U. S. NUCLEAR REGULATORY COMMISSION

REGION II

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License No.:	45-25088-01
Report No.:	45-25088-01/96-01
Licensee:	Professional Service Industries, Inc.
Location:	1788 Island Road, Suite 1 Bristol, VA 24201
Dates:	November 13-21, 1996, and exit meeting on December 4, 1996
Inspectors:	C. Hosey, Team Leader J. Jones, Senior Radiation Specialist, Region III B. Parker, Radiation Specialist, Region II T. Rich, Mechanical/Materials Engineer, NMSS S. Sherbini, Health Physicist, NMSS
Approved by:	B. Mallett, Director Division of Nuclear Materials Safety

EXECUTIVE SUMMARY

Professional Service Industries, Inc.
Bristol, Virginia
Inspection Report 45-25088-01/96-01

On November 5, 1996, the licensee's CRSD received a call from a moisture/density gauge technician at the Bristol, Virginia office reporting a concern that reddening and blistering she had recently observed on her hands may have been a result of exposure to radiation during her use of the gauge. The technician indicated that on a number of occasions she had experienced difficulties in extending the source rod to make measurements in the field, and that because of these difficulties, she had to bring her hands into close proximity with the source rod to extend the rod. She further indicated that she positioned the gauge over the measurement site by carrying the gauge with her hands, one placed over the gauge housing and the other over the extended source rod. She stated during subsequent interviews that she did not know that the source, 10 mCi of cesium-137, was located at the end of the source rod.

In response to the technician's concerns, the licensee had the technician examined by a physician at a local hospital, but the physician was unable to provide a probable cause for the observed symptoms. The licensee also had the technician's film badge processed, and the results indicated that the film was exposed to a dose of about 12 rems. After discussions with the NRC, the licensee arranged for cytogenetic testing of the technician's blood by ORISE, and the results were found to be consistent with an equivalent whole body exposure of about 16 rems. The licensee subsequently arranged for the technician to be evaluated by a physician with expertise in the effects of radiation exposure, but the results of this evaluation were not available at the time this report was issued. The NRC's medical consultant had not completed the evaluation of this case at the time of issuance of this report.

The licensee's response following the initial report was timely and appropriate. In addition to the actions noted above, the licensee promptly notified other technicians of the apparent overexposure and cautioned them not to touch the source rod.

Based on observations and discussions with licensee representatives, the AIT arrived at the following conclusions:

1. The CPN gauge used by the technician was mechanically in good operating condition at the time of the inspection. This is based on the team members' operation of the gauge at the Bristol facility; on subsequent evaluation of the gauge condition by the manufacturer, which found the gauge to be in a mechanically good operating condition, with no indications of any condition

that may have caused the gauge to malfunction sporadically; and also on interviews with other technicians at the Bristol facility who had used the gauge during the period in question and had experienced no difficulties in using it.

2. Available dosimetric data suggest that the technician may have received a whole body dose of about 12-16 rems, but this dose could not have resulted from use of the gauge in the manner described by the technician. This conclusion is based on the film badge and cytogenetic results, both of which indicated a dose in the range of 12-16 rem, and on dose assessments performed by the team based on data obtained from the gauge manufacturer and also from interviews with the technician. The dose assessment indicated that the doses received by the technician from use of the gauge in the manner described could not have resulted in a whole body dose of more than a small fraction of 12-16 rems.

3. The dose to the technician's hands at the time of appearance of symptoms was determined to be below the NRC's annual dose limit for exposures to the hands of 50 rems. This conclusion is based on dose assessments conducted by the team. The assessments indicated a maximum dose of 90 rems during the period in which the gauge was used. Symptoms were reported by the technician to have appeared during the first part of the period of her use of the gauge, and the maximum dose to the hand at that time was estimated to be about 20 rems. This dose assumes consistent use of one hand, with the same location exposed every time. Allowing for the alternate use of both hands, as indicated by the technician, the dose to each hand is estimated to be about 10 rems at the time of appearance of symptoms. Allowing for changes in the point on the skin receiving the highest dose on different exposures, and averaging the dose over the skin area of the hand will reduce the estimated skin dose to a value substantially below 10 rems.

4. The training received by the technician was less than adequate. Records and interviews revealed that she did not receive the required classroom or "hands on" equipment training, the written examination was compromised by making it available to the technician before the examination was given, the individual administering the examination failed to verify the adequacy of training before administering the exam, and documentation failed to demonstrate that the technician received adequate training before certification as a gauge operator. The AIT found similar inadequacies in the implementation of the training program involving other technicians at three of five other licensee's offices inspected.

5. Implementation of the RSO/Instructor training program was less than adequate, in that the licensee permitted the Branch RSO to function as a RSO/Instructor by providing and overseeing the training of technicians although he had not had the RSO/Instructor training and been certified.

6. The licensee had adequate operating and emergency procedures for safely using portable moisture/density gauges; however, adherence to procedures in the areas of storage of gauges, security of gauges at temporary jobsites, maintenance of gauges and wearing personnel monitoring devices was less than adequate.

7. Management oversight of licensed activities was less than adequate, in that corporate-wide deficiencies in the training program were not detected by the corporate radiation safety department, nor during numerous audits of the offices' activities by various company VPs, or during field audits and other management reviews performed by the Branch RSOs. In addition, failure of technicians to follow operating procedures were not identified and corrected by Branch RSOs.

REPORT DETAILS

1.0 Description of Occurrence

On November 6, 1996, the licensee informed NRC Region II that a technician (Technician A) in the Bristol, Virginia office had called the CRSD and reported a concern that reddening and blisters on her hands may have resulted from radiation exposure received while operating a moisture/density gauge at temporary job sites. The technician had been operating a CPN MC-1 (Serial Number M15076224) gauge containing approximately 10 mCi of cesium-137 in a source at the end of a source rod and approximately 50 mCi of americium-241 within the gauge housing. See Section 3.1 below for a description of the gauge. During the interview, Technician A reported routinely touching the source rod in the area of the cesium source while using the gauge. The technician indicated that this was due to difficulties experienced in extending the source rod past the shielded shutter mechanism and out of the gauge housing when density measurements were made. The technician indicated that a ball point pen had been used to force open the shutter while extending the source rod and that the source rod had been held while the gauge was moved to the measurement site. A physician at a local hospital examined the technician's hands and reported observing surface blemishes on the hands that could have earlier been blisters that had not completely healed. The physician indicated that he could not determine if the skin reddening was a result of radiation exposure. An NRC inspector was onsite on November 7 and 8, 1996, to interview the technician and to observe the reenactment of the gauge use by the technician. Based on the discussion between the CRSD and Technician A, observations of the reenactment and observations of Technician A's hands performed by of the physician, the licensee concluded that the technician may have received an extremity exposure in excess of the NRC's annual limit of 50 rems. On November 8, 1996, the licensee reported to the NRC the potential extremity overexposure to the hands of the technician. On November 12, 1996, the licensee reported to the NRC that the technician's film badge for the period of August 25 to November 1, 1996, had received a gamma dose of 12.17 rems. NRC Region II issued a Confirmation of Action Letter on November 8, 1996, to document the licensee's proposed actions which included determining the dose to the technician's hands, determining the cause of the gauge malfunction, and training licensee personnel on lessons-learned from the event. On November 12, 1996, the Regional Administrator, Region II, formed an AIT to review the circumstances surrounding the event and independently determine the dose to the technician.

2.0 Sequence of Events

3/19/96 Technician A received certification as a moisture/density gauge operator.

6/19/96	Technician A first used the CPN MC-1 gauge (Serial No. M15076224) and experienced mechanical problems with the gauge.
8/96	Technician A first noticed "tingling" in hands.
9-10/96	"Tingling" and numbness in Technician A's hands increased.
10/20/96	Symptoms peaked and Technician A went to hospital.
11/4/96	Technician A went to private physician for another medical problem and discussed blisters on hands with physician.
11/5/96	Technician A called the CRSD concerning reddening and blisters on hands. Technician was concerned that radiation exposure may be the cause.
11/7/96	Technician A examined by a physician at a local hospital. Physician indicated that the blemishes shown him by the technician may have been almost completely healed blisters. The physician could not make a definitive statement that the blemishes were caused by radiation exposure.
11/12/96	Licensee's film badge processor reported Technician A's film badge for the period of August 25, 1996 thru November 1, 1996, had a reading of 12.17 rems.
11/14/96	Blood sample drawn from Technician A at the Bristol Regional Medical Center for a cytogenetic study by ORISE.
11/25/96	ORISE reported that, based on the cytogenetic study, Technician A had received an equivalent whole body dose of 16 rems.
12/11/96	Licensee made the arrangements and Technician A was examined by a physician at the University of Cincinnati Medical Center with extensive background in assessment of radiation effects.

3.0 Equipment

3.1 Device Design

The Boart Longyear Company (previously CPN Products) Model MC-1, is a portable moisture density gauge (see Figure 1) used to measure moisture and density of various items such as soils, embankments, concretes, and

asphalt. The device is approximately 35.5 x 23 x 56 cm and weighs approximately 15 kg.

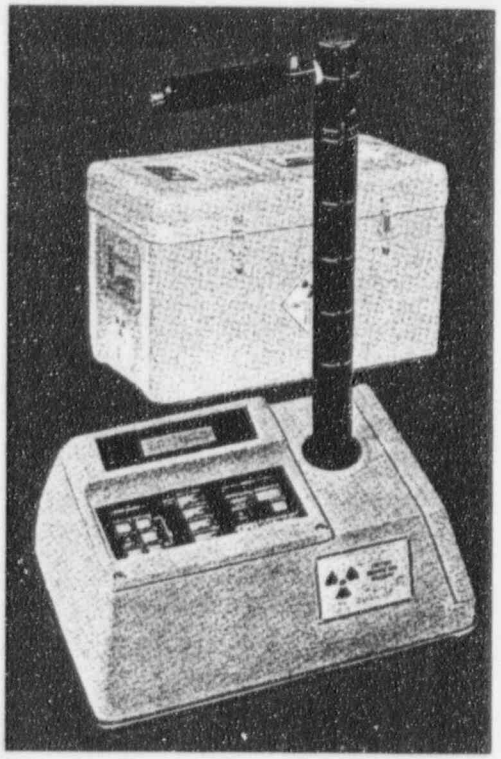

Figure 1

The device contains two radiation sources, a 50 mCi americium-241/beryllium source fixed in the base of the unit which is used to measure moisture content and a 10 mCi cesium-137 source installed in a cup that is welded to one end of a source rod which is used to measure density.

The device basically consists of a cast aluminum box that contains shielding for the radiation sources, shutter assembly, radiation detectors, batteries, necessary electronics for taking the measurements, and a guide tube which contains the source rod. The guide tube is fixed in place within the device and extends vertically from the unit and is used to guide the source rod.

