

7/2/98 EVENT RIDS DIST  
DCD (SP04)  
cc: P Larkins  
To: Quinn, ASPO

**EVENT REPORT COVER PAGE**

**AGREEMENT STATE**

**EVENT REPORT NO. MD- -**

**DATE: NOVEMBER 23, 1998**

**TO: Office of State Programs**

**SUBJECT: FOLLOWUP REPORT ON 7.078 REM RADIATION EXPOSURE THAT OCCURRED DURING SERVICING OF A TOSHIBA TELETHERAPY UNIT, INVOLVING AN NEUTRON PRODUCTS INC. (NPI), DICKERSON, MD, SERVICE ENGINEER**

**STATE: MARYLAND**

**Signature and Title: Raymond E. Manley**  
**Radioactive Material Inspections & Medical Programs**  
**Radiological Health Program**  
**MD Department of the Environment**

11000-

SP-EA  
C/12

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# Event Details for Item No: 980894

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EVENT DATE	DISCOVER DATE	REPORT DATE
01-JUL-98	19-AUG-98	19-AUG-98

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## LICENSEE INFORMATION

**Name:** NEUTRON PRODUCTS, INC.      **License Number:** MD-31-025-03  
**City:** NR      **State:** MD      **Region:** 1  
**Agreement State Status:** YS **Reportable Event:** Y **Abnormal Occurrence:** N

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**ABSTRACT:** The licensee reported to the Maryland Department of the Environment Radiological Health Services Office that one of their teletherapy service engineer's (OSP) TLD for the month of July read 7.078 cSv (rem) whole body. The source of the overexposure is unclear and under investigation. The licensee has removed the engineer from licensed activities pending the outcome of the investigation.

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## EVENT CLASSIFICATION

**Event Type:** EXP **Cause:** NOT REPORTED

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## KEY WORD INFORMATION

**Key Word:** SEALED SOURCE, TELETHERAPY  
**Key Word:** WHOLE BODY

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## EQUIPMENT INFORMATION

### System Level

**System ID:** TELETHERAPY UNIT  
**Manufacturer:** NR  
**Model Number:** NR

**Serial Number:** NR  
**Manufacture Date:** NR  
**Consequences:** FIELD NOT USED

### Component Level

**Component ID:** SEALED SOURCE,  
TELETHERAPY  
**System ID:** TELETHERAPY UNIT  
**Manufacturer:** NR  
**Model Number:** NR  
**Serial Number:** NR

**Manufacture Date:** NR  
**Isotope:** CO-60  
**Activity:** NR  
**Leak Results:** NR  
**Consequences:** FIELD NOT USED

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## REFERENCE DOCUMENTS

Report ID Number	Type of Report
EN34651	EVENT NOTIFICATION

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# MARYLAND DEPARTMENT OF THE ENVIRONMENT

2500 Broening Highway • Baltimore Maryland 21224  
(410) 631-3000 • 1-800-633-6101 • http://www.mde.state.md.us

Parris N. Glendening  
Governor

Jane T. Nishida  
Secretary

NOV 23 1998

**CERTIFIED MAIL: NOTICE OF VIOLATION**

Jackson A. Ransohoff, President  
Neutron Products, Inc.  
22301 Mt. Ephraim Road  
P.O. Box 68  
Dickerson, MD 20842

50110705 0111:27  
PDP

**RE: Radioactive Materials License Number: MD-31-025-03**

Dear Mr. Ransohoff:

This letter refers to an investigation conducted by radioactive material staff of the Maryland Department of the Environment's (MDE) Radiological Health Program (RHP) in August and September 1998. The investigation was conducted pursuant to an August 17, 1998 Neutron Products, Inc. (NPI) notification to RHP regarding the documented June 1998 radiation exposure of a NPI teletherapy service installer that exceeded 5 Rem limit stated in COMAR 26.12.01.01 Section D.201(a) while conducting activities under the above referenced license. NPI has removed this individual from any licensed activities that may result in additional occupational radiation exposure in 1998.

On August 25, 1998, at NPI's Ranson, West Virginia facility Messrs. Raymond Manley and Leon Rachuba interviewed NPI staff and witnessed a reenactment of those licensed activities (without live source) suspected of causing the overexposure. Additionally, on September 2, 1998, at NPI's Dickerson facility, Messrs. Carl Trump, Jr., Raymond Manley and Leon Rachuba interviewed NPI staff and witnessed a reenactment of those licensed activities (with live source) suspected of causing the overexposure.

NPI submitted a summary report of their investigation of the overexposure on September 8, 1998. This report defined NPI's evaluation of licensed activities conducted at Sinai Hospital in Miami Beach, Florida on June 25-26, 1998. Those activities included the multiple adjustments of a mirror assembly by NPI engineers on a Toshiba teletherapy unit while the source drawer was in a partially pulled out position. The report confirmed the NPI activities conducted on the above dates resulted in an unusual and increased occupational exposure, but it could not confirm that the overexposure was entirely from those activities.

Results of RHP's investigation revealed that in June 1998 a NPI teletherapy engineer received an occupational overexposure of approximately 7 Rem while conducting licensed activities. The overexposure was in most, or entirely the result, of the mirror adjustments conducted on a Toshiba teletherapy unit on June 25-26, 1998. During those activities NPI engineers failed to conduct adequate

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radiation surveys to evaluate the hazard. Furthermore, those NPI engineers failed to follow established and licensed procedures specifying the wearing of employee dosimetry and the documentation of dosimetry results. Finally, NPI failed to report the overexposure in writing to RHP within 24 hours of their discovery of the event.

During the investigation, these and other activities were found to be in violation of the Department's requirements. The findings were discussed with Messrs. Marvin Turkanis, Jeffrey Williams and you at various times during the investigation. The violations found are listed in the enclosed "Description of Violations."

In addition to the violations indicated above, RHP has the following specific radiation safety concerns from this investigation:

1. NPI's evaluation of the nature of the incident resulting in the overexposure states that a portion of the overexposure may have been resultant from undefined events. If this is true than some unknown condition may still exist during NPI source transfers or other licensed activities which may result in significant doses to occupational workers.
2. NPI failed to have a copy of the sealed source and device sheet (SS&D) for the Toshiba device being serviced. NPI personnel indicated that at least the lighting assembly had been replaced with a assembly not specified on the SS&D sheet. Have other portions of the teletherapy unit been replaced with systems not specified on its SS&D sheet?
3. One of the potential problems encountered by the NPI service engineers while adjusting the mirror was the quality assurance/quality control of the mirror assembly supplied from the NPI Dickerson facility.
4. Assurance by NPI that the potential for a similar incident does not currently exist.

The Maryland Department of the Environment's Radiological Health Program is extremely concerned that those activities conducted under your MD-31-025-03 license, which resulted in this employee overexposure, reflect an on-going and significant downward trend in over-all radiation safety at the Dickerson facility. NPI currently has unresolved compliance and safety concerns in all four of its specific licenses. These compliance concerns seriously question whether NPI's executive management currently has the competence to effectively oversee and implement critical safety aspects of NPI's radiation safety program.

As a result of these findings, you are expected to correct the violations as soon as possible. Additionally, you are required to respond to the above concerns and the enclosed "Description of Violations" within twenty (20) calendar days of your receipt of this notice. Written statements should be provided for each of the violations indicating:

- a. Corrective steps, which have been or will be taken by you to remedy the present violations and the results achieved or anticipated;
- b. Corrective steps which will be taken to avoid further violations, who will undertake these steps, and who will supervise them; and
- c. The date when full compliance will be achieved.

Failure to provide these statements in the required time frame may result in the Department

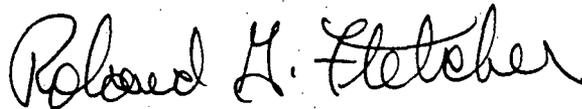
taking escalated enforcement action under Maryland Radiation Regulations to:

- (a) modify, revoke or suspend your license,
- (b) issue a Departmental Order under the Annotated Code of Maryland, Environment Article, Sections 1-301 and 8-101 through 8-601, and
- (c) seek an administrative penalty of up to \$1,000 per violation, per day [Section 8-510(b), or a civil penalty in Circuit Court in an amount not exceeding \$10,000 per violation, per day [Section 8-509(b)].

The serious nature and extent of the deficiencies noted within your program requires that you schedule an enforcement conference at the Agency's address no later than thirty (30) calendar days after your receipt of this letter, at which time, upon review of your compliance response, remedial actions can be discussed. Please identify who will be attending this meeting in your response to the Department.

Please be reminded that Departmental compliance letters and licensee responses shall be posted pursuant to the requirements of the Maryland regulations, Section J.11 (d) titled, "Posting of Notices to Workers." Should you have any questions concerning this letter, please contact Messrs. Raymond Manley, Carl E. Trump, Jr., or me at (410) 631-3302. You may also reach our office by dialing toll-free at 1-800-633-6101 and requesting extension 3302.

Sincerely,



Roland G. Fletcher, Manager  
Radiological Health Program

RGF/CET/REM/cc

Enclosure: Description of Violations

cc. Ann Marie DeBiase  
Attorney General Office

## DESCRIPTION OF VIOLATIONS

Neutron Products, Inc.  
22301 Mt. Ephraim Road  
P.O. Box 68  
Dickerson, MD 20842

**RE: Radioactive Materials License Number: MD-31-025-03**

Certain activities conducted under your license were found to be in violation of Code of Maryland Regulations 26.12.01.01 titled, "Regulations for Control of Ionizing Radiation." These violations are presented below:

1. Section D.201(a) titled, "Occupational Dose Limits for Adults" requires that NPI control the occupational dose to individual adults, except for planned exposures pursuant to D.206, to an annual limit of 5 Rem or less.

Contrary to the above, on June 25-26, 1998 the licensee failed to control the occupational dose to a teletherapy service engineer. That engineer was conducting activities licensed under the above referenced NPI license while exchanging and servicing a teletherapy device at a Sinai hospital in Miami Beach Florida. Specifically, a NPI occupational worker received radiation an overexposure while conducting an unusual licensed activity (multiple mirror adjustments of a teletherapy unit) at Sinai Hospital of Miami Beach Florida. The service engineer received a whole body TEDE radiation exposure dose of 7.078 Rem.

2. Section D.501, titled, "Surveys and Monitoring-General" requires, in part, that each licensee make or cause to be made such surveys as may be necessary for him to evaluate the extent of radiation hazards that may be present and to establish compliance with these regulations.

A. Contrary to the above, a NPI occupational worker received an overexposure while conducting an unusual licensed activity (multiple mirror adjustments of a teletherapy unit) at Sinai Hospital of Miami Beach Florida. Specifically, the moving of the teletherapy source drawer various distances away from its shielded position created substantial and significant increased dose rates. Even after a conference with NPI management (Radiation Safety Officer) and other experienced NPI service personnel, the on-site engineers failed to conduct adequate surveys with their survey meter to evaluate the hazard (increased dose rate or accurate definition of collimation of source of radiation). This failure to adequately survey occurred on both June 25, 1998 and June 26, 1998.

B. Contrary to the above, RHP staff interviews with the participating engineers revealed that those engineers were aware of the increased hazard of the activities being conducted. This was evidenced by the lead engineer's estimation of a 4 Rem extremity dose to one of the installers. These engineers failed to notify NPI management of likely increases to occupational dose resulting from the adjustments of the teletherapy mirror. This directly led to NPI management's failure to immediately process all of the engineer's thermoluminescent dosimeters (TLDs).

3. Section D.1202(b) titled, "Notification of Incidents-Twenty-Four Hour Notification" requires licensees to, within 24 hours of discovery of the event, notify RHP in writing by telegram, mailgram or facsimile, each event involving the loss of control of a licensed source of radiation possessed by the licensee that may have caused, or threatens to cause, an individual to receive in a period of 24 hours, a total effective dose equivalent (TEDE) exceeding 0.05 Sv (5 Rem).

Contrary to the above, on June 25-26, 1998 NPI lost control of a source of radiation which caused an NPI employee overexposure exceeding 0.05 Sv. (5 Rem). NPI's TLD processor Thermo Nutech telephoned NPI's facility on August 7, 1998 and informed a licensee representative that a NPI employee's whole body radiation exposure exceeded regulatory limits. NPI failed to report this overexposure to RHP until August 17, 1998, a period of 10 days after the representative of the licensee became aware.

4. Section D.502 titled, "Conditions Requiring Individual Monitoring of External and Internal Occupational Dose" requires that a licensee monitor exposures from sources of radiation at levels sufficient to demonstrate compliance with the occupational dose limits of Part D.

Contrary to the above, NPI's failure to conduct adequate radiation surveys during the mirror adjustments on June 25-26, 1998 resulted in the collimated radiation source beam not being defined. As a result, two of the participating engineer's whole body TLDs (monthly & quarterly) were worn at belt level instead of mid chest level. The belt level TLDs were not worn in the region of highest potential exposure.

5. Section C.31(c) titled, "Specific Terms and Conditions of License" requires each person licensed by the Agency to confine use of the licensed material to purposes authorized in the license. NPI's specific license condition #14 requires NPI to follow their Specification P-9 titled, "Procedures for Source Transfer, Maintenance, and Service Associated with Teletherapy Devices" as revised March 29, 1990. NPI's specific license condition #17 incorporates NPI Specification P-9 revision 2 with Table I and Appendices I through IX.

NPI's specification P-9 dated March 29, 1990 specifies the minimum dosimetry to be worn by each member of the installation team. That dosimetry is:

- i. A direct reading integrating dosimeter capable of measuring at least 200 mR in at least 5 mR increments, as a whole body dosimeter;
- ii. A direct reading, integrating dosimeter capable of indicating at least 1 R, as a whole body dosimeter;
- iii. Two TLD personal dosimeters (monthly and quarterly);
- iv. A TLD personnel dosimeter for each wrist;
- v. A direct reading, integrating dosimeter on each wrist, capable of measuring at least 10 R; and
- vi. An audible personnel monitor (chirper).

A. Contrary to the above, on June 25, 1998, during the source transfers (old source removed and new source installed), two of the NPI service engineers wore only one whole body SRD. This is contrary to the licensee's procedures that require the wearing of two whole body SRDs (low range and high range).

B. One engineer stated that when he wore wrist SRDs he wore a 1 R SRD on his left wrist and a 500 mRem SRD on his right wrist. The licensee's P-9 procedure requires the wearing of 2 SRDs capable of measuring 10 R.

6. Section C.31(c) titled, "Specific Terms and Conditions of License" requires each person licensed by the Agency to confine use of the licensed material to purposes authorized in the license. NPI's specific license condition #14 requires NPI to follow their Specification P-9 titled, "Procedures for Source Transfer, Maintenance, and Service Associated with Teletherapy Devices" as revised March 29, 1990. NPI's specific license condition #17 incorporates NPI Specification P-9 revision 2 with Table I and Appendices I through IX.

NPI's P-9 procedures clearly indicate that the SRDs of team members are to be last read and recorded after the service engineers replace the cover plates, collimators, retainer, etc., performing maintenance as appropriate. The activity involving the adjustment of the mirror clearly falls into this category.

- A. Contrary to the above, the senior engineer on site stated to the RHP inspector that whole body SRDs were last recorded following the source exchange and prior to the mirror adjustments.
  - B. Contrary to the above, following the source transfer and prior to the mirror adjustment one of the engineers removed his whole body SRD. This action failed to allow for final reading of this SRD following the mirror adjustments.
  - C. Contrary to the above, following the source transfer and prior to the mirror adjustment all three engineers removed their wrist SRDs. This action failed to allow for final reading of those SRDs following mirror adjustments.
7. Section C.31(c) titled, "Specific Terms and Conditions of License" requires each person licensed by the Agency to confine use of the licensed material to purposes authorized in the license. NPI's specific license condition #14 requires NPI to follow their Specification P-9 titled, "Procedures for Source Transfer, Maintenance, and Service Associated with Teletherapy Devices" as revised March 29, 1990. NPI's specific license condition #17 incorporates NPI Specification P-9 revision 2 with Table I and Appendices I through IX.

NPI's P-9 procedures require the recording of whole body SRDs results. Those results are recorded on NPI's teletherapy "Notice Form". On that form whole body SRDs are identified numerically to the individual being monitored.

Contrary to the above, the form specific to the June 25-26, 1998 Sinai teletherapy source replacement, shows two users wearing the identical number SRD and with the identical mRem reading. This represents at least a monitoring documentation error by the licensee. Of specific concern is that the whole body SRD record in question involves an individual who by interview participated in the mirror adjustment for a period of time almost two times greater than the overexposed individual. Also that individual's whole body TLDs were located at the waist and out of the major collimated beam.

8. Section J.12(a)(3) titled, "Instruction to Workers" requires all individuals working in or frequenting any portion of a restricted area shall be instructed in , and instructed to observe, to the extent within the worker's control, the applicable provisions of these regulations and licenses for the protection of personnel from exposures to radiation or radioactive material occurring in such areas.

NPI's 03 license application documentation requires training in licensed activities by installers.

Contrary to the above, two of the three service installers were not aware of requirements in NPI's P-9 procedure. Furthermore, documentation was not available for inspection review regarding P.9 training for three NPI engineer's involved in the June 25-26 licensed

- a. That whole body SRDs were required to be worn till completion of all unit maintenance;
- b. That two whole body SRDs were required to be worn (low range and high range) during teletherapy exchanges.
- c. That wrist SRDs should have a range up to 10 R;
- d. That whole body SRD reading should be recorded following maintenance as appropriate.
- e. That, if knowledge of increased hazard due to radiation was suspected, this should have been verbally transmitted to NPI's RSO.

