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Source Storage and Transfer Cask

Users Guide

G. W. Eccleston
L. G. Speir
D. C. Garcia

Los Alamos Los Alamos National Laboratory
Los Alamos, New Mexico 87545

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SOURCE STORAGE AND TRANSFER CASK

USERS GUIDE

by

G. W. Eccleston, L. G. Speir, and D. C. Garcia

ABSTRACT

The storage and shield cask for the dual californium source is designed to shield and transport up to 3.7 mg (2 Ci) of ^{252}Cf. The cask meets Department of Transportation (DOT) license requirements for Type A materials (DOT-7A). The cask is designed to transfer sources to and from the Fluorinel and Fuel Storage (FAST) facility delayed-neutron interrogator. Californium sources placed in the cask must be encapsulated in the SR-CF-100 package and attached to Teleflex cables.

The cask contains two source locations. Each location contains a gear box that allows a Teleflex cable to be remotely moved by a hand crank into and out of the cask. This transfer procedure permits sources to be easily removed and inserted into the delayed-neutron interrogator and reduces personnel radiation exposure during transfers. The radiation dose rate with the maximum allowable quantity of californium (3.7 mg) in the cask is 30 mR/h at the surface and less than 2 mR/h 1 m from the cask surface.

This manual contains information about the cask, californium sources, describes the method to ship the cask, and how to insert and remove sources from the cask.

Fig. 1. Dual californium source storage and transfer cask.

CASK DESCRIPTION

The source storage and transfer cask (Fig. 1) is designed to provide radiation shielding and to protect SR-CF-100 californium sources during shipment and storage. The cask was designed at Los Alamos National Laboratory and was commercially constructed to shield, transport, and aid in transferring californium sources into and out of the Fluorinel and Fuel Storage (FAST) facility delayed-neutron interrogator.

CASK COMPONENTS

The cask weighs 4563.2 kg (10,060 lb), is a right circular cylinder with a 120-cm- (47.2 in.) diam and 125-cm- (49.2 in.) height and can store two sources. To keep the escaping radiation from intense californium sources at a low level, both the large size and weight of this cask are necessary. Major components of the cask are identified in Fig. 2.

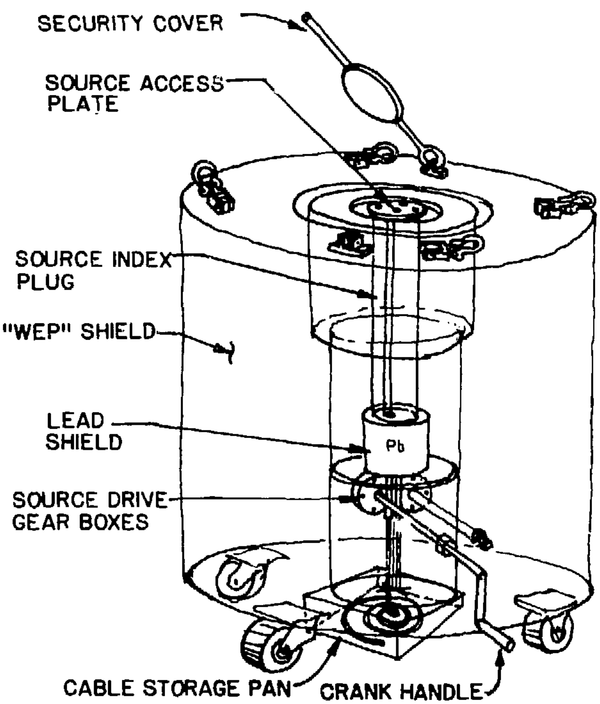


Fig. 2. Cask components.

DESIGN REQUIREMENTS

The cask was designed to meet the following specifications:

- Low radiation dose rate at the cask surface
- Store two californium sources
- Remote source transfers
- Comply with DOT-7A specifications

Dose Rates

Dose rates were calculated using the Los Alamos Monte Carlo code for various materials and cask geometries. Dose measurements on the selected design indicate that the radiation from the largest allowable quantity of californium (3.7 mg) is 30 mR/h at the cask surface and 2 mR/h at 1 m from the cask. This quantity of material can be packaged in one source or divided between two sources.

Dual-Source Cask

The dual-source storage and transfer cask permits an old californium source to be removed from the interrogator and a new source to be inserted into the interrogator.

Remote Transfers

Remote transfers can be accomplished using a hand crank attached to a gear box in the cask. When rotated, the gear will move a Teleflex cable into or out of the cask. Californium sources attached to the ends of the Teleflex cables are then loaded or unloaded from the interrogator.

DOT-7A Specification

Shipping containers for radioactive materials must satisfy Title 49 of the Code of Federal Regulations, Secs. 173.394 and 173.395. These regulations are often referred to as 49CFR173. A certificate is required as evidence that the shipping

DOT-7A Specification (cont)

container is in compliance with the construction methods, packaging design, and materials of construction defined by specification 7A Type A in 49CFR173.

CASK CONSTRUCTION

The cask was designed at Los Alamos and constructed by Seeley Enterprises, Albuquerque, New Mexico; Atkinson Steel Company, Austin, Texas, filled it with BOROTEX shielding material and provided the certificate of compliance.

CASK CERTIFICATION

The cask was certified and assigned serial number 255 on February 2, 1981. Figure 3 is a copy of the certificate.

MAXIMUM SOURCE STRENGTH

The certification allows up to 2 Ci (3.73 mg) of ^{252}Cf encapsulated in a Type A package to be transported in the cask. This quantity of material can be contained in one source or divided between two sources stored in the cask. The SR-CF-100 californium container satisfies the Type A package requirements.

CASK SAFETY ANALYSIS

Atkinson Steel Company provided the safety analysis for the cask. This information is contained in Appendix A.

ATKINSON STEEL CO.

6406-A NORTH LAMAR AUSTIN, TEXAS 78752 PHONE 512/458-1326

CERTIFICATE

In compliance with Title 49 of the Code of Federal Regulations, sections 173.394 and 173.395, this certificate is issued in evidence of the fact that, to the best of my ability, the below-described shipping container is in compliance with the construction methods, packaging design, and materials of construction specified by specification 7A Type A.

Manufacturer: SEELEY ENTERPRISES, LOS ALAMOS SCIENTIFIC LABORATORY, & ATKINSON STEEL CO.

Serial Number: 255

Nominal Dimensions: 48"D x 48"H

Weight: 10,060-LB

Date of Manufacture: 2-2-81

Supporting Safety Analysis: ASC-75 & ASC-255

by

G. D. Atkinson, P. E. 2-5-81

Gardner D. Atkinson Date
Professional Engineer

Fig. 3. Cask certificate.

SOURCE DESCRIPTION

Californium sources that fit into the cask must be encapsulated in the SR-CF-100 package. Large sources, typically containing 1 mg or more of californium, are obtained from the US Department of Energy Savannah River Operations Process and Weapons Division. A copy of a letter requesting a source is contained in Appendix B. A description of the SR-CF-100 source, its encapsulation, operating conditions, and safety analysis is contained in Appendix C. This description was provided by Savannah River Laboratories.

SOURCE-CABLE ATTACHMENT

The source is attached to a Teleflex cable using a stainless-steel transition piece (Fig. 4). Loctite is applied to the cable and to the transition piece and they are then screwed together and secured with two set screws. The source is then Loctited to the transition piece and secured with the other two set screws. The Loctite must be applied to ensure that the source, transition piece, and cable remain firmly attached during use in the interrogator.

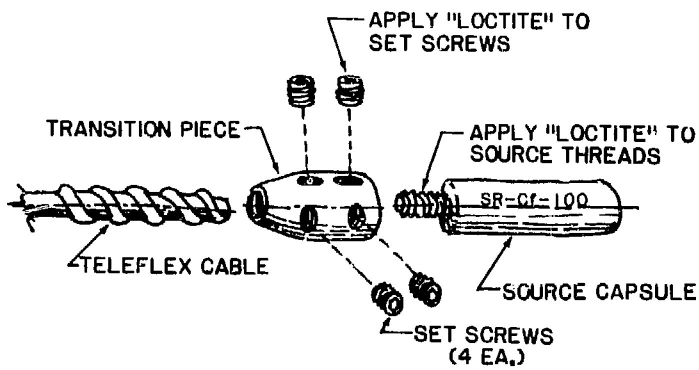


Fig. 4. Source-cable attachment drawing.

FAST INTERROGATOR CABLE LENGTH

The length of cable required for the FAST delayed-neutron interrogator is 458.5 cm (180.5 in.). The distance from the bitter end of the cable to the transition piece where the source attaches is 460.4 cm (181.25 in.). The overall length of the cable, transition piece, and source when assembled is 463.5 cm (182.5 in.).

CALIFORNIUM DATA

Neutron emission rates, dose rates, and decay data for ^{252}Cf sources are contained in Table I.

TABLE I

RATES PER MILLIGRAM OF ^{252}Cf

Neutron emission rate	2.34×10^9 n/s/mg
Gamma dose rate	0.140 R/h/mg[a]
Neutron dose rate	2.4 R/h/mg[a]
Conversion factor	0.558 Ci/mg

[a]One meter (3.28 ft) from an unshielded 1-mg californium source.

USEFUL SOURCE LIFE

A new source for the FAST facility delayed-neutron interrogator contains approximately 3.5 mg of californium. The source can be used until it decays to a level where the neutron emission rate is too low to assay samples. The end of useful source life is determined from several factors such as the sample neutron background rate, the quantity of uranium being measured, and the required measurement precision. As the source decays, the measurement precision for a given sample decreases for a fixed measurement time.

CALIFORNIUM DECAY RATE

Californium-252 has a 2.643-yr half-life, and its decay rate can be calculated using the equation

$$N = N_0 \, e^{-0.2623T} \quad ,$$

where N_0 is the initial source strength,
T is the elapsed time in years, and
N is the source strength at time T.

Decay Calculation

Suppose a source containing 3.5 mg of ^{252}Cf was placed in the delayed-neutron interrogator. After 5 (T = 5) years, the source will have decayed to a level

$$\begin{aligned} N &= 3.5 \, e^{(-0.2623 \cdot 5.0)} \\ &= 3.5 \cdot 0.269 \\ &= 0.943 \text{ mg.} \end{aligned}$$

The neutron emission rate of this decayed source, based on the data in Table I, is

$$\begin{aligned} n/s &= 0.943 \text{ mg} \cdot 2.34 \cdot 10^9 \text{ n/s/mg} \\ &= 2.21 \cdot 10^9 \text{ n/s.} \end{aligned}$$

UNSHIELDED SOURCE DOSE RATES

Large californium sources produce significant dose rates from both neutron and gamma rays. The largest source to be used in the interrogator will

UNSHIELDED SOURCE DOSE RATES (cont)

be in the 3.5-mg range. These sources must be handled carefully, using shielded containers to remove the risk of radiation exposure. The dose rate at 1 m (3.28 ft) from an unshielded 3.5-mg californium source, using Table I data, is as follows:

Gamma rays	0.49 R/h at 1 m
Neutrons	8.40 R/h at 1 m
Total	8.99 R/h at 1 m

Exposure Calculation

A 1-min exposure to an unshielded 3.5-mg source at a 1-m (3.28 ft) distance would produce a 150-mR dose. Increasing the distance to 3 m (9.84 ft) would reduce the exposure by a factor of 9, resulting in a dose of 16.6 mR.