A shutter assembly is located beneath the end of the guide tube and shields the end of the source rod. The shutter assembly consists of a carbide/tungsten block, bolt/spring combination and a shutter plate (see Figure 2).

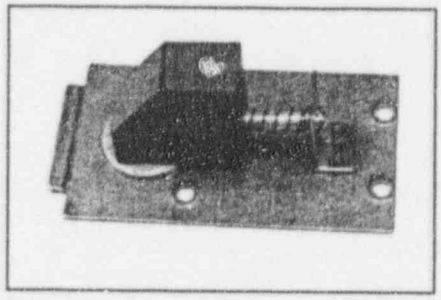

Figure 2

The completed shutter assembly provides an automatic return mechanism whenever the source rod is in the fully upright (i.e., source rod is fully retracted) position. When the source rod is moved downward, the end of the rod contacts a ramp on the block causing the block to move horizontally, thus allowing the source rod to exit through a hole in the shutter plate. The shutter assembly can be removed from the device for cleaning or service by removal of screws which attach the shutter plate (also referred to as the cleanout plate) to the bottom of the device. It is not necessary to extend the source rod to remove the shutter assembly.

A handle is attached to the source rod and contains a trigger which is used to release a spring loaded latch. This latch catches recesses inside the source guide tube which correspond to various depths the source rod has protruded out of the device. This allows for measurements at fixed depths. The operating position is obtained by pulling on the trigger and then pushing down the handle to the desired location. The source rod can be locked in the fully shielded position (i.e., fully upright position) by a padlock in the handle assembly. This lock prevents movement of the trigger.

The electronics, including the battery and charging components can be serviced without disturbance of the shielded sources.

3.2 Interviews with Technicians Concerning Gauge

During interviews with the AIT, Technician A indicated that she had experienced problems getting the source rod to extend each time she used the CPN gauge. In addition, she stated she had experienced problems with the connection on the battery charger and had hard-wired a new battery charger to the device. During an interview, the AIT had

Technician A demonstrate how the CPN gauge was used, using a Troxler demonstration gauge not containing radioactive sources. This gauge is approximately the same weight as the CPN gauge and operates in a similar fashion. Technician A had no problems moving this gauge around. During the demonstration, Technician A showed the AIT how she had used a ball-point pen to push the shutter aside while extending the source rod. She also demonstrated how, after she extended the source rod outside of the gauge housing, she grasped the dummy source rod with a hand to prevent it from moving back in the gauge and then carried the gauge to the hole and placed the source rod in the hole. Using this gauge, Technician A also demonstrated how she handled other model gauges. During this demonstration, it appeared to the team that she knew how to use the gauges safely. Technician A stated that she used the other gauges in the correct manner, and had not experienced any problems extending the source rod of these gauges. Technician A also indicated that on two occasions she had taken the CPN gauge home and had extended the source rod so it could be cleaned and lubricated. Technician A estimated that she was exposed to the extended source rod for approximately 30 minutes on each occasion. Technician A also stated that she had informed the Branch Manager/RSO of the problems she was having with the CPN gauge; however, no corrective actions were taken. The Branch RSO stated that he did not recall Technician A ever mentioning problems with the gauge to him and that he was not aware that the charger had been hard wired to the gauge until November 5, 1996.

The RSO provided the team with the results of interviews he had with other technicians at the Bristol facility regarding the CPN gauge. The results indicated that, with the exception of Technician A, the technicians had only experienced erratic readings due to faulty electronics. The other technicians had not experienced difficulties in extending the source to make measurements. During interviews performed by the team of several technicians who used the CPN gauge prior to Technician A during the months of April and May of 1996, they all reported no mechanical problems with the gauge. Between June and October, 31, 1996, Technician A used the CPN gauge approximately 20 days. During this same time period, other technicians used the CPN gauge for a total of 16 days and each stated during interviews with the AIT that they experienced no problems extending the source rod.

3.3 Condition of Gauge at Licensee's Facility

An NRC inspector observed the gauge on November 7, 1996, and through radiation measurements determined that the radiation profile was consistent with that expected for this gauge. On November 7, 1996, the licensee performed a leak test of the gauge and determined that the radioactive sources were not leaking. Further evaluations were

performed when the AIT arrived on November 13, 1996. The AIT confirmed that the gauge observed was the same gauge Technician A reported using by checking the serial number against the utilizations logs and by observance of the modifications to the battery charger made by Technician A. Based on observations by the AIT, and discussions with licensee personnel and review of licensee records, the AIT determined the following:

The gauge was manufactured on May 20, 1985 and shipped to the PSI's Bristol facility in June 1995.

Two modifications had been made to the device. One to the latch assembly and the other was an electrical modification. The latch assembly was drilled to allow the use of a padlock to lock the latch instead of the conventional keylock. This modification was approved by NRC in August 1990. The electrical modification was an addition of an AC adapter. This adapter did not affect the mechanical operation of the device. Technician A made the electrical modification due to the device's inability to hold a charge. Other than the latch modification, the device design is mechanically consistent with the corresponding Registration Certificate number CA-0208-D-102-S issued April 9, 1976, and modified March 27, 1995.

The AIT observed that the gauge was dirty (i.e., dry, caked mud on the bottom and sides) with scratches and nicks on the outside of the device. The source guide tube containing the source rod appeared straight and no observable wear was seen on the guide tube or shaft. The source rod handle did not appear bent or abused. Other than some minor scratches and nicks on the outside of the device, there were no obvious signs of significant wear or abuse. The device appeared to be mechanically operable.

Based on an evaluation of the gauge and comparisons of pictures taken of the gauge by the NRC inspector on November 7 and 8, 1996, the AIT concluded that no modifications, or maintenance had been performed on the gauge between the initial inspection and the arrival of the AIT. The Team examined the shutter plate and did not observe any indication that the shutter plate had been recently removed (i.e. no cracking or flaking of mud/dirt around the edges of the plate or screws attaching the shutter plate to the gauge and the mud/dirt patterns on the gauge were consistent with the pictures).

3.4 Field Test of Gauge

To determine the operability of the CPN gauge, the AIT had a technician demonstrate how the gauge was used to make a measurement. After the technician made a hole in soil that he considered to be one of the

worst test conditions due to the soil hardness (wet clay), the technician demonstrated the mechanical use of the gauge by extending and retracting the source rod as would have been done during a normal measurement. The technician did not experience any difficulties extending or retracting the source rod. The AIT members also experienced no difficulties moving the source rod.

The AIT concluded that the gauge was operating normally from a mechanical standpoint. The electronics were not tested.

3.5 Evaluation of Gauge at the Manufacturer's Facility

Before the AIT exited the Bristol facility, the gauge and shipping container were locked and packaged to go to the manufacturer (CPN) for further evaluation. A team member was present during the locking of the gauge and shipping container. The keys that were used to lock the device and shipping container were turned over to the team member.

In discussions with representatives of the gauge manufacturer, and review of the gauge design, the AIT determined that the components that could cause difficulty in the source rod movement if they were broken, significantly worn, or dirty included: 1) the shutter assembly; 2) the handle assembly; 3) the source rod; 4) the linear bearing; and 5) the source guide tube. Listed below are the conditions of these components as found during disassembly and their corresponding evaluation performed by the manufacturer and the AIT member. (See Figures 3, 4, and 5.)

On November 19, 1996, a team member met with the RSO and Service Manager and other representatives from CPN to participate in the disassembly and evaluation of the gauge. Also present was an inspector from the State of California, Department of Health Services.

The gauge was disassembled by manufacturer's representatives. The shipping container was unlocked and the gauge removed. Other than wetness, which apparently occurred during shipment, the gauge appeared in the same condition as when it left PSI's facility. The serial number was again confirmed.

a. Initial Observations

Initial observations of the gauge found the gauge to have been modified electrically (AC adapter added), and mechanically (padlock through the handle assembly) and was dirty, but had no signs of abuse. The manufacturer's representatives, based on