**MARYLAND DEPARTMENT OF THE ENVIRONMENT  
AIR & RADIATION MANAGEMENT ADMINISTRATION**

Radiological Health Program

**MEMORANDUM**

**TO:** MD-31-025-03

**FROM:** Ray Manley

**DATE:** October 26, 1998

**SUBJECT:** FINAL REPORT OF 1998 NPI ENGINEER OVER EXPOSURE

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This report is a composite summary of the June 1998 Neutron Products, Inc. service engineer occupational overexposure under the MD-31-025-03 service license. This summary is a composite evaluation of the following documents:

1. August 17, 1998 NPI telephonic notification of overexposure to RHP & 24 hour written report (attached)
2. Employee radiation exposure documentation history for June 1998 and second quarter 1998 (Confidential)
3. NPI's initial written notification of overexposure to RHP (attached) minus attachment identifying the employee (confidential)
4. August 25, 1998 summary of Ranson West Virginia RHP investigation and non source reenactment (attached)
5. Private interviews with NPI installers (confidential)
6. NPI's August 26, 1998 request to conduct live source reenactment (attached)
7. August 27, 1998 telephone interview with Florida Hospital RSO (attached)
8. Follow-up telephonic interviews with NPI service engineers (confidential)
9. RHP response to NPI request for live reenactment (attached)

10. NPI's "Special Outline of Dose Measurement Experiment (attached)
11. RHP summary of live source reenactment (attached)
12. Sealed Source and Device Sheet #NR421D101U (attached)
13. NPI's 30 day written report of the incident (attached) minus the attachment correlating dose exposure to specific individuals (confidential)
14. NPI's specification P-9 procedures (confidential)
15. Inspector's proposed violations with discussion (attached)

## SUMMARY

On August 17, 1998 at about 1508 hours, this writer received a telephone call from Mr. Marvin Turkanis. Mr. Turkanis is the Radiation Safety Officer (RSO) for the Neutron Products, Inc. (NPI) teletherapy servicing license (MD-31-025-03). Mr. Turkanis called to report (in accordance with COMAR 26.12.01.01 Section D.1202(b)) a probable occupational overexposure to one of NPI's teletherapy service engineers. The overexposure was identified from that employee's June 1998 monthly wholebody TLD dose of 7070 millirem (mRem) and the second quarter wholebody TLD dose of 6513 mRem. Both of those exposures indicated that the employee exceeded the annual wholebody occupational limit of 5000 mRem. Extremity exposures were also elevated (12,267 mRem for left wrist and 4133 mRem for right wrist) but were below the occupational limit of 50,000 mRem. Mr. Turkanis informed me that because of this exposure result the engineer had been removed from all duties which might result in additional wholebody radiation occupational dose for 1998. NPI was unsure of how the overexposure occurred and was evaluating those activities conducted by that engineer during June 1998. Mr. Turkanis was reminded of the requirement for 24 hour and 30 day written reports. I informed him the RHP would conduct an investigation of the matter.

NPI subsequently decided that activities conducted by the overexposed service engineer during a June 1998 cobalt-60 source exchange in a hospital in Miami Beach were most likely to have caused the overexposure. On August 25, 1998 Mr. Leon Rachuba and this writer participated in an investigation of the above events at NPI's Region II licensed facility on 416 N. Fairfax Boulevard in Ranson West Virginia. During this investigation two NPI personnel involved in the Florida source exchange were interviewed. Also, a timed activity review of the teletherapy exchange process which occurred at the hospital was reviewed. Specifically, the three NPI engineers involved with the source exchange were Dale Repp, Edward Koontz and Thomas Baugher.

NPI suspected that certain activities conducted by the engineers while adjusting an internal Toshiba Head mirror for field of view on June 24-25, 1998 may have resulted in the overexposure. Those activities were conducted pursuant to a source exchange at a hospital in Miami Beach. Specifically, the hospital was Mount Sinai Medical Center of Greater Miami, Inc. located at 4300 Alton Road, Miami Beach Florida 33140. The hospital has a Florida specific

license (64-12) which authorizes the possession of a Toshiba teletherapy device. Again, the purpose of the reenactment was to evaluate the potential for a radiation overexposure with a Toshiba device (without source) located at the Ranson facility and make available for RHP interview NPI personnel involved. The Toshiba head (RCR-120C3) and the source drawer were slightly different than the ones used at the hospital. One of the three NPI service engineers Tom Baugher was scheduled to participate but was unable to attend due to a last minute doctor's appointment.

During the reenactment NPI demonstrated the general activities required for source plug removal, transfer plate alignments (NPI described that they had modified a Toshiba transfer tube to incorporate more lead and keep to doses to installers lower), and methodology of source drawer removal. The engineers did not recall any unusual events occurring during the removal of the old source or transfer into the head of the new source. Specifically, there were no occurrences of any source hang-up during the transfer. NPI engineers did note that the light assembly used to generate the initial source of light for the optical lens and mirror was not the original manufacturer's design (Dale Repp stated of NPI design), but had been installed at some unknown time by either NPI or Toshiba personnel (they were not sure which). The engineers indicated that there was a room radiation monitor, but did not recall when or if it visually alarmed. The alarm set point was 3 mR/hr. The lead engineer, Mr. Repp, described the dosimetry worn by the service engineer's during source transfers as two whole body SRDs worn in the shirt pocket (of variable ranges from 200 mRem to 10 Rem), monthly and quarterly whole body TLDs worn at either the mid shirt level or on the belt, a wrist TLD for each hand, and two wrist SRDs (variable ranges between 500 mRem to 5 Rem, and a Xetex electronic dosimeter on the belt. He stated that all SRDs are zeroed prior to the beginning of the source exchange. Subsequent interviews with the other participating engineers indicated that the dosimetry they were wearing was different than stated above (see inspector's proposed violations with discussion). All engineers agree that the wrist SRDs were removed following the source exchange and prior to the mirror adjustment. This was due to the inability to easily access the inside of the plug with the ion chambers on each wrist.

Following the source transfer NPI engineers had difficulty aligning the light with the lens and the mirror located on the source drawer. The NPI engineers made between 15-20 attempts (note this number was variable between 11-20~~8~~ during the entire course of this investigation) at adjusting the light field before specifications were met. Possible reasons why this adjustment took so long were:

1. The light system in the Toshiba Head was not the original system.
2. The mirror assembly on the source drawer was out of the specified alignment and needed multiple adjustments.
3. The lens assembly had been incorrectly installed (180 degrees rotated) prior to mirror adjustment. (note, Mr. Repp absolutely denies this reason).

This light field adjustment involved pulling the source drawer out of its fully shielded position to a minimum distance of 2.5 inches. (note, the drawer is capable of being pulled out a substantially greater distance 6-8 inches, before the drawer would become unbalanced and fall from the head.). The adjustment process involved pulling the source drawer, rotating the source

drawer 180 degrees to the source down position, loosening an allen screw, adjusting the mirror assembly on the source drawer, tightening the allen screw, rotating the source drawer 180 degrees to source up position and restoring the source drawer to its fully shielded position. Each one of these adjustments took a maximum of 1 minute. Mr. Repp estimated that Tom Baugher performed most of the mirror adjustments. He estimated that Mr. Baugher conducted 70% of the adjustment work and he conducted 30%. Mr. Koontz indicated that he conducted only the last adjustment.

Mr. Repp indicated that following initial concerns by the NPI engineers regarding the mirror adjustment, he called and spoke to the NPI's 03 RSO Mr. Turkanis. Under Mr. Turkanis's instruction he telephoned other NPI source installers who had experience with the mirror adjustments on Toshiba units. Mr. Turkanis indicated that during this phone call he was not made aware of any additional radiation exposure hazards.

The NPI engineers informed the RHP inspection team that during the mirror adjustments the hospital's RSO (Tom McCloud) conducted radiation surveys of the plug hole with a Victoreen model 450 digital/analog survey meter. He surveyed a dose rate of 2-3 R/hr at 24 inches from the plug hole. NPI understood that his meter either had problems or went off scale (>50 R/hr) when he put the detector into the plug hole. NPI engineers and management (Mr. Turkanis) feels that these measurements were probably in error. NPI personnel indicated their belief that the pulling of the source drawer during the mirror adjustments would not create a significant dose rate. NPI indicated that a reenactment with a live source would probably be needed to confirm increased dose rates.

Discussions were made involving other activities conducted by the overexposed individual during June 1998. Other activities conducted by the NPI engineer who received the whole body overexposure during June 1998 were:

- a. A source removal immediately following the source exchange in Florida. (6/26/98 North Miami Beach Cancer Care Center, Ltd., 125 North Miami Beach Florida)
- b. A radiation processing source installation in Germany. (612-13, 1998 Biersdorf, Hamburg Germany)
- c. Routine work in the LAA. (6/3/98 during hot cell cleanup-on May's TLD)

Each of these activities were examined and neither the installer nor any NPI personnel could determine a potential dose rate sufficient to have caused the overexposure.

NPI's failure to report the exposure within 24 hours of their knowledge of the event was discussed. Mr. Williams indicated that TLD manufacturer (Thermo-NuTech) reported the overexposure to the NPI receptionist on August 7, 1998. She left a note of the results for NPI's dosimetrist. The results were not communicated to NPI management until August 16, 1998 because the dosimetrist was on vacation. Jack Ransohoff indicated that they had remedied this communication lapse by discussions with the TLD manufacturer. The manufacturer now has a

NPI management call down list and is to fax the results to all those individuals on the list (i.e. Jeff Williams, Jack Ransohoff & Marvin Turkanis).

On August 25, 1998 private interviews were held with two of the NPI service engineers who participated in the June 24-25, 1998 mirror adjustments. On various dates (8/26/98, 8/27/98, 8/28/98 & 9/11/98) telephone interviews were held with Mr. Turkanis and all three NPI engineers who participated in the June 24-25, 1998 mirror adjustments. Individual engineer accounts of activities conducted varied in the following areas:

1. Who conducted what activities and length of time of those activities?

Discussion: One engineer conducted 70 % (not the overexposed individual) of the mirror adjustments and the other two engineers time of activity significantly varied. The engineer who did most of the adjustments stated that he kept his whole body dose low by not standing in the radiation beam. The other two engineers specifically stated that the work could not be done unless standing directly in the beam of radiation. The number of mirror adjustments conducted varied from 11 to 20. The amount of time (worst case) for each mirror adjustment varied from 1 minute to 3 minutes.

2. How many mirror adjustments were conducted?

Discussion: The number of mirror adjustments done varied from 11 to 20.

3. Who was wearing what dosimetry and when?

Discussion: One engineer indicated that all engineers were wearing all dosimetry in accordance with the licensee's operating procedures. All engineers admitted that wrist SRDs were removed prior to mirror adjustments. One engineer stated that he was not wearing any whole body SRD during the mirror adjustments. Two engineers stated that when they were wearing wrist SRDs they were in the 500 mRem and one Rem range. Whole body SRDs (when worn) were at chest level by two of the engineers and at waist level by the third engineer. Whole body TLDs were worn at the waist by two engineers and at chest level by the engineer that was overexposed.

4. When were the SRDs read?

Discussion: Two of the engineers did not specifically recall, however the individual who was responsible for the recording of the SRD doses recalls that the doses were recorded on NPI's service sheet before the mirror adjustments began. He further indicated that users whole body SRDs were again checked at the end of the mirror servicing (but not recorded), however, as already noted at least one engineer was not wearing any SRDs at that time.

On September 2, 1998, at about 1030 hours, at NPI's Dickerson facility, RHP inspection staff (Carl E. Trump, Jr, Leon Rachuba, and Ray Manley) participated in a live source evaluation of doses rates from a Toshiba Head when the source drawer is pulled out at various distances. This reenactment was authorized by RHP in an August 31, 1998 letter to NPI, on a one-time basis, pursuant to an August 26, 1998 request by NPI. NPI outlined their purpose for the reenactment in a

attached document called "Special Outline of Dose Measurement Experiment-Toshiba. Surveys were taken by NPI with various survey meters (attached) with the source drawer pulled out from the "in" position at measured distances and with the source in both the up position and the down position. The licensee matrix of dose rates is attached. The reenactment source was approximately one-hundredth of the source strength of the one in Florida. NPI management appeared to be surprised regarding the level of increase in dose rate as the source drawer was pulled. Results of these surveys appear to indicate that there is a substantial increase in dose rate for each inch that the source drawer is moved away from the "in" position. Given the times that engineers were involved with the mirror adjustment, it appears that somewhere between 3-4 inches (source drawer pulled) there exists a sufficient dose rate to have caused the employee overexposure.

NPI submitted a summary report of their investigation of the overexposure on September 8, 1998. This report defined NPI's evaluation of licensed activities conducted at Sinai Hospital in Miami Beach, Florida on June 25-26, 1998. Those activities included the multiple adjustments of a mirror assembly by NPI engineers on a Toshiba teletherapy unit while the source drawer was in a partially pulled out position. The report confirmed the NPI activities conducted on the above dates resulted in an unusual and increased occupational exposure, but it could not confirm that the overexposure was entirely from those activities.

Inspector discussions regarding concerns and alleged violations can be found in the attached document memo to Carl E. Trump, Jr. titled "Proposed NPI violations resultant from RHP investigation of the June 1998 Employee overexposure."

MARYLAND DEPARTMENT OF THE ENVIRONMENT  
AIR & RADIATION MANAGEMENT ADMINISTRATION

Radiological Health Program

**MEMORANDUM**

TO: Carl E. Trump, Jr.

FROM: Ray Manley

DATE: September 15, 1998

SUBJECT: **PROPOSED NPI VIOLATIONS RESULTANT FROM RHP  
INVESTIGATION OF THE JUNE 1998 EMPLOYEE OVEREXPOSURE**

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1. **Violation of Section D.201(a)(1) titled, "Occupational Dose Limits for Adults" (one violation)**

**DISCUSSION**

D.201(a) requires that NPI control the occupational dose to individual adults, except for planned exposures pursuant to D.206, to an annual limit of 5 Rem or less.

On June 25-26, 1998 the licensee failed to control the occupational dose to a teletherapy service engineer while he conducted activities under NPI's MD-31-025-03 license. This engineer was exchanging and servicing a teletherapy device at a hospital in Miami Beach Florida. The service engineer received a whole body TEDE TLD radiation exposure dose of 7.078 Rem. N/C

2. **Violations of Section D.501 titled, "Surveys and Monitoring" (two violations for two days.)**

**DISCUSSION**

Section D.501 requires that a licensee make, or cause to be made, surveys that are necessary under the circumstances to evaluate radiation levels. A NPI occupational worker received an overexposure while conducting an unusual licensed activity (multiple mirror adjustments of a teletherapy unit) at Sinai Hospital of Miami Beach Florida. Specifically, the engineer's needed to access a set screw on the source draw to allow the

adjustment of the mirror alignment for the unit's light field. This required the moving (15-20 times) of the teletherapy source drawer distances away from its shielded position thus creating substantial and significant increased dose rates. Even after a conference with NPI management (Marv Turkanis) and other experienced NPI service personnel, the on-site engineers failed to conduct adequate surveys with their meter to evaluate the hazard (increased dose rate or accurate definition of collimation of source of radiation). N/C This failure to adequately survey occurred on both 6/25/98 and 6/26/98. Dale Repp did conduct one survey with the source drawer in its fully "in" position (250 mR/hr) but NPI failed to evaluate any dose rates during those portions of the mirror adjustment service while the source drawer was not into the fully "in" position. The September 2, 1998 reenactment at NPI showed significant increases of dose rate when the drawer was pulled for the mirror adjustment (e.g. face of plug hole with source drawer pulled 2.5 in. = 20 R/hr, face of plug hole with source drawer pulled 3 in. = 35 R/hr, face of plug hole with source drawer pulled 4 in. = 250 R/hr) **note:** Marv Tarkanis indicated that high dose rates and resultant hazards were not discussed or considered likely during his talks with Mr. Repp regarding the mirror adjustment. A survey was conducted on the source drawer, when not in the fully "in" position, by the clients (Sinai's) RSO, which indicated a significantly high dose rate (2-3 R/hr at 24 inches). NPI personnel apparently chose to disregard this survey. Even during NPI management follow-up evaluations of this event, the client's RSO survey was considered probably inaccurate. During a 9/11/98 telephone interview with RHP, the job supervisor stated his view that all engineers were aware of the increased dose rates (This becomes NPI's justification as to why the engineers would only pull out the drawer a maximum of 2.5 inches). However, it appears that, if indeed there was knowledge of the increased hazard, it was not discussed with NPI management, proper dosimetry was not worn, dosimetry location on the engineer's body was not appropriately changed, surveys by other entities were disregarded and most importantly no additional surveys were conducted by NPI personnel to evaluate the hazard.

Furthermore, and of separate issue, if the NPI engineers were aware of the increased hazard of the work with the mirror (note: one engineer's extremity dose was estimated to be 4 Rem onsite) NPI's management should have been notified and under D.501, all badges immediately processed. N/C Note one engineer claims that he requested that the NPI dosimetrist immediately process all badges. The dosimetrist denies that this request was made.