CRANE

An overhead crane, which is rated for more than 5 tons, is recommended for moving the 4563.2-kg (10 060-lb) cask. Attach the crane to the four lifting blocks (Fig. 5) on the cask top. Slowly lift the cask and if possible, keep it close to the floor during movement. We recommend that the protective skirt be left on the cask during movement.

Fig. 5. Attaching a crane to the cask.

FORKLIFT

A forklift, rated to lift 5 tons, can be used to move the cask by lifting it from the top or by placing the forks under the cask bottom (Fig. 6). The protective skirt must be in place during movement because it restricts placement of the forks when the cask is lifted from its base and it protects the underside of the cask. The underside contains a cable storage pan, which holds the Teleflex cables that are attached to the californium sources.

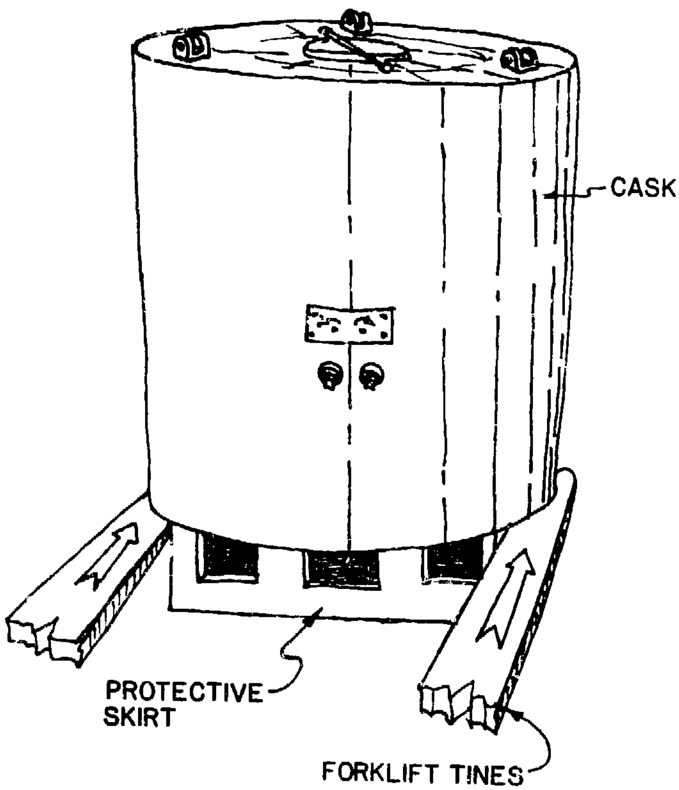


Fig. 6. Inserting forks into the protective skirt.

STEERING GUIDE

When the protective skirt is removed, a steering guide can be attached to the front wheels of the cask. This guide allows the cask to be maneuvered and manually positioned when a forklift or crane is not available.

CAUTION: To prevent runaway, the cask must be maintained on a level surface when manually moving.

Protective Skirt Removal

Remove the four 3/4-10 UNC x 1-1/4 hex-head bolts attaching the protective skirt to the cask (Fig. 7). Using an overhead crane, lift the cask off the skirt (Fig. 8), move it to the side, and gently set the cask on its four wheels.

Fig. 7. Removing the skirt-cask attachment bolts.

Fig. 8. Lifting the cask off the protective skirt.

Cable Storage Pan

The cable storage pan is located underneath the cask. Check the pan to ensure it is not damaged and is closed and locked. If the pan is open, check the Teleflex cable for damage and wind up the cable, placing it in the pan. Close and lock the pan.

Steering Guide Attachment

Attach the steering guide to the cask front wheels (Fig. 9) using 3/4-10 UNC x 1-1/4 socket head bolts. The two front wheels can be rotated allowing the cask to be guided. The two back wheels are fixed and do not rotate.

Fig. 9. Steering guide attached to the cask.

Pushing the Cask

Moving the cask by hand requires several people pushing and one person leading with the steering guide (Fig. 10). Ensure the cask is on a level surface and move the unit slowly.

CASK SHIPPING

For shipment, the cask must have the cable storage pan on the bottom closed and locked, protective skirt firmly attached, source access cover plate locked, and the crank handle access plugs secured and locked. The steering guide is not shipped with the cask; it is stored at the FAST facility.

Fig. 10. Personnel pushing the cask.

Steering Guide Removal

Place the cask and protective skirt in an area with an overhead crane that can lift more than 5 tons. Unbolt the steering guide if it is attached to the cask wheels. Store the steering guide in the interrogator cubicle.

Protective Skirt Attachment

Connect the overhead crane to the four lifting bolts on the top of the cask. Gently lift the cask and position it over the protective skirt. Lower the cask down to the skirt. Align the skirt bolt holes with the cask bolt holes. Ensure that locking washers are on each bolt and screw bolts into the four holes.

Securing and Locking the Cask

Close the top cover plate on the cask and attach the combination lock (Fig. 11). Place the securing bar through the crank-handle rods on the front side of the cask. Attach a combination lock to the securing bar (Fig 12).

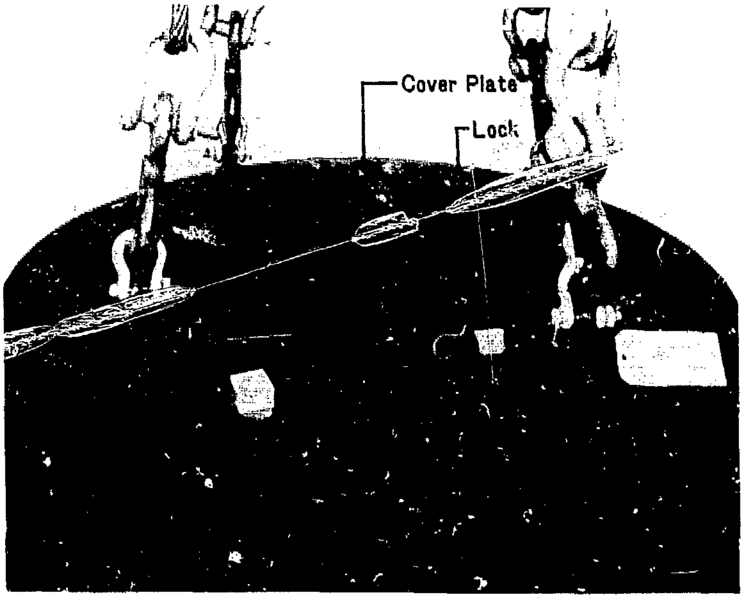


Fig. 11. Locking the cask cover plate.

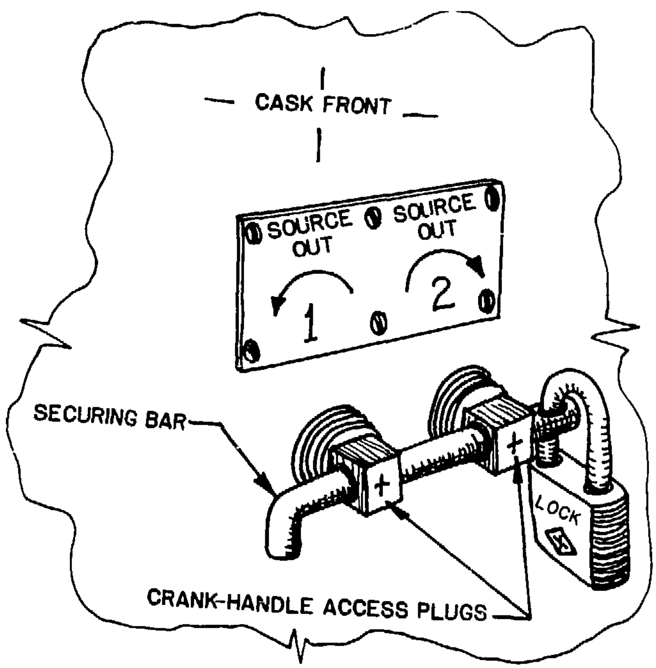


Fig. 12. Locking the crank-handle securing bar.

SOURCE STORAGE LOCATION

The source cask contains two source storage positions. Position 1 is labeled with a green marker and the number 1. Position 2 is labeled with a yellow marker and the number 2. The cask must be configured to the proper position before loading or unloading a source. Once configured, a source can then be inserted or removed from this cask storage position.

RADIATION MONITORING

Health Physics personnel with gamma-ray and neutron dose measurement instrumentation should be monitoring the cask during setup and transfer of sources.

STORAGE POSITION SETUP

To set the cask for access to either of the source positions [number 1 (green) or number 2 (yellow)], follow the directions below. The tools required to configure the cask are an allen wrench set, a screwdriver, and a 10-in. crescent wrench.

Security Cover Plate

Unlock the security cover plate on the cask top. Move it to the edge of the cask (Fig 13).

Source Access Cover Plate

Using an allen wrench, remove the four 1/4-20 hex-socket screws from the source access cover plate (Fig. 13). Set the screws and plate to the side.

Source Index Screw

Remove the source index screw (10-32 hex head) from the LOCK position (Fig. 14). Rotate the source index plug until the indication arrow points at position 1 [green (Fig. 15)] or position 2 [yellow (Fig. 16)] and the source index screw hole is centered in the slot. Insert the source

Source Index Screw (cont)

index screw into the slot and screw it down firmly. The source index plug is now set to source storage position 1 or to source storage position 2.

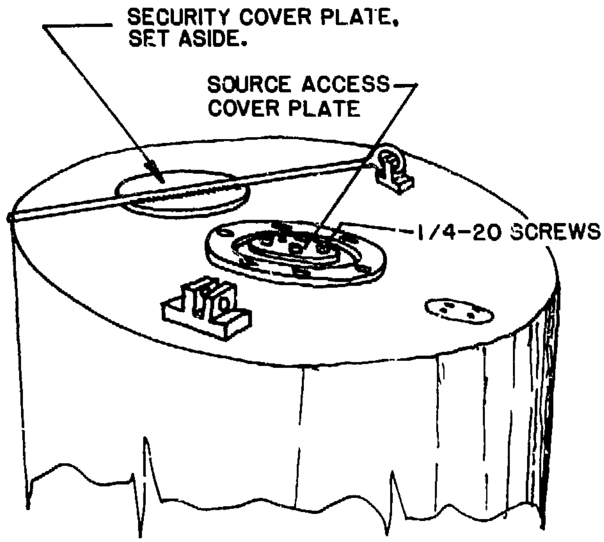


Fig. 13. Security cover plate and source access cover plate.