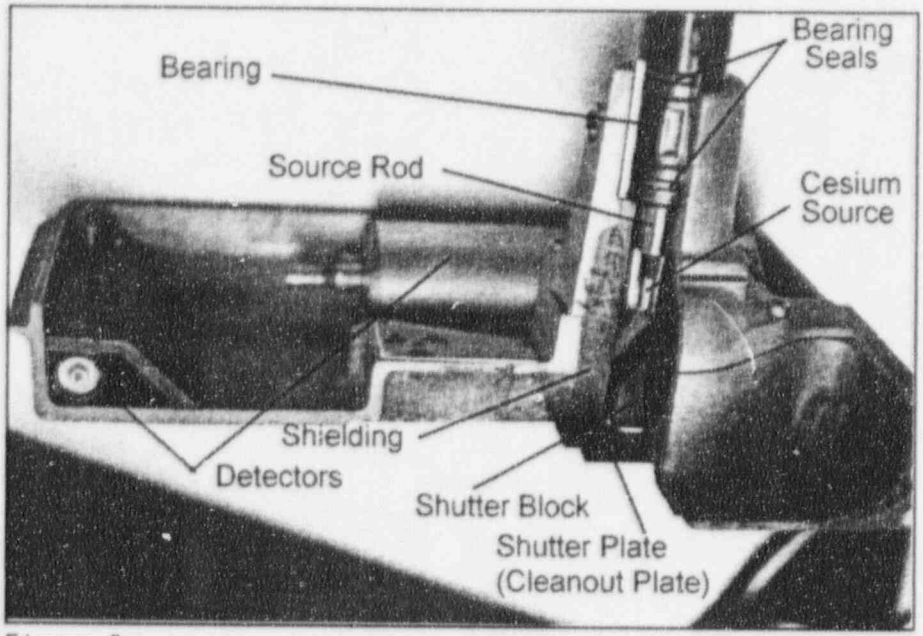

Figure 3

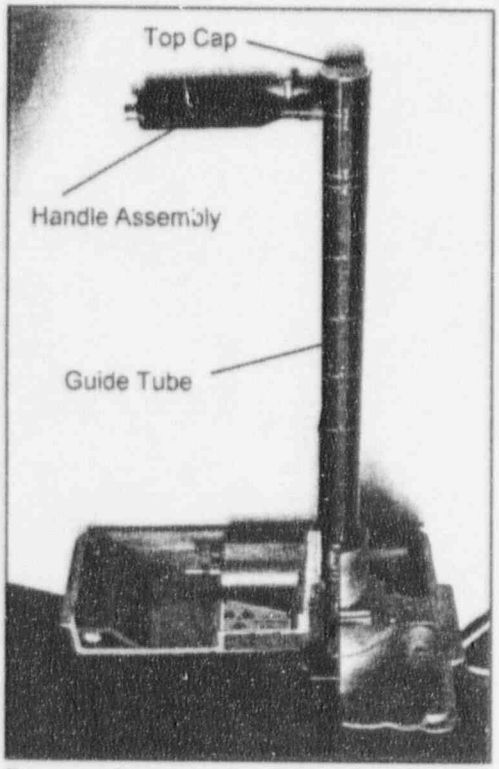

Figure 4

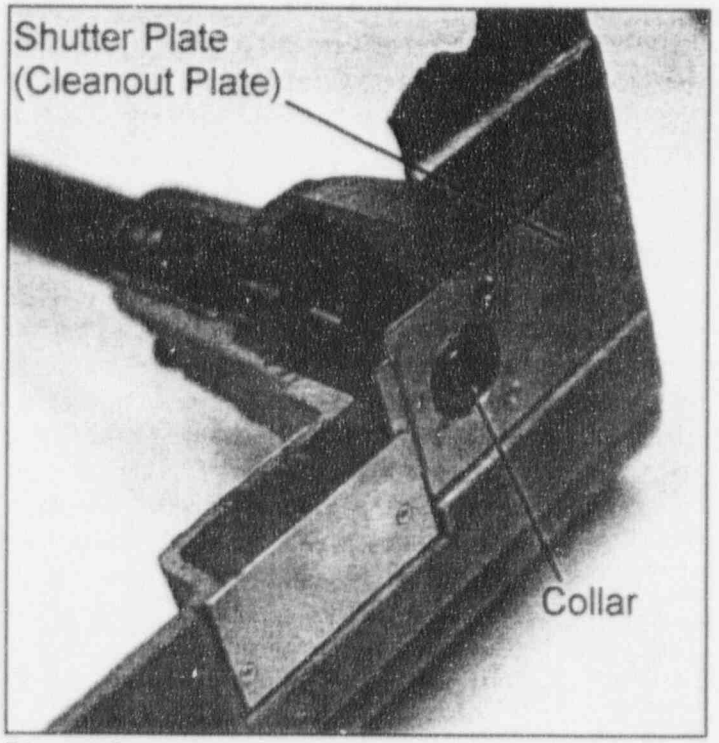

Figure 5

their experience with other gauges of the same model, considered the nicks and scratches on the outside of the device normal for this type of gauge. The service manager tested the handle assembly and movement of the source rod. He indicated that the source rod and handle were straight and useable. The source rod moved freely and there did not appear to be significant play in the bearing. He also indicated that the device should be cleaned but that it did not need any mechanical repairs and that it was mechanically operable. The service manager also noted, that none of the parts appeared to have been recently replaced.

b. Shutter Evaluation

The shutter block assembly (cleanout plate) was removed. The AIT member observed that the shutter mechanism was dirty but working (i.e., freely sliding back and forth). No loose screws rocks or other foreign matter besides a minor amount of dirt (dusting) fell out of the device upon removal of the shutter mechanism. There was no evidence of any foreign objects that could have blocked, jammed or prevented the shutter from moving. The service manager and sales representatives stated that they had seen dirtier gauges than this one that were still operable. They also indicated that they would typically see wear on the end of the source rod, which was not evident with this gauge, before wear on the shutter block since the shutter block was made of a harder material (carbide/ tungsten). The service manager physically tested (i.e., by feel) the spring pressure of the spring attached to the shutter block and stated that it appeared normal. In discussion with the AIT member, the manufacturer's service manager and sales manager indicated that they had not neard of anyone using a ballpoint pen or similar tool to open the shutter. They indicated that more force could be applied to the handle to open the shutter than by using something like a ballpoint pen.

After removal, the shutter block assembly was cleaned and evaluated. The manufacturer's representatives stated that they found no signs of significant wear or damage involving the block where the source rod comes in contact with the block, on any of the surfaces where the block comes in contact with other metal parts or involving any other parts of the shutter assembly. The manufacturer's representative indicated that, due to the materials of construction, if the shutter had been sticking or required excessive force to open, one would expect to find breakage of a component of the shutter assembly or signs of

significant wear due to frictional forces between the metal parts on components in contact with the shutter block, or any combination of these None of these conditions were observed by the manufacturer.

c. Handle Evaluation

The manufacturer removed the handle assembly and noted that the lock latch had high wear (part that contacts recesses in the guide tube). However, the service manager stated that high wear is typical on the lock latch and as this piece wears, the easier it is to move the source rod.

The service manager reviewed the modified lock design. It was determined by the service manager that this modification did not affect the source rod movement. The service manager noted no significant wear or obstructions (such as burrs left during a drilling operation) that could cause the latch to remain closed or partially closed, thus causing increased resistance in moving the source rod.

d. Source Rod Evaluation

The source rod was removed and examined, did not appear to have any significant wear. There was slight wear longitudinally along the rod, but the service manager considered this to be normal wear. This wear could have occurred during manufacturing or as a result of a bad bearing. In reviewing licensee records, the AIT found that the bearing had been replaced in August 1994. It is unlikely that dirt or other foreign objects would have caused this since no corresponding wear was found in the inside of the source guide tube. The guide tube is made of a much softer material, and therefore, wear would be expected to be more significant on this component. The rod was checked for straightness and found to be within manufacturer's specifications.

e. Bearing Evaluation

The bearing was removed from the guide tube and evaluated. The bearing was still packed with grease. The balls in the linear bearing moved freely and there was no apparent flat spots on the balls. Some of the grease was removed and observed. It did not appear to have any significant amounts of grit. The bearing walls and cavities containing the balls did not have any

observable wear. The bearing was tapped hard on a hard surface to check the stability of the balls in their track. This test was repeated around the circumference of the bearing. None of the balls fell out or got stuck.

The only thing noted by the maintenance person removing the bearing was that both the bearing seals were located on top of the bearing. The bearing seals are supposed to be installed with one seal on each side of the bearing. This incorrect installation would allow the possibility of more dirt and other foreign matter entering the bearing. However, as noted above, the bearing was working properly and did not appear to have any significant wear, so this was not considered to have affected the source rod movement.

f. Source Tube Evaluation

The source tube was evaluated and measurements were taken. The source guide tube is made of aluminum. Information provided by the manufacturer indicates that the source rod is approximately 4.6 times harder than the source guide tube. It is expected that if wear were to occur during source rod movement, that it would most likely occur inside the source guide tube. The service manager stated that the wear patterns within the guide tube were normal for these gauges. The wear was consistent with other gauges that the manufacturer had in its facility for maintenance that were about the same age as this gauge. There were no apparent gouges or significant scratches that would possibly indicate that foreign material had entered and caused the source rod to stick, or prevent it from moving easily. The inside diameter of the tube was measured and was found to be within acceptable tolerances. The manufacturer considered the wear on the source rod to not be significant based on manufacturing tolerances and normal wear for an 11 year old gauge.

The inside of the source guide tube is machined to include a recess for holding a bar that is used by the handle assembly to position the source rod at various distances. The bar is attached to the guide tube with screws. The bar and corresponding screws were checked and neither the bar nor the head of the screws had any indications that they were rubbing against the guide tube which may have caused the source rod to stick or become hard to move.

Based on the evaluation of the gauge, the AIT concluded that the gauge was mechanically operable and the team could not duplicate the difficulties Technician A said she experienced using the gauge.

3.6 Adequacy of Repair, Testing and Maintenance of Gauge by the Licensee

PSI's maintenance program is somewhat unique for licensees of portable gauges in that all their maintenance, aside from minor electrical work, is performed at their Pittsburgh, Pennsylvania facility rather than returning gauges to the manufacturer for repairs.

The review of the service/maintenance, shipping and transfer records for the CPN MC-1 gauge (Serial Number M15076224), provided to the AIT indicated that the device was first shipped to the Bristol facility in June 1, 1995. The records indicate the device was only serviced once by the Pittsburgh facility on October 5, 1995, since its transfer to the Bristol facility. At that time, electrical work was performed, the top cap was replaced (cap covering top of source guide tube), and the device was cleaned and lubricated.

Reviewing records on file prior to the transfer of the gauge to the Bristol facility indicated that the following service was performed on the device: (1) on August 2, 1994, electrical work was done and the device was cleaned and lubricated, (2) in October 1994, electrical work was performed, the linear bearing replaced, and the device was cleaned and lubricated, (3) on March 2, 1995, electrical work was performed, the top cap was replaced and the gauge was cleaned and lubricated, and (4) on September 26, 1995, electrical work was performed, the handle replaced, the collar which is attached to the shutter plate and through which the source rod passes was replaced, and the device was cleaned and lubricated.

The manufacturer's manual for this gauge under the General Operating Instructions section, page I-4, states, in part, that after repeated tests the shutter mechanism will become dirty with accumulated soil pulled into the chamber on the end of the source rod and the shutter will jam or become sticky. PSI's Procedure SF-9, Moisture/Density Gauge Manual, Section E, Item 4.1.1 states, in part, that the shutter chamber of each gauge should be cleaned out at least once a week, or more often if conditions warrant. It further states that one should leave the source rod locked in the fully retracted (Safe) position and not to extend the source rod during cleaning. Licensee records indicated that gauges are not routinely cleaned by the Pittsburgh facility unless the device is in for other repairs. In discussions with the technicians at the Bristol office, they indicated that the only maintenance performed on the device at the Bristol office is minor electrical repairs (i.e., replacing batteries, fuses). The technicians, with the exception of Technician A, indicated that they had not cleaned the CPN gauge.

Condition 16 of License No. 45-25088-01 requires that the licensee conduct a physical inventory every six months to account for all sources and/or devices received or possessed under the license. Procedure SF-9, Section B, Item 2.3 specifies the scope of the inventory. Based on interviews with licensee representatives, the Team determined that the licensee performs the inventory on a quarterly basis. During this inventory, the licensee determines if: (1) the handle lock and trigger mechanism is functional, (2) the sliding shutter is operating properly, (3) the source rod extends and retracts smoothly, and (4) the integrity of (internal) source shielding structures are intact.

The records reviewed indicated that the quarterly inventories were performed for the CPN gauge during the period of June 12, 1995 thru October 3, 1996; however, the forms did not indicate the date of inventory, but rather the dates the forms were forwarded to the corporate office. All of the inventory records reviewed indicated that the CPN gauge was functioning properly at the time of the inventory.

3.7 Conclusions

The AIT concluded that the CPN gauge was mechanically operable at the time of the inspection. This conclusion was based on the operation of the gauge by the Team and the evaluation of the gauge by the manufacturer.

The AIT could not repeat the difficulties Technician A stated she was having in extending the source rod in the CPN gauge.

The AIT also determined that other technicians who used the CPN gauge during the time Technician A stated she was having difficulty extending the source rod were not experiencing similar problems and each indicated that the gauge was mechanically operable.

The AIT determined that routine cleaning of the shutter mechanism was not performed weekly as required by licensee procedures.