**3. Violation of Section D.1202 (b) titled, "Notification of Incidents-Twenty-Four Hour Notification" (one violation 9 days)**

**DISCUSSION**

Section D.1202 (b) requires licensees to notify RHP in writing, for each event involving the loss of control of a licensed source of radiation that may have caused, or threatens to cause, an individual to receive in a period of 24 hours, a total effective dose equivalent (TEDE) exceeding 0.05 Sv (5 Rem). On June 25-26, 1998 NPI lost control of a source of radiation which caused an NPI employee overexposure exceeding 0.05 Sv. (5 Rem). NPI's TLD processor Thermo Nutech (NVLAP approved) called NPI's facility, and

because the dosimetry clerk was on vacation, reported on August 7, 1998, to NPI's receptionist, that a NPI employee's whole body radiation exposure exceeded regulatory limits. Due to a breakdown in communication between the receptionist, the dosimetrist, and NPI management, NPI management did not become aware of the overexposure till August 16, 1998. NPI failed to report this overexposure to RHP until August 17, 1998 a period of 10 days after a representative of the licensee became aware. N/C

**4. Violation of Section D.502 titled, "Conditions Requiring Individual Monitoring of External and Internal Occupational Dose"(occurrences-2 persons for 2 days)**

**DISCUSSION**

Section D.502 requires that a licensee monitor exposures from sources of radiation at levels sufficient to demonstrate compliance with the occupational dose limits of Part D. Pursuant to NPI's failure to conduct adequate radiation surveys during the mirror adjustments on June 25-26, 1998, the collimated radiation source beam was not defined. As a result, two participating engineers whole body TLDs (monthly & quarterly) were worn at belt level instead of mid chest level. The belt level TLDS were not worn in the region of highest potential exposure. N/C

**5. Violation of Section C.31(c) titled, "Specific Terms and Conditions of License", License Condition #14 & #17. (7 violations some for two days and some for multiple individuals)**

**DISCUSSION**

Section C.31(c) requires each person licensed by the Agency to confine use of the licensed material to purposes authorized in the license. NPI's specific license condition #14 requires NPI to follow their Specification P-9 titled, "Procedures for Source Transfer, Maintenance, and Service Associated with Teletherapy Devices" as revised March 29, 1990. License condition #17 is the license tie down and incorporates NPI Specification P-9 revision 2 with Table I and Appendices I through IX. NPI's specification P-9 dated March 29, 1990 specifies the minimum dosimetry to be worn by each member of the installation team. That dosimetry is:

- a. A direct reading integrating dosimeter capable of measuring at least 200 mR in at least 5 mR increments, as a whole body dosimeter;
- b. A direct reading, integrating dosimeter capable of indicating at least 1 R, as a whole body dosimeter;
- c. Two TLD personal dosimeters (monthly and quarterly);
- d. A TLD personnel dosimeter for each wrist;

- e. A direct reading, integrating dosimeter on each wrist , capable of measuring at least 10 R; and
- f. An audible personnel monitor (chirper)

On 6/25/98 during the source transfers (old source removed new source installed) two of the service engineers (by interview) wore only one whole body SRD. This is contrary to the licensee's procedures that require the wearing of two whole body SRDs (low range and high range). N/C The P-9 procedure clearly requires that SRDs of team members be last read and recorded after the service engineers replace the cover plates, collimators, retainer, etc., performing maintenance as appropriate. The activity involving the adjustment of the mirror clearly falls into this category. Following the source transfer and prior to the mirror adjustment one of the engineers removed his whole body SRD. This obviously would not allow for final reading of the SRD following mirror adjustment. N/C Following the source transfer and prior to the mirror adjustment all three engineers removed their wrist SRDs. This obviously would not allow for final reading of those wrist SRDs following mirror adjustment. NPI engineers supported the removal of the wrist SRDs because of the confined area of the plug hole. However, if adequate preliminary surveys of the hazard had been conducted NPI engineers would have been aware that ring TLDs could have been used and immediately processed. N/C One engineer stated that when he wore the wrists he wore a 1 R SRD on his left wrist and a 500 mRem SRD on his right wrist. The licensee's P-9 procedure requires the wearing of 2 wrist SRDs capable of measuring 10 R. N/C

As previously indicated the P-9 procedure clearly requires that SRDs of team members be last read and recorded after the service engineers replace the cover plates, collimators, retainer, etc., performing maintenance as appropriate. The activity involving the adjustment of the mirror clearly falls into this category. The senior engineer on site admitted that whole body SRDs were last recorded following the source exchange and prior to the mirror adjustment. N/C That engineer stated that following the mirror adjustments the other engineers indicated that there was no change in their SRD results. This fact was not recorded at the time. (Note one of the service engineers, by admission, failed to wear a whole body SRD during the mirror adjustments so therefore it could not have been read following the mirror adjustment)

NPI's P-9 procedures require the recording of whole body SRDs results. Those results are recorded on NPI's teletherapy "Notice Form". On that form whole body SRDs are identified numerically to the individual being monitored. The form specific to the 6/25-26/98 Sinai teletherapy source replacement shows two users wearing the identical number SRD and with the identical mRem reading. This represents at least a monitoring documentation error by the licensee. N/C Of specific concern is that the whole body SRD record in question apparently involves an individual who by interview participated in the mirror adjustment for a period of time almost two times greater than the overexposed individual. Also that individuals TLDs were located at the waist and out of the major collimated beam.

NPI's 03 license application documentation requires training in licensed activities by installers. Two of the three service installers were not aware of requirements in NPI procedure P-9. N/C Specifically, certain installers were unaware

- a. That whole body SRDs were required to be worn till completion of all unit maintenance;
- b. That two whole body SRDs were required to be worn (low range and high range) during teletherapy exchanges.
- c. That wrist SRDs should have a range up to 10 R;
- d. That whole body SRD readings were required to be recorded following maintenance as appropriate.
- e. If knowledge of increased hazard due to radiation was suspected that knowledge should have been verbally transmitted to NPI's RSO.
- f. Of the need to conduct radiation surveys to evaluate the hazard of special or unusual working circumstances.

#### **OUTSTANDING OR REMAINING CONCERNS:**

1. NPI's evaluation still allows the supposition that the nature of the incident resulting in the overexposure is still not entirely known. If this is true than some unknown condition may still exist during NPI source transfers or other licensed activities which may result in significant doses to their occupational workers.
2. NPI (Bob Alexander) has submitted an evaluation of EDE with weighting factors of less than one. If, following evaluation by RHP and NRC, this method is technically sufficient and based on appropriately substantiated licensee reenactment information, the exposed individuals dose may need to be modified.
3. Neither NPI nor the Florida Hospital has a copy of the SS&D sheet for the Toshiba device being serviced. NPI personnel indicated that at least the lighting assembly had been replaced from the original unit. The light or potentially other systems may not be SS&D sheet specified.
4. One of the problems encountered by the NPI service engineers while adjusting the mirror was the potential failure of QA/QC for the mirror orientation while at the NPI facility.
5. Potential overexposure of other NPI engineers on site (whole body, extremity or eye dose).
6. Assurance by NPI that the potential for a similar incident does not currently exist.

**STATE OF MARYLAND  
DEPARTMENT OF THE ENVIRONMENT  
RADIOLOGICAL HEALTH PROGRAM**

**MEMORANDUM OF TELEPHONE CALL (8/19/98 addendum)**

**DATE:** 8/17/98

**TIME:** about 1508 hours

**INCOMING CALL:** yes

**OUTGOING CALL:**

**MDE PERSON TALKING:** Ray Manley

**PERSON TALKED TO:** Marvin Turkanis

**AFFILIATION OF PERSON:** Vice President and Radiation Safety Officer of the Neutron Products Inc. (NPI) teletherapy servicing license MD-31-025-03

**ESSENCE OF CONVERSATION:** Mr. Turkanis called to report [in accordance with COMAR 26.12.01.01 Section D.1202 (b)] a radiation wholebody overexposure. On 8/17/98 at 0930 hours, Mr. Turkanis became aware that a NPI radiation occupational worker (teletherapy service engineer) received a June 1998 monthly TLD whole body exposure of 7078 milliRem and a quarterly TLD whole body exposure of 6513 milliRem (mRem). Both of these exposures exceed that 5000 mRem whole body annual occupational limit. Extremity radiation exposures were also very high (12,267 mRem left wrist, 4133 mRem right wrist), but did not exceed the annual extremity exposure limit of 50,000 mRem. Pursuant to this exposure, this service engineer has been removed from all duties that might result in additional occupational dose for 1998. The licensee is currently evaluating all activities conducted by this individual during June 1998. His duties in June 1998 have included a source replacement and source exchange in Florida, an irradiator source installation in Germany and general work in the NPI Limited Access Area (LAA). The licensee has not yet determined how the overexposure occurred. Mr. Turkanis was reminded of the initial 24 hour written notification requirement with the 30 day written follow-up when more information is known. I informed Mr. Turkanis that RHP management would be informed and that RHP staff would need to visit the facility to conduct an in-depth investigation.

**FURTHER ACTION REQUIRED:** RHP investigation

**PERSON NOTIFIED:** Roland G. Fletcher

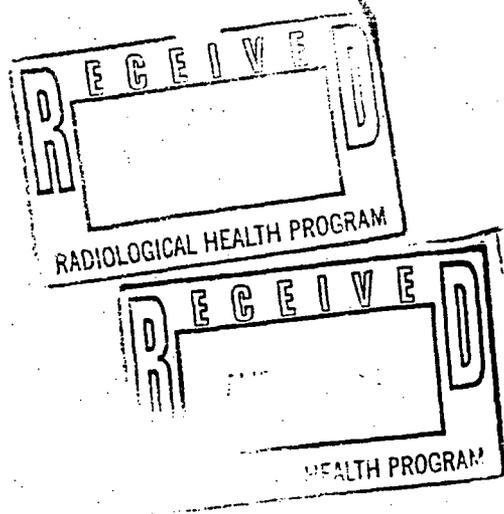
**SIGNATURE:** 

**ADDENDUM:** This event was called into NRC Operations Center on 8/19/98 at about

1300 hours (301) 816-5151. The event was reported pursuant to 10 CFR 20.2202 (b)(1)(i)

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9/4/98 CE



# NEUTRON PRODUCTS inc

22301 Mt. Ephraim Road  
P.O. Box 68  
Dickerson, Maryland 20842 USA  
301-349-5001 FAX: 301-349-5007

August 17, 1998

Mr. Roland G. Fletcher  
Environmental Manager  
Radiological Health Program  
Maryland Department of the Environment  
2500 Broening Highway  
Baltimore, Maryland 21224

Attn: Mr. Carl Trump

VIA FAX: 410/631-3198

Re: License MD-31-025-03

Dear Mr. Fletcher:

This is to confirm my oral report of this afternoon to Mr. Ray Manley of an apparent occupational over-exposure of Neutron's employee number 13.

Employee number 13's monthly TLD for June 1998 and quarterly TLD for the period of April to June 1998 were reported to be 7,078 and 6,513 mr respectively. In addition, his left and right wrist TLDs for the month of June were reported to be 12,267 and 4,133 mr, respectively.

The monthly TLD for June and quarterly TLD for the period of April to June 1998 were submitted to our service on July 10; the report was received by the service company on July 16; an oral report was received at Neutron Products on August 7; the written report was received at Neutron during the week of August 10; the report was reviewed by the dosimetry clerk early on Monday, August 17, when she returned from vacation, and the results were immediately reported to the individual and the RSOs of Neutron's MD-31-025-01 and MD-31-025-03 licenses.

As RSO of Neutron's MD-31-025-03 license, I immediately began an investigation and determined that employee number 13 was involved in one teletherapy source exchange, one teletherapy source removal, one radiation processing source installation, and had entered the LAA several times to perform routine operations that did not involve radioactive material in June.

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Mr. Roland G. Fletcher  
Environmental Manager  
Radiological Health Program  
Maryland Department of the Environment  
Page 2 August 17, 1998

The apparent overexposure was also the evaluated by a 3 hour meeting of Neutron's Radiation Safety Committee meeting which started at approximately noon on Monday, August 17, 1998.

Employee number 13 reports that he wore three (3) SRDs and an alarming dosimeter at both the teletherapy source exchange and the removal. This is confirmed by the recollection of the second person on each job. Employee number 13's highest whole body and right wrist SRD reading were 160 and 400 mr and 20 and 70 mr, respectively for the teletherapy source replacement and teletherapy source removal, per the recordings made at the time.

The highest whole body and wrist SRD readings of the second person at the teletherapy source exchange and teletherapy source removal were 50 and 95 mr, and 30 and 80 mr, respectively, for the exchange and removal.

Based on his recording of his SRD readings on entering and leaving the LAA, there having been no unusual exposure levels in the LAA in June and the exposures of those who normally work in the LAA, there is no basis for his activity in the LAA explaining the apparent overexposure.

Based on the TLD exposure reading of an other employee who was with employee number 13 at all times during the radiation processing source installation when he could have received the exposure indicated by his badges, employee 13 did not receive the apparent exposure during this project.

Employee number 13 reports that he always keeps his TLDs with him and that he has no conception how they could have received the reported exposure. He also has no explanation on why the reported exposure on the left wrist TLD should be higher than that on his right wrist TLD, since he is right handed.

Based on Neutron's standing instructions, Neutron's TLD service called Neutron on August 7 to report employee number 13 exposure. When the dosimetry clerk was not available, they left a message with Neutron's receptionist. When Neutron's dosimetry clerk called for her messages, she was told that all of the reported exposures were for those who had participated in the hot cell cleanup. However, employee number 13 exposure from his participation in the hot cell cleanup was in July.

Mr. Roland G. Fletcher  
Environmental Manager  
Radiological Health Program  
Maryland Department of the Environment  
Page 3 August 17, 1998

Since several TLDs indicate either an overexposure or higher than anticipated exposures, it is reasonable to attribute the apparent exposure to a real exposure. However, at this time, we can not find a explanation for the cause of the apparent overexposure.

Employee number 13 is identified in Attachment I, which we request be treated as confidential information.

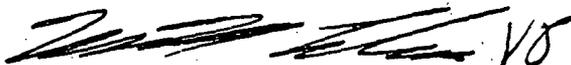
Neutron is treating this apparent overexposure as a actual overexposure and has taken the following actions:

- employee number 13 has been removed from all activities that require radiation monitoring and is not authorized to enter the LAA;
- Neutron's TLD service will be given a list to whom all oral reports are to be given; and,
- we are continuing to investigate and evaluate the apparent over exposure.

Please call me if you have any questions or recommendations.

Sincerely,

NEUTRON PRODUCTS, INC.



Marvin M. Turkanis  
Vice President

Enclosure

MMT/afc

NEUTRON PRODUCTS inc

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**Subject: Investigation NPI overexposure**

**Location: 416 N. Fairfax Blvd in Ranson West Virginia**

**Date: August 25, 1998**

**Persons Present:**

MDE: Raymond E. Manley (HP Lead) & Leon D. Rachuba (HP Lead)

NPI: Jackson A. Ransohoff (President), Marvin Turkanis (V.P. & 03 RSO), Jeff Williams (RSO of 01), Dale Repp (03 Service Engineer), Edward Koontz (03 Service Engineer) & Edward DeRosa (Sales and 03 Service Engineer)

**Summary of investigation concern:** On 8/17/98 NPI reported to RHP that a teletherapy service engineer had received an overexposure (7 Rem) from NPI conducted activities in June 1998. NPI suspects that of those activities conducted by the engineer while adjusting an internal Toshiba Head mirror for field of view on 6/25/98 may have resulted in the overexposure. The activities were pursuant to a source exchange at a hospital in Miami Beach. NPI was to evaluate this potential for exposure with a Toshiba device (without source) located at the Ransom facility and make available for RHP interview NPI personnel involved. The Toshiba head (RCR-120C3) and the source drawer were slightly different than the ones used at the hospital. **Note:** One of the three NPI service engineers Tom Baugher was scheduled to participate but was unable to attend due to a last minute doctor's appointment.

**Details of potential site for the overexposure:**

1. Mount Sinai Medical Center of Greater Miami, Inc., 4300 Alton Road, Miami Beach Florida 33140.
2. Florida license # 64-12 (note: the license authorizes possession of the Toshiba Teletherapy device).
3. Toshiba Head model was RCR-5C, activity of source installed 5810 curies, Catalog # NPI-15-6000W, Model NPTT-Series, s/n T1451, calibration date 6/1/98.
4. Site contacts: Mr. Brain Keller (305)535-3440 & Thomas McCloud (305)-535-2457
5. Date of exchange June 25, 1998.

**Details of source exchange reenactment (without source) and general comments and statements by NPI:**

1. NPI demonstrated the general activity of the source plug removal, transfer plate alignments (NPI described that they had modified a Toshiba transfer tube to incorporate more lead and keep to doses to installers lower), and methodology of

source drawer removal. No unusual events occurred during the removal of the old source or transfer into the head of the new source. Specifically, there were no occurrences of any source hang-up during the transfer. The source transfer was conducted very low to the ground to keep the assembly level with the transfer dolly.