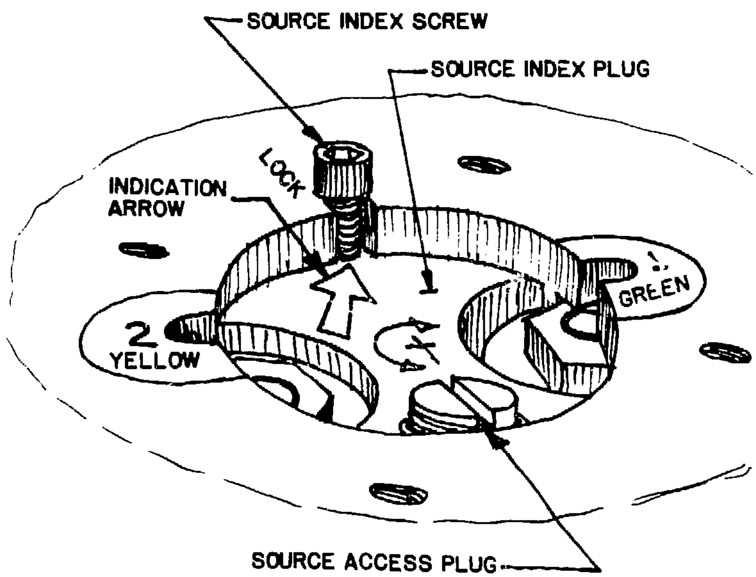


Fig. 14. Source access plug set to the LOCK position.

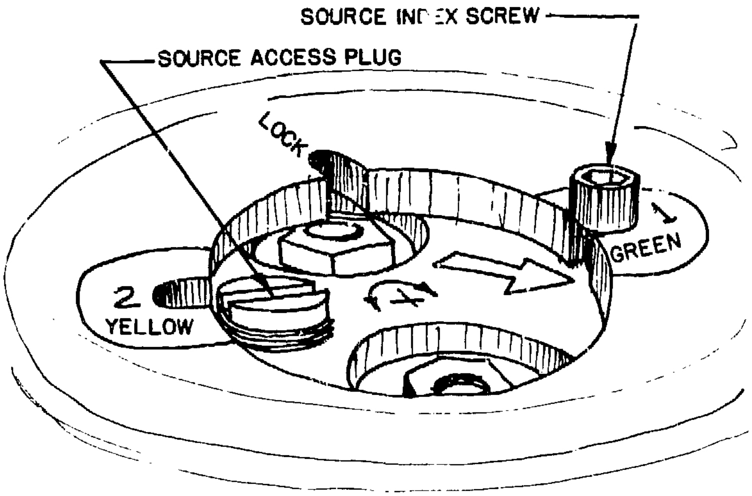


Fig. 15. Source access plug set to source position 1 (green).

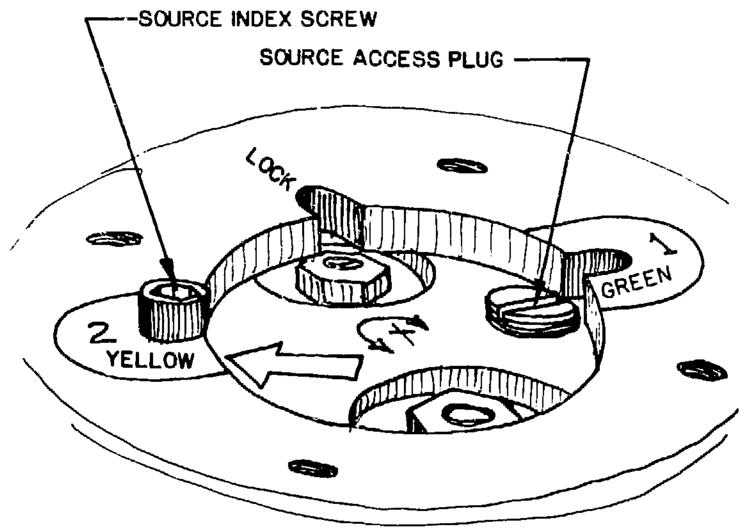


Fig. 16. Source access plug set to source position 2 (yellow).

Crank-Handle Securing Bar

Unlock and remove the crank-handle securing bar, which is located on the cylindrical front face of the cask (Fig. 17).

Position 1

If the source index plug is set to position 1, unscrew and remove the crank-handle access plug from position 1 (green) on the front of the cask and leave the position 2 (yellow) crank-handle access plug in the cask.

Position 2

If the source index plug is set to position 2, unscrew and remove the crank-handle access plug from position 2 (yellow) on the front of the cask and leave the position 1 (green) crank-handle access plug in the cask.

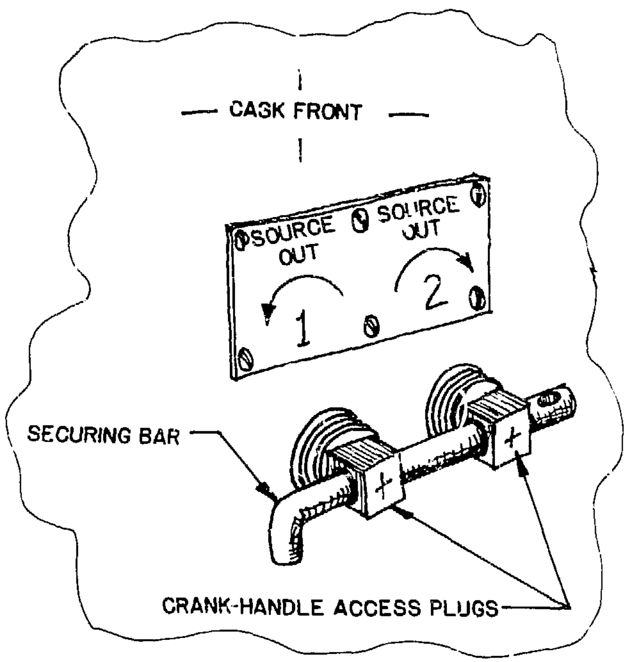


Fig. 17. Crank-handle access locations.

Crank-Handle Insertion

The crank handle is used to remotely move a Teleflex cable, which is connected to a source, into or out of the cask. Unbolt the clamps that secure

Crank-Handle Insertion (cont)

the crank handle to the top of the cask. Insert the handle into the open access hole on the cylindrical face of the cask. Gently rotate the handle while exerting inward pressure until it seats into the Teleflex drive mechanism.

Selected Storage Position

If a source is in the selected storage position, the handle can be rotated approximately one-fourth turn before it encounters resistance to movement. This resistance is due to the source hitting the access shield plug when the source is moved up or hitting the Teleflex gear mechanism when the source is moved down. If restrictive movement is not encountered, the crank handle is not properly seated into the Teleflex drive mechanism, or a source is not at this storage position.

Source Access Plug Removal

Using a screwdriver, remove the brass slotted source access plug, which is located on the top of the cask (Fig. 16). The selected storage position is now open and radiation will stream out of the hole if a source is in this position.

Cable Storage Pan

The cable storage pan, located underneath the cask, should be unlocked and opened. The Teleflex cable is held in this pan when a source is stored in the cask. Before moving a source out of the cask, the Teleflex cable should be unwound from the pan and straightened to prevent binding or tangling during a transfer.

SOURCE TRANSFER

No resistance should be felt when rotating the crank handle while moving a source into or out of

SOURCE TRANSFER (cont)

the cask. If any resistance is felt, stop rotating the crank handle. Determine the reason for the resistance and fix the problem. If the problem is not fixed, a kink could be put in the Teleflex cable.

A source can be inserted or removed from the selected cask storage position by slowly rotating the crank handle. If sources are to be exchanged in the delayed-neutron interrogator, follow the INTERROGATOR SOURCE REPLACEMENT section of this manual.

Crank-Handle Rotation

A label plate on the front face of the cask identifies the crank-handle location for source storage positions 1 and 2 (Fig. 18). Arrows at each location show the direction of crank-handle rotation to move a source out of the cask. Position 1 (green) requires moving the handle counterclockwise and position 2 (yellow) requires moving the handle clockwise to move a source out of the cask.

Cable Movement

No resistance should be felt when moving a source into or out of the cask. The Teleflex cable is moved approximately 20.6 cm (8.1 in.) for each 360° rotation of the crank handle. Three complete turns of the crank handle will move a source from its storage position to the top of the cask.

Inserting a Source

Use a tube to guide the source during transfer between the interrogator and the cask. Feed the bitter end of the Teleflex cable through the tube

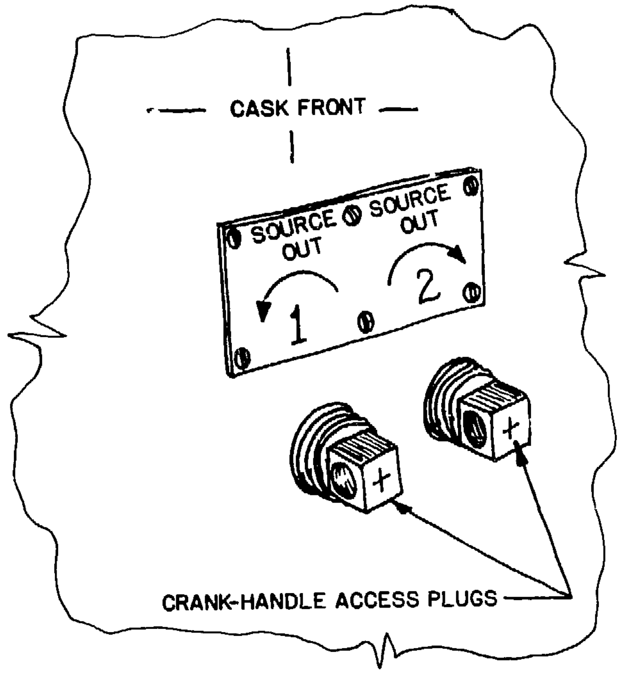


Fig. 18. Crank-handle labeling.

and into the selected source storage position until the cable engages with the gear mechanism. Using the cask as a shield, kneel down below its top and slowly and gently rotate the crank handle in the proper direction to pull the source into the cask. The Teleflex cable used in the FAST facility delayed-neutron interrogator requires between 21 and 22 complete turns of the crank handle to load it into the cask storage position.

