICE

This gamma ray radiography system is used as a radiographic exposure device and Type B shipping container for Tech/Ops, Inc. Sources. *The user should become thoroughly familiar with the instruction manual before attempting operation of the equipment.*

In order to use this equipment or perform source changes, the user must be specifically licensed to do so. Applications for a license should be filed on Form NRC-313R with the Materials Licensing Branch, Division of Fuel Cycle Material Safety, Office of Nuclear Safety and Safeguards, U.S. Nuclear Regulatory Commission, Washington, DC 20555, or with the appropriate Agreement State Office.

Prior to the initial use of the exposure device as a shipping container, the user should register with the Transportation Certification Branch, Office of Nuclear Safety and Security, U.S. Nuclear Regulatory Commission. The user should have in his possession a copy of Certificate of Compliance No. 9033 issued for this exposure device, which may be obtained from Tech/Ops upon request. This paragraph also applies to users from agreement States.

Users of this equipment outside of the United States must comply with regulatory, licensing and transportation rules and regulations as they apply in their respective countries.

## WARRANTY AND LIMITATION OF LIABILITY

Tech/Ops Inc., (hereinafter referred to as the *manufacturer*) warrants its product which it manufactures and sells to be free of 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 it transportation prepaid; or, at its option, to returning the purchase price thereof.

The warranty on other manufacturers' 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.

Tech/Ops 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 that prescribed in the Nuclear Regulatory Commission License or equivalent state license or permitted by any regulation of the 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.



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## Section I General Information

### GENERAL

The 660 series portable gamma radiography systems, shown in Figure 1.1, are used primarily for industrial radiography. The systems operate in similar manner and differ only in the specific control unit supplied.

The portability feature of the system provides both a safe means of transporting the radioactive source and operating flexibility, particularly useful in areas where access is limited. In use, the system safely positions an Iridium<sup>192</sup> radioactive source at a predetermined location. The 360° (panoramic) radiation pattern may be used to full advantage, either for multiple specimen work or for circumferential exposure techniques. Optional collimators are available which limit the panoramic pattern to a directional beam. The systems may be used with Iridium<sup>192</sup> sources up to a maximum of 100 curies. Iridium<sup>192</sup> sources of lesser activities are available. Basic source information is inscribed on the nameplate of the exposure device.

### SYSTEM SAFETY

The systems are designed to provide maximum operator safety. There is a positive mechanical control of the source, and the odometer provides a visual indication of the source's position. In addition, the source connector is designed to be fail-safe so that:

- the system cannot be operated (source exposed) unless a secure connection of the source assembly to the drive cable is made and
- the control unit cannot be disconnected unless the radioactive source assembly is properly stored in the shield.

### SYSTEM COMPONENTS

All components of the gamma radiography systems are identified in Figure 1.1

#### **Gamma Ray Exposure Device Model 660**

The gamma ray exposure device is shown in Figure 1.2. The exposure device serves as the storage and transport device for the radioactive source assembly. The exposure device consists of a steel housing which contains approximately 34 pounds (15.5kg) of depleted uranium shielding material. When the source is properly stored in the exposure device, the shielding properties of the depleted uranium reduce radiation intensities in the vicinity of the exposure device to levels well below the regulatory limits.

Figure 1.2 shows both ends of the exposure device. A special fail-safe control unit connector is located at one end. This connector is used to engage the control unit. The control connector has a three-position selector ring—OPERATE, LOCK and CONNECT. For maximum safety when the control unit and guide tubes are disconnected from the exposure device, the connector should be in the LOCK position with the lock and storage cover engaged and the key removed. All of the connector positions are discussed in detail in Section V, OPERATION.

The guide tube connector is located at the opposite end of the exposure device. Figure 1.2 identifies the connector. Also shown in Figure 1.2 is the storage plug which must be removed before the guide tubes are connected. The storage plug prevents dirt and dust from entering the exposure device whenever the exposure device is not in use.

The total weight of the exposure device is approximately 48 pounds (22kg). The exposure device is 9.5 inches (241mm) high, 4.75 inches (121mm) wide, and 12.75 inches (324mm) long, including handle and connectors.

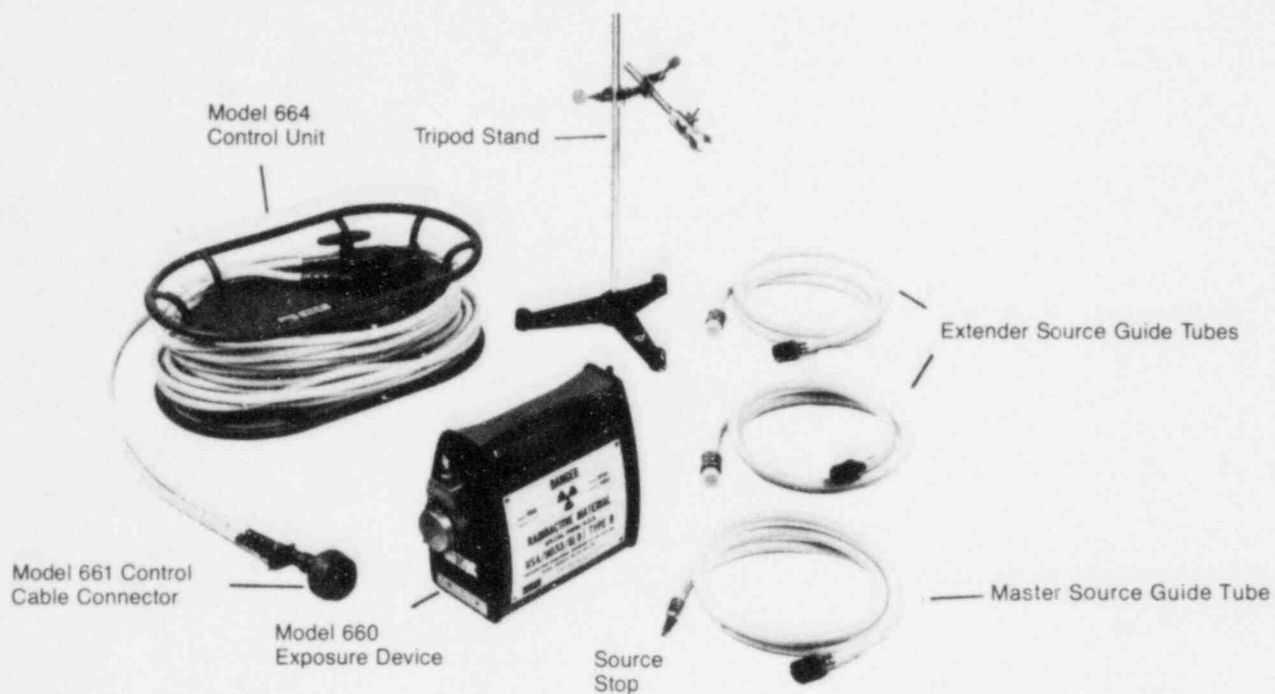
#### **Guide Tube Assembly**

The guide tube assembly consists of one 7 foot (2.1m) master guide tube and two 7 foot (2.1m) extender guide tubes (see Figure 1.1). The master is the guide tube section which contains the source stop at one end. The source stop prevents the source from leaving the end of the guide tube. The system should never be operated without using the master guide tube, since dirt may enter the tubes and the source might not retract properly if it is extended beyond the guide tubes.

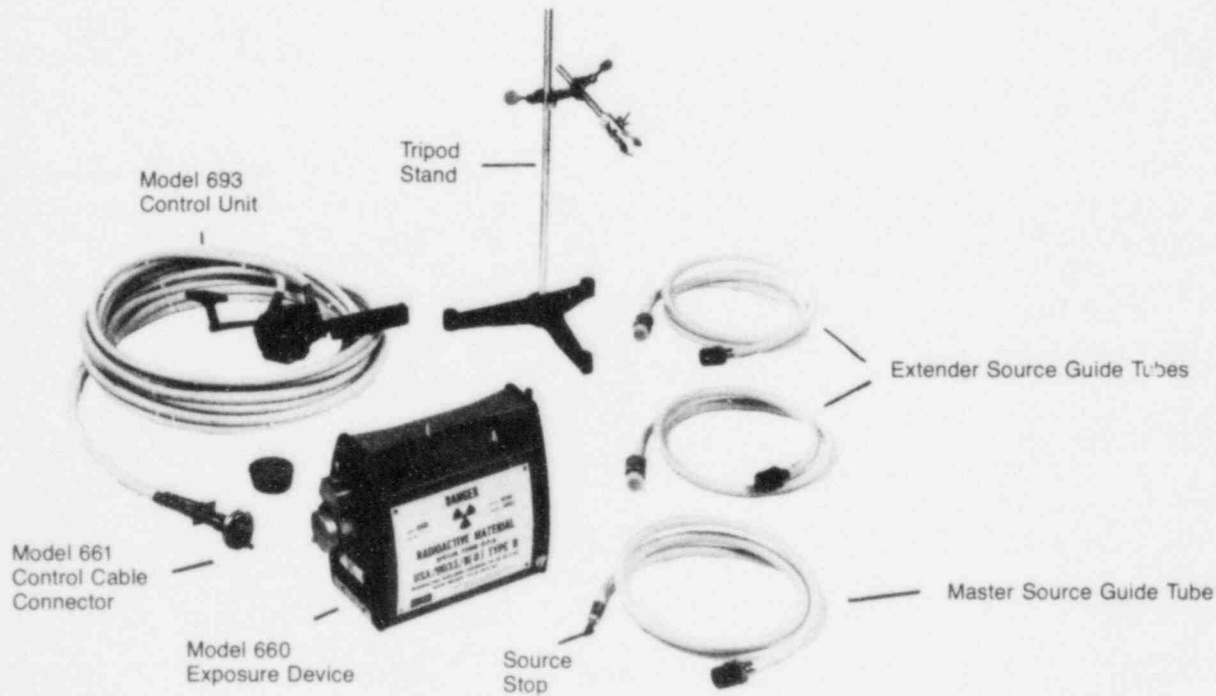
The two extender sections can be used as necessary to increase the length of the guide tube to 14 or 21 feet (4.3 or 6.4m). Both master and extender guide tubes are made from flexible stainless steel tubing with a protective polyvinyl covering. The three guide tube sections weigh approximately 5 pounds (2.3kg).

#### **CAUTION**

Never operate the systems with more than three guide tube sections [master section plus two extender sections—total guide tube length of 21 feet (6.4m)] because the source will be unable to reach the source stop.



(a) Model 660-664 System



(b) Model 660-663 System

Figure 1.1 660 Series Portable Gamma Radiography Systems

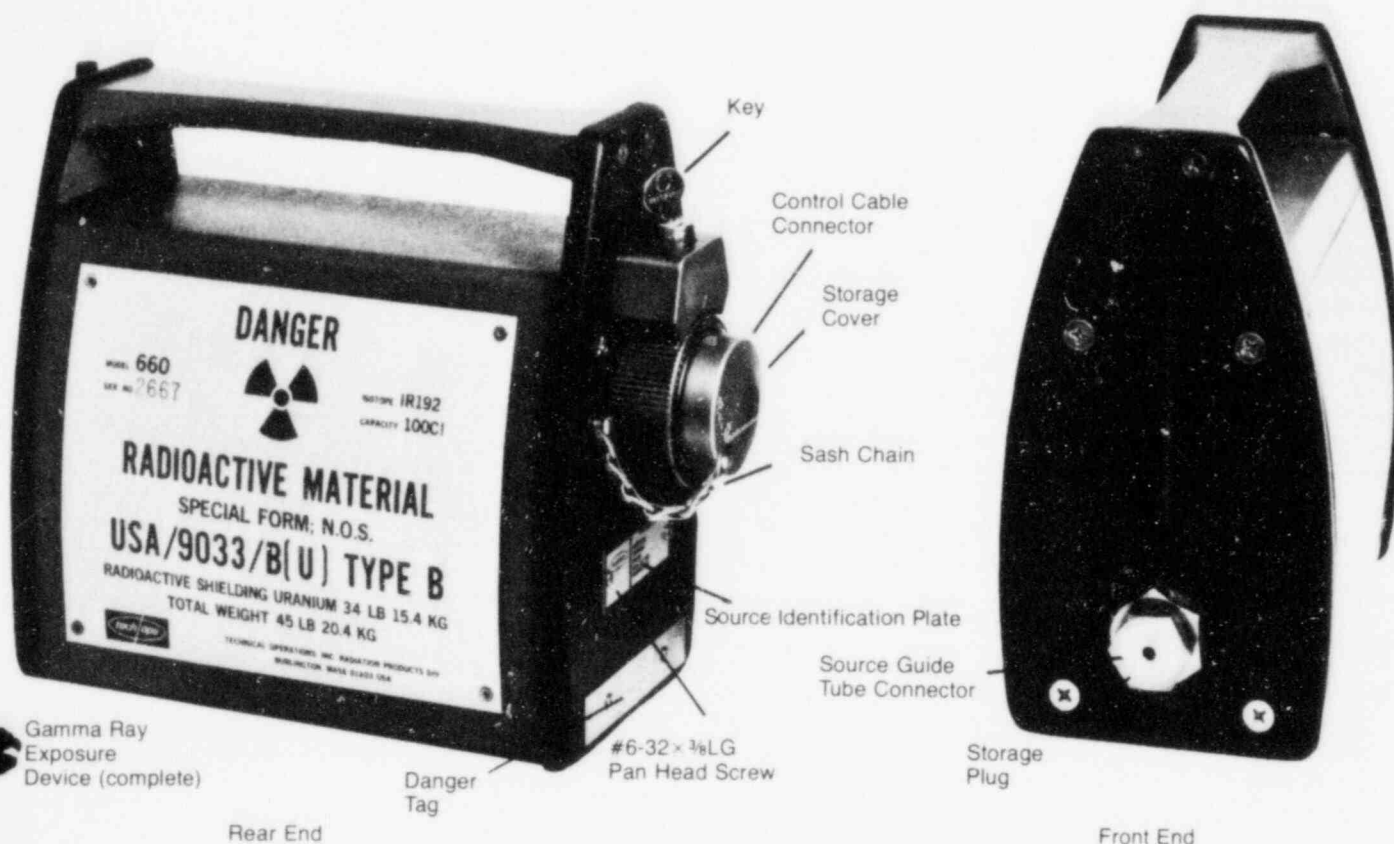


Figure 1.2 Model 660 Exposure Device

**Tripod Stand**

The tripod stand provides a means of securing the source stop to allow the source to be positioned at the desired focal position. The stand has adjustable clamps which will provide an unlimited degree of positioning flexibility. The weighted tripod base provides a solid foundation for the stand. The tripod stand, complete with clamps, weighs approximately 10 pounds (4.5kg).

**Model 664 Control Unit**

The Model 664 control unit consists of a hand crank, odometer, two 25-foot housings, drive cable and lightweight convenient cable storage reel. In operation the hand crank controls the movement of the source between the storage position in the exposure device and the exposure position in the master guide tube. The odometer indicates the distance (in feet and inches) that the source has been moved from its storage position. The reel provides a convenient storage facility for both the control housings and the three guide tubes.

The inner helically-wound flexible steel drive cable (the actual controlling element) terminates with the male section of a swivel-

type drive cable connector used to securely engage the radioactive source assembly. The drive cable connector permits the disconnection of the control unit from the source assembly. A stop spring is installed at the opposite end of the drive cable to prevent the drive cable from being inadvertently cranked off the drive gear. The control housing is terminated at one end by the Model 661 control cable connector assembly which mates with the fail-safe connector on the exposure device and at the other end by fittings which attach it to the main frame of the control unit. The 664 unit with the control housings and drive cable weighs approximately 22 pounds (10kg).

**Model 693 Control Unit**

The Model 693 is similar to the Model 664 control unit. However, the Model 693 unit does not have the storage reel and is provided with a pistol grip handle for convenient operation. The Model 693 control unit with the control cable weighs approximately 19 pounds (8.6kg).

## GENERAL INFORMATION

### Model 692 Control Unit

The Model 692 control unit is similar to the Model 693 control unit. However, the Model 692 unit does not have an odometer. The Model 692 control unit with the control cable weighs approximately 18 pounds (8.2kg).

### RADIOACTIVE SOURCE ASSEMBLY MODEL (A424-9)

The radioactive Iridium<sup>192</sup> source must be ordered separately from other system components. The system can be operated with various activity sources up to a maximum of 100 (+20%) curies of Iridium<sup>192</sup>. The radioactive material is sealed in a stainless steel capsule firmly attached to one end of a short leader cable. The other end of the leader cable has the female section of a swivel-type connector firmly attached to it to provide a secure connection to the drive cable.

The source may be changed only by a user licensed to do so. This is done using Tech/Ops Models 414, 650 or 820 source changers which also serve as shipping containers. See Section VI.

### SYSTEM OPTIONAL ACCESSORIES

Model No.	Description
527	"Rayguide" lead collimator with 360° x 20° panoramic & 30° x 60° directional inserts (incl. labstand)
782	Lead collimator with 30° x 60° side beam
783	Lead collimator with 30° x 60° front beam
784	Panoramic lead collimator
799	Tungsten mini collimator, sides ports 60° directional
714	Lead mini collimator 60° conical beam (for use with source stop)
717	Lead mini collimator 60° conical beam (for use with source switch)
719 (L)	Depleted uranium collimator with 360° x 20° panoramic & 30° x 60° directional lead inserts (incl. labstand)
719 (U)	Depleted uranium collimator with 360° x 20° panoramic & 30° x 60° directional depleted uranium inserts (incl. Labstand)
46403	Labstand for 527 or 719
(Custom made collimators can be supplied on request.)	
534	Slide rule type exposure calculator with leather case
657 Series	Automatic exposure control
957 Series	Automatic exposure control

613	Source stop switch used with the 681 source position indicator. This switch will pass through a 1.25 inch (30mm) diameter hole.
681	Source position indicator used in conjunction with the Model 527 collimator or Model 613 source stop. This unit provides a visual signal to indicate the source fully extended position.
492D	GAMMALARM radiation monitor
492E	GAMMAFLASHER remote indicator used with 492D GAMMALARM

### SPECIFICATIONS

- Source Data
  - Isotope: Iridium<sup>192</sup> (Model A424-9 only)
  - Maximum Activity: 100 curies (+20%)\*
- Shielding: 34 pounds (15.5kg) of depleted uranium
- Dimensions
  - Exposure Device Size: 4.75 inches (121mm) x 9.5 inches (241mm) x 12.75 inches (324mm)
  - Exposure Device Weight: 48 pounds (22kg)
  - Model 664 Control Unit Size: 6.6 inches (168mm) x 12 inches (305mm) x 21 inches (533mm)
  - Model 664 Control Unit Weight: 22 pounds (10kg) (with control housing and drive cable)
  - Model 693 Control Unit Weight: 19 pounds (8.6kg) (with control housing and drive cable)
  - Model 692 Control Unit Weight: 18 pounds (8.2kg) (with control housing and drive cable)
  - Source Guide Tubes (three): 5 pounds (2.3kg)
  - Tripod Stand: 10 pounds (4.5kg)
- Operating Specifications
  - Maximum Distance: Exposure device to control unit: 25 feet (7.6m)
  - Distance, Exposure Device to Exposure Position: 7 feet (2.1m), 14 feet (4.3m) or 21 feet (6.4m)
  - Source Position Reproducibility:  $\pm 1/16$  inch (1.6mm)

\*Note: The Model 660 has been approved for 200 curies of Ytterbium<sup>169</sup>; and users have been licensed for up to 120mCi of Cobalt<sup>60</sup> in the Model 660.

## Section II Personnel Monitoring

Pursuant to NRC and state regulations, all personnel who enter a restricted area or are present during radiographic operations are required to wear a direct reading pocket dosimeter with a range of zero to at least 200 milliroentgens and either a film badge or thermoluminescent dosimeter (TLD). The pocket dosimeter must be recharged at the beginning of each shift. The operator should frequently check the pocket dosimeter reading throughout the shift. Records of the initial and final readings of the pocket dosimeter must be kept for inspection by the NRC until it authorizes their disposal.

In the event that a person's pocket dosimeter is found to be off scale, that person must stop all work with radiation immediately. His film badge must be sent in immediately for processing, and he must not reenter a restricted area until it has been determined that he received less than the maximum allowed occupational exposure as defined in 10CFR Part 20.101.

Radiography personnel should also have a calibrated survey meter capable of measuring from 2mR/hr to at least 1000mR/hr to determine radiation levels when performing radiographic operations.

## Notes



### Section III

## Access To Restricted Areas

Since this gamma radiographic system can emit high levels of radiation when being operated, it is necessary to identify boundaries around the site where the radiography is being done. If a permanent radiographic installation is being used, it must have appropriate personnel access control devices as defined in 10CFR20.203. Otherwise, certain areas must be set off as follows:

Access to the Restricted Area must be controlled. A Restricted Area is defined in 10CFR Part 20.105 as the area where the radiation exposure level exceeds two milliroentgens in any one hour, 100 milliroentgens in seven consecutive days or 500 milliroentgens in one year. The Restricted Area should also be posted with signs reading "Caution (or Danger)—Radiation Area." Signs reading "Caution (or Danger)—High Radiation Area" should be posted around the perimeter where radiation exposure levels can exceed 100 milliroentgens in any one hour. A physical survey with a survey meter should be performed while the source is at its exposing position to confirm the radiation exposure rate at the perimeter of the Restricted Area. In order to minimize radiation exposure to the surveying personnel, a survey is *not* required and *should not* be done to confirm the High Radiation Area boundary.