The AIT concluded that Technician A extended the source rod while cleaning the CPN gauge contrary to specific instructions in licensee procedures.

4.0 Training

4.1 Moisture/Density Gauge Operator Training

Condition No. 23 of License No. 45-25088-01 requires the licensee to conduct its program in accordance with the statements, representations

and procedures contained in the license application dated June 29, 1995 and other referenced documents. Item 8 of the application requires, in part, that licensed material be used only by individuals who have received specific training in the use of the device and have successfully completed the manufacturer's training course or PSI's "in-house" radiation safety training program. Radiation safety training and equipment instruction is provided to trainees at the Branch office using training materials (notes, slides, etc.) prepared by PSI's CRSD, and the exam is administered by the Branch RSO. Once completed, a certificate is issued from the corporate radiation safety department in the operator's name. Item 8 of the application further states, that trainees will receive (1) five to six hours of formal "classroom" radiation safety training provided by a PSI certified RSO/Instructor; and (2) two and a half hours of equipment "hands-on" instruction which shall, at a minimum, include proper storage and removal procedures; transportation and security requirements; security and control of the gauge while in use, including restrictions for members of the public; and device/transport case maintenance, including charging, cleaning, leak testing, etc. Also, a written, closed book exam of no less than 50 questions is to be administered at the end of the training with a minimum score of 80% required to pass. Item 8 of the application further requires Course Instructors to have successfully completed PSI's Moisture/Density Gauge RSO/Instructor training program and have been certified prior to providing radiation safety training to gauge trainees. Procedure SF-9, Section K, describes the licensee's training program for moisture/density gauge operators, including the content of the formal training is to receive. The AIT reviewed the licensee's training program described in Section K of Procedure SF-9 and found that the contents met regulatory requirements for training gauge users.

Procedure SF-9, Section K, Item 4.2, states that initially licensee trainees are required to view "The Story of Radiation" videotape and complete the accompanying study guide, even if the trainee has had prior instruction. An approved instructor shall correct and review the study guide with the trainee.

Based on interviews with the Bristol Branch RSO, CRSD, and the RSO/Instructor who administered the examination to Technician A, and review of records, the team determined the following: Technician A did not receive formal "classroom" training as described in the license application and Procedure SF-9. Technician A indicated that she was provided a copy of the SOP Procedure SF-9 in February 1996, but never actually studied it. The Branch RSO recalled giving Technician A the "controlled copy" of Procedure SF-9 prior to the time he took the examination for moisture/density gauge operator in January 1996. He further recalled asking Technician A to return the "controlled copy" so

he could use it to study for the examination. After receiving the "controlled copy" of Procedure SF-9, Technician A stated she made a copy for her personal use. The Branch RSO recalled Technician A asking him questions on a number of occasions, and he would answer them as best he could. He also indicated that he gave her his copy of the RSO/Instructor Seminar Manual as a study aide. The Branch RSO indicated that these question-and-answer periods were done randomly and informally, and were not documented. Technician A stated that, on occasion, she would ask the Branch RSO questions about the use of the gauge, but she never received answers to her questions. Other technicians interviewed indicated that Technician A often asked questions of them as well, and they would usually provide answers; however, Technician A often asked the same questions repeatedly at later times. Technician A indicated that she was unaware that the cesium-137 source was located in the end of the source rod, and that the source came out of the shielding within the device when the rod was extended. Technician A also indicated that she was not aware of the potential consequences of mishandling a radioactive source (i.e., biological effects, etc.).

Technician A indicated that "The Story of Radiation" videotape was viewed in the November/December 1995 timeframe; however, the videotape study guide was not completed because the licensee never provided it to her. The Branch RSO acknowledged that he did not give Technician A the videotape study guide because he did not know of the study guide's existence at the time.

The team viewed "The Story of Radiation" videotape and found it to be of marginal value to a nuclear gauge user in providing the basic understanding of radiation and its effect on humans. The video provided so much information that the important information needed by a gauge user was lost in the detail.

Regarding "hands-on" training with the equipment, Technician A signed the Training Confirmation Form indicating that two and a half hours of hands-on training had been received; however, it is unclear as to whether two and half hours of actual hands-on training was provided. The licensee did not adequately document the hands-on training, relying mainly upon Technician A's time sheets. For example, Technician A's time sheets for November 20, 1995, and December 6, 1995, indicated "observe nuke gauge - 1.0 hour," and "SWVHEC Compaction - 2.25 hours," respectively. These times could account for the two and a half hours of required hands-on training; however, both Technician A and the Branch RSO acknowledged that these times included travel time to/from the jobsite, and did not accurately reflect the time of actual gauge usage. Technician A indicated that on November 20, 1995, she only observed the gauge and was shown or told nothing of how it worked. The

technician accompanying Technician A in the latter instance indicated that Technician A remained in the truck at the jobsite due to the cold weather and did not actually participate in the use of the gauge. The licensee indicated that Technician A received gauge training on November 8, 9, and 15, 1995. Time sheets for those dates documented a total of 22.0 hours of work for Technician A. The licensee took credit for 10.0 of those 22.0 hours as gauge training in a training summary document provided to the team; however, those time sheets were completely blank in the "Description" column and gave no indication that gauge training was included in the time recorded for those dates. Interviews with the Branch RSO and other technicians indicated that "hands-on" training was provided to Technician A both in the laboratory and in the field on those dates as well as various other occasions.

Since the Branch RSO had not completed the PSI RSO/Instructor training program, he was not qualified to provide radiation safety training nor administer the written examination. Therefore, a certified RSO/Instructor from PSI's Greensboro, North Carolina office came to the Bristol office on March 15, 1996, to administer the examination to Technician A. However, the Greensboro RSO/Instructor did not provide any formal "classroom" training to Technician A. He relied on the statements of Technician A and the Branch RSO that adequate training had been provided, and administered the examination.

Procedure SF-9 contained a blank version of the examination used for testing the knowledge of gauge operator trainees. Also, the license application dated June 29, 1995, contains the examination with the answers filled in (answer key) as part of the attachments describing the gauge operator training program. All of these documents and files are maintained in the Branch RSO's office.

Technician A's copy of the Procedure SF-9 Manual contained a blank copy of the exam. The Branch RSO stated that he was not aware that Procedure SF-9 contained the blank exam until he was studying for his exam in mid-January 1996.

Technician A indicated that on the morning of March 15, 1996, the Branch RSO verbally gave her the answers to the exam prior to the Greensboro RSO/Instructor's arrival, and the answers were written into her blank copy by her. The Branch RSO denied ever giving Technician A any of the answers to the examination. On March 15, 1996, the examination was administered, and, according to Technician A, she used her previously completed copy for reference during much of the examination period. Neither the Branch RSO nor the RSO/Instructor acknowledged proctoring the exam. Technician A scored a 94% on the exam, and was subsequently certified by the Corporate PSI office as a gauge operator on March 19, 1996.

After the examination, both Technician A and the certified RSO/Instructor signed, dated, and initialed the Training Confirmation Form, certifying that she had read and fully understood the training materials (the Procedure SF-9 Manual, the videotape/study guide, etc.); had any questions answered to her satisfaction; and all required training had been offered, given and received.

Item 2.4 of Section K of Procedure SF-9 requires that in addition to equipment instruction, trainees shall receive 24 to 32 hours of supervised field training under the direct supervision of a (certified) RSO, ARSO, or experienced gauge operator. The required field training must be documented and maintained on file, available for inspection. Item 4.5.2 of Section K of Procedure SF-9 states that the documented supervised field training is to be given following certification as a moisture/density gauge operator.

The AIT reviewed the licensee's training summary records. These records documented 29.25 hours of field experience for Technician A. However, 45% of that time (13.25 hours) was in November/December 1995, prior to her certification in March 1996. Therefore, this time should not have been credited towards the supervised field experience requirement since it was received prior to certification. As previously indicated, much of the documented time credited to field experience included travel time to/from the jobsite and/or did not adequately describe the training. Of the remaining 16.0 hours of training after Technician A's certification in March 1996, the team determined that a 4.0 hour of this training was credited for a field training episode on May 20, 1996, which included no gauge usage because upon arrival at the jobsite, the gauge was found to be uncharged. The time only accounted for two hours of travel to and from the jobsite. In another instance, the team determined that 4.5 hour field training episode on June 6, 1996, actually consisted of 15-30 minutes of actual gauge usage and instruction, and two hours of travel each way. These determinations were based on interviews with Technician A and other technicians involved in those instances. Technician A did not recall participation in the remaining 7.5 hours of training documented by the licensee. However, the technicians involved in those additional instances indicated that the training episodes did occur as documented.

Procedure SF-9, Section K, Item 2.6, states that personnel who come to PSI with a training certificate from a manufacturer (Troxler, Campbell Pacific Nuclear [CPN] and Humboldt), or other certificates that have been reviewed and approved by the Corporate Radiation Safety Department may begin using moisture/density gauges immediately upon assignment of a film badge and faxing a copy of the individual's training certificate

to the Corporate Radiation Safety Department. At the end of the initial two weeks, the individual must have successfully completed PSI's "in-house" gauge operator training program or discontinue using gauges.

The team identified at least three technicians who were working with gauges and had not completed the PSI in-house gauge operator training. One of the technicians was certified by a manufacturer on July 20, 1990, and had routinely used gauges since joining PSI in early 1996. Two other technicians were found to be certified by non-manufacturers on July 1, 1995 and April 25, 1996, respectively; however, the licensee allowed these technicians to use gauges upon joining PSI in early 1996, although they were not certified in a manufacturer's course, nor had they had the PSI training.

4.2 Moisture/Density Gauge RSO/Instructor Training Program

Item 8 of the license application dated June 29, 1995, states, in part, that the PSI Moisture/Density Gauge RSO/Instructor Training Program is a 16 hour course consisting of a combination of self-study material and formal classroom instruction. The self-study portion combines text and videotape information prepared by the CRSD and is estimated to require a minimum of eight hours for completion. The classroom portion utilizes materials prepared by the CRSD and is presented under the direct supervision of the CRSD or the Assistant Radiation Safety Director.

Item 8 further states that the prerequisites for the RSO/Instructor training are a degree in Engineering or Science, or equivalent; certification as a gauge operator, either by a manufacturer or through PSI's in-house training program; and at least one week of experience in the use of moisture/density gauges. At the end of the training program, a minimum 50-question test is administered with a minimum passing grade of 80%. The exams are evaluated by the CRCD or the Assistant CRCD. The AIT reviewed the content of the training program for RSO/Instructors met regulatory requirements.