PROCEDURE

After the source transfer process has been completed, the cask must be secured before storage or shipment. The following steps describe the procedure to reassemble the cask components. Following assembly, the cask should be locked to restrict access to stored sources.

Cable Storage Pan

Wind up Teleflex cables protruding from the bottom of the cask. Place the cables into the cable storage pan. Close and lock the pan.

Inserting Source Access Plug

Insert the source access plug into the storage location and tighten the slotted brass fitting using a screwdriver.

Source Index Screw

Remove the source index screw and rotate the source index plug to the **LOCK** position (Fig. 14). Align the screw hole in the **LOCK** slot and then insert the source index screw into the hole and tighten.

Source Access Cover Plate Attachment

Set the source access cover plate and gasket over the source index plug and ensure that the source index screw fits into the hole in the plate (Fig. 13). Insert the four hex-head bolts into the plate and firmly screw them into the cask.

Cask Security Plate

Position the cask security cover plate in the locking slot on the top of the cask and secure with a lock.

Crank Handle	Remove the crank handle from the Teleflex drive gear mechanism on the front of the cask. Secure it with clamps to the top of the cask.
Crank-Handle Shield Plug	Insert the crank-handle shield plug into the crank-handle access hole on the cylindrical front face of the cask and firmly screw it into position.
Crank-Handle Securing Bar	Insert the crank-handle securing bar through the two crank-handle access plugs and secure with a lock (Fig. 12).
Cask Labeling	Label the cask with the contents of each storage location. Monitor the dose rate at the cask surface, and if required, attach a radiation tag with the dose information to the cask.
Storage	To prevent freezing and exposure of the cask computer, store the cask in a covered and heated place.

SOURCE REPLACEMENT

A source must be placed in the FAST delayed-neutron interrogator before it can be used to make measurements. The strength of the source has a 2.67-yr half-life and must be replaced after several years. This section describes the procedure to remove an old source and to then insert a new source into the interrogator. The following discussion assumes we will accomplish the following steps:

Removal Procedure

1. Remove a source from the interrogator and load it into cask storage location 2 (yellow).

Insertion Procedure

2. Unload a new source from cask storage location 1 (green) and insert it into the interrogator.

INTERROGATOR PREPARATION

The old source contained in the interrogator must be moved fully into the instrument. Next, the stepping motor and source-keeper tube are removed from the interrogator and the Teleflex cable is fed through a guide tube into the storage cask. The guide tube is then firmly attached between the interrogator and the cask, and the source is transferred into the cask by rotating a hand crank. The following sections detail this procedure.

Reference Documents

1. Electronics Manual for the FAST Facility Delayed Neutron Interrogator Assay System, Los Alamos National Laboratory report LA-9850-M (March 1984).

Reference Documents (cont)

2. LA-120 User Guide, Digital Equipment Corporation, EK-LA120-UG-003, 3rd Edition, June 1979.

Cubicle Entry

Ensure that the interrogator sample assay through-tubes are blocked and no samples are in the tubes. Open the cubicle door. Monitor the radiation dose from the interrogator and the through-tubes.

Maintenance Terminal

The interrogator maintenance terminal is located in the west service corridor adjacent to the nuclear electronics rack. The power switch is located on the right side underneath the terminal. Turn the power on.

Terminal Control Switch

Open the nuclear electronics rack rear cabinet door and locate the 2-position (position C and position M) terminal control switch. This switch is located on the left side on the back panel of the signal routing chassis. Set the switch to the M position. This setting will allow the maintenance terminal to control the interrogator and will disable the assay terminal in the crane corridor (see ref. 1, pg. 23).

Storing the Source

Open the nuclear electronics rack door in the west service corridor. Turn the key on the signal routing chassis (Fig. 19) to the **STORED** position. The source will then be moved to the shielded interrogator storage position, the green stored light on the front panel will turn on, and the source position digital readout will display zero. Turn the key to the **ENABLED** position.

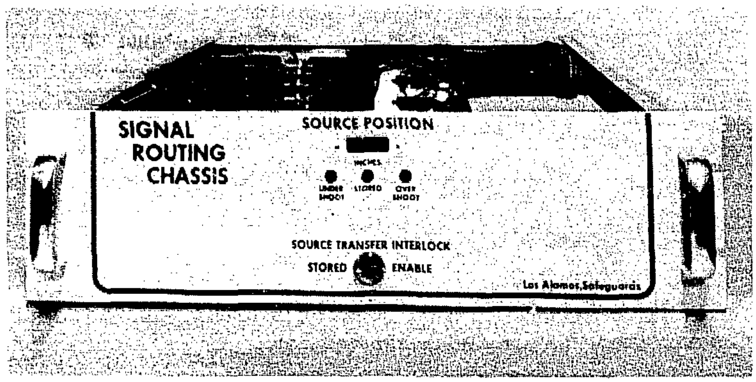


Fig. 19. Signal routing chassis.

TSTCF Software

The TSTCF program is used to move the californium source completely into the interrogator before the stepping motor is unbolted. To use this program, exit the delayed-neutron interrogator assay program by typing

X(RETURN)

on the maintenance terminal keyboard. The symbol (RETURN) represents the return key. Next, run the diagnostic software program **TSTCF** by typing

.R TSTCF(RETURN)

TSTCF Software (cont)

Information describing the TSTCF program is contained in the Diagnostics Manual for the FAST Facility delayed-neutron interrogator.

Program Dialog

When the TSTCF program is run, the dialog shown below is printed on the maintenance terminal. Responses by the operator are shown in bold letters.

PROGRAM TSTCF VERSION-3 11-FEB-85 by GWE
Reading Parameters dated 30-Nov-84 17:01:15 from SY:PARAM.DAT

MUX set to WASTE. MUX reads WASTE.

TSTCF Menu

Following the Enter Option request, the options available to an operator when using the TSTCF program can be listed by typing **H(RETURN)**.

C - Cycle source
K - Collect scaler counts
Z - Read crane vertical position
M - Set MUX to waste/fuel
P - Change parameters
R - Reread parameters from disk
S - Step the motor
X - EXit
Enter Option ->

Positioning the Source

The source must be moved completely into the interrogator before the stepping motor is unbolted. This movement is accomplished by selecting the **S**

Positioning the Source (cont)

option, moving the source to zero, and then specifying a distance to move into the interrogator of 381 cm (150.0 in). When the source is fully inserted in the interrogator, the **OVERSHOOT** sensor on the signal routing chassis front panel will turn on. The maintenance terminal dialog listed below shows the messages and responses to move the source fully into the interrogator.

Enter Option -> **S(RETURN)**

Type A for absolute or R for relative followed by the position in inches. For example, "R-3.5" means move the source -8.9 cm (-3.5 in.) from its current position.

Position? (Use dec. pt., Z to Zero, X to exit) -> **Z(RETURN)**

was 0.04 Now 0.00 Steps 0 Direc 0

Position? (Use dec. pt., Z to Zero, X to exit) -> **A150.0(RETURN)**

was 0.00 Now 123.24 Steps 3625 Direc 0

Stepping-Motor Power

Turn off the stepping-motor power supply located in the interrogator cubicle (Fig. 20).

Unbolt Stepping Motor

Remove the two connectors between the stepping motor and power supply. Unbolt the clamps securing the Teleflex cable tube to the support table (Fig 20). Disconnect the swage-lock connector between the cable take-up tube and stepping motor.

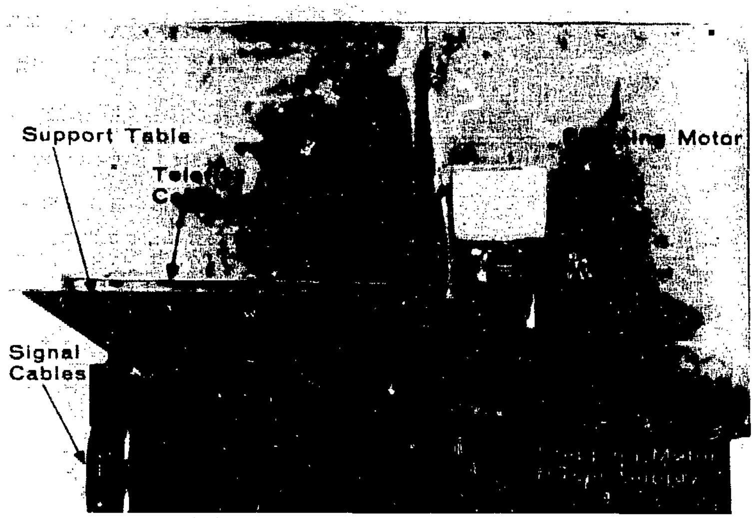


Fig. 20. Stepping-motor components.

Remove the bitter end of the Teleflex cable from the take-up tube. Loosen the swage-lock connector between the stepping motor and interrogator and remove the four hex-head bolts that hold the stepping-motor gear box to the interrogator frame (Fig. 21). Carefully pull the motor away from the instrument while pushing the Teleflex cable through the motor and into the interrogator. Ensure that the cable does not pull out of the interrogator. Set the motor on the support table. Remove the source-keeper tube.

CASK PREPARATION AND POSITIONING

Refer to the CASK MOVING AND SHIPPING section in this manual for procedures to position the source storage and transfer cask. Move the cask to the interrogator cubicle door and position the crank-handle access ports facing out and away from the interrogator.

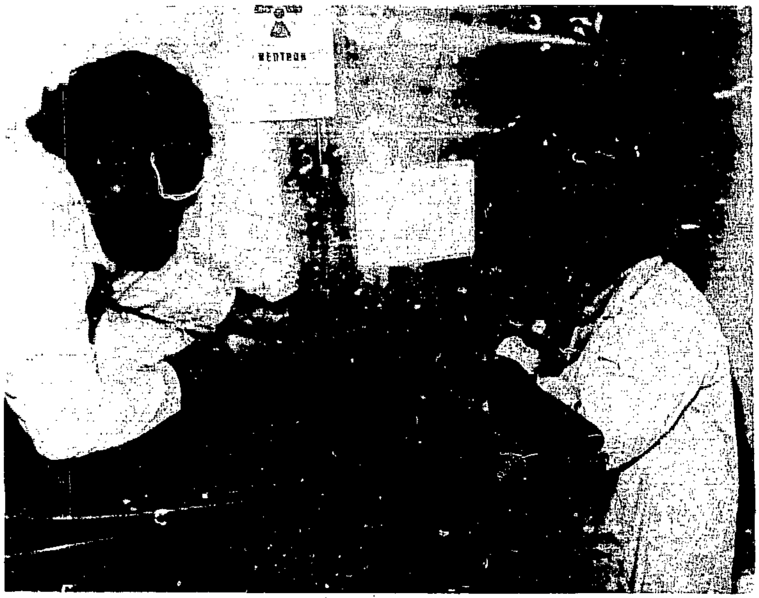


Fig. 21. Unbolting stepping motor.