The radiographer or radiographer's assistant must guard against unauthorized entrance into these areas at all times. No personnel should be allowed into the Restricted Area without a direct reading pocket dosimeter and either film badge or TLD.

## *Notes*

## Section IV Transportation

### RECEIVING RADIOACTIVE MATERIAL

The consignee of a package of radioactive material must make arrangements to receive the package when it is delivered. If the package is to be picked up at the carrier's terminal, 10CFR Part 20.205 requires that this must be done expeditiously upon notification of its arrival.

Tech/Ops portable gamma radiography system components are normally shipped in two crates. Inspect the crates for signs of external damage. If damage is evident, the carrier's agent should be present while unpacking. Survey the exposure device with a survey meter as soon as possible, preferably at the time of pickup and no more than 3 hours later if it was received during working hours. Radiation levels should not exceed 200 milliroentgens per hour at the surface of the exposure device nor 10 milliroentgens per hour at a distance of 3 feet from the surface. Actual radiation levels should be recorded on the receiving report. If the radiation levels exceed these limits, the container should be secured in a Restricted Area, and the appropriate personnel notified.

Open the crates and remove the remaining system components. They are:

- a. swivel clamp
- b. source tube clamp
- c. tripod base
- d. tripod rod
- e. control unit with attached control housing and drive cable
- f. three 7-foot source guide tube sections

These parts should be inspected for physical damage.

The source isotope, activity, model number and serial number and the shipping container model number and serial number should be recorded in the receiving report.

### SHIPPING RADIOACTIVE MATERIAL

The Model 660 meets the requirements for a Type B shipping container under the regulations of the U.S. Nuclear Regulatory Commission, the U.S. Department of Transportation and the International Atomic Energy Agency. The container has been assigned USNRC Certificate of Compliance No. 9033 for domestic shipments and IAEA Certificate No. USA/9033/B(U)T for international shipments.

### MODEL 660-OPERATION AND MAINTENANCE

The following shipping procedures comply with NRC Regulations 10CFR Part 71 and DOT Regulations 49CFR Parts 171 through 179 regarding the transportation of radioactive materials.

1. Ensure that the source is locked into place in its storage position. To check this, the lock should be in the down position, and the selector ring should be immobile. Attach a tamper proof security seal with an identification mark to the storage plug.
2. If the shipping container is to be packaged in a crate or other outer packaging, the outer packaging must be strong enough to withstand the normal conditions of transport. These requirements are outlined in 10CFR Part 71 Appendix A. The shipping container should be put in the outer package with sufficient blocking to prevent shifting during transportation.
3. Perform a radioactive contamination wipe test of the outer shipping package. This consists of rubbing filter paper or other absorbent material, using heavy finger pressure, over an area of 100cm<sup>2</sup> (16 in<sup>2</sup>) of the package surface. The activity on the filter paper should not exceed 0.001μCi of removable contamination.
4. Survey the package with a survey meter at the surface and at a distance of 3 feet from the surface to determine the proper radioactive shipping labels to be applied to the package as required by 49CFR Part 172.403. The radiation exposure limits for each shipping label are given in Figure 4.1. If radiation levels above 200mR/hr at the surface or 10mR/hr at 3 feet from the surface are measured, the container must not be shipped.
5. Properly complete two shipping labels indicating the radioactive isotope, activity 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 milliroentgens per hour measured at a distance of 3 feet from the surface of the package. Put these two labels on opposite sides of the container after making sure any previous labels have been removed. The package should be marked with the proper shipping name (Radioactive Material, Special Form, n.o.s.). If the exposure device is packaged inside an outer container, mark the outside package "INSIDE PACKAGE COMPLIES WITH PRESCRIBED SPECIFICATIONS—TYPE B USA/9033/B(U)."
6. Complete the appropriate shipping papers. Examples are shown in figure 4.2.




MAXIMUM RADIATION LEVELS		
	Surface	3 Feet
<b>RADIOACTIVE-WHITE I</b> 	0.5mR/hr	None
<b>RADIOACTIVE-YELLOW II</b> 	50mR/hr	1.0mR/hr
<b>RADIOACTIVE-YELLOW III</b> 	200mR/hr	10mR/hr

Figure 4.1 Radiation Exposure Limits for Shipping Labels

### CARRYING RADIOACTIVE MATERIAL

Any vehicle that is to be used in transporting radioactive material should be in good operating condition and carry the normal complement of safety equipment such as "Radiation Area" signs, rope, a spare tire, a fire extinguisher, set of vehicle tools, and a set of flares. The glove compartment should have the vehicle's registration certificate and a working flashlight. Additionally, the driver must have a calibrated survey meter and be wearing a dosimeter and a film badge or TLD.

Before placing the container in the vehicle and securing it against movement, the operator should ensure that the container is properly packaged, marked, and labeled, and that the proper shipping papers are completed as described above and are in the drivers compartment. After the container has been placed in

the vehicle, the operator should survey the drivers compartment to ensure that radiation levels are below 2 milliroentgens per hour.

In the event that the vehicle is used for storage, a survey must be conducted to ensure that radiation levels are less than 2 milliroentgens per hour at a distance of 18 inches from the surface of the vehicle. Also, if the vehicle is used for storage, it should be posted with "Caution—Radioactive Material" signs.

If the vehicle is transporting a package bearing a "Radioactive Yellow III" label, 49CFR Part 172.504 requires that the vehicle be posted on all four sides with a "RADIOACTIVE" placard. It should be noted that operation of a vehicle which is required to be placarded must comply with the Federal Motor Carrier Safety Regulations, 49CFR Parts 390-397.

<b>SHIPPER'S CERTIFICATION FOR RADIOACTIVE MATERIALS</b>																																																	
Two completed and signed copies of this certificate shall be handed to the carrier.																																																	
(Use black letters)																																																	
<b>WARNING:</b> Failure to comply in all respects with the applicable regulations of the Department of Transportation, 49 C.F.R., Part 171-177, and/or for international shipments, the IATA Restricted Articles Regulations may be deemed at the shipper's risk, subject to legal penalties. This certification shall not constitute release by IATA Cargo Agent or its subsidiaries from international obligations.																																																	
This shipment is within the limitations prescribed for "Packaging," "Special Event," and "Transportation Methods" as shown on manifests for each class of material to be shipped by regular air transport.																																																	
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### HAND CARRYING

## STORAGE

MODEL 660-OPERATION AND MAINTENANCE

## *Notes*



## Section V Operation

### PRINCIPLES OF OPERATION

The encapsulated radioactive source, which is stored in the center of the exposure device (see Figure 5.1(a)) is attached by means of a short leader to the drive cable. The hand crank on the control unit moves the drive cable through the control housing. Figure 5.1(b) shows the source being moved out of the storage position in the exposure device and into the guide tubes. This action occurs by rotating the hand crank in the EXPOSE (counterclockwise) direction. Figure 5.1(c) shows the source reaching the source stop which serves as a mechanical stop at the radiographic focal position. The hand crank will not turn any farther and the odometer in the control unit should indicate a reading which approximates the total length of the combined guide tubes. To return the source to the exposure device (stored position), the hand crank is turned to the full RETRACT (clockwise) position.

### SAFETY PRECAUTIONS

This system may be operated only by a qualified radiographer and/or his assistant. The radiographer must be physically present and in direct surveillance at all times when the exposure device is being used.

Since the source emits high levels of radiation, it is good practice to operate the system from as great a distance as practical and, if possible, from behind a radiation shield such as a heavy steel or concrete object or the corner of a building.

Radiography must only be performed in a Restricted Area which is marked with the appropriate radiation signs, and secured against unauthorized entrance. While assembling the system, it is important to keep the exposure device locked at all times except when operating. The radiographer and radiographer's assistant must at all times have a pocket dosimeter, either a film badge or TLD, and a survey meter capable of measuring 2mR/hr to at least 1000mR/hr.

### DAILY INSPECTION

Daily inspection of the system is required to ensure that the equipment is in proper operating condition. The inspection should be performed prior to the start of each shift.

1. Inspect the entire length of each source guide tube section and control housing to ensure that each section is free from cuts and dents.

2. Inspect the end fittings to ensure that they are tightly connected. Check the threads on the fittings, the control cable connector and the male source connector for damage.
3. During the first exposure of the shift, check the operation of the selector ring, lock assembly and control crank. If operation is difficult, retract the source to the stored position, and survey the equipment according to the Operating Instructions. The system must be serviced before further operation.

### ASSEMBLY

1. Position and secure the source stop of the master source guide tube at the radiographic focal position using the tripod stand and swivel clamps.
2. Determine where the exposure device will be positioned and connect the extender source guide tubes as required, laying them as straight as possible and with no bend radius less than twenty inches. (Smaller bend radii will restrict the movement of the control cable).

#### WARNING

Never operate the system with more than three guide tube sections (including the master).

3. Remove the storage plug from the exposure device and connect the source guide tube(s) to the exposure device.
4. Determine where the control unit will be positioned (as far away from the radiographic focal position as possible and preferably behind a radiation shield) and lay out the control housing with no bend radii less than 36 inches.
5. Connect the control unit to the exposure device according to the illustrated sequence in Figures 5.2 through 5.6.
6. Before operation check all connections and bend radii, and check the position of the source stop, which represents the radiographic focal position of the source.
7. Check the operation of the survey meter by reading the radiation level 6 inches from the surface of the exposure device. It should read no more than 50mR/hr for a 100 curie <sup>192</sup>Iridium source.

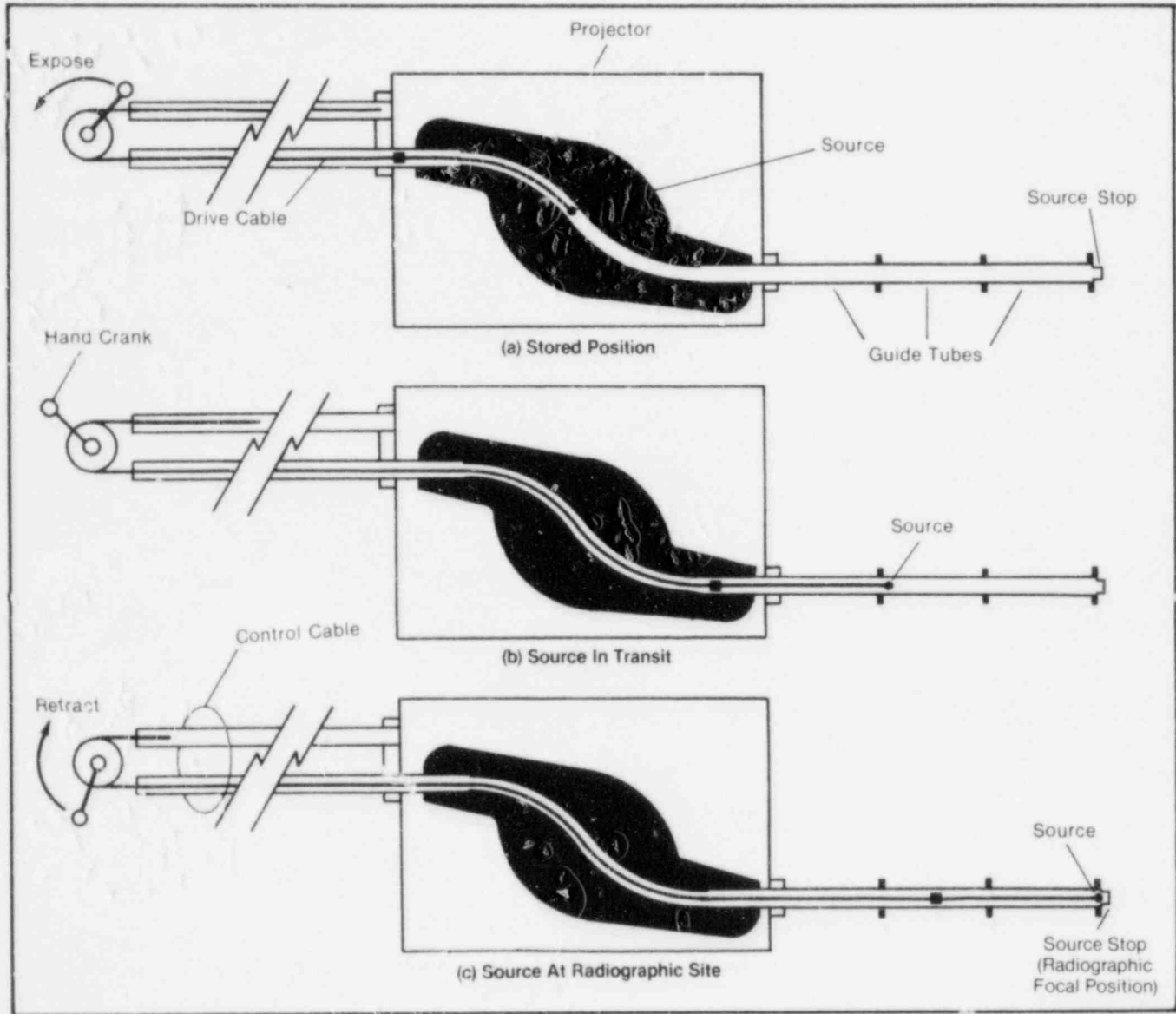


Figure 5.1 Principles of Operation

8. Unlock the exposure device lock and rotate the selector ring to the OPERATE position. The source is now free to move.

## OPERATION

1. Return to the control unit. Adjust the odometer reset knob to obtain a 000 reading on the odometer.
2. Recheck to be sure that no unauthorized personnel are inside the Restricted Area.
3. Rapidly rotate the crank in the EXPOSE (counterclockwise) direction to move the source to the radiographic focal position. The survey meter should read about full scale (1000mR/hr) for a 100 curie Iridium<sup>192</sup> source when the source first leaves the exposure device, drop gradually as the source is driven to the radiographic focal position, and remain steady during the exposure. The survey meter readings will be substantially reduced if the meter is operated behind a radiation shield or if a collimator is used.
4. When the source reaches the source stop, the hand crank will stop turning. Never exert more than 5 ft-lbs of torque on the hand crank, as this may cause damage to the control unit or drive cable. The odometer reading will indicate the total distance the source has traveled (approximately 7 ft. for one source guide tube section, 14 ft. for two source guide tube sections, and 21 ft. for three sections). Set the brake to ON to prevent movement of the source during the exposure.
5. Figure the specimen exposure time from the moment the source reaches the source stop.
6. During the exposure, spend as little time as possible in the Restricted Area to minimize personnel exposure.
7. To return the source to the exposure device after the desired exposure time has elapsed, turn the brake to OFF and rapidly turn the crank in the RETRACT (clockwise) direction until the crank will no longer move. The odometer should read 000. During this process, the survey meter should indicate a continually increasing radiation level up to approximately 1000mR/hr for a 100 curie Iridium<sup>192</sup> source, then drop to background level when the source is shielded in the exposure device.
8. Approach the exposure device with the survey meter and survey the exposure device on all sides. The meter should indicate the same radiation level as observed in step 7 of **Assembly**.
9. Survey the entire source guide tube with the survey meter. If the meter shows a sharp increase, the source could still be exposed or incompletely shielded.
10. If the source is still exposed, attempt to store it properly by cranking the source a short distance toward the source stop and retracting it, repeating if necessary.
11. If the source becomes jammed in an exposed position, do not try to retrieve the source. Treat the situation as an emergency; notify the supervisor and Tech/Ops, Inc. for help if necessary.

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

### NOTE

If the selector ring cannot be rotated to the LOCK position, the source has not been fully retracted. Check the control unit odometer reading. It should be 000. Turn the hand crank to the full clockwise (RETRACT) direction.

## DISASSEMBLY

1. Unlock the exposure device, and rotate the selector ring from LOCK to CONNECT. The control unit connector will partially disengage.
2. Refer to Figures 5.2 through 5.6 to disengage the control unit from the exposure device.
3. Replace the storage cover in the control unit connector and rotate the selector ring to the LOCK position. Remove the key and engage the lock to secure the exposure device. Survey the entire circumference of the exposure device with the survey meter to ensure the source is properly secured.
4. Unscrew the source guide tube sections and remove the master guide tube from the tripod stand. Place the plastic caps on the tubes and on the Model 661 connector to eliminate dust and dirt from entering the tubes.
5. Insert the storage plug into the guide tube connector and tighten.
6. Disassemble the tripod stand and store the system where it will not be subjected to any undue stress or abuse.



Figure 5.2 Unlock the exposure device with the key provided and turn the selector ring from the LOCK position to the CONNECT position. When the ring is in the CONNECT position, the storage cover will disengage from the exposure device as shown.

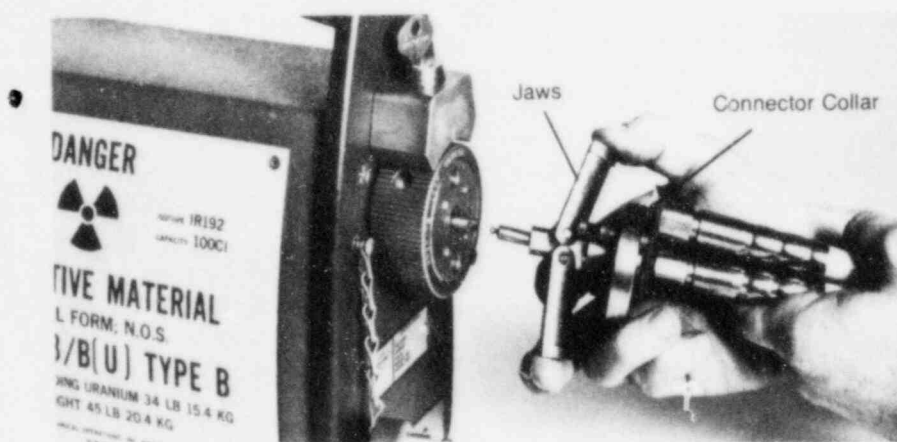


Figure 5.3 Slide the Model 661 connector collar back and open the jaws of the Model 661 connector. This exposes the male portion of the swivel type drive cable connector as shown.

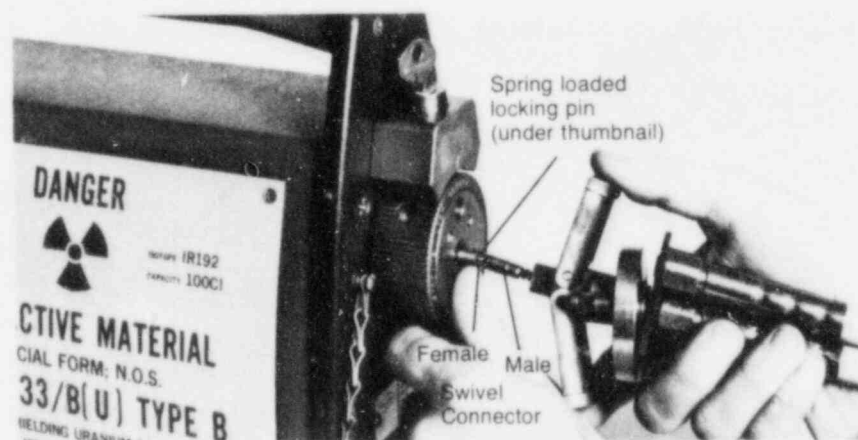


Figure 5.4 Engage the male and female portions of the swivel connector as shown by depressing the spring-loaded locking pin toward the exposure device with the thumbnail. Release the locking pin and test that the connection has been properly made.



Figure 5.5 Close the jaws of the Model 661 connector over the swivel connector.



Figure 5.6 Slide the Model 661 connector collar over the connector jaws. Hold the collar flush against the control unit connector and rotate the selector ring from the CONNECT position to the LOCK position. Keep the exposure device locked until operation is ready to start.



## Notes



## Section VI Source Changes

Source changes may be done using Tech/Ops Models 414, 650 or 820 source changers, which also serve as shipping containers. A source change can be performed only if the user is specifically licensed to do so. If not, Tech/Ops, Inc. can send a qualified person to perform the source change, or the exposure device can be sent to Tech/Ops for source replacement at the plant. The source change must be done in a Restricted Area as described in Section III. Section II on Personnel Monitoring and Section V, on Safety Precautions should be followed here as well.

To perform a source change, do the following:

1. Survey the source changer to ensure the source is in the proper storage position.
2. Position the source changer and exposure device close together so that one section of source guide tube will connect them with no sharp turns or bends. The bend radius of the guide tube should never be less than twenty inches. Shorter bend radii can restrict source movement in the source guide tube.
3. Remove the storage plug from the exposure device, and attach the source guide tube. Remove the source changer cover and attach the other end of the tube to the empty chamber of the source changer.

Attach the control unit to the exposure device as in Section V, Assembly.