2. NPI engineers did note that the light assembly used to generate the initial source of light for the optical lens and mirror was not the original manufacturers design (Dale Repp stated of NPI design), but had been installed at some unknown time by either NPI or Toshiba personnel (they were not sure which).
3. The engineers' indicated that there was a room radiation monitor, but did not recall when or if it visually alarmed. The alarm set point was 3 mR/hr.
4. Mr. Repp described the dosimetry worn by NPI service engineer's during source transfers as two whole body SRDs worn in the shirt pocket (of variable ranges from 200 mRem to 10 Rem), monthly and quarterly whole body TLDs worn at either the mid shirt level or on the belt, a wrist TLD for each hand, and two wrist SRDs (variable ranges between 500 mRem to 5 Rem, and a Xetex electronic dosimeter on the belt. He stated that all SRDs are zeroed prior to the beginning of the source exchange.
5. An unshielded cobalt-60 source of this activity would have a dose of approximately 6000 R/hr at one meter.
6. During the source transfers a meter and chirper were placed 90 degrees (to side of source transfer assembly) into the area which would have the highest dose-rate during the source transfer.
7. When the plug is removed from the plug hole and the source drawer is fully in place the dose-rate at the entrance to the cavity is about 80 mR/hr and 250 mR/hr in the plug hole cavity.
8. Following the source transfer NPI engineers had difficulty aligning the light with the lens and the mirror located on the source drawer.
9. The NPI engineers made between 15-20 attempts at adjusting the light field before specifications were met. Possible reasons why this adjustment took so long were 1. The light system in the Toshiba Head was not the original system (described by Mr. Repp as Rube Goldberg) 2. The mirror assembly on the source drawer was out of the specified alignment and needed multiple adjustments. 3. The lens assembly had been incorrectly installed (180 degrees rotated) prior to mirror adjustment. (note Mr. Repp absolutely denies this reason). This light field adjustment involved pulling the source drawer out of its fully shielded position to a minimum distance of 2.5 inches. The adjustment process involved pulling the source drawer, rotating the source drawer 180 degrees to source down position, loosening an allen screw, adjusting the mirror assembly on the source drawer, tightening the allen screw, rotating the source drawer

180 degrees to source up position and restoring the source drawer to its fully shielded position. Each one of these adjustments took a maximum of 1 minute.

10. Mr. Repp indicated that following initial concerns by the NPI engineers regarding the mirror adjustment, he called and spoke to the NPI 03 RSO Mr. Turkanis. Under Mr. Turkanis's instruction he telephoned other NPI source installer who had experience with the mirror adjustment on Toshiba units (George Brown & Richard Tarker). Mr. Turkanis indicated that during this phone call he was not made aware of any additional radiation exposure hazards. *KS 7/17*
11. Mr. Repp stated that the engineers had removed their wrist SRDs prior to these adjustments because of the small diameter of the plug hole and the inability to get their hands into the plug hole while wearing the SRDs.
12. Mr. Repp estimated that Tom Baugher performed most of the mirror adjustments. He estimated that Mr. Baugher conducted 70% of the adjustment work and he conducted 30%. Mr. Koontz indicated that he conducted only the last adjustment.
13. Mr. Repp estimated that the average whole body dose to individuals conducting a source exchange is 50-60 mRem.
14. During the mirror adjustments the hospital's RSO (Tom McCloud ) conducted radiation surveys of the plug hole with a Victoreen model 450 digital/analog survey meter. He surveyed a dose rate of 2-3 R/hr at 24 inches from the plug hole. His meter either had problems or went off scale (>50 R/hr) when he put the detector into the plug hole. NPI engineers and management (Mr. Tarkanis) feels that these measurements were in error.
15. Discussions regarding NPI's failure to report the exposure within 24 hours of their knowledge of the event was discussed. Mr. Williams indicated that TLD manufacturer (Thermo-NuTech ) reported the overexposure to the NPI receptionist on 8/7/98. She left a note of the results for NPI's dosimetrist. The results were not communicated to NPI management until 8/16/98 because the dosimetrist was on vacation. Jack Ransohoff indicated that they had remedied this communication lapse by discussions with the TLD manufacturer. The manufacturer now has a NPI management call down list and is to fax the results to all those individuals on the list (i.e. Jeff Williams, Jack Ransohoff & Marvin Turkanis).
16. NPI personnel indicated their belief that the pulling of the source drawer during the mirror adjustments would not create a significant dose rate. NPI indicated that a reenactment with a live source would probably be needed to confirm increased dose rates.
17. Other activities conducted by the NPI engineer who received the whole body overexposure during June 1998 were:

- a. A source removal immediately following the source exchange in Florida. (6/26/98 North Miami Beach Cancer Care Center, Ltd., 125 North Miami Beach Florida)
- b. A radiation processing source installation in Germany. (612-13, 1998 Biersdorf, Hamburg Germany)
- c. Routine work in the LAA. (6/3/98 during hot cell cleanup-on May's TLD)

Each of these activities were examined and neither the installer nor any NPI personnel see a potential dose rate sufficient to have caused the overexposure.

RHP concerns given to NPI

1. Importance of knowing during what activity the overexposure occurred.
2. Were any other engineers overexposed during the activity in question (note: two of the engineers were wearing their whole TLDs outside of the collimated beam of radiation) concerned with whole body, extremity and eye dose
3. What type of QA/QC do the mirrors with source drawers get at NPI 's facility.
4. Discrepancies on the readings and numbering of whole body SRD results on the NPI Sinai engineering report. (note: both Ed Koontz's and Tom Baugher's whole body SRD are the same number and the same reported dose & Dale Repp's estimated dose for Tom Baugher's extremity was 4000 mRem.
5. NPI engineers wearing whole body dosimetry outside of the beam of radiation.

  
**URGENT**

Aug 20, 98 10:25 No.007 P.01  
**NEUTRON PRODUCTS, INC.**

22301 Mt. Ephraim Road  
Dickerson, MD 20842  
301-349-5001

**FAX: 301-349-5007**

**FAX LEAD PAGE**

**TO:** Mr. Ray Manley  
Maryland Department of Environment  
Radiological Health Program  
Baltimore, MD

**DATE:** August 28, 1998

**FAX:** 410/631-3198

**PAGES:** 2

**FROM:** Marvin M. Turkanis ~~XXXXXXXXXXXXXXXXXXXX~~

**RE:** Teletherapy Notice for Salick Health Care, Inc.  
North Miami Beach Cancer Care, Ltd.

\*\*\*\*\*  
**MESSAGE:**

In accordance with our telephone conversation of this morning, enclosed is a copy of Neutron Products Teletherapy Notice for the removal at Salick Health Care, Inc., North Miami Beach Cancer-Care, -Ltd.

I left a message on voice mail that I have not found a copy of the S&D registration for the Toshiba teletherapy unit, but have a copy of a 14 page sales brochure for the RCR 120 series unit, vintage 1973.

If you have any questions, please do not hesitate to contact us.

(28)

TELETHERAPY NOTICE  
UNIT AND/OR SOURCE REMOVAL

Approved by: [Signature] Date 4/30/98 Rev. 1:13/20/98 1:5/27/98 01:5/20/98 1:6/10/98 Page 1 of 1

P.O. No./Agreement dated C-52501/4/30/98 L/C No. \_\_\_\_\_ Expires \_\_\_\_\_

Distribution File, ED, DR, JC, LB, EK, MR, CB, HH/INV, Ranson, BK, Logbook

Sold to	Consignee
Salick Health Care, Inc. North Miami Beach Cancer Care, Ltd. 125 N.E. 168 Street North Miami Beach, FL 33169	

Reciprocity Required: State /X/ NRC // No // Received [Signature]  
 /X/ Approval for return source required: Requested 5/13/98 Received 5/15/98

SOURCE REMOVED: Catalog # NPI-15-7100W Model # NPIT-Series S/N T-980 Manuf NPI  
 Current curies: 2030 (75 TBq) Date 6/14/98 Original curies: 7100 Date 12/14/88

UNIT: Manufacturer Toshiba Model No. RCR-120 Head Model \_\_\_\_\_ S/N \_\_\_\_\_

Cust. License No. 223-1 Expires 9/30/01 Amend. # 8 Status: ok for 6000 ci/source

Installer	Whole Body Dosimeter		Wrist Dosimeter
	No.	Reading	Est. Dose
Dale Repp	66	20	70
Ed Koontz	68	30	80
Tom Baugher			

Contact Mr. Brian Keller Phone 305/535-3440 Notified Rem. Date 5/27/98 by Ed DeRosa

SCHEDULE: Remove 6/26/98

Elevator: Type \_\_\_\_\_ Capacity # \_\_\_\_\_ Ceil. H. \_\_\_\_\_ Load. Dock Yes // No //  
 Ramp - Yes // No // Length \_\_\_\_\_ Slope \_\_\_\_\_ Floor Type \_\_\_\_\_ Covering req'd \_\_\_\_\_  
 NRC/State Officials Present: Yes // No //

SPECIAL CONSIDERATIONS

Do not need to pick up check.  
 \*The unit components are to be disposed of at Ranson, unless MMT or JAR approve otherwise.

BASED ON SALE INFORMATION:

Unit // may contain DU  
/X/ should contain DU  
// should not contain DU

BASED ON INSPECTION:

Unit // does not contain DU  
// does contain DU

Customers license expires on 6/30/98 for this facility.

(2)

  
**URGENT**

**NEUTRON PRODUCTS, INC.**

22301 Mt. Ephraim Road

Baltimore, MD 20942

301-349-5001

FAX: 301-349-5007

**FAX LEAD PAGE**

**TO:** Mr. Ray Manley  
Maryland Department of Environment  
Radiological Health Program  
Baltimore, MD

**DATE:** August 26, 1998

**FAX:** 410/631-3198 **PAGES:** 2

**FROM:** *u/* Aline F. Cleveland for Marvin M. Turkanis

**RE:** Teletherapy Notice for Salick Health Care, Inc.  
Mt. Sinai Comprehensive Cancer Center, Miami Beach, FL

\*\*\*\*\*

**MESSAGE:**

In accordance with your telephone conversation with Marvin M. Turkanis, enclosed is a copy of Neutron Products Teletherapy Notice for Salick Health Care, Inc. Mt. Sinai Comprehensive Cancer Center, Miami Beach, FL.

If you have any questions, please do not hesitate to contact us.

Est No. 2539 Customer Code 21 Code N/A

TELETYPE NOTICE FOR  
SOURCE REPLACEMENT

Approved by: \_\_\_\_\_ Date 4/30/98 Rev. 11/4/11/98 2:5/27/98 3:15/28/98 4:6/19/98 Page 1 of 1

P.O. No./Agreement dated C-52501/4/27/98 L/C No. \_\_\_\_\_ Expires \_\_\_\_\_

Distribution Film, ED, DR, JC, LR, EK, MR, CR, HH/INV, Ranson, BK, Logbook

Sold to	Consignee
Salick Health Care, Inc. Mt. Sinai Comprehensive Cancer Center 4300 Alton Road Miami Beach, FL 33140	

Priority Required: State /X/ NRC / / No / / Received \_\_\_\_\_  
N/A /X/ Approval for return source required: \_\_\_\_\_ Received \_\_\_\_\_

SOURCE INSTALLED: Catalog # NPI-15-6000W Model # NPTT-Series S/N T-1451  
Curie 5810 (215 TDq) Date 6/01/98 Output: Pred 6040 Meas 5970 Date 6/01/98

SOURCE REMOVED: Catalog # NPI-15-6000W Model # NPTT-Series S/N T-1284 Manuf NPI  
Curie 3640 (121 TR1) Date 4/15/98 Original curie: 6330 Date 11/15/93

UNIT: Manufacturer Toshiba Model No. RCR-120-C-5 Head Model \_\_\_\_\_ S/N \_\_\_\_\_  
Cust. License No. 64-12 Expires Timely Filed Amend.# 29 Status ok for 8000/ci

Installer	Whole Body Dosimeter		Wrist Dosimeter
	No.	Reading	Est. Dose
Dale Rapp	<u>166</u>	<u>160</u>	<u>400</u>
Ed Koontz	<u>68</u>	<u>50</u>	<u>295</u> <u>h. 40</u>
Tom Baugher	<u>68</u>	<u>50</u>	<u>400</u>

Contact Mr. Brian Keller Phone 305/535-3440 Notified Del. Date 5/21/98 by Ed DeRosa

SCHEDULE: Install 6/25/98

Elevator: Type \_\_\_\_\_ Capacity # \_\_\_\_\_ Cell. #. \_\_\_\_\_ Load. Dook Yes / / No / /  
Ramp = Yes / / No / / Length \_\_\_\_\_ Slope \_\_\_\_\_ Floor Type \_\_\_\_\_ Covering req'd \_\_\_\_\_  
NRC/State Officials Present: Yes / / No / /

SPECIAL CONSIDERATIONS

ED KOONTZ  
Licensed Source Handler  
Service Engineer

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NEUTRON PRODUCTS inc

22301 Mt. Ephraim Road, P.O. Box 68  
Dickerson, Maryland 20842, USA

# Digital/Analog Survey Meter

- **Wide Range:** 0-5 mR/hr to 0-50 R/hr  
5 auto-ranging scales.
- **Ion chamber detector.**
- **"Freeze" action display**
- **Lightweight—only 22 oz.**

This innovative instrument features the proven characteristics of an ion chamber detector plus the latest CMOS microprocessor technology and liquid crystal displays. Operation is simple. The only controls are an ON/OFF button and a FREEZE button.

The display is unique. It offers both a 101-element analog bar graph, fully labelled with scale digits, and a digital readout that includes the proper units of measurement. The bar graph has a faster time constant than the digital display, making the instrument ideal for surveys.

The FREEZE button is a special feature that allows the unit to remember and indicate the highest dose rate from the time the freeze mode is selected. This permits placing the survey meter in a potentially high radiation area and determining the maximum value that it sees.

To guard against a battery-related failure, a "Low-Battery" condition is displayed continuously when a battery change is needed.

## Specifications

**Radiation Detected:** Alpha above 4 MeV; Beta above 100 keV; Gamma above 7 keV.

**Operating Ranges:** 0-5 mR/hr or 0-50  $\mu$ Sv/hr.  
0-50 mR/hr or 0-500  $\mu$ Sv/hr. 0-500 mR/hr or 0-5 mSv/hr.  
0-5 R/hr or 0-50 mSv/hr. 0-50 R/hr or 0-500 mSv/hr.

**Accuracy:** Within 10% of full scale, exclusive of energy response.

**Detector:** Air ion chamber; volume 200 cc.

**Display:** Analog/Digital LCD.

**Analog:** 101-element bar graph, 2½" long.

**Digital:** ¼" high. Units of measurement are indicated at all times. "Low Battery" and "Freeze" messages show the instrument's operating condition.

**Controls:** ON/OFF and FREEZE pushbutton switches.

**Automatic Features:** Auto-ranging and auto-zeroing.

Time Response:	Range	Time Constant (sec.)
	0-5 mR/hr	16.0
	0-50 mR/hr	6.4
	0-500 mR/hr.	1.6
	0-5 R/hr.	1.6
	0-50 R/hr.	0.8



**Precision:** Within 5% of full scale.

**Power:** Two 9V transistor cells. Operating life 200 hours continuously on new batteries.

**Warm-Up Time:** Less than one minute.

**Environmental Effects:** Temperature range -20° to +50° C. Humidity range 0 to 100%. Instrument is moisture-proof. Negligible geotropism.

**Size:** 4" wide x 8" long x 6" high. Net 22 oz.

05-754 Digital/Analog Survey Meter ..... \$795.00

**Minimum Order is \$25.00.**

We are required to collect the state sales tax on equipment shipped to New York. If you are exempt from this tax or pay it direct to the state, we need your certificate.

8/31/98 CE

# NEUTRON PRODUCTS inc

22301 Mt. Ephraim Road, P. O. Box 68  
Dihorson, Maryland 20842 USA  
301-349-5001 FAX: 301-349-5007  
e-mail: neutronprod@erols.com

August 26, 1998

Mr. Roland G. Fletcher  
Environmental Manager  
Radiological Health Program  
Maryland Department of the Environment  
2500 Broening Highway  
Baltimore, Maryland 21224

Attn: Mr. Carl Trump

VIA FAX: 410/631-3198

Re: License MD-31-025-01  
Apparent Occupational Over-Exposure of Neutron's employee number 13

Dear Mr. Fletcher:

This is to request the temporary authorization to possess a Toshiba teletherapy head with a collimator and a single encapsulated, low intensity cobalt-60 teletherapy source in the LAA for the purpose of obtaining radiation measurements to be used in the investigation of the referenced exposure on the most expeditious schedule.

The intensity of the source used in the test is approximately 60 RHM, which is approximately 1/100th the intensity of the source which was installed in the Toshiba head. This will allow for maximizing the number of dose rate measurements with a minimum of personnel exposure, and the subsequent ratioing of the measured intensity to those which occurred during the source transfer and servicing of the unit.

The only significant personnel exposure will be in loading and unloading the head which is estimated to be approximately 50 man-mr. No significant personnel exposure is expected in making the measurements.

Use of a single encapsulated source is requested on the basis of ALARA, since the length of the source capsule that fits in the Toshiba source holder is approximately the same as the length of Neutron's standard once encapsulated teletherapy source. Fabrication of a double encapsulated source in a capsule that fits the Toshiba unit would require removing the bare cobalt-60 from an existing source and reencapsulation in a capsule that fits the Toshiba unit, with an associated higher occupational dose.

Mr. Roland G. Fletcher  
Environmental Manager  
Radiological Health Program  
Maryland Department of the Environment  
Page 2 August 26, 1998

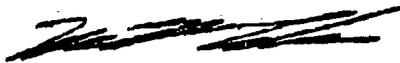
The source will be removed from the Toshiba head and returned to storage after the investigation is complete.