Setting Cask Storage Position

Unlock the security bar cover plate on top of the cask and move it to the side. Remove the four 1/4-20 hex socket screws in the source access plate. Set the plate to the side on the top of the cask. Remove the source index screw and rotate the source index plug to the empty source location, which is assumed to be position 2 [yellow (Fig 22)]. Align the screw hole and reinsert and tighten the source index screw.

Crank Handle

Unlock and remove the crank-handle securing bar on the cylindrical face of the cask (Fig. 23). Unscrew and remove the position 2 (yellow) crank-handle access plug. Unclamp the crank handle from the cask top and gently insert it into crank-handle access position 2 on the cask front.

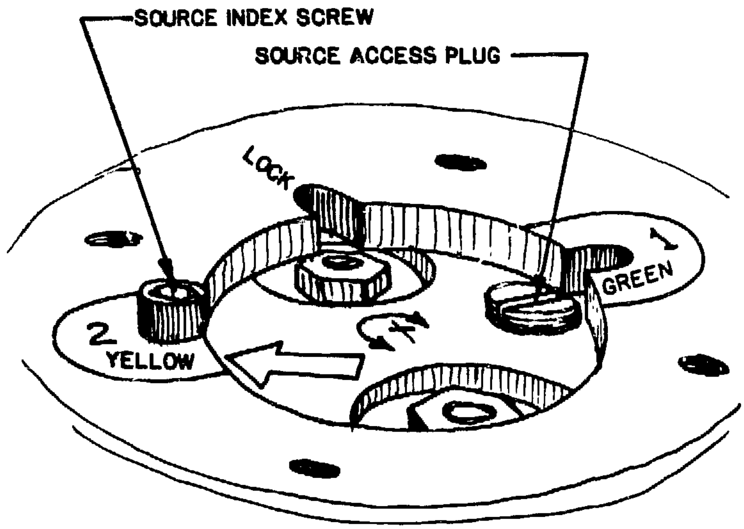


Fig. 22. Source access plug set to source position 2 (yellow).

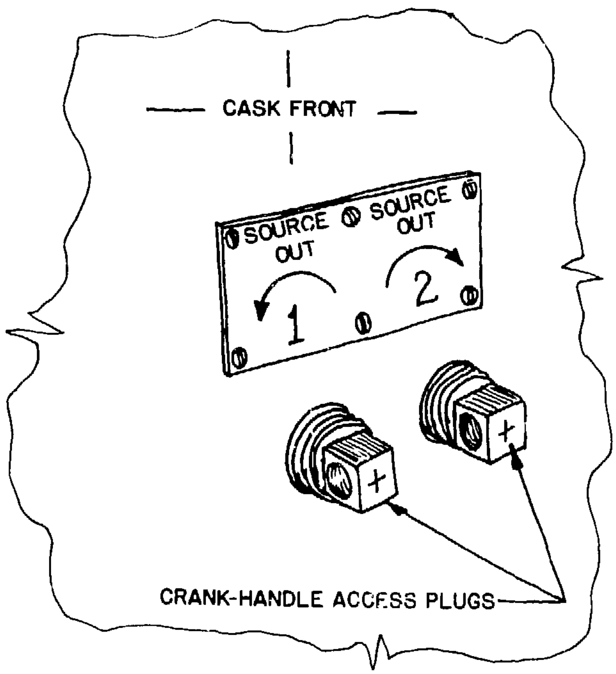


Fig. 23. Crank-handle access locations.

Inserting Crank Handle

Gently rotate the handle while exerting inward pressure until it seats into the Teleflex drive mechanism (Fig. 24). Using a screwdriver, unscrew and remove the source access plug (Fig. 22). Storage position number 2 is now open for access. Using a Teleflex cable mounted to a dummy source, insert the cable into the source cask access hole until it engages the Teleflex gear mechanism. Rotate the crank handle to be sure it moves the cable. No resistance should be felt when the source is moved into or out of the cask. Rotating the crank handle counterclockwise pulls the cable into the cask. Rotating the crank handle clockwise will push the cable out of the cask. Remove the dummy source and cable from the cask and set them aside.

Fig. 24. Inserting crank handle into the cask.

Guide-Tube Attachment

Attach the swage-lock connector to the source access plug hole (Fig. 25). Connect the source guide tube to the swage-lock connector on the cask.

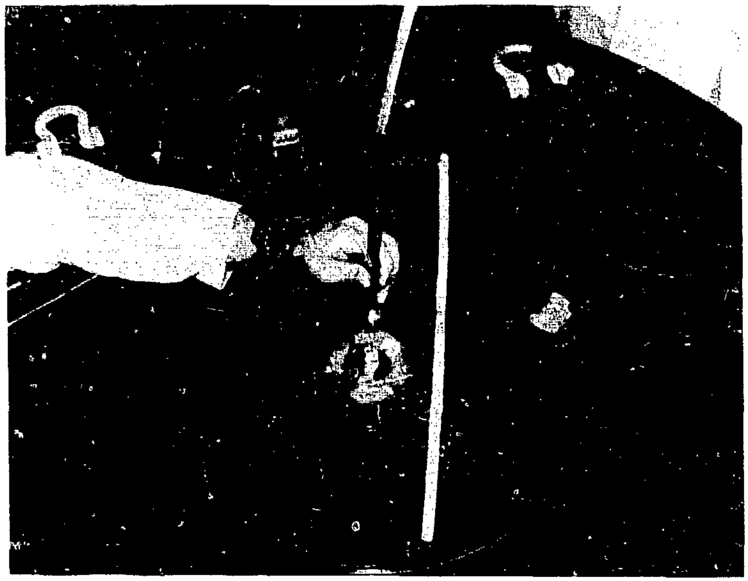


Fig. 25. Attaching source guide tube to the swage-lock connector.

REMOVING A SOURCE FROM THE INTERROGATOR

At the interrogator, push the end of the Teleflex cable into the source guide tube (Fig. 26). Continue to slowly push the cable by hand into the guide tube until it engages the gear mechanism in the cask. When the cable is in the gear, the crank handle can be used to remotely move the source. Secure the guide tube to the swage-lock connector on the interrogator.

Crank-Handle Movement

No resistance should be encountered when moving the source using the crank handle. If resistance

Fig. 26. Pushing the Teleflex cable through the source guide tube.

Crank-Handle Movement (cont)

is encountered and movement is not stopped, the cable could become kinked and damaged. One complete rotation of the handle will move the Teleflex cable approximately (19.1 cm) 7.5 in. Between 21 and 22 turns of the handle are required to move the source from the interrogator into the storage position of the cask.

Storing the Source

Clear the area of personnel. Monitor the radiation dose around the cask and interrogator during the source transfer. Kneel down below the cask and slowly and gently rotate the crank handle in a clockwise direction until the source is seated into storage position 2 (Fig. 27).

Fig. 27. Transferring a source between the interrogator and the cask.

INSERTING A SOURCE INTO THE INTERROGATOR

The following section details the procedure to unload a source from cask storage location 1 (green) and insert it into the interrogator.

Cask Storage Location 1

Disconnect the source guide tube from the swage-lock connector on the cask (Fig. 25). Remove the source index screw and rotate the source access plug to storage position 1 [green (Fig. 28)]. Align the source index screw hole in the slot and reinsert the screw. Reconnect the source guide tube to the swage-lock connector on the cask.

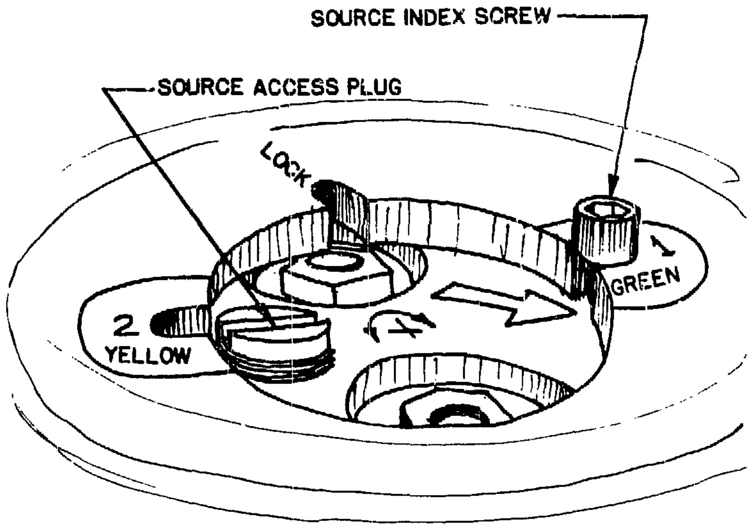


Fig. 28. Source access plug set to position 1 (green).

Cable Storage Pan

Unlock and open the cable storage pan located underneath the cask. Remove the Teleflex cables from the pan. Untangle and straighten the cables.

Reposition Crank Handle

Remove the crank handle from access hole 2 on the cask front. Screw the crank-handle access plug into this hole. Remove the crank-handle access plug from location 1 and push the crank handle into this location 1 (green). Gently rotate the handle while exerting inward pressure until it seats into the Teleflex drive mechanism. Rotating the handle counterclockwise will move the source out of the cask. A clockwise rotation will pull the source into the cask.

Inserting the Source

Clear the area of personnel. Monitor the dose rate as the source is moved out of the cask and into the interrogator (Fig 27). Three turns [62 cm (25 in.)] of the crank handle will move the source from its storage position to the top of the cask. Between 21 and 22 turns of the handle [457.2 cm (180 in.) of cable movement] are required to move the source from the cask into the interrogator where the cable disengages from the cask gear mechanism. No resistance should be encountered when rotating the crank handle.

Pushing the Cable into the Interrogator

Disconnect the source guide tube from the swage-lock connector on the interrogator. Gently pull the guide tube away from the interrogator and push the Teleflex cable by hand into the interrogator. Remove the guide tube from the cask. To move the cask out of the area, follow the directions in SECURING THE CASK section of this manual.

Stepping-Motor Connection

Insert the source-keeper tube over the cable and into the interrogator. Push the Teleflex cable through the stepping motor gear wheel and loosely bolt the motor gear box to the interrogator. Tighten the swage-lock connection between the gear housing and the interrogator as you tighten the bolts holding the gear box to the interrogator frame. Slowly and carefully push and pull the Teleflex cable several feet into and out of the interrogator to ensure that it freely moves through the stepping-motor gear wheel.

Cable Lubrication

Add a light machine oil to the Teleflex cable.