5. Crank the source rapidly from the exposure device to the source changer. During this process, the survey meter reading should increase (to approximately 1000mR/hr for a 100 curie Iridium<sup>192</sup> source) as the source is first exposed, fall slightly as the source is being cranked out, then drop to background when the source is in the source changer.
6. Approach the source changer and source guide tube with the survey meter to ensure that the source is fully within the source changer.
7. Open the source guides and disconnect the drive cable from the source assembly by moving the lock pin down and sliding the drive cable connector ball out through the keyway.
8. Disconnect the source guide tube from the source changer. If a replacement source is to be installed in the exposure device, connect the source guide tube to the fitting above the chamber containing the new source and couple the drive cable to the new source. If the source is being removed to service the exposure device, connect the drive cable to the jumper that is clipped inside the storage cover of the exposure device.
9. Return to the controls and crank the new source (or jumper) into the exposure device. If a new source is being transferred, the survey meter reading should increase as the source leaves the source changer and approaches the exposure device, then drop to background level when the source is shielded in the exposure device. If a jumper is being transferred, the survey meter should indicate only background radiation levels.
10. Survey the exposure device to ensure that the process has been properly completed. Radiation levels should read no more than 50mR/hr at 6 inches from the surface of the exposure device if a new 100 curie source has been transferred. If the jumper is in the exposure device, only background radiation should be detected by the survey meter. Rotate the selector ring to the LOCK position.
11. Survey the source guide tube and source changer to check that the source has been correctly transferred.
12. Secure the source(s) in the source changer in accordance with the appropriate source changer instruction manual.
13. Disconnect the control unit and source guide tube from the exposure device as in Section V, Disassembly, and disconnect the source guide tube from the source changer.
14. Remove the source identification plate from the exposure device and attach it with seal wire to the source holddown cap.
15. If the exposure device contains a source, affix the identification plate of the new source to the exposure device. If not, attach an EMPTY tag to the handle of the exposure device.
16. If the source changer is to be transported, survey it to determine the correct shipping label required as in Section IV, Shipping Radioactive Material. (Radiation levels must not exceed 200mR/hr at the surface nor 10mR/hr at 3 feet from the surface.) Bolt the source changer cover in place and secure it with seal wire.
17. Return the source changer promptly to Tech-Ops, Inc. Demurrage rental charges will be assessed for containers held beyond normal operating time.

## *Notes*

## Section VII Maintenance

To service the Model 660 exposure device and Model 664, 693 or 692 control unit the following equipment is required in addition to standard tools such as screwdrivers, English system wrenches, TRU-ARC pliers, etc.

*Master Key* (P/N A66001-11)

*Jumper* (P/N B66001-20)

*Drive Cable*, short length (P/N BSK 1760)

*U-Tool* (P/N BSK 1761)

*Cleaning solvent* (chlorothene)

*Rivet gun and pop rivets* (.125" diameter x .294" long)

*MIL-G-2387A grease* (TEXACO "Uni-Temp")

### CONTROL UNIT

#### **Drive Cable, Control Housings and Source Guide Tubes—Disassembly**

To service the drive cable, control housings and source guide tubes, follow these steps:

1. Disconnect the control unit from the exposure device.
2. Turn the hand crank of the control unit in the EXPOSE (counter-clockwise) direction until the crank will no longer turn. Do not use force, as this may damage the drive wheel inside the control box. The emergent cable should be cranked into a bucket or other container to keep it clean.
3. Disconnect the control housing from the RETRACT side of the crank and remove the stop spring from the drive cable. The drive cable will now pass through the crank.
4. Turn the crank until the drive cable is totally disconnected.
5. Pull the drive cable out through the Model 661 control cable connector and coil it with a radius of no less than 4 inches.
6. Remove the Model 661 control cable connector and connector plug from the control housings, and disconnect the other control housing from the crank. Label the housings for proper reassembly.
7. Clean the drive cable with chlorothene and flush the control housings and source guide tubes.
8. Using compressed dry air (15psi max.), thoroughly dry the drive cable, control housings and guide tubes. Any remaining solvent can cause permanent damage.

9. Check the source guide tubes for binding by holding them vertical and dropping a dummy source (or jumper) through them.
10. Wipe the guide tubes and control housings with a cloth soaked in chlorothene and flex them to check for internal damage. Damage is evidenced by a crunching feeling when the housing or tube is bent. While doing this, feel for dents. Cut, flattened or burnt control housings or guide tubes should be repaired or replaced.
11. The guide tubes or control housings may be covered with tape where only the outer plastic is cut through.
12. Using a Model 550 no-go gauge, check the male connector of the drive cable. If the ball of the connector fits through the hole of the gauge or the ball shank fits into the slot in the gauge, the connector is worn and the cable must be replaced. Refer to Figure 7.1.
13. Lightly grease the cable using TEXACO "Uni-Temp" grease. Other greases may form tars or corrosive compounds when exposed to radiation.

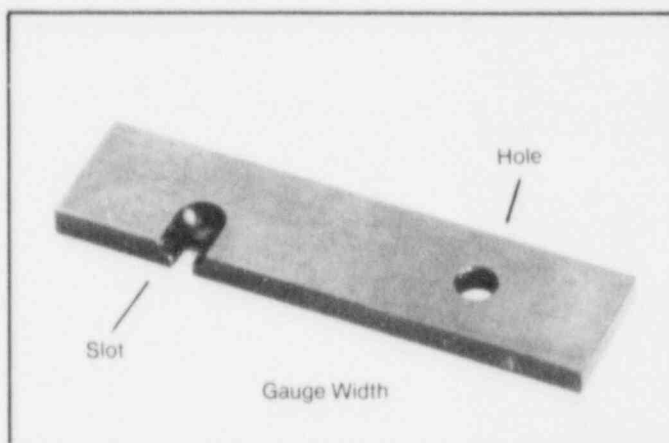


Figure 7.1 Model 550 No-Go Gauge

## MAINTENANCE

### Crank Assembly—Model 664 Control Unit

To service the Model 664 control unit, perform the following steps:

#### Disassembly

1. Remove the control housing and drive cable from the crank assembly as described in the previous section. Refer to Figure 7.2 to aid in disassembly and for component identification of replacement parts.
2. Remove the control box housing (4) from the frame (11) by unscrewing the four binder head screws and  $\frac{3}{8}$ " nuts (1).
3. Remove the crank arm assembly (3) from the control box housing by removing the  $\frac{5}{16}$ " hex head bolt (2).

#### CAUTION

Make sure the cable adapters stay in the lower control box housing during separation. Care should be taken to avoid possible injury from or loss of the tension-loaded wear strip.

4. Separate the two halves of the control box housing, keeping the cable adapters in the lower control box housing to ensure the wear strip (5) does not fly out. Remove the drive wheel (6), wear strip (5), two cable adapters (14), two brake jaws (15), brake arm (16) and brake bearing (13).
5. The two ball bearing assemblies (7) in each side of the control housing may be left in place.
6. Remove the reset knob (29) by loosening the two set screws, and remove the odometer cover (28) by removing the two large binder head screws fastening it to the mounting plate.
7. Check the odometer unit for proper operation. The unit should turn freely and without excessive play. Clean the helical gear (20) with chlorothene and lightly grease it with TEXACO "Uni-Temp" grease. If the odometer assembly is defective, it must be replaced as a unit.
8. To service the odometer assembly remove the unit from the frame by unscrewing the three flat head machine screws holding the gear box (22) to the frame (11).

#### Reassembly

1. Clean all the control box parts in chlorothene and dry them thoroughly with compressed dry air (15psi Maximum). Inspect for damage and excessive wear. Replace any defective parts.
2. Lightly grease all moving parts at their contact surfaces with TEXACO "Uni-Temp" grease.
3. Place two cable adapters (14) in the lower control box housing (4) with the angled sides facing inward in order to provide clearances for the drive wheel (6).
4. Place the wear strip in the control housing.

#### CAUTION

Insert the wear strip with care, since it will be under tension and could pop out.

5. Place the drive wheel (6) in the lower control box housing (4).
6. Position the two brake jaws (15), brake bearing (13) and brake arm (16) in the lower control box housing. When installing the brake jaws, face the worn sides away from the drive wheel, as this increases their life.
7. Place the upper control box housing over the lower control box housing while keeping them level, and press them together.
8. Check the control box for proper reassembly by turning the shaft. It should spin freely. If not, disassemble and reinspect the parts for damage and proper alignment. Reassemble and check the operation again.
9. Mount the odometer assembly on the frame (11) by securing the gear box (22) with three flat head machine screws.
10. Secure the odometer cover (28) to the mounting plate (23) with two binder head screws, and secure the odometer reset knob (29) to the shaft by tightening the two set screws.
11. Mount the control box onto the frame (11) and secure with the four large binder head screws and  $\frac{3}{8}$ " nuts. Secure the crank arm assembly (3) to the shaft with the  $\frac{5}{16}$ " bevel washer (30) and  $\frac{5}{16}$ " hex head bolt (2).
12. After complete reassembly, check for proper operation by turning the crank, it should spin freely. Run the drive cable through the control box and turn the crank. It should turn easily and with no snags. Set the brake to ON and attempt to turn the crank. It should not turn with moderate pressure. Do not apply excessive pressure to the crank, as this may cause damage. If the control box fails any of these tests, disassemble, check the parts for damage and proper alignment, then reassemble and check for proper operation again.

### Crank Assembly—Model 693 Control Unit

To service the 693 control unit, perform the following steps:

1. Follow steps 1-5, Disassembly, Model 664 Crank Assembly. Refer to Figure 7.3 for further disassembly and for part identification numbers.
2. Remove the odometer mount cover (34) from the odometer mount (20) and check the odometer unit for proper operation. The unit should turn freely and without excessive play. Clean the helical gear (27) with chlorothene and lightly grease it with TEXACO "Uni-Temp" grease. If the odometer assembly is defective, it must be replaced as a unit.
3. To service the odometer, remove the odometer mount cover (30) from the odometer mount (20), remove the odometer reset knob (29) by unscrewing the two set screws, and unscrew the two attaching large round head screws (35).

4. Follow steps 1-8, Reassembly, Model 664 Assembly.
5. Resecure the odometer to the odometer mount (20) and secure the odometer reset knob (29) and odometer mount assembly cover (34) in place.
6. Secure the control box to the control handle (17) and odometer mount (20) with the four large binder head screws and  $\frac{3}{8}$ " nuts, and secure the crank arm assembly (3) to the shaft with the  $\frac{5}{16}$ " bevel washer and  $\frac{5}{16}$ " hex head bolt. Follow step 12 of the previous section for checking of operation.

#### **Crank Assembly—Model 692 Control Unit**

1. Follow steps 1-5, Disassembly, Model 664 Assembly. Refer to figure 7.4 for further disassembly and for part identification numbers.
2. Follow steps 1-8, Reassembly, Model 664 Assembly.
3. Secure the control box to the control handle (17) with the four large binder head screws and  $\frac{3}{8}$ " nuts, and secure the crank arm (3) to the shaft with the  $\frac{5}{16}$ " bevel washer and  $\frac{5}{16}$ " hex head bolt. Follow step 12, Reassembly, Model 664 Assembly, to check operation.

#### **Drive cable, Control Housing and Source Guide Tubes—Reassembly**

1. Attach the control housing to the EXPOSE side of the control box and to the Model 661 connector.
2. Feed the drive cable into the control housing as far as it will go. As the drive cable is being fed in, feel the resistance to the drive cable to detect any binding of the cable. This indicates a dent in the control housing which should be repaired or replaced.
3. Turn the hand crank until the drive cable is protruding, and screw the stop spring to the end of the drive cable.
4. Connect the other control housing to the crank and to the connector plug.
5. Turn the crank fully to the RETRACT position and watch for any binding of the drive cable to check the other section of the control housing for dents. Repair or replace the control housing if necessary.
6. Place plastic dust caps on the ends of the source guide tubes and Model 661 control cable connector to eliminate dust accumulation.



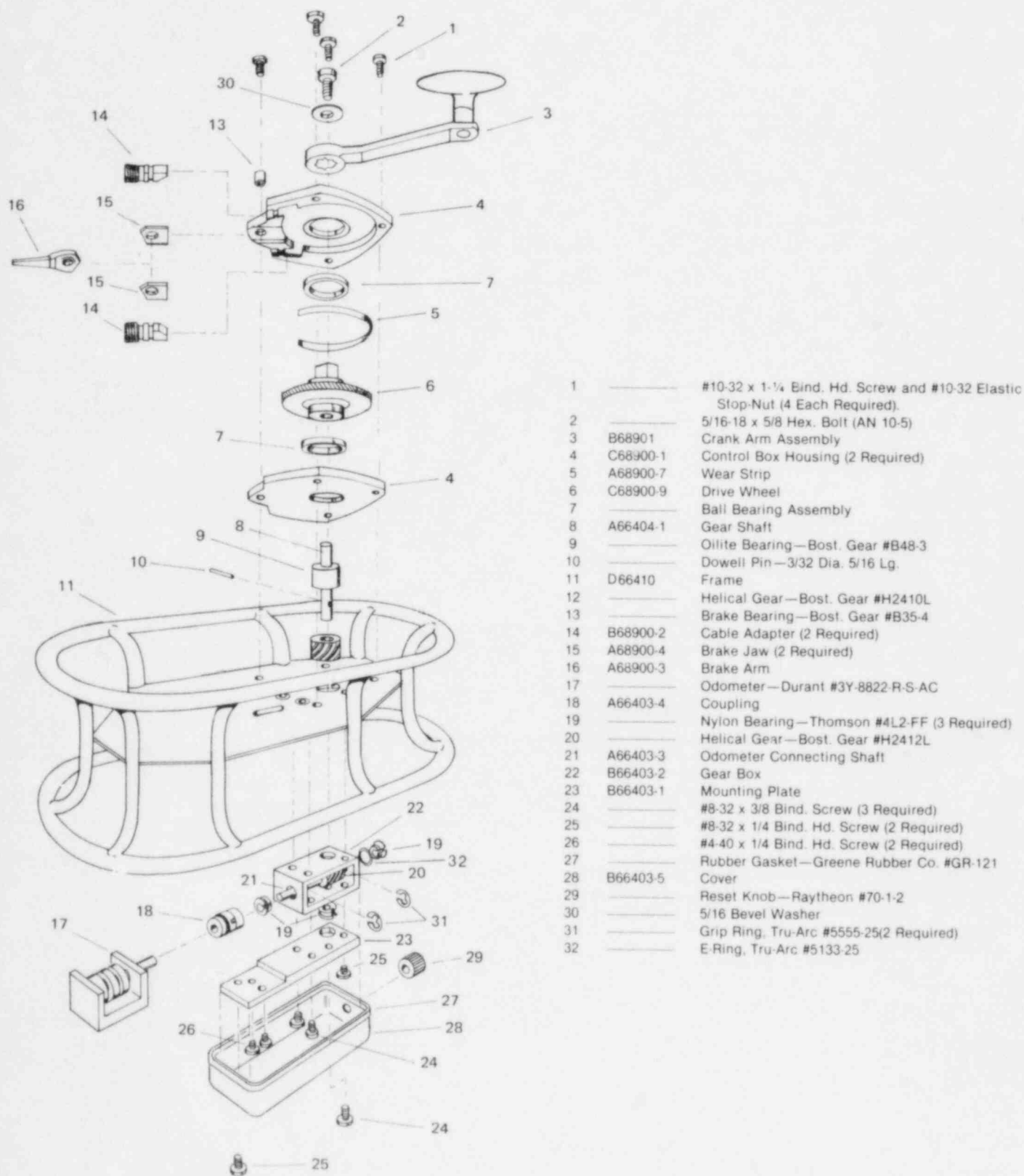


Figure 7.2 Model 664 Control Unit--Exploded View



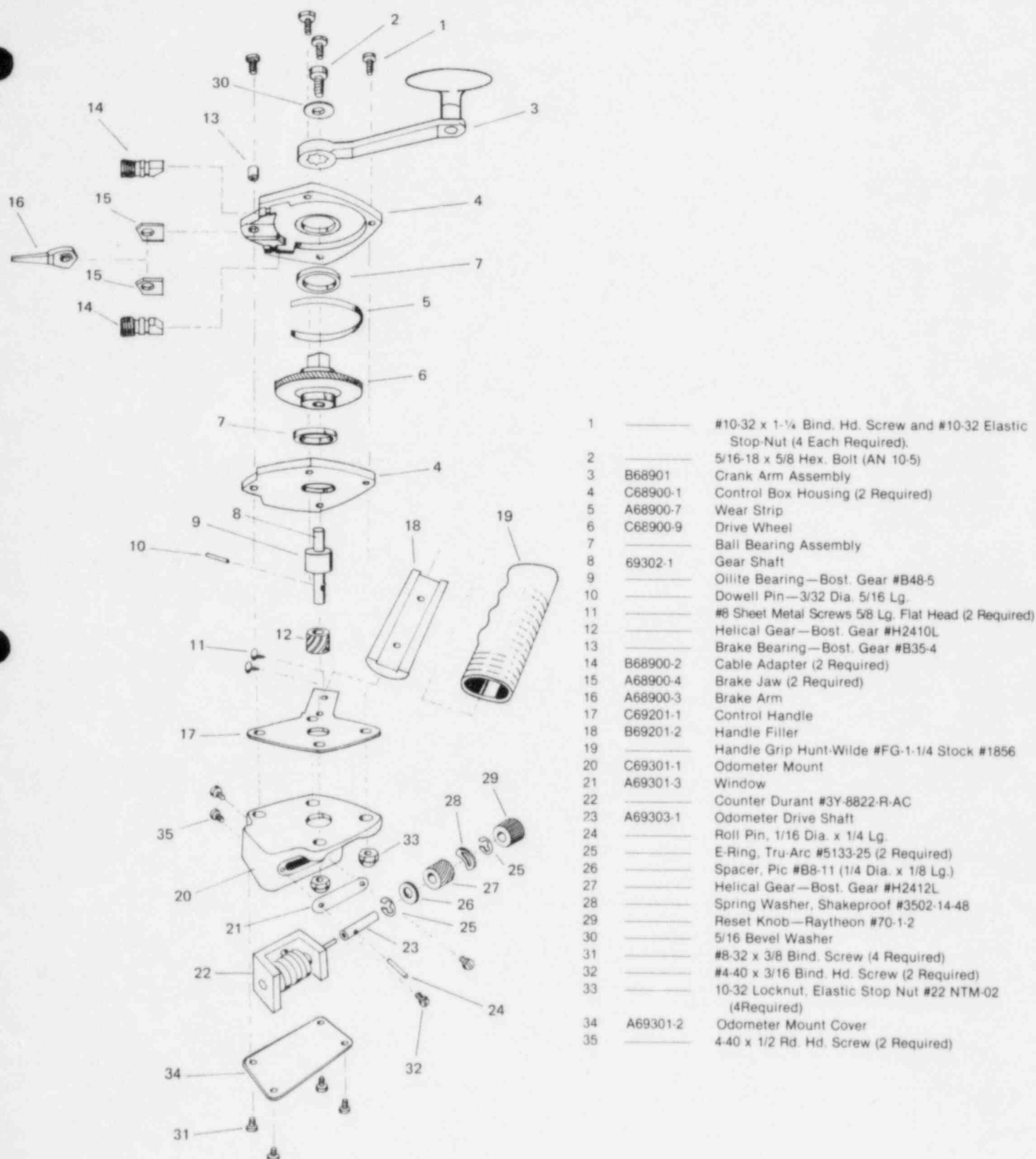


Figure 7.3 Model 693 Control Unit—Exploded View

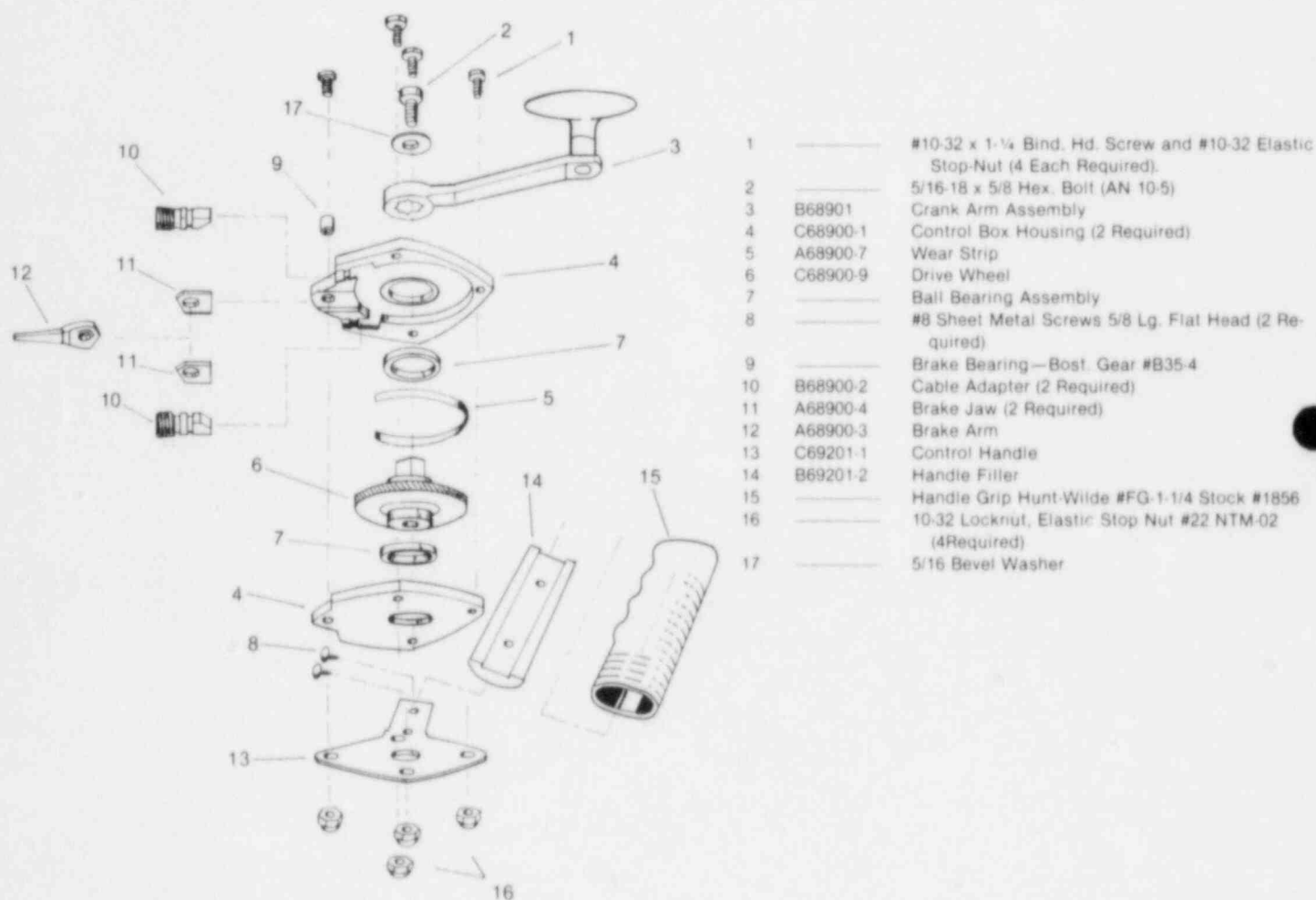


Figure 7.4 Model 692 Control Unit—Exploded View

## MODEL 660 EXPOSURE DEVICE

To service the exposure device, remove the source following the source changing procedures of Section VI. (Before removing the source, check the female drive cable connector of the source with a Model 550 no-go-gauge as in Figure 7.1; if the gauge width can fit into the female slot, the connector is worn and the source must be replaced.) After the source has been removed, service the exposure device by performing the following steps:

1. Remove the Danger Tag (secured with rivets) from the bottom of the rear plate.
2. Remove the rear plate by unscrewing the six phillips head screws securing it to the exposure device body.
3. Unlock the connector lock, and then remove the lock assembly and control unit connector assembly by unscrewing the six socket head screws securing them to the rear plate.
4. Disassemble the control unit connector assembly, referring to Figure 7.5 for component identification and for order of removal. There are several spring loaded parts in the connector assembly, so care should be taken that these parts are not lost.
5. To disassemble the lock assembly, refer to Figure 7.6 for component identification and for order of removal. Remove the lock (5) from the lock retainer (3) by unscrewing the screw (4) and turning the key about 90°.
6. Remove the front end plate from the exposure device, and remove the guide tube connector and retaining ring with Tru Arc pliers, referring to Figure 7.5. The handle may be left on the front plate.
7. Clean all parts in chloroethene and flush the source tube with solvent. Dry the parts and the source tube thoroughly using dry compressed air (20psi maximum). Clean the S-Tube in the exposure device by running a cloth soaked with chloroethene through it several times. Dry the S-Tube by running a dry cloth through the tube.
8. Inspect all parts for damage or excessive wear, and replace if necessary. Use Figures 7.5 and 7.6 for component identification numbers.
9. Lightly grease all moving parts at their contact surfaces with TEXACO "Uni-Temp" grease.
10. Reassemble the front end plate, and secure it to the exposure device with the proper screws.
11. Reassemble the lock by placing the return springs and spring guides into the lock (5), depressing the internal plunger, inserting the lock (5) into the lock retainer (3), and securing the lock with the set screw (4).
12. Attach the lock assembly to the rear plate with two socket head screws.
13. To reassemble the control unit connector assembly, refer to Figures 7.7 through 7.9.
14. Refer to Figure 7.7 and place the compression spring (10) on the hub of the selector ring retainer. The spring should be firmly seated over the hub. Then place the sleeve (11) on top of the compression spring (10).

15. Place the selector body (6) on a flat surface so that it is resting on its  $\frac{5}{8}$ " hub.
16. Insert the two short compression springs (8) and locking pins (7) into the holes on the edge of the selector body.
17. Place the selector ring (5) over the selector body (6) while restraining the locking pins (7). Ensure that the lettering (OPERATE-LOCK-CONNECT) on the selector ring is facing up and that the stop pin on the selector body is in the cam slot of the selector ring. This is shown in Figure 7.8.
18. Hold the selector ring (5) and selector body (6) together and place them over the assembly shown in Figure 7.7. The resulting assembly is shown in Figure 7.9. Align the resulting assembly such that the two large holes in the selector ring retainer (9) line up with the two large holes in the selector body (6). The internal locking cam will partially block these holes.
19. Insert the anti-rotation lugs (4) and long compression springs (3) into the two large holes in the selector body. Secure the resulting assembly onto the rear plate with four socket head screws. The word OPERATE should be facing outward, and should be in the 12 o'clock position.
20. Connect the jumper to the short length drive cable and insert the cable through the rear end plate and control unit connector assembly.
21. Insert the U-tool into the control unit connector assembly and check the operation by turning the selector ring from OPERATE to CONNECT several times. If the connector assembly does not operate properly, disassemble and inspect the parts for damage and proper alignment. Relubricate the parts and reassemble.
22. Secure the rear end plate to the exposure device and handle using the six attaching phillips head screws and replace the protective plate over the bottom two rear plate screws using pop rivets (.125" diameter x .294" long).

## FINAL INSPECTION

1. Check the system for proper reassembly. Check all connections and fittings for tightness. Check for proper operation of the control unit and control unit connector assembly.
2. Reload the source in the exposure device by following Section VI, Source Changes.
3. Survey the exposure device on all sides to ensure that radiation levels do not exceed 200mR/hr at the surface nor 10mR/hr at 3 feet from the surface.
4. Check the exposure device for the proper labels.

## LEAK TESTING

The source assembly in the exposure device must be leak tested at intervals not to exceed 6 months. This can be done using Tech/Ops Model 518 Leak Test Kit. The test must be performed in a properly secured Restricted Area and with the appropriate radiation monitoring equipment.

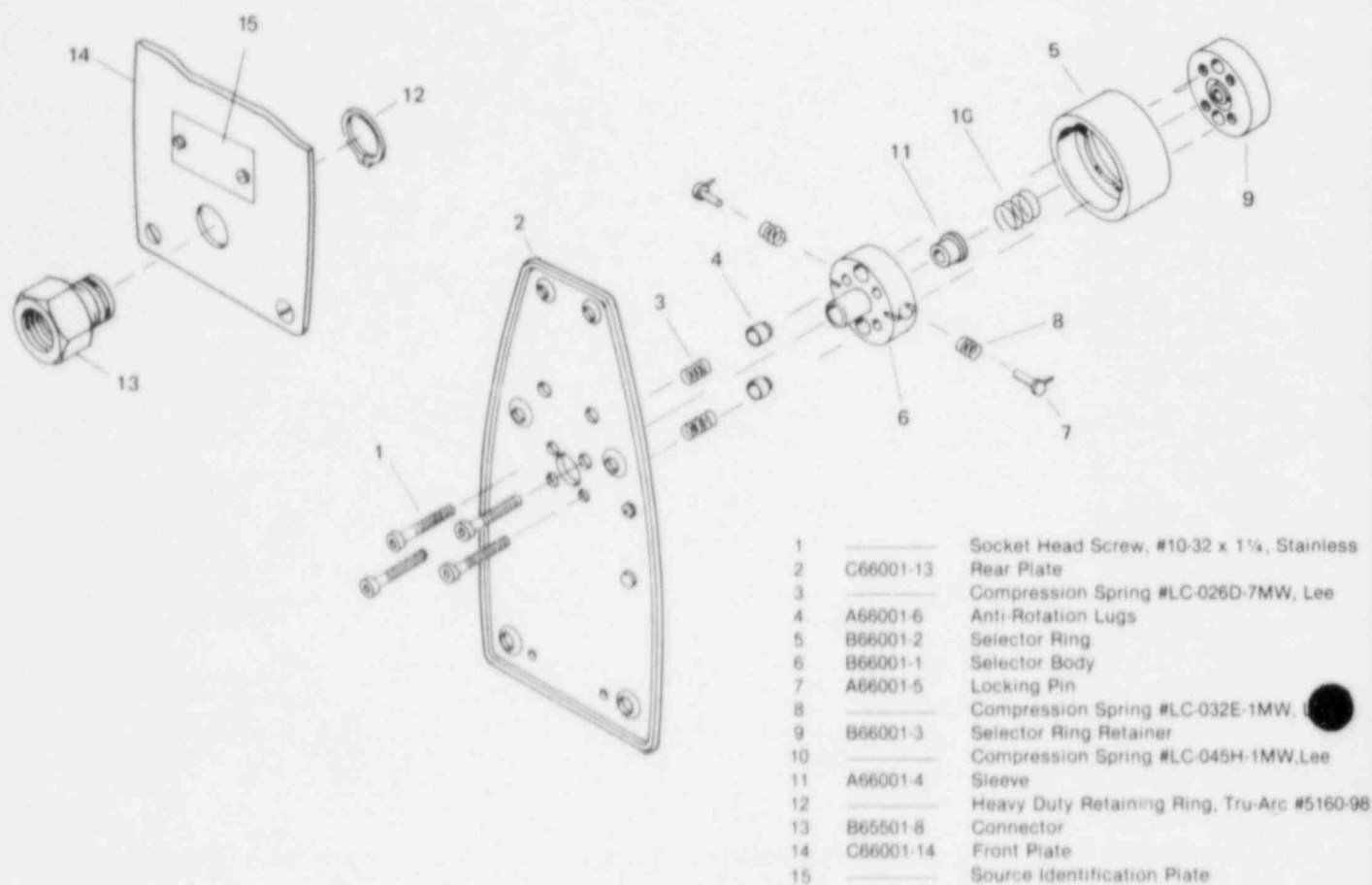


Figure 7.5 Rear End Plate and Control Unit Connector—Exploded View

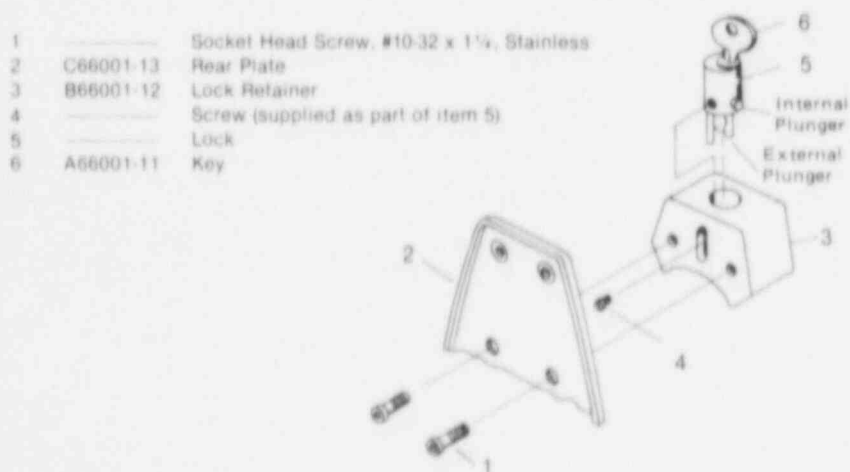


Figure 7.6 Lock Assembly—Exploded View

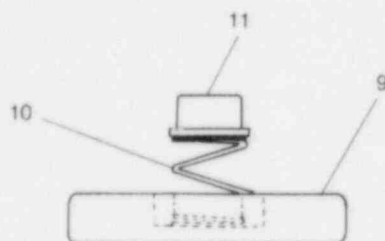


Figure 7.7

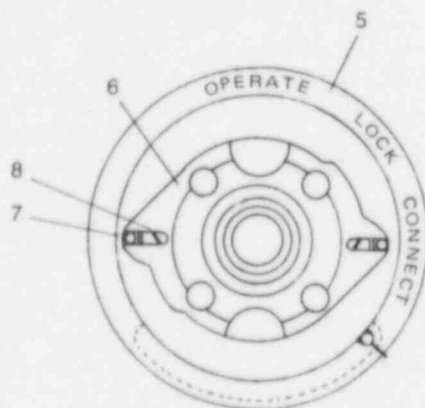


Figure 7.8

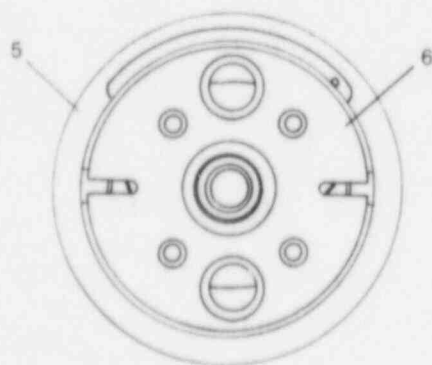


Figure 7.9

## MAINTENANCE

### LEAK TEST CONT.

1. Moisten the wipe test swab with EDTA solution.
2. Remove the shipping plug and wipe the inside of the S-tube and the female connector assembly with the wipe test swab.
3. Place the wipe test swab in the plastic envelope.
4. Set the survey meter on its most sensitive range and place the meter in an area with low background radiation. Move the wipe test swab towards the meter, and observe the radiation level indication.
5. If the radiation level increases less than 0.2mR/hr above background, place the plastic envelope into the mailing box and mail to Tech/Ops, Inc. Be sure to complete and return the identification sheet.
6. If the meter indicates a higher radiation level, do not mail the wipe test patch and do not use the exposure device. Contact Tech/Ops, Inc. for further instruction.

### TRIPOD STAND

Refer to Figure 7.10 for component identification of the tripod stand.

### GUIDE TUBES, CONTROL HOUSINGS AND DRIVE CABLE—REPLACEMENT

Part Number	Component
B48906	Master Guide Tube (with source stop)
B48907	Extension Guide Tube
B59100	Control Housing (25 foot)
A59100-1	Swage Fitting (for control housing)
A55005	Drive Cable

### EXPOSURE DEVICE REPLACEMENT PARTS

Refer to Figure 1.2.

Use these component identification numbers when ordering:

D66001	Exposure Device (Complete)
B66001-7	Storage Cover
—	#6-32 x 3/8 LG pan head screw
C66001-10	Source Identification Plate
A66001-11	Key
B66001-21	Danger Tag
B66001-20	Jumper (Inside Storage Cover)
—	Sash Chain, 2 3/4", steel/copper (NS)
A52401-1	Storage Plug

1	40201-7	Burette Clamp
2	40201-8	Clamp Holder
3	P/O 40201-9	Aluminum Rod, 1/2" Diameter x 32" Threaded 3/8-16 x 5/8"
4	P/O 40201-9	Tripod Base

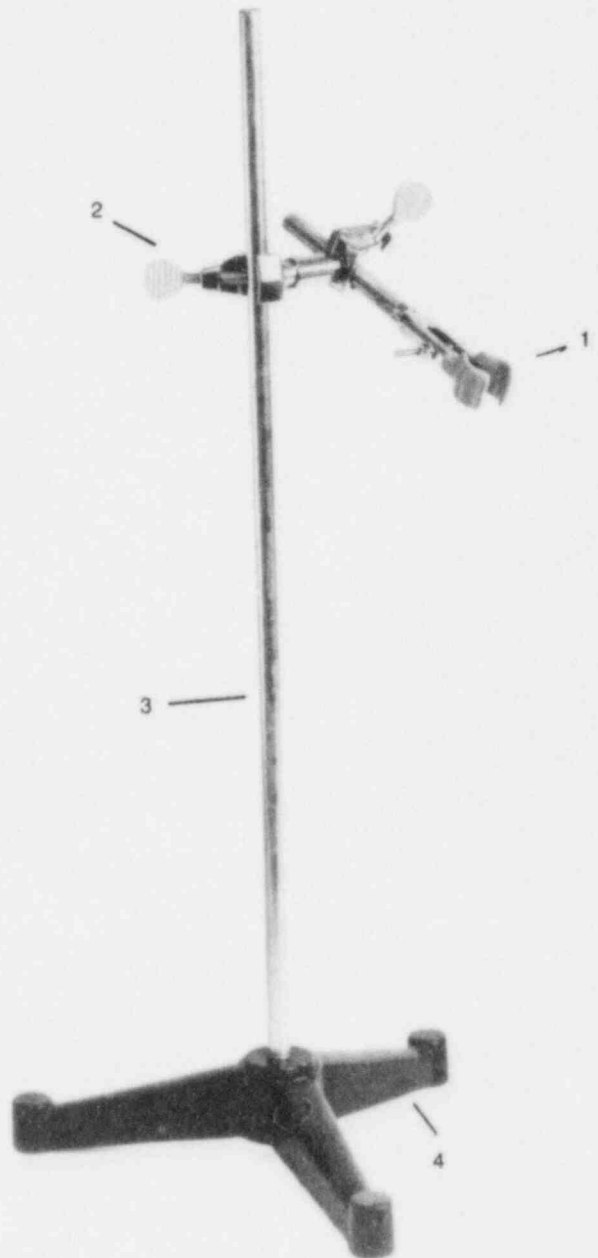


Figure 7.10 Tripod Stand



**Tech/Ops**

Radiation Products Division  
40 North Avenue  
Burlington, Mass. U.S.A. 01803

Telephone (617) 272-2000  
Telex 949313 (TORADPROD BURL)  
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**U. K. DIVISION**

TECH/OPS, INC.  
Radiation Products Division  
Unit 1, Whitworth Road  
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NE 37 IPP, ENGLAND

Telephone 0-632-473191  
Telex 851 538217 (TECOPS G)

Tech / Ops



Radiation Products Division  
40 North Avenue  
Burlington, Massachusetts 01803  
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INSTRUCTION MANUAL

MODELS 900, 910, 920

RADIOGRAPHIC EXPOSURE DEVICES

Revised 4 August 1983

Model 900, 910 and 920  
Instruction Manual

DRAFT: 4 August 1983

NOTICE

This gamma radiography system is used as a radiographic exposure device and Type B shipping container for Tech/Ops, Inc. sources. The user should become thoroughly familiar with the instruction manual before attempting operation of the equipment.

In order to use this equipment or perform source changes, the user must be specifically licensed to do so. Applications for a license should be filed on Form NRC-313R with the Materials Licensing Branch, Division of Fuel Cycle and Material Safety, Office of Nuclear Safety and Safeguards, U.S. Nuclear Regulatory Commission, Washington, DC 20555, or with the appropriate agreement state office.

Prior to the initial use of the exposure device as a shipping container, the user should register with the Transportation Certification Branch, Division of Fuel Cycle and Material Safety, Office of Nuclear Safety and Safeguards, U.S. Nuclear Regulatory Commission. The user should have in his possession a copy of the USNRC Certificate of Compliance issued for the exposure device, which may be obtained from Tech/Ops upon request. This requirement also applies to users from agreement states.

Users of this equipment outside of the United States must comply with the regulatory licensing and transportation rules and regulations as they apply in their respective countries.

SECTION 1  
GENERAL INFORMATION

A. General

The Model 900 Series portable gamma radiography systems, shown in Figure 1.1, are used primarily for industrial radiography. The systems operate in similar manner and differ only in the specific control unit supplied.

The portability feature of the systems provides both a convenient means of transporting the radioactive source and operating flexibility, particularly useful in areas where access is limited. In use, the system allows remote positioning of an iridium<sup>192</sup> radioactive source at a predetermined location. The 360° (panoramic) radiation pattern may be used to full advantage, either for multiple specimen work or for circumferential exposure techniques. Optional collimators are available which limit the panoramic pattern to a directional beam. The systems may be used with iridium<sup>192</sup> sources up to a maximum of 100 curies for the Model 900, 25 curies for the Model 910 or 200 curies for the Model 920. Iridium<sup>192</sup> sources of lesser activity are available. Basic source information is inscribed on the nameplate of the exposure device.

B. System Safety

The systems are designed to provide a number of safety features under normal conditions of use. There is positive mechanical control of the source, and an odometer provides a visual indication of the drive cable

position. In addition, the source connector is designed so that under normal conditions of operation:

- a. The system cannot be operated (source exposed) unless a secure connection of the source assembly to the drive cable is made and
- b. The control unit cannot be disconnected unless the radioactive source assembly is properly stored in the shield.

C. System Components

All components of the gamma radiography systems are identified in Figure 1.1.

1. Gamma Ray Projector Models 900, 910 and 920

The exposure device serves as the storage and transport device for the radioactive source assembly. The exposure device consists of a steel housing which contains a depleted uranium shield. When the source is properly stored in the exposure device, the shielding properties of the depleted uranium reduce radiation intensities in the vicinity of exposure device to levels well below the regulatory limits.

Figure 1.2 shows both ends of the exposure device. A special positive connector is located at one end. This connector is used to engage the control unit. The control connector has a three-position selector ring - OPERATE, LOCK and CONNECT. For maximum safety when the control unit is disconnected from the exposure device, the storage cover should be installed and the connector should be in the LOCK position with the lock engaged and the key removed. All of the connector

positions are discussed in detail in Section IV, OPERATION. The guide tube connector is located at the opposite end of the exposure device. Figure 1.2 identifies the connector. Also shown in Figure 1.2 is the indicator knob, which is connected to the indicator slide. The indicator slide must be in the UP position in order to perform an exposure, and automatically moves to the DOWN position when the source is retracted. The indicator knob serves as a visual positive source position indicator. The indicator slide prevents the entry of foreign material when in the DOWN position. A positive mechanical stop prevents opening the indicator slide unless the source guide tube is connected.

The size and weights of the Model 900 series exposure devices are presented in Section I.E.

## 2. Guide Tube Assembly

Several optional arrangements for guide tube assemblies are available and are described in Section I.E. Guide tubes are made from flexible stainless steel tubing with a protective polyvinyl covering.