Through interviews with licensee representatives and review of records, the team determined that the Branch RSO at the Bristol Office had not completed the required training and was not RSO/Instructor certified. The Branch RSO was hired on October 30, 1995, took the gauge user exam on January 25, 1996, and was certified as a gauge user on January 26, 1996. He was named as RSO on the NRC License on February 21, 1996. Due to his duties as Branch Manager, the Branch RSO did not use a gauge on a regular basis. He received hands-on training from some of the senior technicians, and observed and participated in gauge field work on various occasions. Although not qualified to do so, the Branch RSO

oversaw and/or provided what training was given to Technician A between November 1995 and November 1996. No other technicians from the Bristol office took the PSI in-house training during that period.

4.3 Conclusion

The AIT concluded that the licensee's Moisture/Density Gauge Operator training program was adequate as designed "on paper."

The AIT concluded that the implementation of the Moisture/Density Gauge Operator training at the Bristol Office was less than adequate. Specifically, (1) trainees did not receive the required classroom training, (2) trainees did not receive the required "hands on" equipment training, (3) the written examination was compromised by making it generally available to technicians before the examination was given, (4) employees who had been certified by a manufacturer or other company were permitted to use the gauge beyond the initial two weeks without completing the licensee's in-house training, (4) the RSO/Instructor administering the examination to Technician A failed to verify the adequacy of the training before administering the test, (5) supervised field experience for Technician A was overstated in the documentation, and (6) documentation for Technician A's training was poor and failed to demonstrate that Technician received adequate training before certification as gauge operator.

The AIT concluded that the PSI Moisture/Density Gauge RSO/Instructor training program was adequate "on paper."

The AIT concluded that the implementation of the RSO/Instructor training program was less than adequate, in that the licensee permitted the Branch RSO to function as a RSO/Instructor by providing and overseeing the training of Technician A, although he had not had the RSO/Instructor training and been certified.

The video tape "The Story of Radiation" provided marginal radiation safety instruction needed by gauge operators.

5.0 Procedural Controls

5.1 Requirements

All procedural controls at the facilities located in Bristol, Virginia are defined by the Procedure SF-9, March 1996. Although this manual in it's entirety was not submitted to the NRC as a part of the application dated June 29, 1995, for renewal of License No. 45-25088-01 significant portions of the manual were paraphrased and incorporated into the application. This manual provides procedures for training gauge

operators and RSO/Instructors, as well as for routine use of gauges and handling emergency situations. The manual is provided to all licensee offices for implementation of the specific procedures. Licensee representatives confirmed that the manual is considered official company policy. The manual includes radiation safety methods for keeping radiation doses ALARA, personnel monitoring requirements and operating and emergency procedures.

The AIT interviewed licensee management and staff at the Bristol facility, reviewed records and observed licensee personnel using moisture/density gauges to determine the effectiveness of the procedural controls.

5.2 Operating and Emergency Procedures

Procedure SF-9, Section J provides detailed operating procedures. These procedures include, in part, authorized storage Locations, gauge usage, use of utilization Logs and gauge repair/calibration.

a. Storage of Gauges

Section 9 of the license application states, in part, that gauges will not be stored in residences or hotel rooms. This prohibition is also contained in Procedure SF-9, Section D, Item 8.0. In addition, Procedure SF-9 requires that a utilization log provide information on the date(s) of use, name(s) of users, job sites(s) of use, and an indication of return of gauges(s) to storage.

Technician A indicated in an interview with the team that she routinely took the portable moisture/density gauge home after completing her daily tasks. Technician A indicated that on one occasion, prior to a biannual audit by a licensee vice-president, the Branch RSO told her to take the gauge home because he did not want the gauge to be seen with the hard wired charger attached. The Branch RSO stated to the inspectors that employees were not permitted to keep gauges overnight and that he had not told Technician A to take the gauge home. He stated that taking gauges home for any purpose is strictly against company policy. He stated that he was not aware that Technician A had taken the gauge home until November 5, 1996, when she was paged and asked to return the gauge to the office.

Procedure SF-9, Section J 3.4 states that prior to usage, the utilization log for each gauge shall be completed with the date(s) of use and time of removal, name of individual removing the gauge from storage, and location(s) of use. The time of

return to storage is entered after use. The Bristol facility's office clerk indicated to the team that she completed the utilization logs based on reports given to her by the technicians when they returned from their jobs. The team noted that the form used for the utilization log at Bristol differed from the one found in the Procedure SF-9 in that it does not provide a space for recording the time of return. The inspectors were told by the office clerk that she was not permitted in the gauge storage area, because she was not certified as a nuclear gauge operator; therefore she had no way to know if the gauges were returned other than by reviewing the field report submitted by individual technicians. In reviewing the utilization logs the team noted that the days that Technician A had the CPN gauge in her home (November 1-4, 1996), the utilization log incorrectly indicated that the gauge was at the Bristol office. The clerk stated that she filled out the utilization log indicating the gauge was in storage based on the fact that technicians brought back a field report of their activities for that day. She assumed that the gauge would have been placed back in storage. All the other technicians at the Bristol office that were interviewed by the team indicated that they knew it was improper and against company policy to take gauges home.

Procedure SF-9, Section F, Item 8.0, requires that Moisture/density gauge utilization logs be posted in a conspicuous location near the moisture/density gauge storage enclosure, so that the individual removing the gauge from storage can conveniently complete the utilization log. During the inspection, the team noted that the utilization log was kept by the office clerk and was not posted near the moisture/density gauge storage enclosure as stated in the procedure.

b. Gauge Repair/Calibration

Section 10 of the license application requires, in part, that the licensee not perform any maintenance or repairs involving removal of sealed sources from the device or extension of the source rod. Procedure SF-9, Section E, Item 3.5.6 states, in part, that all normal repairs of moisture/density gauges are conducted "in-house" at PSI's Pittsburgh facility, Electrical Department. Procedure SF-9, Section E, Paragraph 4.1.1 states that each gauge should be cleaned out at least once per week, or more often if conditions warrant. However, this procedure does not provide specific guidance on who is authorized to do the cleaning. During an interview with the team, Technician A acknowledged that between July 1 and October 30, 1996, she attempted repairs to the CPN moisture/density gauge. Technician A indicated that the

gauge had both an electronic problem (a bad charger jack) and a sticky source rod problem. The technician repaired the charger jack by hard-wiring a battery charger into the circuit. She also attempted to correct the source rod problem by cleaning and lubricating the device in the her home. Technician A stated that while cleaning and lubricating the source rod she had the source rod extended and her hands came in direct contact with the source rod.

With the exception of Technician A, technicians at the Bristol facility indicated that they had not removed the cleanout plate and cleaned the shutter mechanism.

Procedure SF-9, Section E, Item 4.1 states, in part, that an individual must always wear a film badge while performing maintenance on a moisture/density gauge. Technician A stated in interviews with the team that she did not wear her film badge while she soldered the battery charger in place, nor did she wear the film badge while she cleaned and lubricated the gauge source rod at her home.

c. Emergency Procedures

Procedure SF-9, Section L, provides detailed instructions to be followed in case of damage sustained through an accident. Included in these instructions are special instructions for the gauge operator, instructions for the RSO, recovery procedures, device recovery/packaging, surveys, disposal of the device, and reporting and notification. The manual also provides detailed instructions to be followed in the event of a gauge having been stolen. All of the instructions were clear and easy to understand. All technicians at the Bristol office interviewed, with the exception of Technician A, indicated an adequate understanding of the emergency procedures to be followed in case of an incident involving loss or damage to a gauge. Technician A appeared to be only vaguely familiar with the emergency procedures. Technician A indicated uncertainty about what to do in case a gauge was damaged at a work site. Although, she did indicate she would attempt to get in touch with someone for help.

5.3 Conclusions

The AIT concluded that the licensee had adequate operating and emergency procedures for safely using portable moisture/density gauges.

The AIT concluded that the implementation of the operating procedures at the Bristol office was less than adequate. Specifically, (1) Technician A carried a gauge home on numerous occasions and the utilization log system did not detect this failure to follow procedures, (2) Technician A performed unauthorized maintenance on a gauge, which may have resulted in the technician receiving a radiation dose in excess of NRC annual limits, and (3) Technician A failed to wear a film badge while performing the unauthorized maintenance.

6.0 Management Oversight of Licensed Activities

6.1 Field Audits

Procedure SF-9, Section H, Item 2.0 states that Field audits are procedural inspections of gauge operators while working in the field. Field audit reminder notices are generated from the corporate radiation safety department database of moisture/density gauge operators. The system of notification includes provisions for notifying the office in advance of the required audit by use of reminder notices, and late notices. The audit is required to be performed every six months. Newly certified moisture/density gauge users are required to have an audit performed no later than three months from the date of certification. The Branch RSO or designated Assistant Branch RSO is authorized to perform the audit. The field audit requires the auditor to address the proper use, transportation, security, knowledge of emergency procedures and personnel monitoring of the operator.

The AIT reviewed the field audit records for audits performed for personnel assigned to the Bristol office. The records indicated that the audits had been performed in a timely manner; however, not all of the audits were done while the technician was working in the field. In interviews with the team, technicians and the Branch RSO indicated that sometimes the field audits were performed in an area just behind the office in order to meet the procedurally required deadlines. Technician A stated that she had not received a field audit since she was certified as a gauge user. However, the Branch RSO recalls performing the audit in an area behind the office and provided the team with an audit report signed by Technician A acknowledging that the audit was performed. The AIT team noted that the documentation of the field audits did not include which gauge was used, the location where audit was performed, and the conditions at the time of the audit.

6.2 Vice President's Bi-Annual Audit (Inspection)

Procedure SF-9, Section H, Item 3.0 states that the VP audit is required to be performed at each branch office each six month period. The audit is performed by a vice president of the licensee and consists

of an on site inspection by the VP using a standard list of questions. The audit includes a review of branch office records pertaining to the use of gauges, compliance with regulations and procedures, condition of gauges and observations. The team reviewed the last VP bi-annual audit which was performed October 23, 1996. The audit report indicated that all but one of the gauges were being used at field locations on the day of the inspection, therefore the condition of only one gauge was inspected. As previously discussed, the CPN gauge was not in use, but had been removed to Technician A's residence. The team noted that the VP's Bi-Annual Audit failed to identify the problem with the utilization logs, the use of gauges by technicians at the Bristol office who had not completed the required licensee training before using gauges and the unauthorized modification to the CPN gauge.

6.3 Conclusion

The AIT concluded that the field audits performed on Bristol office technicians and the biannual management audits of the Bristol office radiation safety program were less than adequate, in that (1) the filed audits were not performed covertly while the technician was working in the field, and (2) the VP Biannual audits failed to identify deficiencies in the training program, unauthorized maintenance and accountability of gauges.