If you have any questions or problems, please call me.

Your most expeditious response is requested.

Sincerely,

NEUTRON PRODUCTS, INC.



Marvin M. Turkatis  
Vice President

MMT/afc

NEUTRON PRODUCTS inc

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**STATE OF MARYLAND  
DEPARTMENT OF THE ENVIRONMENT  
RADIOLOGICAL HEALTH PROGRAM**

**MEMORANDUM OF TELEPHONE CALL**

**DATE:** 8/27/98

**TIME:** about 1400 hours

**INCOMING CALL:**

**OUTGOING CALL:** yes

**MDE PERSON TALKING:** Ray Manley

**PERSON TALKED TO:** Tom McCloud

**AFFILIATION OF PERSON:** Radiation Safety Officer Sinai Hospital in Miami Beach Florida

**ESSENCE OF CONVERSATION:** I called Mr. McCloud (305-674-2457) to discuss the NPI source exchange in June 1998. Mr. Cloud indicated that the teletherapy physicist became apprehensive regarding the problems that NPI was having with the device and asked him to evaluate the situation. Mr. McCloud used a calibrated (1/98) Victoreen 450 survey meter and conducted a radiation survey approximately 24 inches from the face of the plughole. The NPI service personnel informed him that the source drawer was in the position for adjustment of the mirror assembly. The dose rate at this position was 2-3 R/hr. A survey inside of the plughole (best fit of ion chamber) was off scale and blinking. He is not sure if this was because the meter was off scale (>50 R/hr), or because of it being between scales. A HP from his office (Paul Penny) conducted a similar survey with the same meter at a later time and got a survey result of 250 mR/hr. He was informed that the source drawer might have been in a different position during the second survey. Mr. McCloud stated that he has contacted the Florida regulators in Tallahassee regarding the incident (Mike Stevens, Bill Pisetti, 850-487-2437).

**FURTHER ACTION REQUIRED:**

**PERSON NOTIFIED:**

**SIGNATURE:**

*Ray Manley*



MAR AND DEPARTMENT OF THE ENVIRONMENT  
2500 Broening Highway • Baltimore, Maryland 21224  
(410) 631-3000

Parris N. Glendening  
Governor

AUG 31 1998

Jane T. Nishida  
Secretary

Marvin M. Turkanis, Vice President  
Neutron Products, Inc. (NPI)  
22301 Mt. Epraim Road  
P.O. Box 68  
Dickerson, Maryland 20842

**RE: Request for temporary  
authorization to possess Toshiba  
teletherapy head**

Dear Mr. Turkanis:

This letter is in response to your August 26, 1998 written request for temporary authorization to possess a Toshiba teletherapy head with a collimator and a single encapsulated low intensity cobalt-60 teletherapy source in the Limited Access Area (LAA). The purpose of this request is to obtain radiation measurements for use in the on-going investigation of the June 1998 occupational radiation over-exposure of a NPI employee.

Pursuant to the above, the Radiological Health Program (RHP) will authorize NPI to conduct this one time activity under your MD-31-025-01 license. Please arrange for this evaluation to expeditiously occur in order for RHP staff to attend.

Should you have any questions concerning this letter, please contact Mr. Raymond Manley or me at (410) 631-3302. You may also reach our office by dialing toll-free at 1-800-633-6101 and requesting extension 3302.

Sincerely,



Carl E. Trump, Jr., Program Manager  
Radioactive Material Licensing, Inspection  
and Compliance Division

*REM*  
CET/REM/jw

MARYLAND DEPARTMENT OF THE ENVIRONMENT  
AIR & RADIATION MANAGEMENT ADMINISTRATION

Radiological Health Program

MEMORANDUM

TO: Files MD-31-025-03

FROM: Ray Manley *RM*

DATE: September 15, 1998

SUBJECT: SUMMARY OF RHP INSPECTION STAFF PARTICIPATION IN THE  
SEPTEMBER 2, 1998 NPI TELE THERAPY OVEREXPOSURE REENACTMENT.

DATE: September 2, 1998

TIME: about 1030 hours to 1600 hours

LOCATION: NPI facility 22301 Mt. Ephraim Road, Dickerson, Maryland

PERSONS PARTICIPATING:

MDE/RHP: Carl E. Trump, Jr., Leon Rachuba, Ray Manley

NPI: Marvin Turkanis, Jeff Williams, Ed Koontz, Jerry Fogle

NPI PRIVATE CONSULTANT: Robert Alexander

PURPOSE OF REENACTMENT:

In June 1998 a NPI service installer received a TLD whole body dose exceeding the regulatory occupational dose limit. This dose was apparently received while conducting licensed activities during a teletherapy source exchange at Sinai Hospital in Miami Beach. During this source exchange an unusual occurrence required NPI installers to adjust the teletherapy source drawer mirror 15-20 times. Each adjustment required the source drawer to be pulled out of the fully "in" position. This reenactment was designed to have a lower intensity source about 60 Ci in a Toshiba teletherapy head similar the unit at the Sinai job and, under controlled conditions, have the source drawer pulled away from the "in" position to varying distances. Surveys would be taken to determine if dose rates could have been potentially high enough to cause the employee overexposure. Furthermore, using interviews with employees regarding time and distances during activities, to reconstruct exposure to engineers (whole body, extremity, and eye).

#### DETAILS:

1. This reenactment was authorized by RHP in a 8/31/98 letter to NPI, on a one time basis, pursuant to an August 31, 1998 by NPI.
2. NPI outlined their purpose for the reenactment in a attached document called "Special Outline of Dose Measurement Experiment-Toshiba.
3. Personal dosimetry of all participants were reviewed prior to the pulling of the drawer and deemed adequate.
4. Surveys were taken by NPI with various survey meters (attached) with the source drawer pulled out from the "in" position at measured distances and with the source in both the up position and the down position. The licensee matrix of dose rates is attached.
5. An array of TLDs were set up with the drawer in its 2.5 inch position (source up) position at one foot away from the source plug. Total exposure to be 4 hours.
6. The reenactment source is approximately one-hundredth of the source strength of the one in Florida.
7. NPI indicated that mirror adjustment would no longer be a factor for teletherapy exchanges because they, in the future will only used those source drawers that have the mirror in a fixed position.
8. Bob Alexander requested that NPI, through him, request a use of EDE weighting factors less than one. This request is based on the defined collimation of the radiation beam. He stated that if the analysis could be validated the TEDE of the overexposure individual might need to be changed.
9. NPI management appeared to be surprised regarding the increase in dose rate as the source drawer was pulled.

#### CONCLUSIONS:

1. There is a substantial increase in dose rate for each inch that the source drawer is moved away from the "in" position.
2. Given the times that engineers were involved with the mirror adjustment, it appears that somewhere between 3-4 inches (source drawer pulled) there exists a sufficient dose rate to have caused the overexposure.
3. NPI through Mr. Alexander will use the survey results from this reenactment to attempt to reconstruct actual doses (whole body, extremity, and eye) to establish whether additional occupational limits have been exceeded.

  
**URGENT**

**NEUTRON PRODUCTS, INC.**

22301 Mt. Ephraim Road  
Dickerson, MD 20842  
301-349-5001

**FAX: 301-349-5007**

**FAX LEAD PAGE**

---

**TO:** Mr. Ray Manley  
Radiological Health Program  
Maryland Department of the Environment  
2500 Broening Highway  
Baltimore, Maryland 21224

**DATE:** September 3, 1998

**FAX:** 410/631-3198

**PAGES:** 3

**FROM:** Marvin M. Turkanis ~~XXXXXXXXXX~~

**RE:** License MD-31-025-03  
Apparent Occupational Over-exposure of Neutron's employee number 13.  
\*\*\*\*\*

**MESSAGE:**

Per your request, attached are copies of:

- my tabulation of the doserates, and,
- the vertical doserate variation

which we measured yesterday.

All the source drawers are in the LAA and there is no one in the area. Dale and I unsuccessfully looked for a drawing this afternoon. I will have the distance from the centerline of the source to the end of the mirror measured tomorrow and call you.

Dose Rates Measured with 60 RHM Source in  
 Toshiba RCR-120-C3 Head.  
 (mr/hr including 1.5 mr/hr background)

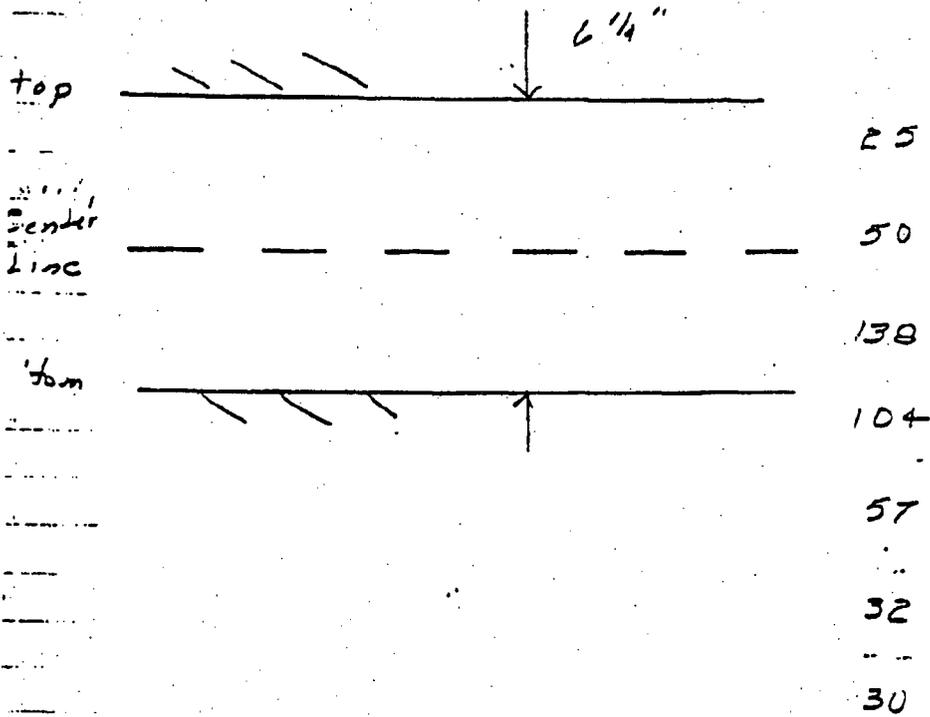
Source direction	Source		Position		2 1/2"		3"		4"		3"	
	down	up	1" up	2" up	up	up	up	up	up	down	down	
Activity	16 A		35 A	190 B	-		1000 D				1400 D	
Face of vial	8 A	14 A	19 A	{ 44 A 80 C	200 C		350 C 390 D		2500 D			
1' from face	1 A	2.4 A	8 A	20 A	37 C		110 B		570 D			
2' from face	2 A	2.4 A	5 A	10 A	22 C		50 B		-			

Survey meter:

- A End window
- B Ludlum 14C - external detector
- C - internal detector
- D Extenda Probe

Y radiation of Dose Rate  
 Source holder: 3"  
 Source position: up  
 Ludlum 14C, External (:)

mr/hr  
 2" increments



1' from face

Special Outline of Dose Measurement Experiment - Toshiba

September 2, 1998

**SOURCE IN HOT CELL**

Remove outer capsule of T-115, a 1.5 cm, 40 RHM teletherapy source;

Wipe test inner capsule and decontaminate as necessary;

Helium Leak test inner capsule;

Place inner capsule in an outer capsule "cup" to provide centering in the source drawer;

Load in Toshiba head; and,

Wearing wrist TLDs, install source drawer fixing piece.

**UNIT**

Install and secure brass lead filled plug;

Perform general survey all around the head;

Suspend head using wire rope slings and/or chains from of the existing handling points;

Survey and record dose rate in primary beam definer;

Attach collimator;

Suspend head from fork lift tongs;

Brace forklift tongs with dunnage to prevent dropping of head in the event of pneumatic failure;

Brace head so head can not move;

Measure the head leakage at the 18 points; and

Remove the brass lead filled plug.

Check dose rate in front of cavity to confirm that it can be surveyed safely.

Place 200 mr SRD in cavity for 10 minutes and read exposure.

With the source in its storage position, using the Lundlum 14C survey meter, measure the dose rate at the face of the cavity, at 1' and 2' from the cavity.

With the source in its storage position, using the end window survey meter with the window pointed to the cavity:

- measure the uniformity of the radiation emitted from the cavity;
- place a measuring stick on pipe holders with one end abutting the source holder and level it in the center of the cavity;
- measure the dose rates along the measuring stick in 6" (15 cm) increments to at least 3' (90 cm) from the cavity;
- move the measuring stick so that it intersects the highest radiation level emitted from the cavity while maintaining one end abutting the source holder and level; and
- measure the dose rates along the measuring stick in 6" (15 cm) increments to at least 3' (90 cm) from the cavity;

Wearing wrist TLDs, if necessary, remove the source holder fixing piece, rotate the source drawer so that the source window is at the top of the cavity, and repeat the above measurement which are appropriate with the source withdrawn:

- 1 inch
- 2 inch
- 3 inch
- 4 inch

At each source position measure the dose rate at the face of the cavity, at 1' and 2' from the cavity using the Lundlum 14C survey meter.

With the measuring stick 10" (25 cm) below the centerline with one end in the plane of the end of the source holder and level, measure the dose rate in 6" (15 cm) increments up to 3' (90 cm) from the plane of the end of the source holder.

Try to map the dose distribution from the cavity using film.

Map the dose distribution from the cavity using an array of TLDs.

Wearing wrist TLDs, if necessary, install the source holder fixing piece.

**NEUTRON PRODUCTS inc**

22301 Mt. Ephraim Road, P. O. Box 68  
Dickerson, Maryland 20842 USA  
301-349-5001 FAX: 301-349-2433

September 8, 1998

Mr. Roland G. Fletcher  
Environmental Manager  
Radiological Health Program  
Maryland Department of the Environment  
2300 Broening Highway  
Baltimore, Maryland 21224

Attn: Mr. Ray Manley

Re: Apparent Occupational over-exposure of Neutron Employee 13 ("NE13").  
License MD-31-025-03

VIA FAX: 410/631-3198

Dear Mr. Fletcher:

We are writing to provide the 30 day written report of an apparent overexposure of NE13 as required by Code of Maryland Regulations 26.12.01.01 titled "Regulations for Control of Ionizing Radiation", Section D.1203.

#### EXECUTIVE SUMMARY

Last month Neutron's receptionist received a telephone report from its TLD badge provider advising that an apparent overexposure of NE13 had occurred during the month of June, 1998. Errors in internal communication delayed the notification of RHP and the initiation of our evaluation by about ten days, at which point a preliminary evaluation commenced. Although NE13 had engaged in a number of activities during June that could conceivably contribute to such an exposure, only one activity appeared to be a likely cause, and it was evaluated in considerable detail.

The activity entailed the efforts of a teletherapy field service team, comprising three experienced source handlers ("NE13, NE195 and NE297") that travelled to Florida during the last week in June to remove one Toshiba teletherapy unit and to install a new source in another (the "Florida Activity"). Although the unit removal was ostensibly uneventful, the source installation effort encountered unexpected difficulties in adjusting the unit's light field mirror that resulted in higher than normal exposures to both NE13 and NE297. To assist in its efforts to evaluate cause and effect, Neutron assembled critical portions of a comparable Toshiba unit, first in its Ranson, WV unit reconditioning plant without a source, then in the Limited Access Area of Neutron's Dickerson Plant. At Dickerson, the unit's source wheel was loaded with a 60 curie teletherapy trade-in source which was used to reproduce and measure (at 1% of the intensity) the radiation fields in which NE13, NE297, and to a lesser extent, NE195, had worked in Florida.

HH

Mr. Roland G. Fletcher  
September 8, 1998  
Page 2

Although we have not developed a model that resolves all reporting discrepancies, the analyses thus far performed have enabled us to use the TLD data received to verify that NE195 did not receive an elevated exposure, and to place upper and lower limits on the whole body, upper torso and extremity exposures received by NE13 and NE297. In addition, our evaluation of the Florida Activity uncovered both some strengths in our teletherapy field service program that warrant further development, and some deficiencies that require remedial action.

#### LEVELS OF ASSIGNED EXPOSURE

Pending further analysis, and the receipt of regulatory approval to assign other exposures, NE13 has been assigned, for the month of June, 1998:

- an upper torso exposure of 7078 mR;
- a whole body exposure of 7078 mR;
- a left wrist exposure of 12267 mR; and
- a right wrist exposure of 4133 mR.

Although the whole body TLD which Employee 13 wore for the second quarter of 1998 indicated an exposure of 6513 mR, it has been Neutron's policy to use the monthly TLD readings as the exposure of record unless the RSO can document a basis for assigning a different exposure. Moreover, although we have not yet been able to verify a plausible cause of the the monthly TLD readings, neither can we document irrefutable grounds for rejecting them in favor of other values. As noted in the summary of analyses which follow, if the remaining discrepancy can be dispelled, there may be sound grounds for assigning lower exposures to NE13 at some future date.

NE195 has been assigned, for the month of June, 1998:

- a whole body exposure of 892 mR;
- an eye lens exposure of 4 mR;
- a left wrist exposure of 2381 mR; and
- a right wrist exposure of 442 mR.

NE195 undertook only a minor role in the light field mirror adjustment effort, and we have no reason to believe that he received exposures appreciably different than those recorded on his monthly TLD's.