The system should never be operated without a source stop in place at the end of the guide tube assembly. This source stop may be a fixed stop attached to a master guide tube section, a removable stop attached to an extender guide tube section, or a collimator containing a source stop attached to an extender guide tube. Use of the system without a source



stop in place at the end of the guide tube can allow the source assembly to emerge from the guide tube to a position from which it may not properly retract. This may also allow dirt to enter the guide tube causing operational difficulties.

The length of the guide tube assembly must always be less than the length of the control unit. When using a 25 ft. (7.6m) long control unit, we recommend that the guide tube assembly does not exceed 22 feet (6.7m). When using a 35 ft (10.7m) long control unit, we recommend that the guide tube assembly does not exceed 30 feet (9.1m).

### 3. Tripod Stand

The tripod stand provides a means of securing the source stop to allow the source to be positioned at the desired focal position. The stand has adjustable clamps which will provide an unlimited degree of positioning flexibility. The weighted tripod base provides a solid foundation for the stand. The tripod stand, complete with clamps, weighs approximately ten pounds (4.5kg).

### 4. Model 664 Control Unit

The Model 664 control unit consists of a hand crank, odometer, two control housings, drive cable and lightweight convenient cable storage reel. The standard control unit has 25 ft (7.6m) control housings. Option lengths are available up to 35 feet (10.7m).

In operation, the hand crank controls the movement of the source between the storage position in the exposure device and the exposure position in the guide tube. The odometer indicates the distance (in feet and inches) that the source and drive cable has been moved from its storage position. The reel provides a convenient storage facility for both the control cable and the guide tubes.

The inner helically-wound flexible steel drive cable (the actual controlling element) terminates with the male section of the swivel-type cable connector used to securely engage the radioactive source assembly. The drive cable connector permits the disconnection of the control unit and replacement of the source. A stop spring is installed at the opposite end of the drive cable to prevent the drive cable from being inadvertently cranked off the drive gear. The control housing is terminated at one end by the control cable connector which mates with the positive connector on the exposure device and at the other end by fittings which attach it to the main frame of the control unit. The 664 control unit with the control housings and drive cable weigh approximately twenty-two pounds (10kg).

#### 5. Model 693 Control Unit

The Model 693 control unit is similar to the Model 664 control unit. However, the Model 693 unit does not have the storage reel. It is provided with a pistol grip handle for convenient operation. The Model 693 control unit with the control cable weighs approximately nineteen pounds (8.6kg).

#### 6. Model 692 Control Unit

The Model 692 control unit is similar to the Model 693 control unit. However, the Model 692 unit does not have an odometer. The Model 692 control unit with the control cable weighs approximately eighteen pounds (8.2kg).

#### D. Radioactive Source Assembly

The radioactive iridium<sup>192</sup> source must be ordered separately from other system components. The Model 900 series exposure devices can operate with various activity sources up to a maximum of 200 (+20%) curies as described in Section I.E. The radioactive material is sealed in a stainless steel capsule which is installed inside a source holder assembly. The end of the source holder assembly has the female section of a swivel-type connector firmly attached to it to provide a secure connection to the drive cable.

The source may be changed only by a user licensed to do so. This is done using a Tech/Ops Model 850 source changer which also serves as a shipping container. An unlicensed user can have Tech/Ops either send a qualified person to perform this operation, or change the source at its plant location.

E. Specifications1. Exposure Device

Model	<u>910</u>	<u>900</u>	<u>920</u>
Length	12.25in (311mm)	12.25in (311mm)	12.25in (311mm)
Width	5.25in (133mm)	5.25in (133mm)	5.25in (133mm)
Height	7.75in (197mm)	7.75in (197mm)	7.75in (197mm)
Mass	34lbs (15kg)	44lbs (20kg)	48lbs (22kg)
Shielding (Depleted Uranium)	18lbs (8.2kg)	28lbs (13kg)	32lbs (15kg)
Capacity	25Ci(+20%)	100Ci(+20%)	200Ci(+20%)
Source Assembly	Model 91003	Model 90003	Model 90003
Type B Identification	USA/9149/B(U)	USA/9141/B(U)	USA/9143/B(U)

2. Control Unit

Model	<u>664</u>	<u>693</u>	<u>692</u>
Type	Reel (6.6in x 12in x 2lin)	Pistol Grip	Pistol Grip
Standard Control Length	25ft (7.6m)	25ft (7.6m)	25ft (7.6m)
Optional Lengths to 35ft (10.6m) available			
Odometer	Yes	Yes	No
Weight (Standard)	22lbs (10kg)	19lbs (8.6kg)	18lbs (8.2kg)

### 3. Guide Tubes

EXHIBIT R

<u>Model</u>	<u>Length</u>	<u>Terminations</u>
90201	7 ft (2.1m)	Quick Disconnect - Fixed Source Sto
90202	7 ft (2.1m)	Quick Disconnect - Female Thread
90203	7 ft (2.1m)	Male Thread - Female Thread
90204	7 ft (2.1m)	Male Thread - Fixed Source Stop
90205	14 ft (4.3m)	Quick Disconnect - Fixed Source Sto
90206	21 ft (6.4m)	Quick Disconnect - Fixed Source Sto

### F. Optional System Accessories

Model 40201	Tripod Stand
Model 90207	Removable Source Stop
Model 903	Panoramic Lead Collimator (360° x 30°; 15 pounds; 7 kg)
Model 904	Directional Lead Collimator (30° x 60°; 15 pounds; 7 kg)
Model 906	Directional Lead Collimator (60° cone; 3 pounds; 1.4 kg)
Model 907	Directional Lead Collimator (60° cone; 3 pounds; 1.4 kg)
Model 911	Directional Tungsten Collimator (60° cone; 2 pounds; 0.9 kg)
Model 912	Directional Tungsten Collimator (60° cone; 5.5 pounds; 2.5 kg)
Model 913	Directional Tungsten Collimator (60° cone; 15 pounds; 6.8 kg)
Model 914	Panoramic Tungsten Collimator (360° x 20°; 6 pounds; 2.7 kg)
Model 915	"J" Tube Radiography Fixture
Model 534	Slide Rule Exposure Calculator
Model 550	Connector Wear Gage
Model 492D	GAMMALARM Radiation Monitor
Model 492E	GAMMALARM Remote Flasher
Model 850	Source Changer

SECTION II  
PERSONNEL MONITORING

Pursuant to NRC and state regulations, all personnel who enter a restricted area or are present during radiographic operations are required to wear a direct reading pocket dosimeter with a range of zero to at least 200 milliroentgens and either a film badge or thermoluminescent dosimeter (TLD). The pocket dosimeter must be recharged at the beginning of each shift. The operator should frequently check the pocket dosimeter reading throughout the shift. Dosimeter readings must be recorded at the end of each shift. Records of the initial and final readings of the pocket dosimeter must be kept for inspection by the NRC until it authorizes their disposal.

In the event that a person's pocket dosimeter is found to be off scale, that person must stop all work with radiation immediately. His film badge (or TLD) must be sent in immediately for processing, and he must not reenter a restricted area until it has been determined that he received less than the maximum allowed occupational exposure as defined in 10CFR Part 20.101.

Radiography personnel should also have a calibrated and operable radiation survey meter capable of measuring from 2mR/hr to at least 1000mR/hr to determine radiation levels when performing radiographic operations.



SECTION III  
ACCESS TO RESTRICTED AREAS

Since this gamma radiographic system can emit high levels of radiation when being operated, it is necessary to identify boundaries around the site where the radiography is being done. If a permanent radiographic installation is being used, it must have appropriate personnel access control devices as defined in 10CFR20.203. Otherwise, certain areas must be set off as follows:

Access to the restricted area must be controlled. A restricted area is defined in 10CFR20.105 as the area where the radiation exposure level exceeds two milliroentgens in any one hour, or 100 milliroentgens in seven consecutive days or 500 milliroentgens in one year. The restricted area should also be posted with signs reading "Caution (or Danger) - Radiation Area." Signs reading "Caution (or Danger) - High Radiation Area" should be posted around the perimeter where radiation exposure levels can exceed 100 milliroentgens in any one hour. A physical survey with a survey meter should be performed while the source is at its exposing position to confirm the radiation exposure rate at the perimeter of the Restricted Area. In order to minimize radiation exposure to the surveying personnel, a survey is not required and should not be done to confirm the High Radiation Area boundary.

The radiographer or radiographer's assistant must guard against unauthorized entrance into these areas at all times. No personnel should be allowed into the restricted area without a direct reading pocket dosimeter and either film badge or TLD.

SECTION IV  
TRANSPORTATION AND STORAGE

A. Receiving Radioactive Material

The consignee of a package of radioactive material must make arrangements to receive the package when it is delivered. If the package is to be picked up at the carrier's terminal, 10CFR Part 20.205 requires that this be done expeditiously upon notification of its arrival.

Tech/Ops portable gamma radiography system components are normally shipped in two crates. Inspect the crates for signs of external damage. If damage is evident, the carrier's agent should be present while unpacking. Survey the exposure device with a survey meter as soon as possible, preferably at the time of pickup and no more than three hours later if it was received during working hours, or no more than 18 hours later if it was received after normal working hours. Radiation levels should not exceed 200 milliroentgens per hour at the surface of the exposure device nor 10 milliroentgens per hour at a distance of three feet from the surface. Actual radiation levels should be recorded on the receiving report. If the radiation levels exceed these limits, the container should be secured in a Restricted Area, and the appropriate personnel notified.

Open the crates and remove the remaining system components. They are:

- a) swivel clamp
- b) source tube clamp
- c) tripod base

- d) tripod rod
- e) control unit with attached control housing and drive cable.
- f) guide tubes

These parts should be inspected for physical damage.

The source isotope, activity, model number and serial number and the shipping container model number and serial number should be recorded in the receiving report.

B. Shipping Radioactive Material




The Model 900 series exposure devices and the Model 850 source changer meet the requirements for Type B shipping containers under the regulations of the U.S. Nuclear Regulatory Commission, the U.S. Department of Transportation and the International Atomic Energy Agency. The devices have been assigned USNRC Certificates of Compliance for domestic shipments and IAEA Certificates of Competent Authority for international shipments. The package identification numbers are listed in Section I.E.

The following shipping procedures comply with USNRC Regulations 10CFR Part 71 and USDOT Regulations 49CFR Parts 171 through 179 regarding the transportation of radioactive materials.

each shipping label are given in Figure 4.1. If radiation levels above 200mR/hr at the surface or at 10mR/hr at one meter from the surface are measured, the container must not be shipped.

- 5) Properly complete two shipping labels indicating the radioactive isotope, activity 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 milliroentgens per hour measured at a distance of three feet from the surface of the package. Put these two labels on opposite sides of the container after making sure any previous labels have been removed. The package should be marked with the proper shipping name (Radioactive Material, Special Form, n.o.s.) and the identification number (UN 2974). If the exposure device is packaged inside an outer container, mark the outside package "INSIDE PACKAGE COMPLIES WITH PRESCRIBED SPECIFICATIONS-TYPE B USA/xxxx/B(U)."
- 6) Complete the appropriate shipping papers - Examples are shown in Figures 4.2 and 4.3. These shipping papers must include:
  - a. Proper Shipping Name (Radioactive Material, Special Form, n.o.s.) and Identification Number (UN2974).
  - b. Name of Radionuclide (Iridium-192)
  - c. Activity of the Source (in curies)

Figure 4.1

	Maximum Radiation Level	
	at Surface	at One Meter
Radioactive White I 	0.5 mR/hr	None
Radioactive Yellow II 	50 mR/hr	1.0 mR/hr
Radioactive Yellow III 	200 mR/hr	10 mR/hr

- d. Category of Label Applied (i.e. Radioactive Yellow II)
- e. Transport Index
- f. Package Identification Number (i.e. USA/9141/B(U) Type B)
- g. 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."

- Notes: 1. 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, packed, marked and labeled and are in proper condition for carriage by air according to applicable national governmental regulations."

2. For air shipments to, from or through the United States, a "CARGO AIRCRAFT ONLY" label and the shipping papers must state:

"THIS SHIPMENT IS WITHIN THE LIMITATIONS PRESCRIBED FOR CARGO-ONLY AIRCRAFT."

#### C. Shipping Empty Packages

This section applies to shipping the Model 900 series exposure devices or Model 850 source changer without a radioactive source. Since these devices use depleted uranium for shielding, shipment of these devices is governed by the requirements for transporting radioactive material.

1. If the container is to be packaged inside a crate or other outer packaging, the outer packaging must be strong enough to withstand the normal conditions of transportation. Place the container in the outer package with sufficient blocking to prevent shifting during transportation.



2. Perform a radioactive contamination wipe test of the shipping package and assure that the wipe test does not exceed 0.001 microcurie per 100 square centimeters.
3. Survey the package at the surface and at one meter from the surface to determine the proper radioactive shipping labels to be applied to the package.
  - a. If the surface radiation level is less than 0.5 millirem per hour and there is no measurable radiation level at one meter from the surface, no label is required. Mark the outside of the package with the proper shipping name and identification number (Radioactive Material, Article Manufactured from Depleted Uranium, UN 2909). Mark the outside of the package with the statement:

"EXEMPT FROM SPECIFICATION PACKAGING, SHIPPING PAPER AND CERTIFICATION, MARKING AND LABELING, AND EXEMPT FROM THE REQUIREMENTS OF PART 175 PER 49 CFR 173.421-1 AND 49 CFR 173.424".

Additionally, a notice must be enclosed in or on the package, included with the packing list or otherwise forwarded with the package. This notice must include the name of the consignor or consignee and the statement:

"THIS PACKAGE CONFORMS TO THE CONDITIONS AND LIMITATIONS SPECIFIED IN 49 CFR 173.424 FOR EXCEPTED RADIOACTIVE MATERIAL, ARTICLES MANUFACTURED FROM DEPLETED URANIUM, UN2909".

- b. If the surface radiation level exceeds 0.5 millirem per hour, or if there is a measurable radiation level at one meter from the surface, use the criteria of Figure 4.1 to determine the proper radioactive shipping labels to be applied to the package. Mark the outside of the package with the proper shipping name (RADIOACTIVE MATERIAL, LSA, n.o.s.) and the Identification Number (UN2912). If the container is packaged inside a crate or other outer packaging, mark the outer package with the statement: "Inside Package Complies with Prescribed Specifications."

Properly complete the shipping papers indicating:

- (1) Proper shipping name (Radioactive Material, LSA, n.o.s.) and Identification Number (UN2912)
- (2) Name of Radionuclide (Depleted Uranium)
- (3) Physical or Chemical Form (Solid Metal)
- (4) Activity (in curies or millicuries)
- (5) Category of Label Applied (i.e. Radioactive Yellow II)
- (6) Transport Index
- (7) Package Identification Number (i.e. USA/9141/B(U))
- (8) 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."

- Notes: 1. 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, packed, marked and labeled and are in proper condition for carriage by air according to applicable national governmental regulations."

2. For Air Shipments to, from or through the United States, "CARGO AIRCRAFT ONLY" label and the shipping papers must state:

"This shipment is within the limitations prescribed for cargo-only aircraft."

D. Carrying Radioactive Material

Any vehicle that is to be used to transport radioactive material should be in good operating condition and carry a normal complement of safety equipment such as Radiation Area signs, rope, spare tire, fire extinguisher, vehicle tools and flares. The glove compartment should have the vehicle's registration certificate and an operable flashlight. Additionally, the driver must have a calibrated and operable radiation survey meter and be wearing a direct reading pocket dosimeter and either a film badge or a thermoluminescent dosimeter.

Before placing the container in the vehicle and securing it against movement, the operator should ensure that the container is properly packaged, marked, and labeled and that the proper shipping papers are completed according to Part IV.B or IV.C. The operator should survey the driver's compartment to ensure that radiation levels are below two milliroentgens per hour.

In the event that the vehicle is used for storage, a survey must be conducted to ensure that radiation levels are less than two milliroentgens per hour at a distance of 18 inches from the surface of the vehicle. Also, if the vehicle is used for storage, it should be posted with "Caution - Radioactive Material" signs.

If the vehicle is transporting a package bearing a "Radioactive Yellow III" label, 49CFR Part 172.504 requires that the vehicle be posted on all four sides with a "RADIOACTIVE" placard. It should be noted that operation of a vehicle which is required to be placarded must comply with the Federal Motor Carrier Safety Regulations, 49CFR Parts 390-397.

E. Hand Carrying

In order to minimize radiation exposure, it is recommended that care be taken when hand carrying the unit. Dosimeter and film badge should be worn on the side of the body closest to the exposure device. If more than one person is present, it is good practice to alternate the hand carrying between them to minimize radiation doses to any one individual. Likewise, no person should be permitted to sit on or lounge against the exposure device.

F. Storage

When storing the system, the exposure device must be kept physically secure to prevent tampering or removal by unauthorized personnel. The storage area must be secured such that no unauthorized personnel are allowed entrance where radiation exposure levels exceed 2 millirem in any one hour. When storing the system between uses, keep the plastic caps (supplied with the system) in place on the guide tubes. This eliminates dust accumulation within the tubes. 10CFR Part 34.22 requires that the exposure device be kept locked, and the storage plug inserted during storage.

## SECTION V OPERATION

### A. Principles of Operation

The source holder assembly, which contains the encapsulated radioactive source, is stored in the center of the exposure device (see Figure 5.1a)) and is attached by means of a swivel connector to the drive cable. The hand crank on the control unit moves the drive cable through the control housing. Figure 5.1(b) shows the source being moved out of the storage position in the exposure device and into the guide tubes. This action occurs by rotating the hand crank in the EXPOSE (counterclockwise) direction. Figure 5.1 (c) shows the source reaching the source stop which serves as a mechanical stop at the radiographic focal position. The hand crank will not turn any further and the odometer in the control unit should indicate a reading which approximates the total length of the combined guide tubes. To return the source to the exposure device (stored position), the hand crank is turned to the full RETRACT (clockwise) position. When the source is fully retracted, the indicator knob will automatically return to the STORED (down) position, signaling that the source is properly shielded.

### B. Safety Precautions

This system may be operated only by a qualified radiographer and/or his assistant. The radiographer must be physically present and in direct surveillance at all times when the exposure device is being used.

Since the source emits high levels of radiation, it is good practice to operate the system from as great a distance as practicable and, if possible, from behind a radiation shield such as a heavy steel or concrete object or the corner of a building.

Radiography must only be performed in a Restricted Area which is marked with the appropriate radiation signs, and secured against unauthorized entrance. While assembling the system, it is important to keep the exposure device locked at all times except when operating. The radiographer and radiographer's assistant must at all times have a pocket dosimeter, either a film badge or TLD, and a survey meter capable of measuring from 2mR/hr to at least 1000 milliroentgen/hr.

#### C. Daily Inspection

Daily inspection of the system is required to ensure that the equipment is in the proper operating condition. The inspection should be performed prior to the start of each shift.

- 1) Inspect the entire length of each source guide tube section and control housing to ensure that each section is free from cuts and dents.
- 2) Inspect the end fittings to ensure that they are tightly connected. Check the threads on the fittings, the control cable connector and the male source connector for damage.
- 3) During the first exposure of the shift, check the operation of the selector ring and lock assembly and control crank. If



operation is difficult, retract the source to the stored position, and survey the equipment according to the Operating Instructions. The system must be serviced before further operation.

D. Assembly

- 1) Position and secure the source stop of the master source guide tube at the radiographic focal position. Note that the radiographic focal position is  $3\frac{1}{2}$ " (8.9cm) behind the tip of the source stop.
- 2) Determine where the exposure device will be positioned and connect the extender source guide tubes as required, laying them as straight as possible and with no bend radius less than twenty inches. (Smaller bend radii will restrict the movement of the control cable).

WARNING

Never operate the system with the total source guide tube length greater than the length of the control housing because the source will be unable to reach the source stop.

- 3) Connect the source guide tube(s) to the exposure device.
- 4) Determine where the control unit will be positioned (as far away from the radiographic focal position as possible and preferably behind a radiation shield) and lay out the control housing with no bend radii less than 36 inches.
- 5) Connect the control unit to the exposure device according to

the illustrated sequence in Figures 5.2 through 5.6.

- 6) Before operation check all connections and bend radii, and check the position of the source stop which represents the radiographic focal position of the source.
- 7) Check the operation of the survey meter by reading the radiation level AT the surface of the exposure device. It should read no more than 200mR/hr if the exposure device is loaded to maximum capacity.
- 8) Unlock the exposure device lock and rotate the selector ring to the OPERATE position. Lift the indicator knob up until the indicator slide locks in place. The source is now free to move.

#### E. Operation

- 1) Return to the control unit. Adjust the odometer reset knob to obtain a 000 reading on the odometer.
- 2) Recheck to be sure that no unauthorized personnel are inside the Restricted Area.
- 3) Rapidly rotate the crank in the EXPOSE (counterclockwise) direction to move the source to the radiographic focal position. The survey meter should read about full scale (1000mR/hr) for a 100 curie 192 Iridium source when the source first leaves the exposure device, drop gradually as

the source is driven to the radiographic focal position and remain steady during the exposure. The survey meter readings will be substantially reduced if the meter is operated behind a radiation shield or if a collimator is used.