Attaching Cable Take-Up Tube

Insert the cable into the interrogator take-up tube and connect the tube to the stepping motor. Clamp the tube to the interrogator support table (Fig. 20). Connect the two stepping-motor and power supply cables.

Check Stepping Motor

Turn the stepping-motor power supply on. Select the Z option to zero the source position and move it to the interrogator storage location. The following tests should be completed using the TSTCF program:

1. Check single-step motor operation.

2. Check slow motor movement.

3. Move the cable all the way into and all the way out of the interrogator. Check overshoot, undershoot, and store sensor operation. The state of the sensors is shown on the front panel of the signal routing chassis.

4. Cycle the source to check high-speed source transfers.

Appendix A contains the safety analysis by Atkinson Steel Company for the californium source storage and transfer cask.

SAFETY ANALYSIS:

ADDENDUM 255

ATKINSON STEEL CO.
7A TYPE A NUCLEAR SHIPPING CONTAINERS
SERIAL NUMBER 255

ATKINSON STEEL CO.
6406-A NORTH LAMAR
AUSTIN, TEXAS 78752

DOCUMENT ASC-255
FEBRUARY 4, 1981

ADDENDUM

This document is to accompany Atkinson Steel Co. Safety Analysis ASC-75, for the purpose of further describing container #255, fabricated for the University of California Los Alamos Scientific Laboratory. The metal and polyethylene components were fabricated by Seeley Enterprises, 4800 Hawkins N.E., Albuquerque, New Mexico 87109 and by the Los Alamos Scientific Laboratory. The Borotex water-extended polyester resin shielding material was cast in place by Atkinson Steel Co. The significant differences from the standard Atkinson Steel Co. containers are as follow:

1) The container is lined with lead one-inch thick.
2) There is a large central cavity running the entire height of the container.
3) A teleflex cable drive assembly is used to displace either of two californium sources vertically out of the container.
4) Central portions of the container contain polyethylene.

The safety aspects of these differences will be discussed individually as they affect conformance with specification 7A of Title 49 of the Code of Federal Regulations. Refer to

LASL drawings 68Y-155596D-1 through 24, Shipping/Handling Cf-252 Source Cask, by Safeguards Group, Q-1.

Filling a lead-lined steel container with water-extended polyester (WEP) presents little safety consideration other than that the lead greatly increases the weight of the container. Sagging of the lead into the WEP over time would not be a consideration, since the compressive strength of WEP precludes any loss of shielding. The increased weight of the container was taken into consideration by using increased containment thickness, with 1.00-inch thick steel end plates and 0.50-inch thick cylinder wall, in excess of minimum thicknesses specified by ASC-75. Further, the lifting lugs share their load with both top and bottom plates with rods running the length of the container.

The central cavity plug rests in a stepped annulus, precluding the possibility of its falling through the container if dropped. Allen-head cap screws fix the plug flanges.

The cable drive assembly has serpentine cable feed tubes to prevent radiation streaming, and these tubes exit downward. The two crank access tubes are plugged when the container is in transit, and since these lateral tubes are significantly displaced from the source storage area, a beam port effect would be small and localized if the plugs were removed. The most important consideration with this drive mechanism, however, is that the sources are bound positively in place with the cover plug when it is in the lock position--no amount of jiggling could allow the sources to creep out of their shipping configuration provided the plug is correctly oriented.

The polyethylene shielding components are mentioned solely because the material per se has not been addressed specifically in ASC-75. In fact, though, polyethylene has better neutron shielding properties than WEP. (WEP has better characteristics in a fire, but that is not a consideration for type A containers.) Polyethylene has long been used in neutron source shipping containers, and 49 CFR 178 Appendix B even specifies acceptable properties for polyethylene.

Thus despite departure from the standard Atkinson Steel Co. design, container #255 meets or exceeds the requirements for 7A containers.

Los Alamos

Los Alamos National Laboratory
Los Alamos,New Mexico 87545

DATE October 4, 1984
IN REPLY REFER TO Q-1-84-1025
MAIL STOP E540
TELEPHONE 505/667-3887

Energy Division

Mr. C. G. Halsted
Directory Process and Weapons Division
U.S. DOE Savannah River Operations
P.O. Box A
Aiken, SC 29801

Dear Mr. Halsted:

A nominal 3.3 mg (milligram) quantity of californium-252 encapsulated in an SR-CF-100 package is requested from your facility for use by the Los Alamos National Laboratory Safeguards Assay Group (Q-1). The source will be placed in a californium delayed neutron Shuffler located at the Fluorinel and Fuel Storage (FAST) facility at Idaho Falls. This facility is operated by Westinghouse Nuclear Idaho Company (ENICO) for the Department of Energy. The Shuffler will assay spent fuel and reprocessed wastes to determine uranium content. This system is being developed as a cooperative program between the DOE's FAST facility and our DOE Office of Safeguards and Security.

Los Alamos purchase order U2223 has been completed and sent to Ms. M. L. Toole to cover the cost for preparation of the californium-252 source. We request your personnel attach and loctite the source to a stainless steel Teleflex cable, place it in Cask #255, and then ship it directly to the FAST facility. This attachment operation has been performed by your personnel on other SR-CF-100 sources and a diagram of the attachment procedure is enclosed for your information. Los Alamos will provide the Teleflex cable and attachment coupling.

Current plans are to deliver the source to the FAST facility in November 1984 using Los Alamos dual storage and transport cask #255. This cask, certified to carry 3.7 mg of californium-252, will be sent by Los Alamos to Savannah River Laboratories for loading and transportation of the source. Los Alamos will handle all details required to ship the source from your facility to the FAST facility.

If you have any questions, I may be reached by calling FTS 843-3887 or FTS 843-6141.

Sincerely yours,

George W. Eccleston

George W. Eccleston
Safeguards Assay Group

GE/gjm

Cy: M. L. Toole, SRO
W. S. Curlee,SRL
L. Decker, ENICO
B. Carlson, ENICO
J. Shipley, Q-DO/SG, MS E550
CRM-4, MS A150 (2)
Q-1 Files (2)
A. Hakkila, Q-DO/SG, MS E550
D. Smith, Q-DO/SG, MS E550
M. Baker, Q-1
J. Foley, Q-1
W. Atencio, Q-1
T. Van Lyssel, Q-1

Appendix C is a description of the SR-CF-100 source, its encapsulation, operating conditions, and the source safety analysis.

This description was provided by Savannah River Laboratories.

^{252}Cf SOURCE AND SHIPPING CAPSULE ASSEMBLY DESIGN AND TEST INFORMATION

This document is a compilation of information related to the design and testing of Savannah River ^{252}Cf industrial sources and ^{252}Cf shipping packages updated as a result of the availability for sale of developmental Pd-Cf_2O_3 cermet wire. Included in this compilation are the following publications:

1. Specifications for Pd-Cf_2O_3 Cermet Pellets and Wire
2. Industrial Sources, SR-Cf-100 Series, Appendix B
3. ^{252}Cf Shipping Capsule Assembly, SR-Cf-1000 Series, Appendix C
4. Primary Capsule, SR-Cf-XX Series, Appendix D
5. Primary Capsule, SR-Cf-1X Series, Appendix E

The primary capsule of SR-Cf-XX series design is generally used for containment of Cf_2O_3 but may also be used for containment of Pd-Cf_2O_3 source forms. Item 4, which defines this capsule design, is included in this compilation for reference purposes.

NOTICE

U. S. Atomic Energy Commission
Savannah River Operations Office
Post Office Box A
Aiken, South Carolina 29801

May 15, 1972

PRODUCT DESCRIPTION
SPECIFICATIONS FOR Pd-Cf_2O_3 CERMET PELLETS AND WIRE

In addition to the Cf_2O_3 previously provided, ^{252}Cf is available for sale to encapsulators in the form of cermet pellets or wire consisting of a uniform distribution of ^{252}Cf oxide particles in a palladium metal matrix. The pellets will be made to a specified ^{252}Cf content, whereas, measured lengths of wire can be cut from stock to obtain sources of different sizes. Cermet provides the encapsulator physically contained ^{252}Cf, with reduced contamination potential compared to that characteristic of handling oxide. ^{252}Cf loss or waste is reduced substantially. These factors are expected to simplify the processes and equipment required for encapsulation.

Palladium was selected as the matrix material for the following reasons. Palladium is a noble metal, providing a high degree of containment in various chemical, atmospheric, and thermal environments. It is relatively unaffected by immersion in water or heating in air, and melts at 1552°C. Of the noble metals, palladium has the lowest cross section for neutron capture and produces the least delayed and prompt gamma rays that might interfere in applications of neutron activation analysis. Palladium is very ductile, and can be readily formed into wire or other shapes. Should the ^{252}Cf need to be recovered, palladium dissolves in concentrated nitric acid. The separation of ^{252}Cf and palladium by ion exchange techniques has been demonstrated.

A process has been developed to uniformly admix ^{252}Cf as oxide with palladium metal. Pellets for direct use, or for rolling into wire, are made by pressing and sintering. Wire is annealed at 800°C to a dead soft condition before packaging; unannealed wire that offers greater stiffness is available on request. Wire rolled to the highest concentration (500 μg/in.) has a smearable surface contamination of $\sim 10^6$ alpha disintegrations per minute, a factor of $\sim 10^6$ lower than the total alpha inventory in the wire.

Specifications

The product specifications are shown in Table I. Combinations of the three concentration levels in the wire should allow fabrication of sources from about 2 μg to 2000 μg or larger within ±10% of the nominal ^{252}Cf requirement. However, other loadings and shapes may be accommodated on special order. For example, uniform cermet powders, square rod, or larger wires could be fabricated.

Uniformity is measured by densitometer analyses of gamma autoradiographs of the finished wire. Uniformity generally is within ±5% of the average ^{252}Cf concentration. This allows a reasonable tolerance in cutting to length to yield a maximum error of ±10% in individual sources. ^{252}Cf levels and uniformity data on lengths of wire cut shorter than 0.5 inch may not meet these specifications because of cutting precision and end effects. Lengths of six inches or longer may be accommodated on special order. Total ^{252}Cf is assayed to ±3% by neutron counting in a calibrated fission counter. Terbium is added as a carrier to precipitate ^{252}Cf quantitatively.

Packaging

Wire segments, nominally 2-3/4 inches long, and pellets are packaged in a stainless steel container equipped with a threaded closure shown in Figure C-2. The container is equivalent to the DOT type 2R container. It is individually marked so that the contents are identified. Wire from only one batch is included in a container. On request, lengths over 2-3/4 inches may be coiled as required to fit the container.