7.0 Radiation Dosimetry

7.1 Radiation Source

Information on the construction of the cesium-137 source contained in the gauge was obtained from the gauge manufacturer, who provided detailed drawings of the source assembly. Licensee records indicate that the source was assayed on May 20, 1985, and at that time contained 10.7 mCi of cesium-137. Allowing for a decay period of about 11.2 years, from May 1985 to July 1996, the source activity at the time of the apparent exposure was about 8.27 mCi. The source assembly, called the source cup, is welded to the end of the source rod in the gauge, and consists of a stainless steel cylinder, 1.6 cm in diameter and 2.7 cm long. This is the part that Technician A stated was held in the palm of the hand when positioning the gauge in preparation for taking a density reading. A cavity is machined in the source cup and the source is held in place and sealed within this cavity by a steel plug. The active volume of the source is in the form of a disk, 0.5 cm diameter and 0.1 cm thick, located at the bottom end of the source cup. The thickness of stainless steel between the active volume and the cylindrical surface of the source cup is about 0.48 cm. The steel thickness between the source and the bottom end of the source cup is 0.16 cm.

7.2 Exposure Distance and Duration

The length of time the source was outside the gauge shield and in contact with Technician A's hand was estimated on the basis of re-enactments of the use of the gauge by Technician A. The re-enactments were conducted using a gauge similar in design to the one used in the field, but containing no radioactive sources. Technician A was asked to go through the entire process of extending the source rod and positioning the source at the test location in preparation for a measurement. The technician was also asked to repeat this re-enactment several times, and the time during which the source was outside the shield and in contact with the technician's hand was measured for each re-enactment. The distances of the source from the technician's head and dosimeter were also measured.

The results of the re-enactments showed that contact time of the source with the hand was between 8-15 seconds for each measurement using the gauge. The technician stated that when measurements were being performed inside a ditch, handling the gauge was a little more difficult because of the confined space, resulting in contact times toward the high end of the range noted above. An average exposure time of 12 seconds per measurement appeared to be representative of contact time and was used in the dose calculations.

The distance from the source to the technician's face was measured and found to vary between 20-40 cm during the time the source was unshielded. A distance of about 25 cm appears appropriate based on observations during re-enactments, and will be used in this dose assessment. The re-enactments showed that much of the technician's body was shielded from direct irradiation by the base of the gauge during source handling, but the head and parts of the neck and arms were in direct line of sight with the source. The film dosimeter was worn by the technician on the shirt pocket in such a manner that appears to have shielded it from direct exposure to the source. However, this was not certain, and it will be assumed in the calculations that the dosimeter was in the direct radiation field during source handling, and at about the same distance as the head from the source.

Based on time-keeping records maintained by the licensee, Technician A used the gauge in question to make three measurements in June 1996, none in July, 26 in August, three in September, 94 in October, and six in November, for a total of 132 measurements. Time-keeping records were missing for four days during that period, and it is therefore not known if the technician made measurements on any of these four days. In addition, the technician stated during interviews and re-enactments that the time-keeping records showed only those measurements for which

official results were reported by the technician. The technician stated that, in addition to the officially reported measurements that are indicated on the time sheets, an average of two additional, unofficial, measurements for each official measurement were made to verify the accuracy and uniformity of the results of the density test. Interviews with other technicians who performed similar duties indicated that it was not common practice to perform measurements without recording the results. The Team assessed the times Technician A spent at the various sites, as indicated on the time sheets, and concluded that it would have been difficult, but not physically impossible, for her to have conducted the additional measurements that she said were conducted. The dose estimates will therefore be based on two values for the number of measurements conducted with the gauge: 132 measurements, which is the documented number, and which probably represents a lower limit for this parameter, and about 400 measurements (132 x 3), which probably represents an upper limit.

In addition to the exposures received during field measurements using the gauge, Technician A stated that, on two occasions, the gauge was taken to the technician's house for maintenance. On each of these two occasions, the technician stated that the gauge was disassembled, including extending the source rod from its housing, for cleaning and lubrication. An accurate estimate of exposure times and distances was impossible to make, mainly because the technician could not remember the exact sequence and duration of all movements made during these episodes. However, based on interviews with the technician, it was determined that the total duration of exposure to the unshielded source was not in excess of 30 minutes for each maintenance episode. During this time, the source was handled only briefly for cleaning. The source was placed on the work table during the remainder of the 30-minute period. For purposes of dose estimation, each of the these two episodes will be assumed to have involved holding the source for a period of one minute, and also whole body exposure to the unshielded source for a period of 30 minutes at a distance conservatively estimated to have been about 25 cm. Technician A stated that the film dosimeter was not worn during the occasions when the gauge was being serviced at home.

7.3 Dose Rate to the Hand

As noted above, the source consists of a very thin wafer of cesium-137 encapsulated in a stainless steel cylindrical cup. The dose rate at the surface of the cup is expected to be higher than the dose rate from a similar source embedded in tissue equivalent material, because of the

enhanced contribution by the electron fluence established by the photon radiation in the steel. The dose rate at the interface between the hand and casing was calculated to be about a factor of 1.3 higher than if the steel encapsulation had not been present.

The equilibrium dose rate in tissue due to the cesium-137 photon radiation was calculated using the dimensions provided by the manufacturer and discussed above, and was found to be 0.51 rem/min. After considering the change in dose rate due to electrons generated in the steel, contribution from scatter radiation, and absorption of electrons in the outer layer of the skin, the dose rate to the basal layer of the hand was calculated to be 1.1 rem/min. This is the dose rate that was used to estimate the dose to the hand.

The dose rate at 25 cm from the source was calculated to be 0.86 mrem/min. This is the dose rate that was used to estimate the dose to the head and neck region.

In summary, the following parameters were used in dose calculations:

Number of measurements performed with the gauge in question	= 132 (400)
Distance of head from source during measurements	= 25 cm
Distance of film dosimeter from source during measurements	= 25 cm
Exposure duration per measurement	= 12 sec
Total exposure time to the hand and also to the head region	= 27 (80) min
Number of maintenance episodes at technician's house	= 2
Duration of exposure of body per episode	= 30 min
Distance of body from source	= 25 cm
Duration of hand contact per episode	= 1 min
Total exposure time to the hands	= 2 min
Total exposure time to the body	= 60 min

Source activity (cesium-137) = 8.27 mCi

Dose rate on contact with hand = 1.1 rem/min

Dose rate at 25 cm (whole body) = 8.6×10^{-4} rem/min

The numbers in parentheses are the total number of measurements and total exposure times that the technician stated included those measurements that did not appear in the official record.

7.4 Estimated Doses

Based on the above data and calculations, the total dose to the hands is estimated to be:

D_{h1} = (27 min + 2 min) x 1.1 rem/min = 31.9 rems
D_{h2} = (80 min + 2 min) x 1.1 rem/min = 90.2 rems

where D_{h1} is the dose to the hand using the lower contact time estimate, and D_{h2} is the corresponding dose using the higher time estimate. The dose to the head and neck area is estimated to be:

D_{w1} = (27 min + 60 min) x 0.00086 rem/min = 0.075 rem

D_{w2} = (80 min + 60 min) x 0.00086 rem/min = 0.12 rem

where D_{w1} is the dose to the head and neck area using the lower exposure time estimate, and D_{w2} is the corresponding dose using the higher time estimate.

The higher estimated dose to the hand is the dose calculated assuming the higher estimate of the number of density measurements made by the technician. The doses to the hand are upper limits because the same hand was not always used to handle the source. The technician stated during interviews that the hands were alternated during source handling to relieve the strain because of the heavy weight of the gauge. If the hands were used with equal frequency, the dose to each hand would be about 15 rems (45 rems). In addition, observations during re-enactments showed that the hand was not always placed on the source cup, but was sometimes placed on the source rod above the source cup. The contact dose rate at that point is very much lower than that opposite the source location in the cup. In addition, if the dose is averaged over an area of 1 cm^2 around the point of highest dose opposite the source, it will be about a factor of about 1.8 lower than the dose at the point of maximum dose, or about 8.3 rems (25 rems), and would be much lower when averaged over the skin area of the hand. Therefore, if it is assumed that the two hands were used with equal frequency in

handling the source, and if the dose is averaged over an area of 1 cm^2 centered on the point of highest dose opposite the source, the dose to the skin will be 8.3 rems (25 rems) for the entire period involving handling the gauge in question.

In summary, based on the physical data on the source and gauge obtained from the manufacturer, and the data provided by Technician A during interviews and re-enactments, the doses are estimated to be:

Dose to the hand	= 8.325 rems
Dose to the head and neck	= 0.1 rem
Dose to the film dosimeter	= 0.1 rem

where the results were rounded to one significant figure.

7.5 Personal Dosimeter Readings

The licensee provided its technicians who used the moisture/density gauges with film dosimeters to be worn when handling the gauges. The dosimeters are changed monthly. Interviews with the technicians indicated that the dosimeters were usually worn as required, and that they were normally worn over their shirt pockets. A review of the dosimetry records for the past three years, starting in January 1994 to the present, showed that an average of 6-8 technicians were issued dosimeters during any one month period. The record also showed that recorded doses were generally less than the minimum detectable level for the dosimeter of 10 mrem reported by the processor. However, occasionally results were noted that were above the minimum detectable, mostly in the range of 20 mrem for the month. However, as indicated in the dosimetry processor's reports, these were all gross readings, with no control badge readings subtracted. They were apparently cases in which the dosimeters were sent back to the processor without control badges. The only significant dosimeter reading found in the record was that for Technician A issued for the badging period August 25 - September 24, 1996, for which the reading was 12.2 rems deep dose equivalent. Although this badge was issued for the period July 25 - August 24, 1996, Technician A turned it in for processing on November 7, 1996. The dosimeter result for the period July 25 - August 24, 1996, for this technician was missing from the record. The licensee stated that they did not know the reason for the missing data, but speculated that the most likely reason was that the technician did not turn in the dosimeter for processing at the end of the monthly badging period or, if the badge was turned in, it was lost and therefore not returned to the processor for evaluation. Technician A offered no explanation for the missing badge.

In their report on the results of processing of the technician's film dosimeter, the processor stated that the exposure pattern observed on the film was unusual for a radiation source such as cesium-137. The film in the dosimeter is shielded at various locations by lead (Pb), Aluminum (Al), and Plastic (Pl), and one location is unshielded, that is, an open window (OW). The film processor indicated that the energy of the radiation that exposed the film is determined using an algorithm that examines the ratios of the film densities under the various shields and the open window. Each type and energy of radiation shows a characteristic set of such ratios. In this case, the ratios were not consistent with those normally observed for cesium-137. The pattern observed on the technician's film dosimeter, and the pattern expected for a cesium-137 source, are shown below.

Ratio	Observed Pattern	Expected pattern
Al/Pb	0.68	0.621
Pl/Al	0.74	0.982
OW/Pl	0.72	1.010
(Al-Pb)/(Pl-Al)	1.74	34.450

The processor stated that the observed pattern was not familiar to them, and unexpected for the source of radiation in question. They speculated that the observed pattern may have been produced if the film was partially shielded, or if only the lead and aluminum filters were in the primary beam. The processor further stated that the Al/Pb ratio may have been produced by gamma ray exposure, but that the other ratios were not consistent with this assumption. The processor was unable to provide a definitive explanation for the observed pattern, nor were they able to determine whether the film was exposed only once or many times to produce the observed effects.