- 4) When the source reaches the source stop, the hand crank will stop turning. Never exert more than 5 ft-lbs of torque on the hand crank, as this may cause damage to the control unit or drive cable. The odometer reading will indicate the total distance the source has traveled (approximately 7 ft. for one source guide tube section, 14 ft. for two source guide tube sections, and 21 ft. for three sections.) Set the brake to ON to prevent movement of the source during the exposure.
- 5) Figure the specimen exposure time from the moment the source reaches the source stop.
- 6) During the exposure, spend as little time as possible in the Restricted Area to minimize personnel exposure.
- 7) To return the source to the exposure device after the desired exposure time has elapsed, turn the brake to OFF and rapidly turn the crank in the RETRACT (clockwise) direction until the crank will no longer move. The odometer should read 000. During this process, the survey meter should indicate a continually increasing radiation level (up to approximately 1000mR/hr for a 100 curie  $^{192}\text{Ir}$  iridium source), then drop to



background level when the source is shielded in the exposure device. When the source is fully retracted into the exposure device, the indicator knob will automatically close, signaling that the source is properly shielded.

NOTE

Do not maintain tension on drive cable as this will prevent the source position indicator from being latched in the open position for the next exposure. After retracting the source and after the indicator knob has closed, relax the tension on the drive cable using the hand crank.

- 8) Approach the exposure device with the survey meter and survey the exposure device on all sides. The meter should indicate the same radiation level as observed in step 7 of Assembly.
- 9) Survey the entire source guide tube with the survey meter. If the meter shows a sharp increase, the source could still be exposed, or incompletely shielded.
- 10) If the source is still exposed, attempt to store it properly by cranking the source a short distance toward the source stop and then retracting it, repeating if necessary.
- 11) If the source becomes jammed in an exposed position, do not try to retrieve the source. Treat the situation as an emergency; notify the supervisor and Tech/Ops, Inc. for help if necessary.
- 12) When the source is properly stored in the exposure device, rotate the selector ring from the OPERATE position to the LOCK position and secure it with the exposure device lock.



## NOTE

If the selector ring cannot be rotated to the LOCK position, the source has not been fully retracted. Check the control unit odometer reading. It should be 000. turn the hand crank to the full clockwise (RETRACT) direction.

F. Disassembly

- 1) Unlock the exposure device, and rotate the selector ring from LOCK to CONNECT. The control unit connector will partially disengage.
- 2) Refer to figures 5.2 through 5.6 to disengage the control unit from the exposure device.
- 3) Replace the storage cover in the control unit connector and rotate the selector ring to the LOCK position. Remove the key and engage the lock to secure the exposure device. Survey the entire circumference of the exposure device with the survey meter to ensure the source is properly secured.
- 4) Disconnect the source guide tube sections. Place the plastic caps on the connector plug to eliminate dust and dirt from entering the tubes. Coil the control housing around the control unit.

SECTION VI  
SOURCE CHANGES

Source changes may be done using a Tech/Ops Model 850 source changer, which also serves as a shipping container. A source change can be performed only if the user is specifically licensed to do so. If not, Tech/Ops, Inc. can send a qualified person to perform the source change, or the exposure device can be sent to Tech/Ops for source replacement at the plant. The source change must be done in a Restricted Area as described in Section III. Section II on personnel monitoring and Part V.B. on Safety Precautions should be followed here as well.

To perform a source change, do the following:

- 1) Survey the source changer to ensure the source is in the proper storage position.
- 2) Position the source changer in an upright position and near the exposure device so that one section of source guide tube will connect them with no sharp turns or bends. The bend radius of the guide tube should never be less than twenty inches. Shorter bend radii can restrict source movement in the source guide tube.

WARNING

The source changer must remain in an upright position during source changing operations. Do not position source changer on its side.

- 3) Remove any foreign matter from the guide tube connector and attach the source guide tube to the exposure device. Remove the source changer cover plates by breaking the seal wire and removing the bolts. Attach the other end of the tube to



the empty chamber of the source changer. Assure that the lock assembly of the chamber containing the source is in the LOCKED position. Unlock the key operated lock over the empty chamber and slide the lock bar to the OPEN position.

- 4) Attach the control unit to the exposure device as in Part V.D. and lift the indicator knob up until the indicator slide locks in place. The source is now free to move.
- 5) Crank the source rapidly from the exposure device to the source changer. During this process, the survey meter reading should increase (to approximately 1000mR/hr for a 100 curie iridium<sup>192</sup> source) as the source is first exposed, fall slightly as the source is being cranked out then drop to background when the source is in the source changer.
- 6) Approach the exposure device, source changer and source guide tube with the survey meter. Survey the exposure device on all sides, the guide tube and the source changer on all sides to ensure that the source is fully within the source changer. The maximum radiation levels should not exceed 200mR/hr on the surface of the source changer nor 10mR/hr at three feet from the surface.
- 7) Slide the lock bar to the locked position and engage the key operated lock.

WARNING

Do not remove the guide tube from the source changer fitting until the lock slide is in the lock position and the key operated lock is engaged.

- 8) Disconnect the source guide tube from the source changer lock assembly. Disconnect the drive cable from the source holder assembly by moving the lock pin down and sliding the drive cable connector out through the keyway.
- 9) If a replacement source is to be installed in the exposure device, couple the drive cable to the new source holder assembly and connect the source guide tube to the fitting on the source changer. Unlock the key operated lock on the chamber containing the source to be transferred and slide the lock bar to the OPEN position.
- 10) Return to the controls and crank the new source or drive cable into the exposure device. If a new source is being transferred, the survey meter should increase as the source leaves the source changer and approaches the exposure device, then drop to background level when the source is shielded in the exposure device. If a source is not being transferred, the survey meter should indicate only background radiation levels.
- 11) Approach the exposure device with a survey meter. Survey the exposure device on all sides, survey the guide tube and survey the source changer on all sides to ensure that the process has been properly completed. Radiation levels should read no more than 200mR/hr at the surface of the exposure device if it has been loaded to maximum capacity. If no source has been transferred, only background radiation should be detected by the survey meter. Rotate the selector ring to the lock position.

- 12) Assure that the source is secure in the source changer by assuring the slide mechanism is in the lock position and the lock plunger is depressed.
- 13) Disconnect the control unit and source guide tube from the exposure device as in Part V.F. and disconnect the source guide tube from the source changer.
- 14) Remove the source identification plate from the exposure device and attach it with seal wire to the source changer.

- 15) If the exposure device contains a source, affix the identification plate of the new source to the exposure device. If not, attach an EMPTY tag to the handle of the exposure device.
- 16) If the source changer is to be transported, bolt the source changer cover plates in place and secure them with seal wire, and follow the transportation instructions of Section IV.
- 17) Return the source changer promptly to Tech/Ops, Inc. Rental charges will be made for containers held beyond normal operating time.



## SECTION VII

## MAINTENANCE

It is recommended that inspection and maintenance of the Model 900 series exposure devices and control units be performed at intervals not to exceed ninety days.

To service the Model 900 series exposure devices and control units, the following equipment is required, in addition to standard tools such as screwdrivers, wrenches, etc.

Master Key (PN A66001-11)

Cleaning Solvent (chloroethene)

Rivet gun and pop rivets (.115" diameter x .294" long)

MIL-G-13827A grease (Texaco "Uni-Temp")

Vibratite

A. Control Unit

1. Drive cable, control housings and Source Guide Tubes-Disassembly

To service the drive cable, control housings and source guide tubes, follow these steps:

1. Disconnect the control unit from the exposure device.
2. Turn the hand crank of the control unit in the EXPOSE (counter-clockwise) direction until the crank will no longer turn. Do not use force, as this may damage the drive wheel inside the control box. The emergent cable should be cranked into a bucket or other container to keep it clean.
3. Disconnect the control housings from the RETRACT side of the crank and remove the stop spring from the drive cable. The drive cable will now pass through the crank.

4. Turn the crank until the drive cable is totally disconnected.
5. Pull the drive cable out through the control cable connector and coil it with a radius of no less than four inches.
6. Remove the control cable connector and connector plug from the control housings, and disconnect the other control housing from the crank. Label the housings for proper reassembly.
7. Clean the drive cable with chlorothene and flush the control housings and source guide tubes.
8. Using compressed dry air (15psi max.), thoroughly dry the drive cable, control housings and guide tubes. Any remaining solvent can cause permanent damage.
9. Check the source guide tubes for binding by holding them vertical and dropping a dummy source (or jumper) through them.
10. Wipe the guide tubes and control housings with a cloth soaked in chlorothene and flex them to check for internal damage. Damage is evidenced by a crunching feeling when the housing or tube is bent. While doing this, feel for dents. Cut, flattened or burnt control housings or guide tubes should be repaired or replaced.

11. The guide tubes or control housings may be covered with tape where only the outer plastic is cut through.
12. Using a Model 550 no-go gauge, check the male connector of the drive cable. If the ball of the connector fits through the hole of the gauge or the ball shank fits into the slot in the gauge, the connector is worn and the cable must be replaced. Refer to Figure 7.1.
- 13) Lightly grease the cable using TEXACO "Uni-Temp" grease. Other greases may form tars or corrosive compounds when exposed to radiation.

## 2. Crank Assembly - Model 664 Control Unit

To service the Model 664 control unit, perform the following steps:

### Disassembly

1. Remove the control housing and drive cable from the crank assembly as described in the previous section. Refer to Figure 7.2 to aid in disassembly and for component identification of replacement parts.
2. Remove the control box housing (4) from the frame (11) by unscrewing the four binder head screws and 3/8" nuts (1).
3. Remove the crank arm assembly from the control box housing by removing the 5/16" hex head bolt.(2)



## CAUTION

Make sure the cable adapters stay in the lower control box housing during separation. Care should be taken to avoid possible injury from or loss of the tension loaded wear strip.

4. Separate the two halves of the control box housing, keeping the cable adapters in the lower control box housing to ensure the wear strip (5) does not fly out. Remove the drive wheel (6), wear strip (5), two cable adapters (14), two brake jaws (15), brake arm (16) and brake bearing (13).
5. The two ball bearing assemblies (7) in each side of the control housing may be left in place.
6. Remove the reset knob (29) by loosening the two set screws, and remove the odometer cover (28) by removing the two large binder head screws fastening it to the mounting plate.
7. Check the odometer unit for proper operation. The unit should turn freely and without excessive play. Clean the helical gear (20) with chlorothene and lightly grease it with Texaco Uni Temp grease. If the odometer assembly is defective, it must be replaced as a unit.
8. To service the odometer assembly remove the unit from the frame by unscrewing the three flat head machine screws holding the gear box (22) to the frame (11).

Reassembly

- 1) Clean all the control box parts in chloroethene and dry them thoroughly with compressed dry air (15psi maximum). Inspect for damage and excessive wear. Replace any defective parts.
- 2) Lightly grease all moving parts at their contact surfaces with TEXACO Uni-Temp grease.
- 3) Place the two cable adapters (14) in the lower control box housing (4) with the angled sides facing inward in order to provide clearance for the drive wheel (6).
- 4) Place the wear strip in the control housing.

## CAUTION

Insert the wear strip with care, since it will be under tension and could pop out.

- 5) Place the drive wheel (6) in the lower control box housing (4).
- 6) Position the two brake jaws (16), brake bearing (13) and brake arm (16) in the lower control box housing. When installing the brake jaws, face the worn sides away from the drive wheel, as this increases their lifetime.
- 7) Place the upper control box housing over the lower control box housing while keeping them level, and press them together.
- 8) Check the control box for proper reassembly by turning the shaft. It should spin freely. If not, disassemble and reinspect the parts for damage and proper alignment. Reassemble and check the operation again.

- 9) Mount the odometer assembly on the frame (11) by securing the gear box (22) with three flat head machine screws.
- 10) Secure the odometer cover (28) to the mounting plate (23) with two binder head screws, and secure the odometer reset knob (29) to the shaft by tightening the two set screws.
- 11) Mount the control box onto the frame (11) and secure with the four large binder head screws and 3/8" nuts. Secure the crank arm assembly (3) to the shaft with the 5/16" bevel washer (30) and 5/16" hex head bolt.
- 12) After complete reassembly, check for proper operation by turning the crank, it should spin freely. Run the drive cable through the control box and turn the crank. It should turn easily and with no snags. Set the brake to ON and attempt to turn the crank. It should not turn with moderate pressure. Do not apply excessive pressure to the crank, as this may cause damage. If the control box fails any of these tests, disassemble, check the parts for damage and proper alignment, then reassemble and check for proper operation again.

3. Crank Assembly - Model 693 Control Unit

To service the 693 control unit, perform the following steps:

1. Refer to steps 1-5 in the previous part for disassembly of the control box housing. Refer to Figure 7.3 for further disassembly and for part identification numbers.
2. Remove the odometer mount cover (30) from the odometer mount (20) and check the odometer unit for proper operation. The unit should turn freely and without excessive play.

Clean the helical gear (27) with chlorothene and lightly grease it with TEXACO Uni-Temp grease. If the odometer assembly is defective, it must be replaced as a unit.

3. To service the odometer, remove the odometer mount cover (30) from the odometer mount (20), remove the odometer reset knob (29) by unscrewing the two set screws, and unscrew the two attaching large round head screws.
4. Follow steps 1-8 for the Model 664 crank assembly reassembly.
5. Resecure the odometer to the odometer mount (20) and secure the odometer reset knob (29) and odometer mount assembly cover (30) in place.
6. Secure the control box to the control handle (17) and odometer mount (20) with the four large binder head screws and 3/8" nuts, and secure the crank assembly (3) to the shaft with the 5/16" bevel washer and 5/16" hex head bolt. Follow step 12 of the previous section for checking of operation.

4. Crank Assembly - Model 692 Control Unit

1. Refer to steps 1 - 5 for the Model 664 control unit for disassembly. Refer to Figure 7.4 for further disassembly and for part identification numbers.
2. Follow steps 1 - 8 for the Model 664 Crank Assembly Reassembly.
3. Secure the control box to the control handle (17) with the four large binder head screws and 3/8" nuts, and secure the crank

arm assembly (3) to the shaft with the 5/16" bevel washer and 5/16" hex head bolt. Follow step 12 of the Model 664 Crank Assembly - Reassembly for checking of operation.

5. Drive Cable, Control Housing and Source Guide Tube Reassembly

1. Attach the control housing to the EXPOSE side of the control box and to the control cable connector.
2. Feed the drive cable into the control housing as far as it will go. As the drive cable is being fed in, feel the resistance to the drive cable to detect any binding of the cable. This indicates a dent in the control housing which should be repaired or replaced.
3. Turn the hand crank until the drive cable is protruding, and screw the stop spring to the end of the drive cable.
4. Connect the other control housing to the crank and to the connector plug.
5. Turn the crank fully to the RETRACT position and watch for any binding of the drive cable to check the other section of the control housing for dents. Repair or replace the control housing if necessary.
6. Place plastic dust caps on the ends of the source guide tubes and control cable connector to eliminate dust accumulation.



B. Exposure Device Model 900, 910 and 920

To service and exposure device remove the source following the source changing procedures of Section VI. (Before removing the source, check the female drive cable connector of the source with a Model 550 no-go gauge as in Figure 7.1; if the gauge can fit into the female slot width, the connector is worn and must be replaced). After the source has been removed, service the exposure device by performing the following steps:

1. Front End Disassembly

- 1) to disassemble the front end, refer to Figure 7.5.
- 2) Remove the guide tube connector(5) which is secured to the front plate with four phillips head screws.
- 3) Remove the indicator slide(6), indicator rod(7), compression spring( ), safety pin(9) and compression spring (21).
- 4) Remove the slide tube (10) and compression spring (23).

NOTE

When necessary, steps 1),2), and 3) can be performed with the source assembly in the exposure device. Before commencing this operation, reassure that the source assembly is in the proper shielded storage position, that the selector ring is in the lock position and the key operated lock is engaged. Monitor all operations with a calibrated and operable radiation survey instrument.

2. Rear End Disassembly

- 1) To disassemble the rear end, refer to Figure 7.6.
- 2) Remove the rear end plate which is secured to the exposure device body with 4 phillips head screws and to the handle with two phillips head screws.
- 3) Unlock the lock assembly, and remove it by unscrewing the two attaching socket head screws.

### 3. Connector Disassembly

- 1) Remove the connector assembly by unscrewing the four socket head screws. Hold the connector assembly in place while doing this to avoid losing parts.
- 2) Remove the connector assembly and set it horizontally with the cover plate (8) facing up. Remove the cover plate (8), lock slide (4), lock pin (12) and compression spring (16).
- 3) Rotate the selector ring to either OPERATE or CONNECT and lift it off the selector body (2).

### 4. Lock Disassembly

- 1) To disassemble the lock assembly, refer to Figure 7.7.
- 2) Remove the set screw (4) from the lock (5) and lift the lock (5) out of the lock retainer (3) by turning the lock 90°.

Clean all the parts in chloroethene, and dry them thoroughly using compressed dry air at 15psi maximum. Clean the source tube by running a cloth (soaked in chloroethene) through the tube several times. Dry the tube by running a dry cloth through. Inspect the parts for damage or excessive wear and replace any defective parts. Lightly grease all moving parts at their contact surfaces using TEXACO "Uni-Temp" grease. Other types of grease may form tars or corrosive compounds when exposed to radiation.



### 5. Lock Reassembly

- 1) To reassemble the lock assembly, refer to Figure 7.7.
- 2) Insert the return springs and spring guides into the lock body (5).
- 3) Depress the internal plunger so it clears the hole in the lock retainer (3) and insert the lock (5) into the retainer.
- 4) Align the screw hole in the lock with the slot in the retainer (3) and secure the lock with the set screw (4).
- 5) Secure the lock assembly to the rear plate (2) using two socket head screws.

### 6. Connector Reassembly

- 1) To reassemble the connector assembly, refer to Figure 7.6.
- 2) Insert the selector body (2) into the rear end plate.
- 3) Set the rear end plate on a horizontal surface with the selector body facing upwards. Position the selector body so that the hole for the lock pin is to the right of the centerline hole.
- 4) Place the selector ring (7) over the selector body (2) in either the OPERATE or CONNECT position, push the ring onto the selector body, and rotate the ring to LOCK while holding the selector body stationary.

- 5) Place the compression spring (16), lock pin (12) and lock slide (4) into the selector body (2)
- 6) Place the cover plate (8) over the selector body so that the word LOCK is visible on the selector ring. Secure the cover to the rear end plate with four socket head screws.

#### 7. Rear End Assembly

- 1) Secure the rear end plate to the exposure device body with four phillips head screws and to the handle with two phillips head screws.

#### 8. Front End Reassembly

- 1) To reassemble the front end, refer to Figure 7.5.
- 2) Insert the two compression springs (11 and 23), slide tube (10) and safety pin (9) into the front end plate.
- 3) Insert the compression spring ( ) into the indicator slide (6) and hold the indicator slide in place.
- 4) Apply Vibratite to the threads of the indicator rod (7) and screw it in the indicator slide.
- 5) Secure the guide tube connector (5) to the front end plate with four phillips head screws.

### C. Final Inspection

- 1) Check the system for proper reassembly. Check all connections and fittings for tightness. Check for proper operation of the control unit and connector assembly.
- 2) Reload the source in the exposure device by following the section on source changes.
- 3) Survey the exposure device on all sides to ensure that radiation levels do not exceed 200mR/hr at the surface or 10mR/hr at three feet from the surface.
- 4) Check the exposure device for the proper labels.

### D. Leak Testing

The source assembly in the exposure device must be leak tested at intervals not to exceed six months. This can be done using Tech/Ops Model 518 Leak Test Kit. The test must be performed in a properly secured Restricted Area and with the appropriate radiation monitoring equipment.

- 1) Moisten the wipe test swab with EDTA solution. Depress the safety pin on the front end plate and lift the indicator slide up.
- 2) Wipe the exit port of the exposure device and the female connector assembly. Be sure to reset the indicator slide to the down position.
- 3) Place the wipe test swab in the plastic envelope.

- 4) Set the survey meter on its most sensitive range and place the meter in an area with low background radiation. Move the wipe test swab towards the meter, and observe the radiation level indication.
- 5) If the radiation level increases less than 0.2mR/hr above background, place the plastic envelope into the mailing box and mail to Technical Operations, Inc. Be sure to complete and return the identification sheet.
- 6) If the meter indicates a higher radiation level, do not mail the wipe test patch and do not use the exposure device. Contact Technical Operations for further instructions.