A maximum of three containers are sealed in a type SR-Cf-1000 outer shipping capsule, shown in Figure C-5. If fewer than three containers are required for a shipment, spacers are inserted in the shipping capsule to prevent damage to the containers during shipment. The seal on the outer shipping capsule is obtained by welding; welds are leak tested with a helium leak detector whose lower detection limit is 1.0×10^{-8} cm^3 (STP) He/sec. The outer capsule must show no detectable leak. Following the leak test, the assembly is decontaminated until the final flush of water contains <50 disintegrations/(min-ml) alpha and <200 counts/(min-ml) beta gamma. Transferable contamination, as determined by a wipe test, is less than 9 disintegrations/minute alpha and 10 counts/minute beta-gamma. The shipping capsule assembly meets all requirements for "Special Form Radioactive Materials" given in 49 CFR 173.398a.

Although every effort is made to decontaminate the outside surface of the sealed shipping capsule assembly, it should be handled as though it were contaminated. Proper radiological safety procedures should be followed at all times.

The shipping capsule assembly is nonreturnable. Detailed unloading instructions accompany each shipment.

Encapsulators are cautioned that enough void space must be built into the capsules they provide so that internal pressures and capsule stresses are not excessive even in a fire. It is recommended that calculations allow for infinite decay of the

^{252}Cf, which results in 0.088 cc He (0°C, 1 atm.) per initial mg of ^{252}Cf. Allowable internal pressures for SR-Cf-1X series capsules of 304 stainless steel or Zircaloy-2 are given in Appendix E.

TABLE I

SPECIFICATIONS FOR ^{252}Cf CERMET

^{252}Cf Concentration:	As specified, but <10 μg for pellets Nominally 5, 50, or 500 μg/in. for wire
Total ^{252}Cf:	Within ±10% of order, assayed to ±3% for pricing
Dimensions:	
Pellets: (as sintered)	
Diameter	0.15 in. max.*
Length	Depends on ^{252}Cf concentration (max L/D = ∿2)
Density	70 to 90% of Theo. Density*
Wire:	
Thickness	0.040 ±0.002 in. sq. cross section
Length	0.5 to 2-3/4 in.
Uniformity of ^{252}Cf Distribution	1/8-in. segments within ±10% of average concentration
Metallurgical Condition:	Annealed (as sintered for pellets)
Chemical Purity:	Oxide: as for Cf_2O_3 (SRO-153) Tb_2O_3 carrier is added to a maximum of 2 vol % of the total oxide in the cermet Palladium: 99.9% Pd
Isotopic Purity:	See SRO-153
Neutron Emission:	See SRO-153
Gamma Spectrum:	Similar to oxide in Pt-Rh capsules**— typical spectrum for cermet available on request

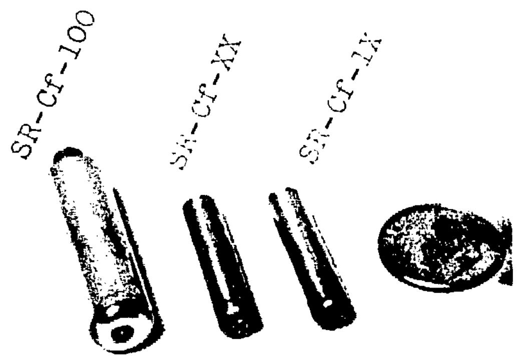
* A variable shrinkage, depending on composition, occurs during sintering to increase the as-pressed density of 40 to 50% to the values given.

** W. R. McDonell, et al p 182. "Neutron Sources and Applications, Vol. II." Proc. of American Nuclear Society National Topical Meeting, April 19-21, 1971 (CONF-710402).

APPENDIX B - Revised May 1972

Industrial Sources, SR-Cf-100 Series (0 to 10 mg or 0 to 5.2 Ci)

A. Identification



Outer and Inner Capsules of SR-Cf-100 Series

Description Encapsulated source of ^{252}Cf. The inner capsule is 0.217 inch diameter, 0.970 inch long of 90% platinum and 10% rhodium (SR-Cf-XX series, see Appendix D), or 304L stainless steel or Zircaloy-2 (SR-Cf-1X series, see Appendix E.) The outer capsule is 0.370 inch diameter, 1.48 inches long 304L stainless steel or Zircaloy-2 including a threaded shank for 10-32 UNF-1A thread (see sketch SK-184-PM).

B. Proposed Use

The model SR-Cf-100 Series (101-999) source was designed for industrial applications where a source of up to 10 milligrams (5.2 curies) ^{252}Cf is needed. The applications will include, but are not restricted to, uses such as:

- Petroleum exploration
- mineral exploration
- moisture measurement
- radiography
- process control by neutron activation or neutron scattering.

Specific details on the environment and operating conditions will be supplied by the evaluator.

Appendix B (continued)

C. Radioisotope

The industrial sources of this design contain isotopes of californium in the following typical abundance:

Typical Analysis - Cf

Isotope	Atom %
249	4
250	11
251	2
252	82.5
253	0.5
254	<0.025

D. Construction

The decontaminated inner capsule, of either series SR-Cf-XX or SR-Cf-1X design, is placed in an outer 304L stainless steel or Zircaloy-2 capsule. The outer capsule is sealed by fusion welding a plug in the end. The completed assembly is leak tested, decontaminated, and assayed before packaging and shipping.

E. Prototype Tests

The integrity of the source construction and seal weld was demonstrated by successfully subjecting the secondary capsule to internal and external pressure tests far in excess of pressures expected under the most adverse service conditions. Infinite decay pressure created in the inner capsule from alpha decay and fission gas buildup is calculated to be 0.789 atmospheres (11.6 psia) per milligram of ^{252}Cf at standard temperature, or 3.06 atmospheres (46 psia) per milligram at 800°C and infinite decay.

1. Burst Test of Circumferential Weld

Hydrostatic burst tests on the circumferential closure weld in the outer capsule revealed that the average burst strength of the circumferential weld is 52,000 psi for stainless steel and 41,000 psi for Zircaloy-2 at 25°C. At 800°C the calculated burst strength for stainless steel is 2800 psi and >10,000 psi for Zircaloy-2 (internal pressure).

Appendix B (continued)

2. External Loading Tests

The two worst conditions to which the source is likely to be subjected are: a) crushing by a heavy object such as the shipping cask; and b) collapse under hydrostatic pressure, such as the capsule would experience in deep-well or deep-sea environment.

a) Crush Test

A large shipping cask for several milligrams of ^{252}Cf may weigh as much as 20 tons. Assuming half the weight of the cask might come to rest on the capsule, prototype sources were placed between stainless steel anvils loaded with a total of 10 tons, removed and pressurized with helium at 300 psi for 30 minutes, then tested for leaks with a helium leak detector. At a lower detection limit of 1×10^{-8} standard cubic centimeters of helium per second, no leaks were detected. A photograph of a prototype source after test is shown in Figure B-1.

b) Hydrostatic Compression Test

The hydrostatic pressure at 10 miles depth in a bore hole is about 25,000 psi. Test capsules were subjected to 25,000 psi helium pressure without measurable deformation, and then tested for leaks with a helium leak detector whose lower detection limit is 1.0×10^{-8} standard cubic centimeters of helium per second. No leaks were detected.

3. Additional Tests

The integrity of the source construction and seal welds was demonstrated by successfully subjecting the secondary capsule to tests simulating expected adverse service conditions as specified in AEC Manual, Chapter 0529-05, Safety Standards for the Packaging of Radioactive and Fissile Materials, Annex 4, as described below.

a) Free Drop - A free drop through a distance of 30 feet onto a flat essentially unyielding horizontal surface, striking the surface in such a position as to suffer maximum damage.

b) Percussion - Impact of the flat circular end of a 1-inch diameter steel rod weighing 3 pounds, dropped through a distance of 40 inches. The capsule or material shall be placed on a sheet of lead, of hardness number 3.5

to 4.5 on the Vickers scale, and not more than 1 inch thick, supported by a smooth essentially unyielding surface.

c) Heating - Heating in air to a temperature of 1475°F (800°C) and remaining at the temperature for a period of 10 minutes.

d) Immersion - Immersion for 24 hours in water at room temperature. The water shall be at pH 6-pH 8, with a maximum conductivity of 10 micromhos per centimeter.

After each of the four tests the test capsule was externally pressurized with 300 psi helium and helium leak tested. At a lower detection limit of 1 x 10^{-8} standard cubic centimeters of helium per second no leaks were detected.

F. Quality Control Procedures

The process for fabrication of sources was described in Section D. Quality control aspects of the process steps are discussed in the following paragraphs.

1. Californium Assay and Analyses

Quality control for the californium is accomplished by measurement of the neutron emission rate of an aliquot of the starting material and analyses for isotopic content (Section C) and chemical purity. The neutron emission rate is assayed in a fission counter. Isotope content is measured by mass spectrometry and chemical purity by spark source mass spectrometry. The completed assembly is leak tested, decontaminated and assayed before packaging and shipping.

2. Inspecting Capsule Components

Prior to cleaning, capsule components are inspected for dimensional accuracy and machining flaws.

3. Cleaning Capsule Components Prior to Use

All metal components used in californium source fabrication are thoroughly degreased and cleaned prior to use to remove cutting oil, grease, fingerprints, and dirt. Presence of these materials could cause pressure buildup during capsule sealing or the formation of undesirable products due to long-term radiolytic degradation inside the source. The following cleaning procedure is used for metal components of the system.

Appendix B (continued)

a) Soak the component for 10 minutes in clean acetone in a new or very clean vessel.

b) Remove the component from acetone with clean forceps and allow to air-dry for a few minutes.

c) Soak component for 10 minutes in clean absolute ethyl alcohol.

d) Rinse in clean acetone.

e) Air-dry in a dessicator for at least 30 minutes or dry on a lintless towel.

f) Store the clean, dry components in clean glass vials.

4. Welding Control

The plug in the outer capsule is seal-welded with an argon-shielded or helium-shielded tungsten electrode DC arc. The capsule is rotated under the automatically controlled arc to produce a minimum weld penetration of 0.050 inch (Figure B-2). The welded capsule is helium leak tested and decontaminated to a level of less than 9 d/m α and 10 c/m β-γ transferable radioactivity as determined by a wipe test.

5. Helium Leak Testing

Sealed capsules are pressurized in 300 psi helium for 30 minutes. Leak tests are performed on individual capsules in a helium leak detector whose lower detection limit is 1.0×10^{-8} standard cubic centimeters of helium per second. All capsules must show no detectable leak.

G. Labeling

Standard industrial sources for the Model SR-Cf-100 sources are identified by the engraved designation "SR-Cf-101," "SR-Cf-102," through "SR-Cf-999" as illustrated in Figure B-3. Each source is provided with an information sheet listing pertinent construction, test, and calibration data as shown in the attached Information Sheet.