Based on the analysis which follows, pending further work, if any, and the receipt of appropriate regulatory approvals, NE297 has been assigned, for the month of June, 1998:

- an upper torso exposure of 1400 mR;

NEUTRON PRODUCTS inc

Mr. Roland G. Fletcher  
September 8, 1998  
Page 3

- a whole body exposure of 1400 mR;
- an eye lens exposure of 46 mR; and
- an extremity exposure of 3500 mR.

Neutron Employees 13, 195 and 297 are identified by name in Appendix I as is the hospital at which the exposures were incurred.

A Report prepared by Robert E. Alexander, Neutron's Health Physics Consultant, and relevant to the assignment of exposures, is appended hereto as Appendix II and is an intrinsic part of this Report.

### **ANALYSIS OF THE LEVELS OF RADIATION AND THE RESULTING EXPOSURES**

The radiation to which the exposures are attributed was from a substantially shielded Neutron Products cobalt-60 teletherapy source Serial Number T-1451, Model NPTT-SERIES, Catalogue NPI-15-6000W. At the time of installation, it contained 5750 curies and emitted approximately 5910 RHM.

During the course of work in which the exposures were incurred, said source was housed within, and substantially shielded by, a Toshiba teletherapy unit, model RCR-120-C-5, Serial number 005. The elevated exposures are attributed to the repeated adjustment of the light field mirror by NE13 and NE297. Each adjustment of the mirror entailed five steps:

1. the removal of a brass, lead filled lens assembly from the unit in a radiation field of only a few mR/hr;
2. reaching into the cavity in the shield created by said removal, and removing the source retaining fixture, a process estimated to take no more than one minute in a radiation field estimated to be about 160 mR/hr;
3. reaching into the cavity, turning the source drawer 180 degrees, withdrawing the source drawer a minimum distance of 2.5", loosening the light field mirror set screw, rotating, and or laterally moving, the light field mirror slightly, and lightly tightening the set screw, an operation requiring 20 to 60 seconds, performed in a radiation field that ranged from 35 to 150 R/hr depending on the extent of source drawer withdrawal and the precise location of fingers in the cavity;
4. the reversal of step 2; and
5. the reversal of step 1.

Based on extensive interviews with the persons involved, it is our best estimate that between 10 and 25 mirror adjustments were attempted, with NE195 attempting one, NE13 performing between two and ten, and NE297 the balance.

NEUTRON PRODUCTS inc

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Mr. Roland G. Fletcher  
September 8, 1998  
Page 4

The radiation levels reported above are based on the measurements of dose rate with a shielded Neutron Products cobalt-60 teletherapy source Serial Number T-115 (activity about 60 curies) which had its outer capsule removed so that it could be loaded into Toshiba teletherapy unit, model RCR-120-C-3, which was partially assembled at Dickerson for the purpose of obtaining accurate data under benign radiation conditions. The radiation measurements obtained therefrom are presented in both tabular and graphic form in Appendix II.

The estimated number of adjustments performed, and the periods of exposure required for each step are based on extensive interviews with NE13, NE195 and NE297, and on simulated operations performed without a source.

For the purpose of assigning whole body and upper torso exposures, it is estimated that the person performing the mirror adjustment was located at a distance of about one foot from the face of the unit, a location at which the radiation exposure has been determined by measurement to range from 3 R/hr at a source drawer removal distance of 2.5" to about 20 R/hr at a source drawer removal distance of 3.5".

#### Estimated Exposures to Neutron Employees

# Regarding the probable exposures received by NE195, as stated earlier, NE195 was involved only in a peripheral way with the light field mirror adjustments, and we do not have a basis for adjusting the exposures indicated by his TLD readings. At most, he spent one minute in an upper torso dose field of about 3 R/hr, receiving an upper torso exposure of about 50 mR thereby, and an equal time with his fingers in a radiation field of about 60 R/hr for an extremity dose of about 1 Rem. Thus, the exposures assigned to NE195 are the TLD exposures reported.

# Regarding the probable exposures received by NE13, in order for him to have received a whole body exposure of 7 Rem, he would have had to undertake 10 light mirror adjustments of a full minute or more, for each of which the source drawer would have been withdrawn nearly 4", an extremely unlikely scenario. More likely, if he had undertaken two light mirror adjustments of 60 seconds each, and a source drawer withdrawal distance of 2.75" each, his upper torso exposure would have been only 200 mRem, a level more consistent with the 160 mR reading of his pocket dosimeter than the multiRem readings of his TLD's. Thus, while it is physically plausible that his TLD readings could be the result of the episode evaluated, we cannot conclude that it is credible. Nor have we defined another credible contributor of the magnitude required to rationalize the radiation levels received by his upper torso TLDs.

Nor are NE13's wrist badge readings confirmed. Given ten one minute light mirror adjustments at a source drawer removal distance of 3.5", a wrist badge dose approaching 12 Rem would be indicated, and it is rational to expect the other wrist badge to experience a much lower exposure. However, that scenario lacks credibility, and four 60 second light mirror adjustments at a source withdrawal distance of 2.75" seems much more likely. In such event, the indicated wrist badge dose would be only about 2 Rem. In either case, the wrist badge exposure is not governing; and in the more realistic case of four light field mirror

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adjustments of about 60 seconds each, the finger exposures of both hands would be in the range of 4 Rem or so.

What we can conclude with considerable certainty is that the TLD readings do not understate the exposures likely to have been received by NE13's whole body and extremities in the course of the Florida Activity.

# With regard to the probable exposures received by NE297, we cannot conclude that his TLD readings are either accurate or conservative. Moreover, we believe that the analyses performed provide us with a prudent basis for assigning probable exposures within a realistic range.

While we have no reason to doubt the validity of his whole body TLD readings as indicative of whole body exposure, they were worn on his belt, often a reasonable choice, but grossly inadequate for recording the exposure of the upper torso in the course of the work performed in the course of the light field mirror adjustments.

Similarly, the wrist badge TLD's, even if worn on each light mirror adjustment occasion, would not record the finger exposures which would clearly dominate extremity dose considerations.

Moreover, based on the radiation measurements made at Dickerson and the estimates of time required to perform the various functions, it is practical, as undertaken above, to assign probable extremity, eye lens and upper torso exposures, and to supplement the whole body exposures recorded by NE297's whole body badge readings.

## CAUSES AND REMEDIES

The elevated occupational exposures experienced were incurred in the course of work performed by experienced source handlers, only one of whom, NE13, is licensed to work on Toshiba units. The other two are not licensed to work independently on such units, but are authorized to do so under the supervision of a duly licensed person. Moreover, NE13, has personally been the responsible source handler on more than a thousand prior incident free source installations, unit removals and unit installations, including more than a dozen Toshiba; and he has participated in, or been responsible for, the training of about a dozen source handlers who have successfully performed, both domestically and internationally, on hundreds of other incident free unit installations, removals and source exchanges.

Nevertheless, the Florida Activity, though amply staffed by an experienced team, constituted a truly sub-par performance that we have tentatively attributed to a combination of the following causes, all of which can and must be remedied:

Cause #1 The source was loaded into a Toshiba source holder in which the adjustment of the light field mirror required a lessening of the shielding of the source. In the course of evaluating the Florida Activity, it became apparent to us that, by the use of other source holders, some of which are in our possession, it is possible to effect the light field mirror

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adjustment without decreasing the shielding of the source. In addition, the Toshiba unit had an unusual field light hulk assembly that added an additional variable to the light field adjustment problem.

**Remedy #1** For future work on Toshiba units, make it a priority to confirm light field mirror and source alignment before loading source, and consider all available alternatives for light field mirror adjustment with minimum lessening of source shielding.

**Cause #2** Without assigning fault at this point, it is a fact that the field service team members failed to take full advantage of their collective experience and intellectual resources in resolving the uncertainties and difficulties they encountered in Florida.

**Remedy #2** Conduct periodic and continuing "no holds barred" reviews (by peers as well as lead installers and management) of overall preparedness; viable alternatives to established practices; and where appropriate, plans for specific source and unit installations, and unit removals, including, to the extent practical, all field service team members.

**Cause #3** There was an inadequate field effort to resolve substantive technical disagreements among field service team members, and it appears likely that the failure to reach accord increased personnel exposures to some extent.

**Remedy #3** While the primary responsibility and authority for resolving any such disputes rests with the team leader, in the event of his inability to timely establish a mutual understanding he must call Corporate headquarters for assistance and further instructions before proceeding with further operations.

#### **OTHER CORRECTIVE ACTIONS TO PRECLUDE EXACERBATION OR A RECURRENCE**

1. For the balance of 1998, Employee 13 has been reassigned from all activities that could result in any additional occupational exposure.
2. The procedure which calls for the responsible source handler or his assignee to record individual SRD readings on the Source Installation Notice after each source exchange or removal has been changed to require each member of the team to record their own radiation measurements and for the responsible source handler to review said records.
3. Neutron will purchase new, smaller, direct reading, alarming dosimeters to allow them to be worn in the area of potentially highest radiation to replace the current alarming dosimeter whose size results in them being worn on the belt.
4. A cross-fertilization training program will be instituted for all Neutron's source handlers which will include the Neutron's health physics consultant and will occur no less often than annually.
5. The requirement to wear SRDs and an alarming, integrating dosimeter will be extended to include the servicing of teletherapy units, whether or not a source exchange is involved.

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6. The other source handlers who Neutron knows to be licensed to service Toshiba teletherapy units in the United States are on Neutron's -03 license, and will be made aware of the details and our analysis of the Florida Activity; and the Toshiba source handler in England has been told of the episode and will be given the details.

7. Timely documented surveys will be performed at appropriate intervals at the beginning of, during and after all field operations.

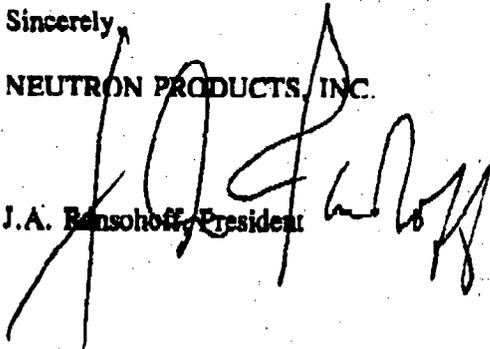
Thank you very much for your expeditious approval of our request to perform radiation measurement experiments on a loaded Toshiba head in the LAA. It was very helpful to us in performing our evaluation.

If you have any questions, please call.

Sincerely,

NEUTRON PRODUCTS, INC.

J.A. Benschhoff, President



Attachments

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## RECONSTRUCTION OF RADIATION DOSES RECEIVED BY NPI TELETHERAPY SOURCE INSTALLERS

R.E. Alexander  
September 8, 1998

### I. The Minimum Exposure Case

The installers would have received the minimum doses under the following conditions:

1. The source drawer position during light field mirror adjustments would have been 2.5 inches out, the minimum withdrawal distance to permit access to the set-screw.
2. The number of adjustments would have been 20—14 by NE297, 5 by NE13, 1 by NE195.
3. The exposure distance would have been 1 foot for the adjuster.
4. The exposure distance for observer NE13 during adjustments by NE297 would have been 3 feet.
5. The exposure time for each adjustment would have been 30 seconds.

#### A. Exposure Rate in Plug Cavity

The wrist badges were located about 6 inches from the tips of the curved fingers. The cavity is 4.75 inches deep. Thus these badges were a little more than an inch outside the cavity. The workers' wrists moved about as the TLD integrated the dose. Due to the nature of the work, the dosimeters most probably were not exposed to the highest rates, which were located toward the cavity bottom. Therefore the wrist badge results are not accurate indications of exposure rates in the plug cavity.

With the drawer at 2.5 inches the exposure rate at the face of the plug cavity was measured during the mockup to be 200 mR/hr; during the actual exposures the rate was two orders of magnitude higher, or 20 R/hr actual. Mockup data provide exposure-rate ratios, cavity-to-plug face, for drawer positions of 1, 2, and 3 inches. The average value is ~2, i.e., the rate at the far end of the cavity is close to twice the rate at the cavity opening. Thus where the tips of the fingers holding the Allen wrench were located the rate was ~40 R/hr, or 0.7 R/min.

#### B. Exposure Rate Profile at 1 Foot

Figure 1 is a simplified schematic of the conditions of exposure, drawn to scale. The plug cavity and protruding source drawer are shown at the left of the page. To the right a replica of a worker is shown from head to waist. The worker's face is located 1 foot from the face of the plug cavity. The beam angles are defined by straight lines extending from the aperture above and below the drawer to the exterior edges of the cavity and beyond. The upper line intersects the top of the worker's head. The lower line reaches the body at a point 5 inches below the shoulder and leaves the body about 4 inches above the waist. This schematic enabled identification of the organs significantly exposed by the conical beam (see Table A, Attachment).

As part of the mockup effort an array of 8 TLDs was exposed 1 foot from the plug face, with the

As part of the mockup effort an array of 8 TLDs was exposed 1 foot from the plug face, with the source drawer withdrawn 2.5 inches. The TLD locations are marked a through h. Five instrument readings were made at the same time at distances above and below the array. These results were corrected for a difference that existed between them and the TLD results. They are marked  $\alpha$  through  $\phi$ . These 13 exposure rates provide the profile necessary to identify the location on the body which received the highest dose. Most probably it would have been in the vicinity of the thyroid gland. The highest rate is 3.072 R/hr, or 51.2 mR/min.

### C. Exposure Rate Profile at 3 Feet

NE13 observed the work of NE297 from a vantage point directly behind him. Neglecting shielding afforded by TB's body, the largest exposure rate in the profile at 3 feet was determined by extrapolation to be 1.1 R/hr or 18.3 mR/hr.

### D. Exposure Rate at Location of Lens

From Figure 1 it can be seen that the appropriate exposure rate to use in the calculation of the lens is ~0.2 R/hr, or 3.3 mR/min.

### E. Doses That Would Have Been Received

From section I.A, the exposure times of interest in the minimum-dose case are: 7, 2.5 and 0.5  
 TB: 7 minutes — NE13: 2.5 minutes adjusting and 7 minutes observing — NE195: 0.5 minutes

Their doses are tabulated below.

Table L. MINIMUM DOSES RECEIVED BY INSTALLERS (Source Drawer Position = 2.5")			
	NE297	NE13	NE195
Deep Dose Equivalent (DDE)	358 mrem	256 mrem	26 mrem
Lens Dose Equivalent (LDE)	23 mrem	16 mrem	2 mrem
Extremity Dose (SDE)	4.9 rem	1.75 rem	0.35 rem

## II. The Exposure Case Consistent With the NE13 "Whole-Body" TLD for June, 1998

### A. Deep Dose Equivalent

Since this dose greatly exceeds the 256-mrem minimum dose derived for Table I, a considerable effort has been made to find out whether it would have been possible for NE13 to have received 7.078 rems while performing the task in question. NE13's dose could not be compared with NE297's because the latter worker's TLD was worn on his belt, out of the beam. It is worthy of note that NE13's self-reading dosimeter, which he has reported as being worn near his TLD, registered a dose not greatly different from the calculated minimum of 256 mrems.

A mockup of the task was conducted at NPI, the results of which are reported here. Identical teletherapy equipment was employed along with a source of strength smaller by a factor of 100. Following this exercise it was concluded that the only way a dose as high as 7.1 rems could have been received was for the source drawer, for access convenience, to have been withdrawn more than the 2.5 inches reported by the installers. An attempt is made below to identify how far out the source would have to have been withdrawn in order deliver the upper torso TLD to NE13.

Withdrawal distances of 2.5, 3, and 4 inches were analyzed under exposure conditions intended to maximize NE13's dose; for example, the exposure time per adjustment was doubled, the number of adjustments was increased from 20 to 25, and the number of these performed by NE13 was also doubled. Then the results were graphed, Figure 2, to enable identification of the source position that would have delivered 7.1 rems. Details of the analysis appear in Tables II through V.