E. Tripod Stand

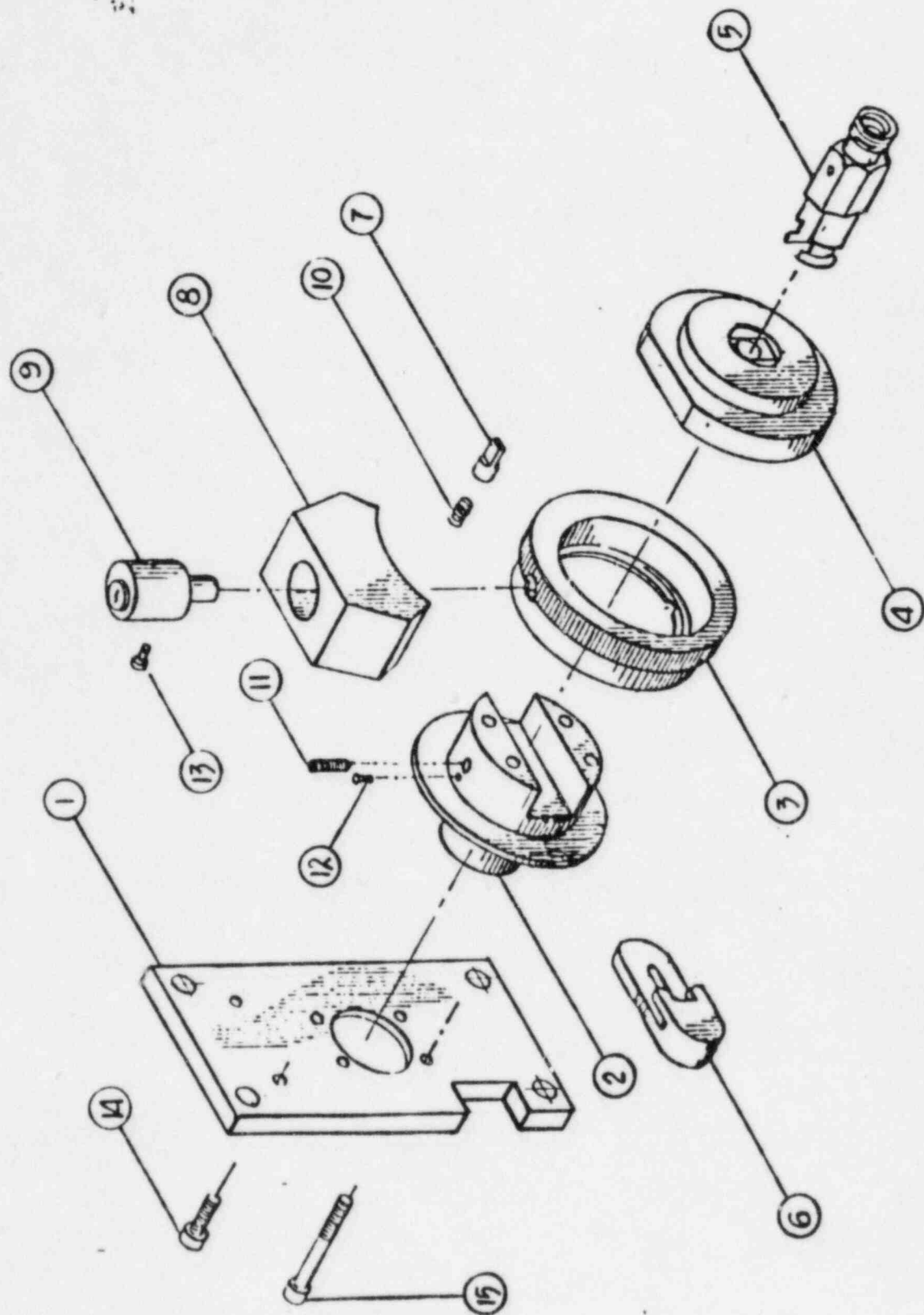
Refer to Figure 7.10 for component identification of tripod stand.

F. Guide Tubes, Control Housings and Drive Cable - Replacement

<u>Component</u>	<u>Part Number</u>
Master Guide Tube with male connector	B90204
Extender Guide Tube with quick disconnect fitting	B90202
Extender Guide Tube with male and female fittings	B90203
Control Housing (25 foot)	B59100
Swage Fitting (for control housing)	A59100-1
Drive Cable (50 feet)	A55005

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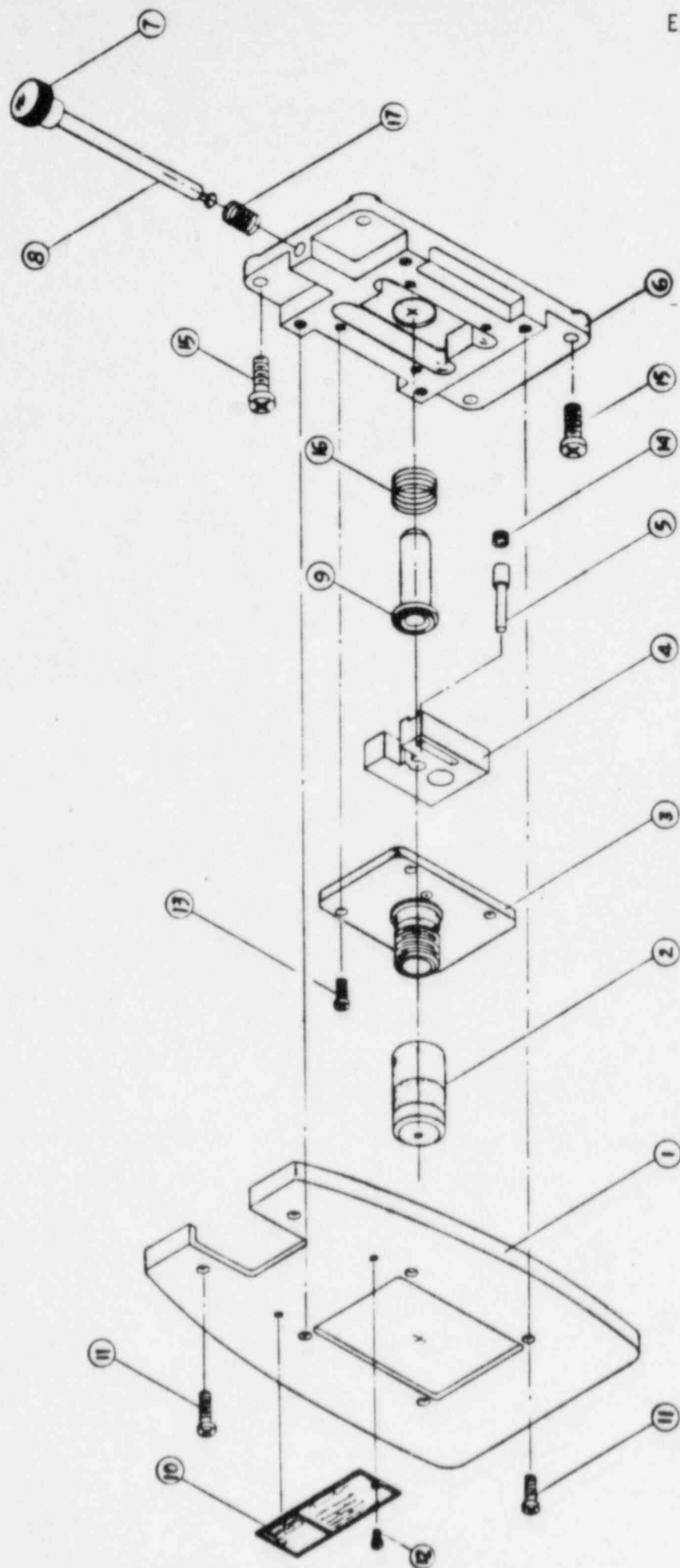


# — RETAR END - EXPLOSION —

EXHIBIT R

MODEL NO. _____		BILL OF MAT.		WORK ORDER NO. _____			
DESCRIPTION <b>GENESIS 88 ROTATING LOCK ASSY</b>		NO. <b>90006</b>		NO. OF UNITS _____			
ITEM	DESCRIPTION	DRAWING NO.	REV. NO.	THIS ASM.	ON HAND	THIS ORDER	TOTAL
1	RETAR PLATE	C90006-8		1			
2	BODY, MACHINED	C90006-1		1			
3	SELECTOR RING, MACHINED	C90006-3		1			
4	COVER PLATE	B90006		1			
5	SHIPPING PLUG	B90006-6		1			
6	LOCK SLIDE	B90006-2		1			
7	LOCK PIN	A90006-9		1			
8	MODIFIED LOCK RETAINER	A90006-15		1			
9	MODIFIED LOCK	A90006-13		1			
10	COMP. SPRING LEE LC-024C-2 ST STL	~		1			
11	BALL PLUNGER VLIER SSB-52N	~		2			
12	DRIVE SCREW, PARKER KALON NO. 2 x 3/16	~		1			
13	NO. 4-40 x 3/16 L S.H.C.S. ST STL			1			
14	NO. 10-32 x 3/4 L S.H.C.S. ST STL			2			
15	NO. 10-32 x 1 1/2 L S.H.C.S. ST STL			4			





# FRONT END - EXPLOSIVE

EXHIBIT R

MODEL NO. 900

BILL OF MAT.

WORK ORDER NO.

DESCRIPTION

NO. 90001

NO. OF UNITS

GENESIS BB PROTECTOR  
ASSY (FRONT END ONLY)

SHEET 1 OF 1

NO. OF PIECES

ITEM	DESCRIPTION	DRAWING NO.	REV. NO.	THIS ASM.	ON HAND	THIS ORDER	TOTAL
1	FRONT PLATE, -MACHINED	C90001-1		1			
2	PROTECTIVE CAP	A90001-18		1			
3	CONNECTOR PLATE	A90001-16		1			
4	INDICATOR SLIDE	B90001-5		1			
5	SAFETY PIN	A90001-8		1			
6	FRONT HOUSING, MACHINED	D90001-3		1			
7	INDICATOR KNOB	A90001-7		1			
8	INDICATOR ROD	A90001-6		1			
9	SLIDE TUBE	C90001-9		1			
10	SOURCE I.D. TAG	A90001-19		1			
11	NO 10-32 X 5/8 LG B.H.M.S. ST <u>PHILLIPS HD</u>			6			
12	BIND HD MAIN SCR. #4-40 X 3/16 LG ST STL <u>PHILLIPS HD</u>			2			
13	BIND " " " #8-32 X 1/2 LG ST STL <u>PHILLIPS HD</u>			4			
14	COMP SPRING, LEE # LC-024C-2SS <u>PHILLIPS HD</u>			1			
15	BIND HD MAIN SCR. #1/4-20 X 7/8 LG ST. STL <u>PHILLIPS HD</u>			4			
16	COMP SPRING, LEE # LC-055J-5SS <u>PHILLIPS HD</u>			1			
17	COMP SPRING, LEE # LC-042E-11SS <u>PHILLIPS HD</u>			1			

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## OPERATING INSTRUCTIONS - MODEL 850 SOURCE CHANGER

DRAFT: 4 NOVEMBER 1981

General Description

The Model 850 source changer is a portable, shielded container for transferring encapsulated radioisotope sources into Model No. 900, 910 and 920 radiographic exposure devices. The source changer is designed to safely contain a radiographic source during shipment and to permit source changes while minimizing radiation exposure to the operator.

Quick Reference Data

Source Type:	Tech/Ops Model 90003 and Model 91003 source assemblies (Special Form: USA/0179/S)
Container Capacity:	200 curies (+20% of iridium <sup>192</sup> )
Shielding:	49 lb. (22kg) of depleted uranium
Housing:	Stainless Steel
Design:	Type B(U) Radioactive Material Shipping Container (USNRC Certificate of Compliance No. 9147 and IAEA Certificate of Competent Authority No. USA/9147/B(U)T)
Effective Radiation:	Below regulatory radiation exposure limits prescribed in 10CFR34.21 and 49CFR173.393(i) and IAEA Safety Series No. 6
Dimensions:	10.4 in. (264mm) high x 8.5 in. (216mm) long x 8.8 in (224mm) wide
Shipping Weight:	77 lb. (35kg)

Shipment Data

1. Source decay chart and leak test certification. Keep for user's records.
2. Source identification (ID) plate. Affix to user's exposure device.
3. Return shipping labels
4. Tamperproof seals
5. Instruction manual

Operation

Note: All the precautions used when making radiographic exposures must be followed. Wear personnel monitoring devices during all source changing operations. Monitor all operations with a calibrated, operable survey meter.

1. Survey the source changer upon receipt to ensure that the source is in the proper storage position. Radiation levels should not exceed 200 milliroentgens per hour at the surface of the source changer, nor 10 milliroentgens per hour at three feet from the surface.
2. Locate the source changer and exposure device in a restricted area. Position the source changer in an upright position and near the exposure device so that one section of source guide tube will connect them with no sharp turns or bends. The bend radius of the guide tube should never be less than twenty inches. Shorter bend radii can restrict source movement in the source guide tube.

## WARNING

The Source Changer Must Remain in an Upright Position During Source Changing Operations. Do Not Position Source Changer on its Side.

3. Remove any foreign matter from the guide tube connector and attach the source guide tube to the exposure device. Remove the source changer cover plate by breaking the seal wire and removing the bolts. Attach the other end of the tube to the empty chamber of the source changer. Assure that the lock assembly of the chamber containing the source is in the locked position. Unlock the key operated lock over the empty chamber and slide the lock bar to the OPEN position.
4. Attach the control unit to the exposure device following the exposure device operating instructions and lift the indicator knob up until the indicator slide locks in place. The source is now free to move.
5. Crank the source rapidly from the exposure device to the source changer. During this process, the survey meter reading should increase (to approximately 1000mR/hr for a 100 curie iridium<sup>192</sup> source) as the source is first exposed, fall slightly as the source is being cranked out then drop to background when the source is in the source changer.
6. Approach the exposure device, source changer and source guide tube with the survey meter. Survey the exposure device on all sides, survey the guide tube and survey the source changer on all sides to ensure that the source is fully within the source

changer. The maximum radiation levels should not exceed 200mR/hr on the surface of the source changer nor 10mR/hr at three feet from the surface.

7. Slide the lock bar to the locked position and engage the key operated lock.

#### WARNING

Do Not Remove the Guide Tube from the Source Changer Fitting until the Lock Slide is in the Lock Position and the Key Operated Lock is Engaged.




8. Disconnect the source guide tube from the source changer lock assembly. Disconnect the drive cable from the source holder assembly by moving the lock pin down and sliding the drive cable connector out through the keyway.
9. Couple the drive cable to the new source holder assembly and connect the source guide tube to the fitting on the source changer. Unlock the key operated lock on the chamber containing the source to be transferred and slide the lock bar to the OPEN position.
10. Return to the controls and crank the new source or drive cable into the exposure device. If a new source is being transferred, the survey meter should increase as the source leaves the source changer and approaches the exposure device, then drop to background level when the source is shielded in the exposure device. If a source is not being transferred, the survey meter should indicate only background radiation levels.



11. Approach the exposure device with a survey meter . Survey the exposure device on all sides, survey the guide tube and survey the source changer on all sides to ensure that the process has been properly completed. Radiation levels should read no more than 200mk/hr at the surface of the exposure device if it has been loaded to maximum capacity. Rotate the selector ring to the lock position.
12. Assure that the source is secure in the source changer by assuring the slide mechanism is in the lock position and the lock plunger is depressed.
13. Disconnect the control unit and source guide tube from the exposure device as described in the exposure device operating instructions and disconnect the source guide tube from the source changer.
14. Remove the source identification plate from the exposure device and attach it with seal wire to the source changer. Attach the identification plate for the new source to the exposure device.
15. Remove the keys from the lock plungers and bolt the two cover plates to the source changer. Secure the bolts with seal wire using a security seal.
16. Survey all exterior surfaces of the source changer to ensure that radiation levels do not exceed 200 milliroentgens per hour at contact. Measure the radiation level three feet from all exterior surfaces of the source changer and ensure that the radiation

level is less than 10 milliroentgens per hour. The maximum radiation level measured three feet from any exterior surface is the Transport Index. (Example: With a maximum radiation level of 2.2 milliroentgens per hour, the Transport Index is 2.2).

17. Select the proper shipping labels according to the radiation levels at the surface and at 3 feet from the surface of container as described in the following table. Complete two labels listing the radioisotope contained (Iridium-192), the activity (the number of curies) and the Transport Index as determined above.

	Surface	3 Feet
RADIOACTIVE-WHITE I 	0.5mR/hr	None
RADIOACTIVE-YELLOW II 	50mR/hr	1.0mR/hr
RADIOACTIVE-YELLOW III 	200mR/hr	10mR/hr

18. Assure that the old shipping labels are removed. Apply the shipping labels, properly completed, to two opposite sides of the container.
19. Properly complete the shipping papers indicating:
  - a. Proper shipping name (i.e. Radioactive Material, Special Form, n.o.s.) and identification number (NA91E2).
  - b. Name of radionuclide (<sup>192</sup>Iridium)
  - c. Activity of source (expressed in curies)
  - d. Category of label applied (i.e. Radioactive Yellow III)
  - e. Transport Index
  - f. USNRC Identification Number (USNRC: USA/9147/B)
  - g. For international shipments, IAEA Identification Number IAEA: USA/9147/B(U)
  - h. 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."

- Notes:
1. 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, packed, marked and labeled and are in proper condition for carriage by air according to applicable national governmental regulations."

2. For air shipments to, from or through the United States, 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."

20. Return the container to Tech/Ops, Inc., according to proper procedures from transporting radioactive material as established in Title 49 Code of Federal Regulations, Parts 172-178.

Note: Please return container promptly. Demurage charges will be made for containers held beyond normal transportation time.

Drive Cable Connector

WARNING

Assure that the source assembly is properly locked in the source changer when connecting, disconnecting or testing for proper connection.

To Engage Connector

To Disengage Connector

- |  |   |
|--|---|
| <p>1. Using a fingernail, move the connector pin forward (toward stored position of source) to move the connector sleeve away from the keyway in the female connector.</p> <p>2. Slide the drive cable connector into the female connector and release the pin. Assure that the connector sleeve has returned to its original position closing the keyway.</p> <p>3. Test the connection by pulling between the source and the drive cable. (Note WARNING)</p> | <p>1. Using a fingernail, move the connector pin forward (toward stored position of source) to move the connector sleeve away from the keyway in the female connector.</p> <p>2. Slide the drive cable connector out of the female connector and release the pin.</p> |
|--|---|

CAUTION

Move connector sideways only.  
Do not bend or twist.

## RADIOGRAPHER TRAINING PROGRAM

### INITIAL TRAINING

Initial training for Radiographers and Radiographer's Assistants will be accomplished by using the services of Technical Operations, Incorporated, Radiation Products Division, Burlington, Massachusetts, Diano Corporation NDT Products Division, Cleveland, Ohio, or Gamma Industries, Incorporated.

In addition to the training by the above, each Radiographer and Radiographer's Assistant will be given training in the following:

#### I. Radiation Detection Instrumentation To Be Used - 3 Hours

##### A. Use of survey instruments

##### 1. Operation

- a. Units of Measurements and Definitions
- b. Dose Rate Measurements
- c. Geiger Counters

##### 2. Calibration

- a. Internal
- b. Records

##### 3. Limitations

- a. Range

##### 4. Characteristics

##### B. Survey Techniques

##### 1. Establishing Safe Working Distances

- a. Exposure Limits
- b. Radiation Area
- c. High Radiation Area

##### 2. Checking Exposure Device

- a. Source in shielded position
- b. Return of source to shielded position in exposure device
- c. Check where source has been, to assure it has returned to the shielded position in exposure device.

##### C. Use of Personnel Monitoring Equipment

##### 1. Film Badge

- a. Use and Assignment
- b. Replacement
- c. Wearing
- d. Processing
- e. Care

## INITIAL TRAINING - Cont'd

### I. Radiation Detection Instrumentation To Be Used - 3 Hours - Cont'd

#### 2. Pocket Dosimeters

- a. Use and Assignment
- b. Calibration
- c. Recording of Reading
- d. Range
- e. Action to be taken if Dosimeter goes off scale.
- f. Care

### II. Radiographic Equipment To Be Used - 4 Hours

#### A. Radiographic Exposure Devices

##### 1. Design

##### 2. Functions and Components

- a. Source Guide Tube and Fittings
- b. Storage Containers
- c. Capsule and Pigtail
- d. Retainer and Lock
- e. Flexible Cable, Housing and Fittings
- f. Pigtail and Cable Connections
- g. Gear and Housing

##### 3. Preventative Maintenance

- a. Daily Inspection
- b. Three Month Inspection and Maintenance  
(EXHIBIT F, EXHIBIT H and EXHIBIT R of Operating and  
Emergency Procedures)
- c. Records of Maintenance  
(EXHIBIT I of Operating and Emergency Procedures)

##### 4. Malfunctions

##### 5. Operations

#### B. Storage Containers

##### 1. Design

##### 2. Operating Procedures to Exchange Sources Between Exposure Device and Shipping Container

##### 3. Preparation, Packaging, Surveying, Recording, and Shipping of Sources.

- a. Shipping containers authorized by license
- b. Step-by-step instructions issued by the manufacturer of the  
container

INITIAL TRAINING - Cont'd

II. Radiographic Equipment To Be Used - 4 Hours - Cont'd

3. Preparation, Packaging, Surveying, Recording, and Shipping of Sources - Cont'd
  - c. Source security and locking
  - d. Shielded position and recording of surveys to assure source is locked in shielded position
  - e. Permissible levels of radiation at surface of container and at one (1) meter
  - f. Labeling, Certification, and Shipping

III. Calibration Equipment - 4 Hours

- A. Design
  1. Dosimeters
  2. Survey Meters
- B. Use
  1. Operation
  2. Procedure
- C. Maintenance
  1. Leak Testing
- D. Storage
  1. Labeling
  2. Security

IV. The Requirements of Pertinent Federal Regulations - 3 Hours

- A. Rules and Regulations
  1. Parts 19, 20, 30, and 34 of Title 10

V. The Licensee's NRC License - 2 Hours

VI. The Licensee's Operating and Emergency Procedures - 4 Hours

VII. Oral Review - 4 Hours

VIII. Operational Competance Tests - 4 Hours

IX. Written Test - 3 Hours

After satisfactory completion of the Written and Operational Competance Tests, the candidate will be designated as Radiographer's Assistant.



### ON-THE-JOB TRAINING

After all newly hired radiographic personnel have received the initial training, they will be assigned to work as a Radiographer's Assistant under the direct supervision of the Radiographer. The minimum duration of On-The-Job Training and Evaluation will be as follows:

- A. Personnel with no prior experience shall assist and observe all Radiographer's work for a minimum of 30 working days and observe at least 100 radiographic exposures.