The processor also conducted tests to determine if the observed exposure on the film may have been caused by defects in the film material or other environmental causes, such as excessive temperature, pressure, humidity, and similar factors. Their tests all confirmed that the film was not defective, nor was it likely to have been subjected to any environmental conditions that may have produced the observed patterns on the film. The film badge processor concluded that the observed effects on the film were consistent with a radiation exposure by energetic gamma radiation, but under unusual exposure conditions that resulted in a unique and unexplained exposure pattern.

7.6 Accountability of Film Badges

Procedure SF-9, Section I, describes the licensee's dosimetry program. Film badges are exchanged on a monthly basis and are required to be worn when using gauges. Procedure SF-9 requires that if a dosimeter is lost or damaged, a copy of a written, signed statement of explanation and an estimate of exposure must be submitted to the corporate radiation safety department. Based on interviews with licensee representatives at the Bristol office and review of records, the team determined that the Bristol office did not have a system in place to ensure that film badges were returned and processed. Film badges are provided to technicians on the 25th of each month. A review of dosimetry records indicated that on approximately 12 occasions in 1996 technician film badges were never returned for processing. Four out of the nine badges issued to Technician A were never returned. The team found that the licensee did not have a written, signed statement of explanation and an estimate of dose for each of missing film badges. The team also found that one technician who started using the nuclear gauges in May 1996 had never been issued a film badge.

7.7 Cytogenetic Testing

In an attempt to obtain more information on the possible exposure received by the technician, the licensee requested that Technician A undergo a cytogenetic test. Technician A consented to the drawing of the necessary blood sample. The blood sample was drawn at the Bristol Medical Center on November 14, 1996, and sent by overnight delivery to the Environmental and Health Sciences Division of ORISE for evaluation. Cytogenetic testing is a specialized technique for examining the chromosomes in the circulating blood lymphocytes for specific defects that are known to be characteristic of radiation exposure. These defects are known as dicentrics, and are observed under an optical microscope after the blood sample is cultured and prepared in a manner designed to facilitate observation of the chromosomes in the cells.

The background rate of dicentrics in the general population is approximately one per 500 cells in the first division metaphase stage of the cell cycle, with a variability of ±1 at the 90% confidence level. The technician's blood showed four dicentrics per 500 cells. Using calibration curves developed by ORISE in their laboratory, the whole body equivalent dose that would result in the observed dicentrics rate was estimated to be 16 rems, with a 90% confidence interval of 6-30 rems.

In discussion with the team, an ORISE representative stated that the doses reported by ORISE are the doses which, if delivered to the whole body, would produce the observed dicentric frequency. This frequency

is roughly proportional to the fraction of the lymphocytes that were in the radiation field at the time of exposure. Whole body exposure would irradiate all the lymphocytes in the body. Localized exposure to the same dose would produce fewer dicentrics, since a smaller fraction of the lymphocytes will be in the radiation field. However, it is difficult to accurately estimate the magnitude of a specified local dose that would produce the observed dicentric frequency. This is because of the complex effects of other factors, such as dose rate, volume of blood at the exposed location, fraction of lymphocytes in circulation at any given time, the proportion of time lymphocytes remain in and out of the circulating blood, and other factors.

7.8 Dose Rate Measurements

The licensee arranged for the dose rates from the gauge used by the technician to be measured by an independent contractor. The measurements were made at the gauge manufacturer's facility using a variety of measurement techniques. These included contact measurements with a GM counter of a type known as a teletector, a pocket ionization chamber, and a TLD, as well as measurements at a distance of 2 feet from the source using a standard survey instrument. The results of the contact measurements were reported by the contractor as follows:

Teletector	18 R/hr
Pocket ionization chamber	9.6 rem/hr
TLD	112.5 rem/hr

The results using the teletector and the ionization chamber are not accurate because of the sizes of these detectors, which are 1 inch diameter for the teletector and 5/8 inch diameter for the pocket ionization chamber. The large detector size results in a measured dose that is substantially lower than the dose at the surface of the gauge. This is because the relatively large detector diameter moves the effective point of measurement away from the surface of the source housing, and also indicates a dose rate that represents the average dose over the relatively large sensitive volume of the detector. The TLD results is considered the most representative of the surface dose rate because of the small size of the sensitive element in this type of dosimeter.

Comparison of the calculated and measured dose rates shows the measured dose rate of 113 rem/hr to be higher than the calculated surface dose rate of 66 rems/hr by a factor of 1.7. However, the calculated dose rate is the rate at a depth of 40 mg/cm^2 in tissue. If this value is adjusted to a surface dose rate, the rate becomes 78 rems/hr, and the measured dose rate in this case is higher by a factor of 1.4. Some of the factors that may account for this difference in dose rates include:

uncertainties in the response of the dosimeter to electrons generated in the steel source housing, uncertainties caused by the exposure geometry (which apparently was such that radiation was incident on the back of the dosimeter), and uncertainties in the method used to calibrate the dosimeter. Uncertainties in the calculated dose rate include uncertainties in estimation of the contribution of the electron fluence generated in the steel to the surface dose rate, uncertainties in the value of the buildup factor used in the calculations, as well as uncertainties in the exact dimensions of the source. The source specifications used in the calculations were generic to that source model, and the actual dimensions of the source in the gauge used by the technician may differ slightly. Nevertheless, the measured dose rate of 113 rem/hr and the corresponding calculated dose rate of 78 rems/hr differ by a factor of only about 1.4, and are considered in substantial agreement given the uncertainties involved in both numbers.

The licensee's contractor also measured a dose rate at 2 feet from the source of 7-8 mrem/hr. Adjusting these rates to a distance of 10 inches gives a measured dose rate of 40-46 mrem/hr. The calculated dose rate at 10 inches was 52 mrem/hr, and is therefore in good agreement with the measured values.

7.9 Discussion

The results of the dose assessments are summarized below.

Calculated dose rate to the hand	= 1.1 rem/min
Calculated dose rate at 10 inches	= 0.009 rem/min
Calculated hand dose	= 30 - 90 rems
Calculated whole body dose	= 0.1 rem
Film dosimeter results	= 12.1 rems
Cytogenetic results	= 16 rems

The hand dose noted above is the dose at the point on the hand directly opposite the source, and assumes that the same point on the hand was irradiated each time the source was handled. If it is assumed that the hands were alternated in using the gauge, and if the dose to the skin as defined by NRC is used, namely a dose averaged over a skin area of 1 cm^2, the hand dose is estimated to be 8-25 rems.

The film and cytogenetic results are in fairly good agreement and suggest a whole body dose of the order of 12-16 rems. However, the source in the moisture/density gauge is not capable of delivering this high dose based on the re-enactments and account of the exposures provided by Technician A. At a dose rate of about 0.009 rem/min, the exposure time required to deliver a dose of 15 rems is approximately 300 hours. This is well outside the range of any uncertainty in the estimated dose rate or contact time with the source during use of the gauge. Reducing the distance to the source by a factor of two, to 12.7 cm, would reduce the required exposure time to approximately 80 hours, still well outside the range of uncertainty. In addition, the dose delivered at a distance of 13 cm from the body would not be considered a whole body dose, but rather a localized one.

In addition to the above uncertainties, the technician stated during interviews that symptoms were first experienced in the hands toward the end of August, 1996. These symptoms included reddening of the hand, as well as blistering, numbness, and tingling in the hands. Based on the gauge use records, the number of measurements completed by the end of August represents about 22% of the total measurements estimated to have been made using the gauge in question. The dose delivered to the hands at that point would be 22% of the estimated total dose, or about 7 rems to 20 rems, depending on whether the recorded or higher number of measurements is assumed. Both of these dose values are well below the annual dose limit to the hand of 50 rems permitted by NRC regulations in 10 CFR Part 20. In addition, as discussed above, the 7-20 rems dose range represents a considerable overestimate of the actual dose delivered to the sensitive layer of skin of the hands. The reasons for this, as noted above, are because the technician alternated hands when using the gauge, the hand was not always placed over the source but was sometimes placed on the source rod, away from the source, the dose to the sensitive layer of the skin falls off rapidly at points not directly opposite the source, and the area of skin that may have received the calculated dose is a small fraction of the total area of the skin of the hand.

The NRC's medical consultant report has not been issued at the conclusion of this report; it will be added to this report (as an attachment) at a later date.

7.10 Conclusions

Available dosimetric data suggest that Technician A may have received a whole body dose of about 12-16 rems. However, the AIT concluded that this dose could not have resulted from use of the moisture/density gauge in the manner described by the technician. to penetrating

radiation of approximately 16 rems. Based on the information provided by Technician A and the size of the source in the gauge, the Team could not account for this equivalent whole body dose.

The AIT concluded that the maximum dose to the extremities (hands) was not greater than 30-90 rems. The range in the dose is based on whether the number of measurements recorded on licensee records is used in the calculation or the number of measurements Technician A estimated she made. The most likely dose, averaged over an area of 1 cm^2 of skin, is 8-25 rems, not taking into account the fact that the hand was not always placed in the same location relative to the source every time the source was handled. Thus the most likely dose to the hands was significantly less than the NRC annual limit of 50 rems and the dose received by Technician A before she observed the apparent skin damage was also less than the NRC limits.

The AIT concluded that the accountability of film badges and the adherence to personnel monitoring procedures was less than adequate in that a number of film badges worn by Technician A and other technicians at the Bristol office were never processed nor the dose received by the technicians evaluated. In addition, Technician A failed to wear a film badge while performing maintenance on the CPN gauge.

8.0 Licensee's Investigation and Immediate Corrective Actions

The CRSD was initially contacted by Technician A with radiological and other concerns on the afternoon of November 5, 1996. The CRSD responded to the Bristol office on November 6, and began investigating Technician A's claims. NRC Region II was contacted on the afternoon of November 6, and informed that an apparent overexposure had occurred. Following an interview with Technician A on November 8, the CRSD officially reported the apparent overexposure to the NRC Operations Center.

On November 7, 1996, the licensee made arrangements for Technician A to be examined at a local hospital. In addition, the licensee made arrangement for a blood sample to be drawn on November 15, 1996, for cytogenetic evaluation to determine the magnitude of the radiation dose. The licensee also made arrangements to have the CPN gauge returned to the manufacturer on November 15, 1996, to determine if there were any mechanical problems with the gauge which could have resulted in difficulties in extending the source rod Technician A said she experienced.

During the CRSD investigation, he found that two gauge operators had not completed the training required by licensee procedure and suspended them from gauge use pending completion of the required training. The CRSD conducted a safety meeting with all technicians to discuss the event and reemphasized that the source rod is never to be touched or handled.