**Table II. ESTIMATED EXPOSURES — SOURCE DRAWER POSITION @ 2.5"**

Total exposure time per light field mirror adjustment:	1 minute
Distance of adjustor from cavity plug face	1 foot
Distance of observer from cavity plug face	3 feet
Source drawer position, out	2.5 inches
Source direction	up
Largest Exposure rate at 1 foot, actual	3.072 R/hr = 51.2 mR/min
Exposure rate at 3 feet, actual	1.1 R/hr = 18.3 mR/min
Exposure at 1 foot per light field mirror adjustment	51.2 mR
Exposure at 3 feet per light field mirror adjustment	18.3 mR
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Number of exposures	25
14 by NE297 adjusting light field mirror	717 mrem
10 by NE13 adjusting light field mirror	512 mrem
14 by NE13 observing TB	256 mrem
NE13 total	768 mrem
1 by NE195	51 mrem

**Table III. ESTIMATED EXPOSURES — SOURCE DRAWER POSITION @ 3"**

Total exposure time per light field mirror adjustment:	1 minute
Distance of adjustor from cavity plug face	1 foot
Distance of observer from cavity plug face	3 feet
Source drawer position, out	3 inches
Source direction	up
Largest Exposure rate at 1 foot, actual	9.124 R/hr = 152 mR/min
Exposure rate at 3 feet, actual	3.267 R/hr = 54.5 mR/min
Exposure at 1 foot per light field mirror adjustment	152 mR
Exposure at 3 feet per light field mirror adjustment	55 mR
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Number of exposures	25
14 by NE297 adjusting light field mirror	2.13 rem
10 by NE13 adjusting light field mirror	1.52 rem
14 by NE13 observing NE297	0.77 rem
NE13 total	2.29 rem
1 by NE195	0.15 rem

**Table IV. ESTIMATED EXPOSURES — SOURCE DRAWER POSITION @ 4"**

Total exposure time per light field mirror adjustment:	1 minute
Distance of adjustor from cavity plug face	1 foot
Distance of observer from cavity plug face	3 feet
Source drawer position, out	4 inches
Source direction	up
Largest Exposure rate at 1 foot, actual	47.31 R/hr = 789 mR/min
Exposure rate at 3 feet, actual	16.94 R/hr = 282 mR/min
Exposure at 1 foot per light field mirror adjustment	789 mR
Exposure at 3 feet per light field mirror adjustment	282 mR
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Number of exposures	25
14 by NE297 adjusting light field mirror	11.05 rem
10 by NE13 adjusting light field mirror	7.89 rem
14 by NE13 observing TB	3.99 rem
NE13 total	11.88 rem
1 by NE195	0.789 rem

**Table V. ESTIMATED EXPOSURES — SOURCE DRAWER POSITION @ 3.7"**

Total exposure time per light field mirror adjustment:	1 minute
Distance of adjustor from cavity plug face	1 foot
Distance of observer from cavity plug face	3 feet
Source drawer position, out	3.7 inches
Source direction	up
Total upper torso dose registered by TLD of NE13	7.1 rem
Fraction of NE13 upper torso dose as he made light field mirror adjustments	0.6
Fraction of NE13 upper torso dose as he observed light field mirror adjustments	0.4
Upper torso exposure while making light field mirror adjustments	4.26 rem
Exposure per adjustment	0.426 rem
Upper torso exposure while observing light field mirror adjustments	2.84 rem
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Number of exposures	25
14 light field mirror adjustments by NE297	5.96 rem
10 light field mirror adjustments by NE13	4.26 rem
15 observations by NE13	2.84 rem
NE13 total	7.1 rem
1 by NE195	0.426 rem

In Figure 2 the total doses assigned to NE13 for the 3 drawer positions are graphed to permit identification of the drawer position previously mentioned. It is evident that the drawer would have to have been positioned at about 3.7 inches for each adjustment made in order to deliver the 7.1-rem dose. The exposure rate profile for this drawer position is provided in Figure 3.

All three installers insist that they minimized exposure rates by minimizing the withdrawal distance. They maintain that 2.5 inches was essential for adjusting the light field mirror and that great care was taken to avoid withdrawing the source drawer more than necessary.

Assuming that the TLD actually received 7.1 rems, it is difficult to avoid the tentative conclusion that it was exposed to most of the radiation in some unknown manner.

### B. Lens Dose Equivalent (LDE)

In Figure 3 the exposure rate applicable to the lens is 2.5 R/hr, or 41.7 mR/min. The LDEs assumed for this hypothetical case are:

TB::584 mrem      NE13::417 mrem      NE195::42 mrem

### C. Extremity Dose Equivalent

In this subsection maximum doses to the hands are calculated assuming a source drawer position of 3.7 inches.

#### 1. Exposure Rate for Calculating Hand Doses

With the drawer at 2.5 inches, the exposure rate at the face of the plug cavity was measured

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(during the mockup) to be 200 mR/hr (20 R/hr actual). With the drawer at 3 inches the rate rose to 35 R/hr actual. At 4 inches the actual rate was 250 R/hr. The rate with the drawer at 3.7 inches was not measured but was interpolated. The three data points enabled construction of the curve shown in Figure 3, from which it is evident that at 3.7 inches the rate must have been very near 115 R/hr, or -1.9 R/min. (The wrist badge would have been exposed about 2 inches further away than the cavity face to a rate a little less than 115.) In section I.A it was shown that the rate at the far end of the cavity is close to twice the rate at the cavity opening. Thus the exposure rate assumed for this hypothetical case, with the drawer withdrawn to 3.7 inches, is 3.8 R/min, equivalent to 3.8 R per light field mirror adjustment. NE13's extremity dose is assumed to be 38 rem for purposes of this case. The counterpart extremity dose assumptions are 53 rems (14 x 3.8) for NE297 and 3.8 rems for NE195.

**2. Wrist TLD Results**

The wrist badge results for NE13 were 12.29 rem left and 4.146 right. Since the worker is right-handed, a higher dose to the right wrist might have been expected. Also, the right hand was exposed deeper into the cavity than the left. But the right hand was of necessity elevated into the upper region near the set-screw, and exposure rates were lower in that region. The left hand, which was used to keep the drawer from rotating, was located in the lower region where the highest exposure rates existed.

As previously mentioned, the cavity is less than 5 inches deep, so that the wrist badges were probably exposed just beyond the cavity-plug face with the drawer at 2.5 inches. For the hypothetical case examined in this section, (II), it is assumed that the drawer position is 3.7 inches out. Thus the wrist badges would have been about an inch further away from the cavity face.

Exposure rates were measured at the cavity face during the mockup using survey instruments. The results for 3 drawer positions (multiplied by 100 for source-strength correction) were:

2.5 inches — 20 R/hr; 3 inches — 35 R/hr — 4 inches — 250 R/hr.

At -2 inches from the cavity face the following rates have been interpolated:

2.5 inches — 13 R/hr; 3 inches — 28 R/hr — 4 inches — 180 R/hr.

If a worker's wrist badge were exposed to these rates for 10 minutes, the exposures would be:

2.5 inches — 2.2 R; 3 inches — 4.7 R — 4 inches — 30 R.

Interpolations at a drawer position of 3.7 and 3.5 inches yield 17 R and 12 R respectively. This rough estimate suggests that the drawer may have been withdrawn about an inch further than the 2.5-inch minimum.

**III. BIOLOGICAL EFFECTS**

**A. Cataracts**

A question has arisen as to whether a photon absorbed dose on the order of those received, virtually single exposure, could cause cataracts (eye lens). There is no evidence that such small doses could do so. When ICRP-26 was first issued in 1977 it established an annual occupational dose limit of 30 rads, permitting lifetime LDEs on the order of 1500 rads. It was indicated that no vision impairing opacities could occur at smaller doses. Several researchers later pointed to

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evidence that non-vision-impairing opacities caused by doses as small as 350 rads had progressed to the vision impairing stage later in life. The ICRP responded by lowering their LDE limit to 15 rads in a year — the current regulatory limit. The lifetime limitation implied is about 750 rads. The small LDEs assigned to the installers bring their lifetime LDEs to levels far below the cataract threshold.

### **B. Hands, Tissue Damage**

Another concern that has arisen is whether doses to the hands of the installers were sufficiently large to cause biological effects. Working from an extensive and convincing human exposure data base (primarily medical therapeutic) the ICRP was able to establish that nonstochastic (or deterministic) effects will not be experienced in any organ or tissue that receives 50 rems or less per year for a working lifetime. The Commission therefore established an annual limit of 50 rems to achieve its objective of preventing such effects. (Of course, radiogenic organs are limited to 5 rems in a year to control stochastic effects.) It is therefore safe to say that the hands of the installers will exhibit no clinically detectable effects as a result of the exposures discussed here. In fact, this statement would remain applicable were they to receive exposures of this magnitude every year.

Forty-three years ago I received absorbed doses (occupational) of ~2,400 rads to the tips of my right index finger and thumb. Burning sensations began in about an hour and continued off and on for about 3 months. No other effects have been experienced. I am certain that neither NE13 nor NE297 will experience any deleterious effects whatsoever.

### **IV. Conclusions**

Apparently it would be unreasonable to draw the conclusion that any installer actually received doses associated with NE13's TLD result of 7.1 rems during the course of the task examined here. While at present it does not seem possible to avoid assigning a DDE of 7.1 rems to NE13, it would not be reasonable to assume that a large fraction of the dose was received during the task analyzed here. It would also be unreasonable to assign the associated large DDE to NE297, who evidently was not present when NE13's TLD received most of the 7.1 rems.

In this analysis the minimum doses have been estimated (in section I) along with doses consistent with the ~7.1 rems integrated by NE13's TLD for June, 1998 (in section II). The results of both analyses appear as ranges in Table VI.

If it were my responsibility to assign the doses for the task in question, I would assume a 1-minute average exposure time for each light field mirror adjustment. This conservative assumption would double the minimum doses, as shown in Table VII. I would like to emphasize, however, that these were partial-body exposures. Therefore, at a convenient time I would suggest an NPI request to MDE for authorization to reassess the DDEs shown in Table VII by calculating the EDEs, a topic briefly discussed in the attachment to this document.

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<b>Table VI. RESULTS OF DOSE RECONSTRUCTION EFFORT</b> (rem)			
<b>Installer</b>	<b>DDE</b> (rem)	<b>LDE</b> (mrem)	<b>Extremity</b> (rem)
NE297	0.717 to 5.96	23 to 584	4.9 to 53
NE13	0.768 to 7.1	16 to 417	1.75 to 38
NE195	0.051 to 0.426	2 to 42	0.35 to 3.8

<b>Table VII. Recommended Assignment of Doses for Task (rem)</b>			
<b>Installer</b>	<b>DDE</b> (rem)	<b>LDE</b> (mrem)	<b>Extremity</b> (rem)
NE297	1.4	46	9.8
NE13	1.5	32	3.5
NE195	0.1	4	0.7

### ATTACHMENT: EFFECTIVE DOSE EQUIVALENT

Prior to 1977 neither the ICRP nor the NCRP provided guidance on (1) how to add external to internal dose or (2) a reasonable way to include the concept of risk in protection standards for partial-body exposure. The first omission resulted in non-conservative regulation; the second made the regulations overly conservative.

An official solution to both problems became available with the publication of ICRP-26. The Commission developed a straightforward way to convert non-additive dose to additive probabilities, viz., the probability of radiation-induced fatal cancer. A simple, familiar weighting-factor procedure for accomplishing this objective was adopted. The risk factors for the individual radiogenic organs were summed, giving  $165 \times 10^{-6}$  cancer deaths per person-rem, which means 165 deaths among 1 million adults who collectively receive 1 million rems. (Later, in ICRP-61, 1990 this factor became 400 out of a million for adults; the risk factors are called "nominal probability coefficients.") Then the smaller risk factors for individual organs were divided by the sum to obtain the fraction of the overall risk attributed to each organ. These fractions are the weighting factors. When the dose to an organ is multiplied by the weighting factor for that organ, the result is a risk value that can be added to such values for other organs.

Clearly, it does not matter whether the organ received the dose from external or internal radiation; the weighted doses can be added to obtain the *effective dose equivalent (EDE)* for the organ. If more than one organ is significantly exposed, all of the doses are properly weighted and summed to obtain the EDE for the entire person.

The EDE system works just as well for partial body external exposure. For example, if a small beam significantly irradiates only two internal organs as it passes through the body, the worker is at risk from those two organs only. The risk is represented by the EDE, which is calculated by multiplying the dose for each organ by its weighting factor and adding these two organ EDEs together.

Annual EDE limits can be established, and compliance can be demonstrated by calculating the organ EDEs from any and all manner of exposures and simply adding them up.

The various national governments could not act upon this improved system of control at once because an acceptable way of measuring the dose from external radiation to internal organs, as received in the workplace, was not available. It was not until December 27, 1995, that the necessary official guidance was published by the NCRP (NCRP Report No. 122, "Use of Personal Monitors to Estimate Effective Dose Equivalent and Effective Dose to Workers for External Exposure to Low-Let Radiation"). This report primarily addresses broad-beam radiation as measured by conventional personal dosimeters. Partial-body (organ) dosimetry, as received from small beams, is normally reconstructed from multiple sources of data and is thus outside the scope of a report focusing on the use of routine workplace dosimetry results. In other words, small-beam organ dosimetry is a great deal easier than the difficult problem encountered by NCRP-122.

The major revision of 10 CFR Part 20 was issued by the NRC well before NCRP-122 was published. The staff was faced by an uncomfortable dilemma because Presidential Guidance to Federal Agencies in 1988 specified use of the EDE in regulations although the agency could not

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require it when telling licensees an acceptable way to do it was not yet possible. The impossible was accomplished by invention of the circumventing TEDE. For external radiation the TEDE is defined as the normally obtained personal dosimeter result simply multiplied by a weighting factor a weighting factor of 1. No real change. The licensee is required to assume that every organ received the same dose, viz., that assigned to the highest DDE (determined at 1-cm depth). The partial-body problem remains. However, calculation of the real EDE may be permitted on a case-by-case basis; licensee-specific NRC or Agreement State approval is required. This provision may be found in NRC and MDE regulations as a footnote to the table of weighting-factors.

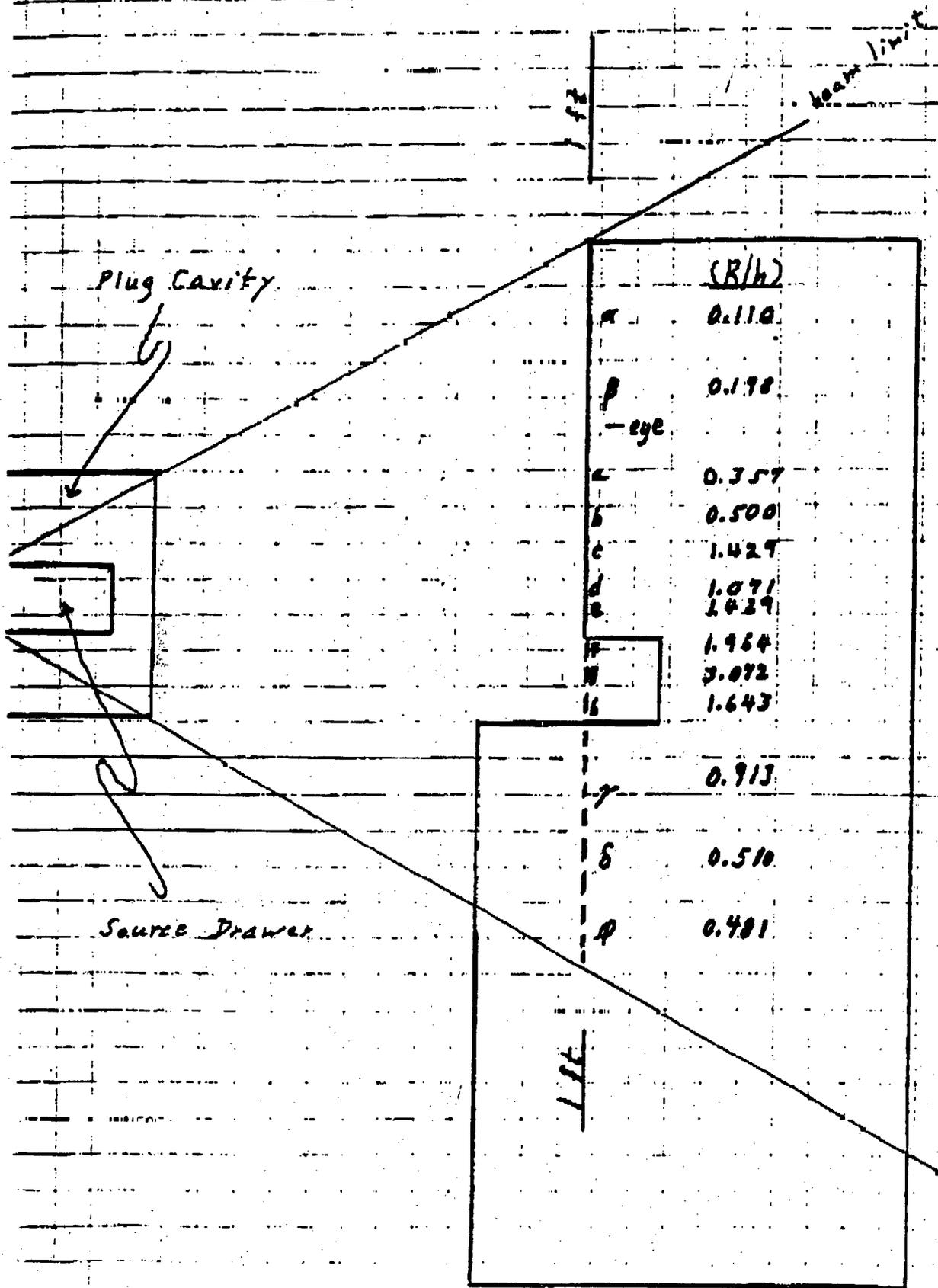
In my opinion it is sometimes unrealistic to record and report partial-body exposures to external radiation in a manner which indicates that every organ in the body received the recorded dose. Were litigation to arise over a malignancy that developed in an organ which was reported to have been exposed but actually received a very small or zero dose, justice certainly would not be served. Injustices also arise when an apparent overexposure damages the reputation of a licensee because of the requirement to assume that every organ receives the dose assigned to the maximally exposed organ. This can and does happen when partial-body (small-beam) external exposures occur. One of the reasons the ICRP and NCRP introduced the EDE was to avoid such injustices.

An example of an EDE determination is shown in Table 4, based on organ doses that appear in Figure 3. A source drawer position of 3.6 inches is assumed. In this example the EDE rate is 0.122 rem/minute of exposure. I find the EDE to be a more reasonable measure of radiation risk. It is more representative of the actual degree of control exercised by regulatory agencies and their licensees.