After observing 100 radiographic exposures, trainee will successfully complete 300 exposures under the direct supervision of the Radiographer.

- B. Personnel with prior experience shall work as a Radiographer's Assistant for a minimum of five calendar days and shall correctly perform 50 radioactive exposures.
- C. After the above On-The-Job Training has been given, each trainee will be given a performance test by the Radiation Safety Officer or the Assistant Radiation Safety Officer which will include all facets of performance that is required of a radiographer. This will include:
  - 1. Setting up exposure equipment
  - 2. Proper survey of exposure equipment
  - 3. Establishing and posting of radiation area and high radiation area
  - 4. Surveys of exposure equipment and recording of readings
  - 5. Proper use of film badge, dosimeter, and survey meters
  - 6. Security of exposure device on transporting vehicle, survey at driver's location and exterior of vehicle, and levels of these readings and proper recording of same.
  - 7. Changing sources, requirements for return of sources, labeling, shipping certification, and recording of readings at surface of shipping container and at one (1) meter
  - 8. Placarding of transporting vehicle
  - 9. Quarterly maintenance of equipment
  - 10. Complete review of Company's NRC Byproduct Materials License, Operating and Emergency Procedures, Parts 19, 20, 30, and 34 of Title 10.

A minimum of forty (40) questions will be given. See attached questions and answers.

## REFRESHER

In addition to the On-The-Job Training, the Company will conduct Refresher Training annually.

### REFRESHER TRAINING OUTLINE

- I. Operating and Emergency Procedures
- II. NRC Title 10 CFR, Parts 19, 20, 30, and 34.
  - A. Existing
  - B. Revisions
- III. Radiographic Equipment
  - A. Maintenance
  - B. Use
- IV. Methods of Controlling Radiation Dose
  - A. Time
  - B. Distance
  - C. Shielding
    1. Collimator
- V. Radiographic Surveys
  - A. Instruments
  - B. Techniques
- VI. Personnel Monitoring Equipment
  - A. Use

A minimum of Ten (10) Questions will be given. See attached questions and answers

### QUALIFICATION EXAMINATIONS

A Radiographer may be required to retest any time there is reason to doubt his competence. A minimum of forty (40) questions will be given. See attached list of questions and answers.

WRITTEN TEST FOR QUALIFYING  
RADIOGRAPHERS AND ASSISTANT RADIOGRAPHERS

This group of 75 questions covers five categories in which the trainee will have had instruction and training. Each trainee will be given forty (40) questions, eight in each category. A score of 75% will be considered as a passing grade, provided no more than three (3) questions in any one category are missed. If more than three (3) questions are missed in any category, the trainee will be given a minimum of one hour additional training in this category and then retested.

GROUP A - CHARACTERISTICS OF GAMMA RADIATION AND FUNDAMENTALS OF RADIATION  
SAFETY

- A - 1. Does the energy level of radiation emitted by a given isotope decrease as the curie strength of the isotope decreases?
- A - 2. What is the unit of measurement for the ionizing effect of penetrating radiation on air?
- A - 3. Explain the difference between radiation dose rate and radiation dose.
- A - 4. How is the number of disintegrations per second taking place in a given radioactive source expressed?
- A - 5. What is an isotope?
- A - 6. When an isotope has gone through 3 half lives, what fraction of its initial strength is left?
- A - 7. What parts of the body are regarded as least sensitive to radiation? As most sensitive?
- A - 8. If the radiation intensity from a source is 10r/hr at a distance of two (2') feet, how much would it be at the following distances?
- (a) Four (4') feet \_\_\_\_\_
- (b) Ten (10') feet \_\_\_\_\_
- (c) Twenty (20') feet \_\_\_\_\_
- (d) One (1') foot \_\_\_\_\_
- A - 9. What is the HVL thickness of lead for Iridium 192? For Cobalt 60?

WRITTEN TEST FOR QUALIFYING  
RADIOGRAPHERS AND ASSISTANT RADIOGRAPHERS - Cont'd

GROUP A - CHARACTERISTICS OF GAMMA RADIATION AND FUNDAMENTALS OF RADIATION  
SAFETY - Cont'd

- A - 10. Calculate the dose received from a 10 curie Cobalt 60 source in ten minutes at a point two feet from the source after the radiation has been attenuated by one HVL of lead.
- A - 11. What effect would a single, whole body exposure of 600 r have on a human?
- A - 12. Would a single exposure of 600 r to only one hand be fatal? Explain your answer.
- A - 13. Define the half life of an isotope.
- A - 14. Will radiation produce greater biological effects on minors or adults? Explain your answer.
- A - 15. What is the unit of measurement for the effect of any type of radiation on man that is the equivalent of the effect of one roentgen of gamma radiation to man?

GROUP B - RADIATION DETECTION AND INSTRUMENTATION

- B - 1. Why is it so important to survey your exposure device after each exposure is made?
- B - 2. Why do most film badges contain two films of different speeds?
- B - 3. Suppose your survey meter was found to be broken or badly out of adjustment on a field trip. What would you do?
- B - 4. Are you permitted to use a survey meter which has no calibration date or expiration? Why?
- B - 5. List the radiation levels indicated on a survey meter when:
- |  |       |       |
|--|-------|-------|
| (a) range switch set on .1, meter reads 6    | _____ | mr/hr |
| (b) range switch set on X100, meter reads 25 | _____ | mr/hr |
| (c) range switch set on X1, meter reads 65   | _____ | mr/hr |
| (d) range switch set on X10, meter reads 8   | _____ | mr/hr |

WRITTEN TEST FOR QUALIFYING  
RADIOGRAPHERS AND ASSISTANT RADIOGRAPHERS - Cont'd

GROUP B - RADIATION DETECTION AND INSTRUMENTATION - Cont'd

- B - 6. When performing radiography, when must radiation surveys be made and what survey results must be recorded?
- B - 7. What minimum and maximum ranges are required for a survey meter?
- B - 8. How often must radiation survey meters be calibrated?
- B - 9. Can film badges be transferred from one user to another? Why?
- B - 10. Pocket dosimeters are designed to measure:
- (a) Gamma rays and x-rays only
  - (b) Gamma rays, x-rays, and beta particles
  - (c) Gamma rays, alpha and beta particles
  - (d) Alpha and beta particles only
- B - 11. What personnel monitoring devices must a Radiographer's Assistant wear?
- B - 12. How do survey meters and pocket dosimeters differ in the way they measure radiation?
- B - 13. What does a pocket dosimeter measure?
- B - 14. What does a survey meter measure?
- B - 15. What does a film badge measure?

WRITTEN TEST FOR QUALIFYING  
RADIOGRAPHERS AND ASSISTANT RADIOGRAPHERS - Cont'd

GROUP C - RADIATION EQUIPMENT AND ITS USE

- C - 1. Describe the procedures you would follow if your source should become uncoupled from the flexible cable while in the exposed position?
- C - 2. For a 30 minute exposure in a restricted area, your "CAUTION RADIATION AREA" sign could be placed where your survey meter reads \_\_\_\_\_ mr/hr.
- C - 3. Can the position of a source (i.e. fully exposed or fully retracted) be accurately determined by counting the number of hand crank revolutions? Why?
- C - 4. What is the maximum allowable dose rate at 6 inches from the exterior surface of an exposure device that measures 3 inches from the sealed source storage position to any exterior surface of the device?
- C - 5. If a radiographic exposure device measures 5 inches from the sealed source storage position to the exterior surface of the device, what is the maximum allowable dose rate at the surface?
- C - 6. What is a collimator?
- C - 7. What is the maximum strength of the source of Iridium 192 you are allowed to use in a Technical Operations Model 660 exposure device?
- C - 8. A Technical Operations Model 660 exposure device has a capacity of 100 curies of Iridium 192. Could you use this same camera for 25 curies of Cobalt 60? Explain.
- C - 9. Why are exposure devices which are made from depleted uranium lighter than those made of lead?
- C - 10. How often must a sealed source be leak tested? What is the maximum allowable removable activity?
- C - 11. If a leak test of a gamma ray source shows excessive leakage, what must be done?



WRITTEN TEST FOR QUALIFYING  
RADIOGRAPHERS AND ASSISTANT RADIOGRAPHERS - Cont'd

GROUP C - RADIATION EQUIPMENT AND ITS USE - Cont'd

- C - 12. What portion of a crank operated, remotely controlled exposure device should be inspected most frequently to avoid creating a hazardous situation?
- (a) The locking mechanism on the camera
  - (b) The control cable crank assembly
  - (c) The hookup between the pigtail and the control cable
  - (d) All are of equal importance
- C - 13. How could you make a set of remote handling tongs in an emergency when you have only a kit of conventional hand tools available?
- C - 14. Why are Cobalt 60 cameras so much heavier than Iridium 192 cameras when both are rated for the same curie capacity?
- C - 15. What can happen if you try to force the flexible control cable and source through the guide tube with the hand crank?

GROUP D - NUCLEAR REGULATORY COMMISSION REGULATIONS

- D - 1. Is a dose of one roentgen due to gamma or x-radiation considered to be the same as a dose of one rem? Why?
- D - 2. Define Radiation Area.
- D - 3. Unless special records are maintained, a radiographer is not permitted to receive a radiation dose to the whole body in excess of \_\_\_\_\_ rem per calendar quarter.
- D - 4. Regulations covering surveys are found in Paragraph \_\_\_\_\_ of Part 20 of NRC Regulations, Title 10.
- D - 5. If special forms are maintained, a radiographer may receive a radiation dose to the whole body of \_\_\_\_\_ rem per calendar quarter.



WRITTEN TEST FOR QUALIFYING  
RADIOGRAPHERS AND ASSISTANT RADIOGRAPHERS - Cont'd

GROUP D - NUCLEAR REGULATORY COMMISSION REGULATIONS - Cont'd

- D - 6. The standards for protection against radiation are set forth in Part \_\_\_\_\_ of NRC Title 10.
- D - 7. Regulations covering licenses for radiography and radiation safety requirements for radiographic operations are set forth in Part \_\_\_\_\_ of NRC Title 10.
- D - 8. Any radiographic area to which access is controlled by the licensee is called a \_\_\_\_\_.
- D - 9. No person can act as a Radiographer until he has received copies of and instruction in the regulations covered in NRC Title 10, Part \_\_\_\_\_ and Part \_\_\_\_\_.
- D - 10. Fill in the maximum allowable exposures of individuals to radiation in restricted areas. (Rems per calendar quarter.)
- (a) Whole body; head and trunk; active blood forming organs; lens of the eyes or gonads. \_\_\_\_\_
  - (b) Hands and forearms; feet; ankles. \_\_\_\_\_
  - (c) Skin of whole body. \_\_\_\_\_
- D - 11. Name two (2) types of personnel monitoring equipment required by NRC Regulations.
- D - 12. Draw a rough sketch and explain the radiation symbol used on "CAUTION RADIATION AREA" signs and indicate the colors which must be used for the symbol and its background.
- D - 13. What is your responsibility as a worker (employee) as outlined in Form NRC-3 "Notice to Employees"?
- D - 14. Can you use a "CAUTION RADIOACTIVE MATERIAL" sign to post a high radiation area? Explain.
- D - 15. What are the locking requirements for radiographic exposure devices? For storage containers?

WRITTEN TEST FOR QUALIFYING  
RADIOGRAPHERS AND ASSISTANT RADIOGRAPHERS - Cont'd

GROUP E -OPERATING AND EMERGENCY PROCEDURES

- E - 1. When working at a customer's plant, what steps must be taken to advise customer personnel that you are working?
- E - 2. Can a Radiographer's Assistant keep the jobsite under surveillance or is a Radiographer required for this?
- E - 3. Suppose someone ignores your signs and barriers and insists on entering the radiation area. What steps should you take?
- E - 4. On a Radiation Report, are the exposure device serial number and source serial number the same?
- E - 5. What would you do if you had a wreck with a truck carrying an exposure device loaded with a source?
- E - 6. What would you do if you checked your pocket dosimeter and found it had gone off scale?
- E - 7. What radiation dose rate is allowed at the outside of a truck used to transport a radioactive source? At the driver's location?
- E - 8. You barricade a temporary radiographic area and the dose rate measured at the barricade is 2 mr/hr. How many signs must you use to post the area? Where must they be placed, and what words are on the signs?
- E - 9. What reports must the Radiographer keep a copy of at the jobsite?
- E - 10. What would you do if your exposure device was lost or stolen?
- E - 11. When must a pocket dosimeter be recharged?
- E - 12. How must you restrict each temporary radiographic area to control access?

WRITTEN TEST FOR QUALIFYING  
RADIOGRAPHERS AND ASSISTANT RADIOGRAPHERS - Cont'd

GROUP E -OPERATING AND EMERGENCY PROCEDURES - Cont'd

- E - 13. List three documents that the company must make available to each Radiographer?
- E - 14. What company document must each Radiographer's Assistant have?
- E - 15. What is the requirement for surveillance of a radiographic exposure device when it is in use?

ANSWER SHEET FOR WRITTEN TEST  
FOR QUALIFYING RADIOGRAPHERS AND ASSISTANT RADIOGRAPHERS

GROUP A - CHARACTERISTICS OF GAMMA RADIATIONS AND FUNDAMENTALS OF RADIATION SAFETY

- A - 1. No. It remains constant.
- A - 2. Roentgen.
- A - 3. The intensity at which the dose is being received is called the dose rate. The total dose received in a given length of time is called the dose or total dose.
- A - 4. Curie.
- A - 5. An isotope is a variation of an element which has the same atomic number and chemical characteristics as the element, but differs in atomic weight, making it unsuitable.
- A - 6. One-eighth.
- A - 7. The hands, forearms, feet and ankles are least sensitive. The whole body, head and trunk, active blood forming organs, lens of the eye or gonads are the most sensitive.
- A - 8. (a) 2-1/2 r/hr; (b) 400 mr/hr; (c) 100 mr/hr; (d) 40 r/hr.
- A - 9. Approximately .20" for IR 192 and .50" for Co 60.
- A - 10. Approximately 3,021 mr.
- A - 11. It would probably cause death.
- A - 12. No. The hands are less sensitive to radiation exposure than other parts of the body.
- A - 13. The length of time it takes for the isotope to lose one half of its strength, as measured from any given time.
- A - 14. Minors. Their bodies have not fully developed and are more susceptible to damage from ionizing radiation.
- A - 15. Rem.

ANSWER SHEET FOR WRITTEN TEST  
FOR QUALIFYING RADIOGRAPHERS AND ASSISTANT RADIOGRAPHERS - Cont'd

GROUP B - RADIATION DETECTION AND INSTRUMENTATION

- B - 1. To assure the source has returned to a safe secured stored position.
- B - 2. To increase the diagnostic range of the film badge.
- B - 3. Shut down the job and obtain another survey meter that has been calibrated within the past three months and is operable before transporting or using the radiographic equipment.
- B - 4. No. Regulations require that the calibration date be affixed to all survey meters in use.
- B - 5. (a) 0.6 (b) 2500 (c) 65 (d) 80
- B - 6. A physical radiation survey after each radiographic exposure, prior to securing the exposure device (which must be recorded) and prior to making exposures to determine the perimeter of the restricted area.
- B - 7. 2 mr/hr through 1 r/hr.
- B - 8. At least every three (3) months.
- B - 9. No. There would be no way of knowing what percent of the total measured dose was received by each wearer.
- B - 10. (a) gamma rays and x-rays only.
- B - 11. A film badge and dosimeter.
- B - 12. A survey meter measures dose rate. A pocket dosimeter measures the total dose received.
- B - 13. A pocket dosimeter measures the total radiation dose received.

ANSWER SHEET FOR WRITTEN TEST  
FOR QUALIFYING RADIOGRAPHERS AND ASSISTANT RADIOGRAPHERS - Cont'd

GROUP B - RADIATION DETECTION AND INSTRUMENTATION - Cont'd

B - 14. A survey meter measures dose rate.

B - 15. A film badge measures the total radiation dose.

GROUP C - RADIATION EQUIPMENT AND ITS USE

C - 1. Restrict and post the area in accordance with the Operating and Emergency Procedures. Contact Radiation Safety Officer or Assistant Radiation Safety Officer. Keep the restricted area under constant personal surveillance.

C - 2. 2 mr/hr.

C - 3. No. Regulations require a survey meter be used for this purpose because drive cable slippage can result from worn mechanisms.

C - 4. 50 mr/hr.

C - 5. 200 mr/hr.

C - 6. A ported, shielding metal attachment used to reduce scatter and confine the primary beam of radiation to the area being examined.

C - 7. 100 curies of Iridium 192 (or 120 curies, with 20% allowable).

C - 8. No Additional shielding would be required for the higher energy level of Cobalt 60.

C - 9. The density and absorption efficiency of uranium is greater than that of lead.

C - 10. At least every six (6) months. 0.005 microcuries.

ANSWER SHEET FOR WRITTEN TEST  
FOR QUALIFYING RADIOGRAPHERS AND ASSISTANT RADIOGRAPHERS - Cont'd

GROUP C - RADIATION EQUIPMENT AND ITS USE - Cont'd

- C - 11. Place exposure device and attachments, if they are contaminated, in a plastic bag (after first having secured and locked the source) and place it in a locked container or room. Contact Radiation Safety Officer or Assistant Radiation Safety Officer for instructions.
- C - 12. (d) All are of equal importance.
- C - 13. Tape two extensions handles made from sticks or poles to the handles of a pair of pliers.
- C - 14. Because of the great difference in energy level and penetrating ability between Cobalt 60 and Iridium 192.
- C - 15. Guide tube can be damaged; source could become uncoupled from drive cable; cable drive gear could become stripped; source could stick in guide tube.

GROUP D - NUCLEAR REGULATORY COMMISSION REGULATIONS

- D - 1. Yes. The biological effect of other radiation on body tissue is measured relative to a dose of one reontgen (r) of x-rays and is defined as a rem.
- D - 2. That area in which any major portion of the body could receive in any one (1) hour a dose in excess of 5 millirem or in any 5 consecutive days a dose in excess of 100 millirems.
- D - 3. 1.25
- D - 4. 20.201
- D - 5. 3
- D - 6. 20



ANSWER SHEET FOR WRITTEN TEST  
FOR QUALIFYING RADIOGRAPHERS AND ASSISTANT RADIOGRAPHERS - Cont'd

GROUP D - NUCLEAR REGULATORY COMMISSION REGULATIONS - Cont'd

- D - 7. 34
- D - 8. Restricted Area.
- D - 9. 20, 34.
- D - 10. (a) 1.25 rem (b) 18.75 rem (c) 7.50 rem.
- D - 11. Pocket dosimeter and film badge.
- D - 12. A purple colored propellor shaped figure upon a yellow background. It has three (3) blades equally spaced with the bottom blade in a vertical position.
- D - 13. You should familiarize yourself with the provisions of the N.R.C. Regulations and the Operating Procedures which apply to the work in which you are engaged. You should observe their provisions for your own protection and protection of your co-workers.
- D - 14. No. Sign must read "CAUTION HIGH RADIATION AREA"
- D - 15. Each radiographic exposure device shall be kept locked except when under the direct surveillance of the Radiographer or Radiographer's Assistant. Each storage container shall be kept locked when containing sealed sources, except when under the direct surveillance of the Radiographer or Radiographer's Assistant.

GROUP E - OPERATING AND EMERGENCY PROCEDURES

- E - 1. Notify the Plant Manager or Shop Supervisor and ask him to notify the Safety Department if they have one. Obtain permission from the person in charge before starting the radiographic operation.
- E - 2. The Assistant may do it by himself.

ANSWER SHEET FOR WRITTEN TEST  
FOR QUALIFYING RADIOGRAPHERS AND ASSISTANT RADIOGRAPHERS - Cont'd

GROUP E - OPERATING AND EMERGENCY PROCEDURES - Cont'd

- E - 3. Retract source and secure exposure device. Do not resume operations until area has been cleared of unauthorized personnel. Inform the violator's Supervisor of his conduct.
- E - 4. No.
- E - 5. Follow the instructions outlined in the Operating and Emergency Procedures.
- E - 6. If operating an exposure device, retract source and secure the exposure device. Contact Radiation Safety Officer for instructions.
- E - 7. 2 mr/hr at outside surface of truck; 1 mr/hr at driver's location.
- E - 8. Place a minimum of four (4) "CAUTION RADIATION AREA" signs, one (1) at each 90 degrees around the perimeter.
- E - 9. Daily Radiation Report.
- E - 10. Notify the local Civil Authorities and contact the Radiation Safety Officer or the Assistant Radiation Safety Officer. Follow Operating and Emergency Procedures.
- E - 11. Before the start of each day's operation.
- E - 12. Rope off area at 2 mr/hr perimeter. Place "CAUTION RADIATION AREA" signs 90 degrees apart at 2 mr/hr perimeter. Place four (4) "CAUTION HIGH RADIATION AREA" signs in 100 mr/hr area.
- E - 13. A copy of the Company's Operating and Emergency Procedures, a copy of the Company's N.R.C. Materials License, and Parts 20 and 34 of N.R.C. Rules and Regulations, Title 10.
- E - 14. A copy of the Company's Operating and Emergency Procedures.
- E - 15. Unlocked exposure device must be under constant surveillance. Device may be unlocked only while exposures are being made. Do NOT leave device unattended at any time.