FIGURE B-1. Welded Outer Capsule Before and After 20,000-lb Crush Test

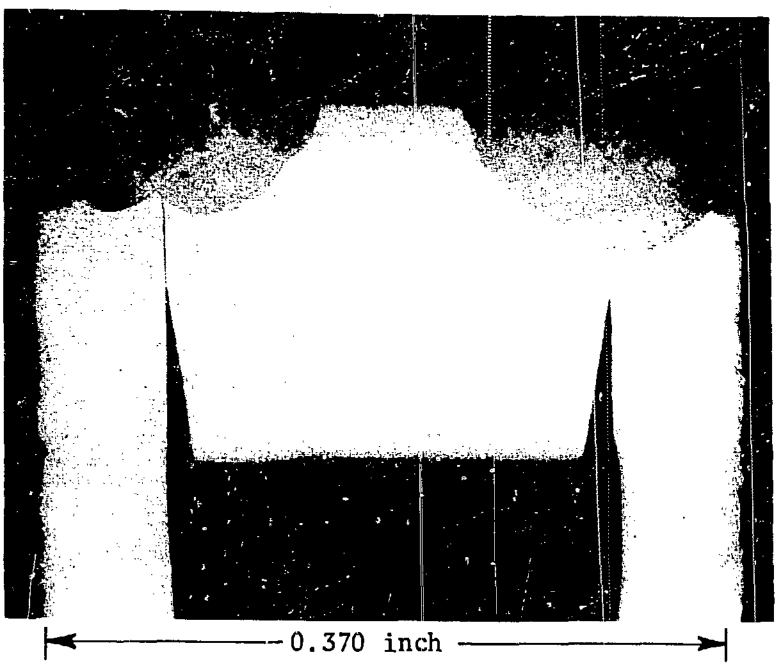


FIGURE B-2. Model SR-Cf-100 Series Outer Capsule Weld-Section (Type 304L Stainless Steel)

Appendix B (continued)

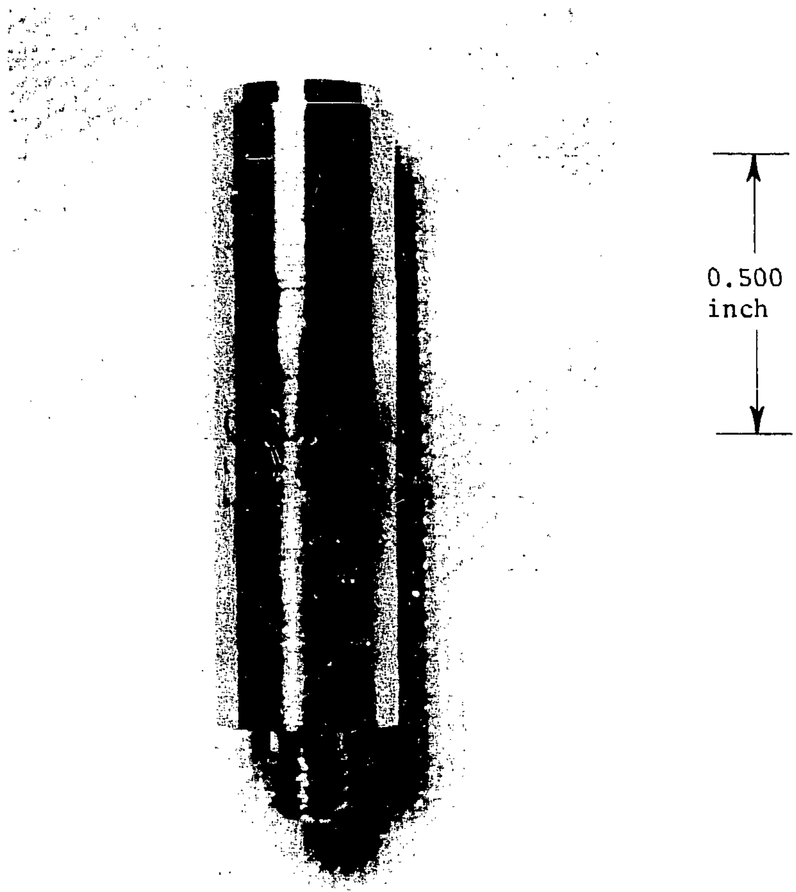
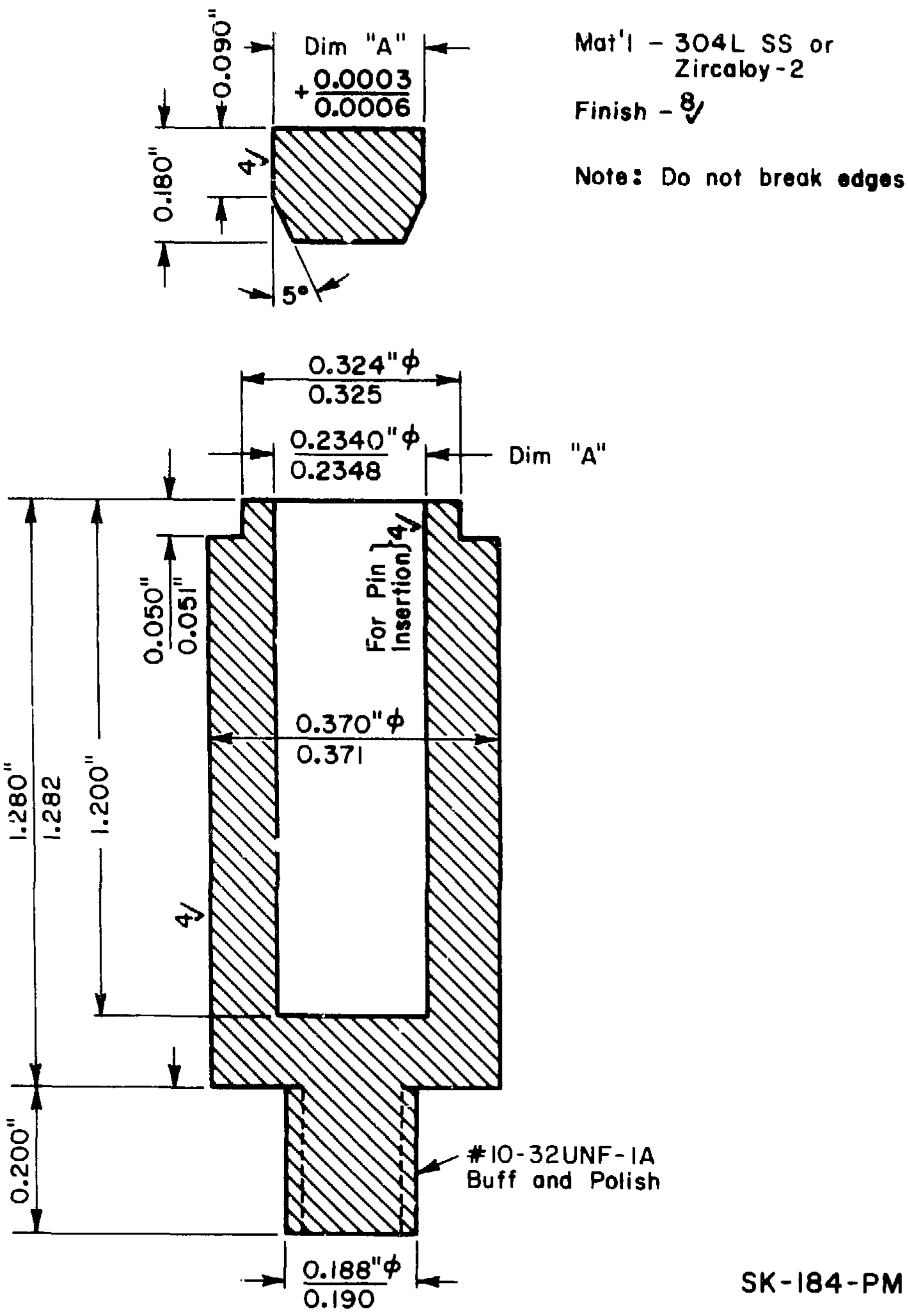


FIGURE B-3 Labeling

Typical ^{252}Cf-100 Series
Outer Capsule

Appendix B (continued)



SR-Cf-100 SERIES - SECONDARY CAPSULE

Appendix B (continued)

INFORMATION SHEET
"Special Form" - ^{252}Cf Neutron Source

Source Identification Number ________________________ Date: ________

Shipped To: ____

____

Specification: Outer Capsule Reference Drawing ______________
Primary Capsule Reference Drawing ______________

DECONTAMINATION AND CLOSURE TESTS

Method

Capsule surfaces are decontaminated after closure in an untrasonic bath until the flush solution contains less than 200 d/m per milliliter total alpha activity. The capsule is further decontaminated, if necessary, until all exterior surfaces are free of contamination (<9 d/m alpha and 10 c/m beta-gamma) as determined by a wipe test. Each assembly is immersed in a helium atmosphere with a pressure of at least 300 pounds per square inch for a period of 30 minutes, then transferred to a helium leak detector. The leak detector has a minimum sensitivity of 1.0×10^{-8} standard cubic centimeters of helium per second.

Tests

The finished capsule was found free of detectable leaks and contamination on ______________.

CALIFORNIUM CONTENT

Assay

The neutron emission rate of the finished assembly is determined by comparing its strength to that of a ^{252}Cf source calibrated at the National Bureau of Standards. The comparison is made by inserting the capsule assembly in an array of fission tube counters and measuring the subsequent induced electric current by a sensitive ammeter. The ^{252}Cf content given below is the effective or net californium content calculated from the neutron emission rate and is given in equivalent weight units assuming 2.311×10^{6} neutrons per second per microgram of ^{252}Cf. Corrections are made, when necessary, for the ^{254}Cf contribution to the total neutron emission rate. The ^{252}Cf present is assumed to decay with an effective half-life of 2.646 years; the ^{254}Cf, if present, is assumed to decay with a 60.5 day half-life.

Contents

The total neutron emission rate of this source was found to be ________ neutrons per second with a standard error of ±3.0% on ______________. The ^{254}Cf contribution to the total was calculated to be ____________ per second on the same date. The effective ^{252}Cf content was calculated to be ________ µg equivalent with a standard error of ±3.0%.

The radiation intensity at three meters from a source in air at standard atmospheric conditions and without contributions from scattering media is no greater than 400 mrem/hr neutrons plus 30 mR/hr γ for each milligram of ^{252}Cf in the capsule.

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E. S. Goldberg, Chief
Planning and Development Branch
SROO, USAEC
Aiken, South Carolina 29801

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S. Mirshak, Director
Nuclear Engg and Materials Section
Savannah River Laboratory
E. I. du Pont de Nemours and Co.

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