<b>Table A. EFFECTIVE DOSE EQUIVALENT RATE FOR INSTALLERS</b>				
<b>Organs Included</b>	<b>Dose Rate (rem/hr)</b>	<b>Weighting Factor</b>	<b>Dose Rate Assigned (rem/minute t)</b>	<b>Organ/Tissue EDE (rem/minute t)</b>
gonads		0.20		
marrow	20.8	0.12	0.35t	0.042t
colon		0.12		
lung	3.4	0.12	0.06t	0.007t
stomach		0.12		
bladder		0.05		
breast	3.2	0.05	0.05t	0.0025t
liver		0.05		
esophagus	20.8	0.05	0.35t	0.018t
thyroid	20.8	0.05	0.35t	0.018t
skin	20.8	0.01	0.35t	0.0035t
bone surface	20.8	0.01	0.35t	0.0035t
<b>EDE SUBTOTAL RATE (not remainder organs/tissues)</b>				<b>0.095t</b>
<b>Remainder Organs/Tissues</b>				
<i>adrenals</i>				
<i>brain [0.8 rem/hr]</i>			0.013t	
<i>upper large intestine</i>				
<i>small intestine</i>				
<i>kidney</i>				
<i>muscle [20.8 rem/hr]</i>			0.35t	
<i>pancreas [3.4 rem/hr]</i>			0.06t	
<i>spleen [3.2 rem/hr]</i>			0.05t	
<i>thymus [3.4 rem/hr]</i>			0.06t	
<i>uterus</i>				
<b>Remainder Subtotals</b>		<b>0.05</b>	<b>0.533t</b>	<b>0.027t</b>
<b>Total EDE per Minute of Exposure</b>				<b>0.122t</b>

Notes: (1) EDE = 0.122 t where t is the exposure time in minutes. (2) This EDE constant was derived for a source drawer position of 3.6 inches, source up. (3) Conservatively, no credit is taken for photon attenuation by the body. (4) ICRP-60, 1990, recommendations are followed here.

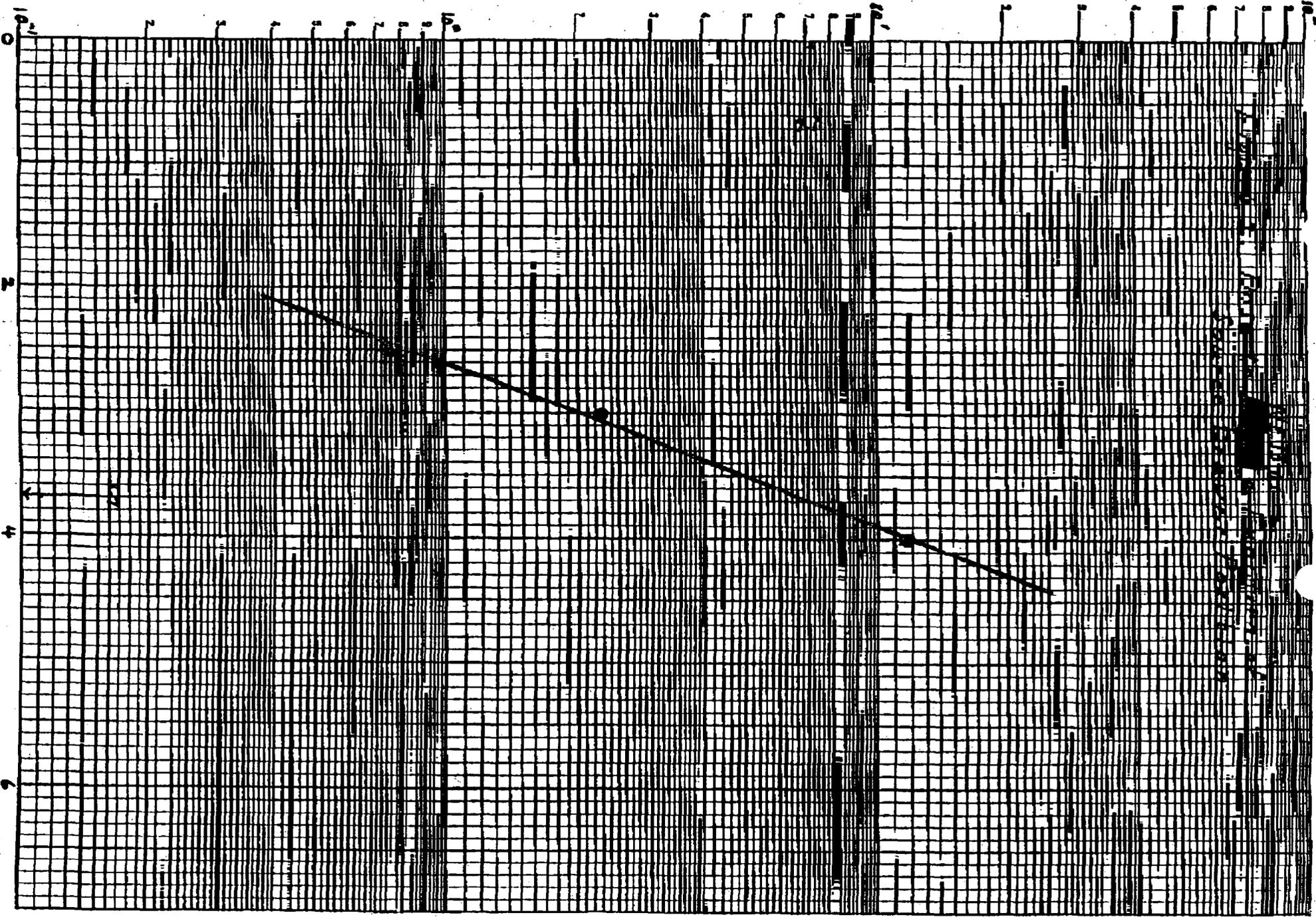
Figure 1. Exposure Rate Profile With Source-Drawer Position at 2.5"



head-to-eye  
 head-to-waist  
 head width  
 head length  
 neck length  
 body width

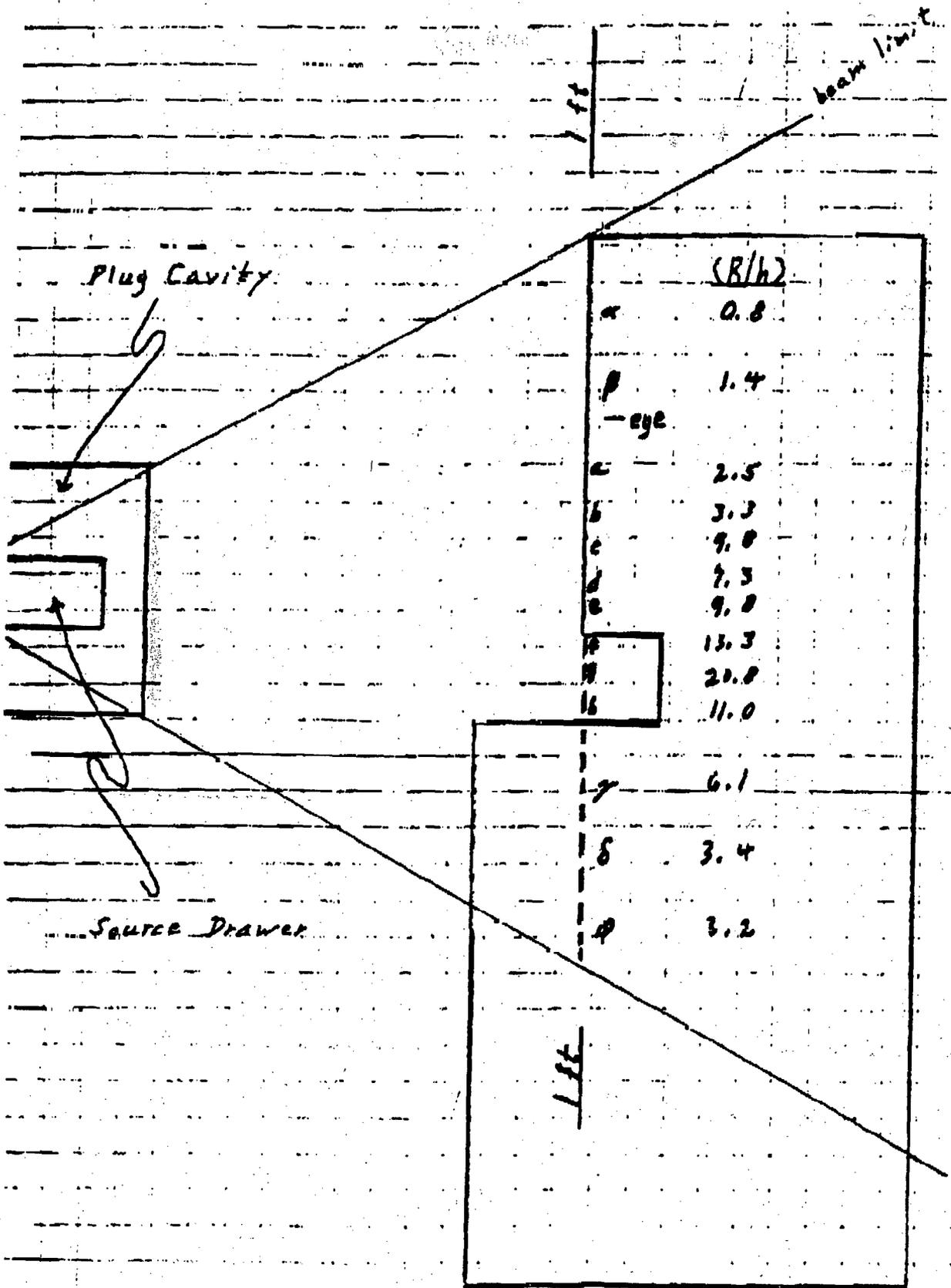
(2)

Dose (rem)



13

Figure 3. Exposure Rate Prof. With Source-Drawer Position at 3.6'



(14)

head-to-eye  
 head-to-voice  
 head width  
 head length  
 neck length  
 body width



**NUCLEAR REGULATORY COMMISSION**

REGION I

476 ALLENHURST ROAD

KING OF PRUSSIA, PENNSYLVANIA 19408-1416

DATE:

9/8/98

MESSAGE TO:

Ray Marshall State of  
Maryland

TELECOPY NUMBER:

410-681-3198

NUMBER OF PAGES:

7  
(INCLUDING THIS REQUEST FORM)

MESSAGE FROM:

Anthony LaNorte

(U.S.N.R.C., REGION I, KING OF PRUSSIA, PA)

TRANSMITTED BY:

DATE & TIME:

VERIFIED BY:

(65)

REGISTRY OF RADIOACTIVE SEALED SOURCES AND DEVICES  
SAFETY EVALUATION OF DEVICE

NO.: NR421D101U

DATE: February 05, 1969

PAGE 1 OF 3

DEVICE TYPE: Rotational Teletherapy Unit

MODEL: Toshiba RCR-120

MANUFACTURER/DISTRIBUTOR: Litton Medical Products, Inc.  
Profexray Division  
515 E. Touhy Avenue  
Des Plaines, IL 60018

MANUFACTURER/DISTRIBUTOR:

SEALED SOURCE MODEL DESIGNATION: GE Drawing 106D3949

ISOTOPE: Cobalt-60

MAXIMUM ACTIVITY: Up to 9700 curies

LEAK TEST FREQUENCY:

PRINCIPAL USE: Medical Teletherapy

CUSTOM DEVICE: \_\_\_ YES X NO

9804060102 2RP

(16)

REGISTRY OF RADIOACTIVE SEALED SOURCES AND DEVICES  
SAFETY EVALUATION OF DEVICE

NO.: NR421D101U

DATE: February 5, 1969

PAGE 3 OF 13

DEVICE TYPE: Rotational Teletherapy Unit

DESCRIPTION (CONT'D):

The model identification number contains the following information:

Ex: Toshiba C - 2 - R - F - 80 - B  
treatment  
head

- 1 - standard collimator
- 2 - simplified conformational collimator
- R - rotational unit
- S - floorstand unit
- M - movable head
- F - fixed head
- 65 - SAD in cm
- 80 - SAD in cm
- A - beam barrier
- B - counterweight

EXTERNAL RADIATION LEVELS:

The unit loaded with 3,000 curies of cobalt-60 (3,100 rhm) was surveyed by the manufacturer and found to have an average and a maximum radiation level at 1 meter from the source of 0.57 mr/hr and 0.95 mr/hr, respectively, with the source in the "off" position. Beam "on" leakage is less than 0.01%.

LIMITATIONS AND/OR OTHER CONSIDERATIONS OF USE:

Installation of the unit with a source already loaded in the head will normally be performed by Litton Medical Products, Inc., Des Plaines, Illinois, under its AEC License No. 12-13085-01. Source exchanges are planned to be performed by personnel of Litton Medical Products, Inc., (i.e., they do not have this type license authorization at present) and will involve an exchange operation of the cylindrical source drawer between the shipping container and the treatment head.

ISSUING AGENCY:

U.S. Atomic Energy Commission

(19)

REGISTRY OF RADIOACTIVE SEALED SOURCES AND DEVICES  
SAFETY EVALUATION OF DEVICE

NO.: NR421D102U

DATE: December 15, 1971

PAGE 1 OF 3

DEVICE TYPE: Rotational Teletherapy Unit

MODEL: Toshiba RCR-120-C1, RCR-120-C3

MANUFACTURER/DISTRIBUTOR: Litton Medical Products, Inc.  
Profexray Division  
515 E. Touhy Avenue  
Des Plaines, IL 60018

MANUFACTURER/DISTRIBUTOR:

SEALED SOURCE MODEL DESIGNATION: GE Drawing 106D3949

ISOTOPE: Cobalt-60

MAXIMUM ACTIVITY: 10,000 curies

LEAK TEST FREQUENCY:

PRINCIPAL USE: Medical Teletherapy

CUSTOM DEVICE:  YES  NO

9704060076 30P.

(68)

610 337 5269 P.06

REGISTRY OF RADIOACTIVE SEALED SOURCES AND DEVICES  
SAFETY EVALUATION OF DEVICE

NO.: NR421D102U

DATE: December 15, 1971

PAGE 2 OF 3

DEVICE TYPE: Rotational Teletherapy Unit

DESCRIPTION:

The Toshiba RCR-120-C1 is a rotational teletherapy unit with the head and beam catcher on a "C" arm which rotates about the patient. The Toshiba RCR-120-C3 differs from the C1 in that it has a counterweight instead of a beam catcher. The units come with a source-to-center of rotation distance of 80 centimeters. The beam catcher subtends an angle of about 70 degrees from the patient and transmits approximately 0.05% at the beam. The unit is 7 feet 6 inches high with a maximum source-floor distance of 6 feet 5 inches. The distance between the source and back of the unit is approximately 8 feet 10 inches.

The unit is supplied with a standard head designated as "Toshiba C10". This head consists of a spherical cast steel shell filled with lead. A tungsten alloy sleeve inside the head provides additional shielding in the "off" position. A 1.9" in diameter by 8.3" long cylindrical source drawer made of tungsten alloy fits horizontally into the lead turntable shutter. The teletherapy capsule is held in the source cavity, which is 30 mm (1.182") in diameter by 34.5 mm (1.36") in height, of the drawer by a threaded cap and metal retaining hoop which are placed into position inside a hot cell. The shutter rotates in a horizontal plane from the "on" to the "off" position by an electric motor working against a torsion spring. In case of power failure, the shutter will return automatically to the "off" position.

The tungsten alloy collimation assembly defines a field size which can be varied from 5 cm square to 35 cm square at 80 centimeters from the source.

The head will swivel 165° in either direction and tilt 130° forward from the downward position and 30° back. Beam orientation can be limited by electrical or mechanical stops.

Lights on the unit and on the control panel indicate the "on" and "off" conditions. The mechanical source position indicator is a drum attached to the shutter drive shaft and is viewed through a window toward the top of the teletherapy head cover. Red color indicates beam "ON" condition and green color indicates beam "OFF" condition. The turntable shutter retracts to the "OFF" position by the return spring when the power fails or when the interlocked door is opened; the unit must then be reset to continue treatment. In an emergency, the shutter can be mechanically rotated to the "off" position by inserting an emergency bar in the slot on top of the teletherapy head and rotating counterclockwise 180 degrees.

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REGISTRY OF RADIOACTIVE SEALED SOURCES AND DEVICES  
SAFETY EVALUATION OF DEVICE

NO.: NR421D102U

DATE: December 15, 1971

PAGE 3 OF 3

DEVICE TYPE: Rotational Teletherapy Unit

EXTERNAL RADIATION LEVELS:

The manufacturer has determined the head can be loaded with 10,000 curies of cobalt-60 with an output of 11,800 rhm and yield an average and maximum radiation level at 1 meter from the source of 1.17 mr/hr and 5.3 mr/hr, respectively, with the source in the "off" position. Beam "on" leakage is less than 0.01%.

LIMITATIONS AND/OR OTHER CONSIDERATIONS OF USE:

Installation of the unit with a source already loaded in the head and source exchange operations will normally be performed by Litton Medical Products, Inc., Des Plaines, Illinois, under its AEC License No. 12-13085-01. In a source exchange operation the cylindrical source drawer is moved from the turntable shutter to the shipping container and a new source drawer is moved from the shipping container to the turntable shutter.

ISSUING AGENCY:

U.S. Atomic Energy Commission

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