As followup to the event, the corporate radiation safety department sent out various mailings in mid to late November 1996 to all licensee offices informing them of the event and some subsequent corrective actions. All licensee technicians were each sent a notice in "Confidential" envelopes reminding them of their right to report safety concerns without fear of retaliation, and the methods to report such concerns. Licensee managers were sent a bulletin entitled "It Could Have Been You" that described the event and the results of the licensee's investigation. In addition, licensee managers were sent a newsletter and a notice regarding the reporting of safety concerns for review and posting within their respective offices. The newsletter described the event and indicated items for immediate review by each office. The newsletter included the following information: (1) no licensee employee is authorized to modify a moisture/density gauge; (2) each PSI employee has the right and the responsibility to report radiation safety concerns; (3) no employee should ever directly handle any radioactive source; (4) radioactive material utilization logs are required to be maintained on a daily basis; (5) moisture/density gauges are never to be stored at a private residence or in a hotel room; (6) only RSO/Instructor certified persons can provide radiation safety training for certification purposes as a gauge operator; (7) the two and a half hours plus of radiation safety training (beyond "The Story of Radiation" home study program) is to be conducted in the office in a "sit-down" session with the certified RSO/Instructor; and (8) no gauge tech may be utilized based on any certifications other than those issued by licensee without prior written permission from the corporate radiation safety department.

The team found that the licensee's response and followup actions to the event were timely and proactive.

9.0 Root Causes and Contributing Factors

The AIT concluded that the root causes of the apparent overexposure was inadequate knowledge of the gauge, radiation safety and operating procedures on the part of Technician A, failure of the licensee to adhere to procedures in the training of Technician A and inadequate management oversight by the Branch RSO and the licensee's corporate radiation safety department of the training program and the daily use of the gauges. In addition, Technician A improperly handled the gauge and performed unauthorized maintenance on the gauge.

10.0 Inspections at Other PSI Offices

10.1 General Findings

In addition to the inspection at the Bristol, Virginia office, inspections were also conducted at PSI's offices in Ann Arbor, Lansing, and Detroit, Michigan; St. Louis, Missouri; and Roanoke, Virginia. The

team reviewed and discussed gauge operator training with licensee personnel at these locations. The review included essentially the same elements as the Bristol office review. The team concluded that the licensee's Moisture/Density Gauge Operator training program was adequate as designed. In general, the team found the implementation of the training program was not in accordance with the licensee's procedures. Specifically, no formal classroom training was provided to recently certified gauge operators at any of the licensee's offices. In some cases, more care was taken by the local RSO to sit down and discuss the training materials with the trainee(s); however, none of it would be considered formal "classroom" training. Some technicians at the other offices were provided copies of the Procedure SF-9 containing the blank exam. The team did not find any evidence at other offices of technicians obtaining answers to the examination and referring to them while they took their examination. Interviews with several technicians at other offices regarding the videotape/study guide indicated instances where the study guide was not utilized while viewing the videotape. In those instances, the study guides were either provided but not used, or not provided at all.

The team did not identify other instances in which the primary trainer within an office was not a certified RSO/Instructor, or at least a certified and experienced gauge operator. At the Ann Arbor, Detroit, and St. Louis offices, the local RSOs provided the primary training of new employees and were PSI RSO/Instructor certified. At Roanoke and Lansing, the primary trainers were certified gauge operators with significant field experience. In addition, new employees received training and were tested by certified RSO/Instructors brought in from other offices.

The team noted in reviewing the examinations taken by technicians at all of the offices, that a significant number of the technicians missed the question that related to the consequence of touching the source rod (Question No. 20). In addition, in several of those cases, that missed question was not highlighted in technicians' certification notifications as one of the questions that should be reviewed with the technician by the RSO after the exam, as required by Procedure SF-9.

The team determined that the other PSI offices also did not document supervised field experience very well. The RSO's at the other offices were aware of the 24-32 hour experience requirement, and acknowledged that the time recorded more accurately reflected the total time a trainee spent with a certified gauge operator in the field (i.e., travel time to/from jobsites, other non-gauge related work activities, etc.), and not actual time spent observing and using gauges.

During interviews with office management and staff, the inspectors determined that personnel at the other offices were well aware of the requirement in the Procedure SF-9 that, regardless of previous training/certification, newly hired technicians were to complete PSI training prior to operating gauges unsupervised for more than two weeks after they began employment with PSI. Review of training records and interviews at other offices confirmed that office management adhered to this requirement.

The team noted no additional instances where non-RSO/Instructor certified trainers were relied upon for all of the training and/or verifying gauge operator training.

10.2 Specific Findings

Other specific findings identified during these inspections included:

a. ANN ARBOR, MI OFFICE (License No. 21-26141-01)

Through a review of records and discussion with licensee representatives, the team identified an instance where a technician took the exam on June 11, 1996, and used a moisture/density gauge alone on June 11 and 12, 1996, but was not certified as a gauge operator through the licensee's in-house training program until June 17, 1996. The technician did not have a previous manufacturer's certification. This same technician also indicated that he did not review "The Story of Radiation" videotape (and/or the study guide) as a part of his training, although this is considered to be significant part of the training.

Although this same technician was certified on June 17, 1996, and had used a gauge on numerous occasions since that time, he had not received a field audit at the time of the inspection, which by procedure was due three months after certification.

b. LANSING, MI OFFICE (License No. 21-26141-01)

The team identified an instance where a technician took the exam on September 20, 1995, used a moisture/density gauge alone on September 25 and 26, 1995, but was not certified as a gauge operator through the PSI in-house training until October 4, 1995. The technician did not have a previous manufacturer's certification.

The team also, identified an instance where a certified technician used a gauge on numerous occasions since becoming certified on February 16, 1996, but did not received a field audit until June 20, 1996, a period more than three months after certification.

c. DETROIT, MI OFFICE (License No. 21-26141-01)

10 CFR 20.1802 requires that the licensee control and maintain constant surveillance of licensed material that is in an unrestricted area and that is not in storage. As defined in 10 CFR 20.1003, "unrestricted area" means an area, access to which is neither limited nor controlled by the licensee. On November 19, 1996, the team observed a moisture/density gauge in the back of a licensee pickup truck parked at a construction site at Henry Ford Community College. The CPN MC-1 portable moisture/density gauge was inside a standard closed CPN transport case and the transport case was secured with a chain and padlock to the inside right rear of the truck bed. However, the gauge was not locked inside the transport case and the inspectors determined that the gauge could have easily been removed from the transport case. During an interview, the technician stated that he always locked the gauge the way the team observed it. The team reviewed field audits of this technician and noted that field audits had not identified this problem with the security of the gauge.

The team also noted that a certified technician used a gauge on numerous occasions since becoming certified on July 16, 1996, but, at the time of inspection, had not received a field audit since certification, which by procedure was due three months after certification.

d. ST. LOUIS, MO OFFICE (License No. 24-26154-01)

The team identified no specific negative findings at this office.

e. ROANOKE, VA OFFICE (License No. 45-25086-01)

The team identified no specific negative findings at this office.

10.3 Conclusion

The team concluded that implementation of the training program at other PSI offices was not in accordance with licensee policy and procedures. Specifically, no formal classroom training was provided; informal training was not well documented; study guides to be completed with the

training videotape were not always provided and/or used; in some cases, copies of the exam were inadvertently given to trainees with the copy of Procedure SF-9; and, hands-on training and supervised field experience were not well documented.

The team found that managers at the other licensee offices were fully aware of the requirement that all gauge users must complete the licensee's training program regardless of their previous qualifications.

The team identified one instance where a gauge was not under constant surveillance and was not secured from unauthorized removal.

The team also identified two instances in which technicians were allowed to operate gauges unsupervised prior to certification, and three instances in which newly certified gauge operators were not field audited within three months of certification as required.

The team also concluded that the PSI Moisture/Density Gauge RSO/Instructor training program was adequate, as was the implementation of the program at the other offices inspected. Those individuals who received the training were knowledgeable and had a good understanding of the needs of gauge operator trainees. No additional instances where non-RSO/Instructor certified trainers were relied upon for conducting and/or verifying gauge operator training were identified.

11.0 Licensee's Response to Confirmation of Action Letter

Region II issued a Confirmatory Action Letter to PSI dated November 8, 1996, that indicated that PSI was taking the following actions:

1. Restrict the exposed individual from further occupational radiation exposure until the investigation of the exposure event is completed and the findings have been reviewed with the NRC.

2. Provide medical assistance to the exposed individual and continue to do so to evaluate any medical consequences from the exposure.

3. Quarantine the gauge used by the exposed individual and place it in secure storage. No maintenance, repairs, modifications, or other changes will be made to the gauge without first discussing the proposed actions with the NRC and obtaining the NRC's agreement.

4. Evaluate the dose to the individual to determine the actual dose to the extremities and whole body.

5. Inspect other gauges possessed under this license to determine whether there are operability problems, and inform the NRC of any problems identified prior to making any changes or repairs.

6. Inform all individuals who use licensed materials of the problems with the use of the gauge that resulted in the exposure of the individual and remind them that the source is not to be touched. This will be completed for each individual prior to their next use of a gauge.

7. Evaluate the extremity exposure(s) of other individuals who used the gauge.

As of December 4, 1996, the licensee had completed all of the actions contained in the CAL for Items No. 1, 3, 5, 6, and 7. As of January 8, 1997, Item Nos. 2 and 4 remained open as the licensee's investigation of the event continued.

Regarding the medical follow-up of Technician A, the Corporate RSO contacted ORISE and arranged for cytogenetic testing of Technician A's blood. In addition, the licensee made arrangements to have Technician A examined and evaluated by a physician at the University of Cincinnati Medical Center on December 10, 1996.

12.0 Exit Meeting

At the conclusion of the inspection at the Bristol facility on November 15, 1996, an exit meeting was requested with the licensee to summarize the inspection scope and findings. This meeting was to have been open for public observation. The licensee declined to attend this meeting. The team held a public meeting/news conference on November 15, 1996, during which the NRC representatives briefed attendees on the event, discussed team findings, and answered questions from attendees.

On December 4, 1996, the inspection scope and findings were summarized at an exit meeting with those personnel indicated in Appendix B. The exit meeting was held in the Region II offices and was open for public observation. The NRC discussed the areas inspected and the inspection findings. The licensee agreed to provide the NRC with a letter within seven days of the exit meeting which provided corrective actions the licensee had taken or would take to address the apparent overexposure event and the findings of the AIT. The licensee sent a letter to NRC Region II on December 11, 1996, describing the actions which had been taken or would be taken to address the findings of the AIT.

No dissenting comments were received from the licensee.

Although proprietary material was reviewed during the inspection, none is contained in this report.