SWVA, INC. *a subsidiary of*
STEEL OF WEST VIRGINIA, INC.

February 3, 2003

Douglas M. Collins, Director
Division of Nuclear Materials Safety
61 Forsythe Street, SW Suite 23T85
Atlanta, GA 30303

Subject: CONFIRMATORY ACTION LETTER (CAL No. 02-02-005)

Dear Mr. Collins:

Enclosed please find our report to you to answer the questions you posed to us in your December 23, 2002 letter. It was prepared by Don Jordan, Ph.D. and Jerry Wiza from RAM Services.

If you have any questions, please let us know.

Sincerely,

Bruce Groff

Bruce Groff, SPHR
Vice President, Administration

cc: John M. Pelchat
Timothy R. Duke

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RAM Services, Inc.

ESTIMATION OF EMPLOYEE EXPOSURES DURING THE REMOVAL OF A DAMAGED GAUGE AT SWVA ON 16 DECEMBER 2002

Report Date 03 February 2003

Table of Contents

Definitions

The following terms are used in this report as defined below.

Gauge	The portion of a radioactive gauging system containing the radioactive source, shielding, and source housing and exclusive of the other elements of the system, e.g., detector, electronics, frame, etc.
Source	The sealed source capsule containing the radioactive material and itself contained within the gauge.
SWVA	Steel of West Virginia

Damaged Gauge Radiation Profile

The damaged gauge was received at ADCO on the morning of 23 January 2003. Shortly thereafter, the gauge was removed from its transport container and placed on the floor of ADCO's warehouse

Radiation measurements were obtained with a Victoreen Model 450P ion chamber, whose 300 cc. chamber is pressurized to 6 atmospheres. The conductive plastic chamber walls have a thickness of 200 mg/cm^2. Since the maximum range of the instrument is 5 R/hr, the surface measurement of 5.5 R/hr must be regarded with suspicion. Proper operation of the instrument was verified with a check source both before and after the measurements were obtained. Background radiation levels were in the range of a few microroentgens per hour.

Measurements were made at the surface of the damaged housing and at distances of 12" and 36" *from the housing exterior surface.* The gauge housing is 6 ¾ inches in diameter. Distances were measured from the gauge housing surface to the ion chamber mid-point indicator marking on the instrument case. The ion chamber was oriented so that the measurements were made through the side of the instrument.

Table 1. Survey Instrumentation.				
Survey Date 23 January 2003		Surveyed by: Jerry Wiza, RRPT		
Survey Description Damaged Kay Ray level gauge, Model 7060SD, S/N 29662, nominally containing 500 mCi of Cs-137 as of 30 January 1991 and formerly installed at Steel of West Virginia. Measurements made at ADCO Services, Inc. in Tinley Park, Illinois				
Instrumentation				
Manufacturer	Model	Type	S/N	Calibration Date
Victoreen	450P	Pressurized Ion chamber	1412	29 May 2002
Check Source S/N	Isotope	Activity	Reference Reading	Current Readings
(Dedicated check source located at ADCO, no other ID available)	Cs-137	□ 8 □Ci	440 □R/hr	420 □R/hr (before) 410 □R/Hr (after)

In the table of survey measurements below, 0□ refers to the top of the gauge as it was installed at SWVA and angles are measured in the counter clockwise direction from this reference. These measurements were made in a plane bisecting the gauge housing and perpendicular to the beam axis. The "Back Surface" referred to below is the surface of the gauge housing opposite the beam port and the "Front Surface" is the plane containing the shutter mechanism.

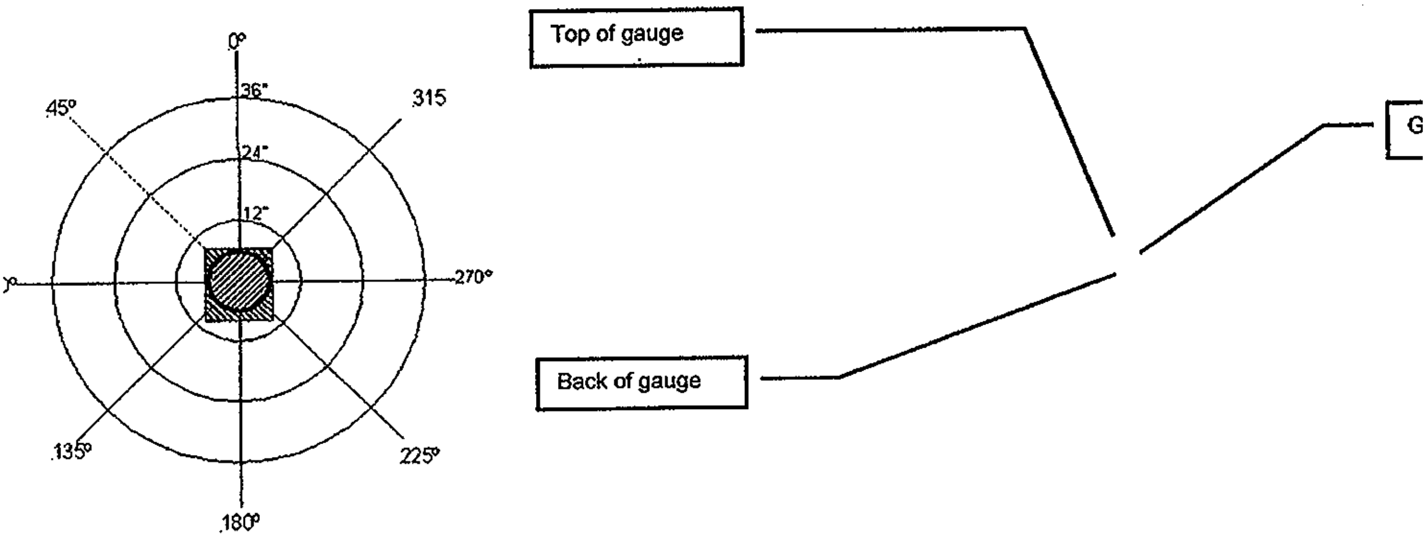

Figure 1. Radiation Survey Coordinate System Depicting Gauge as Installed at SWVA

Table 2. Raw Survey Measurements										
	Exposure Rates in milliRoentgen/hr									
Distance	Angle in Plane Normal to Beam Axis								Surface	
inches	0□	45□	90□	135□	180□	225□	270□	315□	Back	Front
Surface	2,500	3,500	5,500	3,800	860	1,450	2,500	1,670	153	17

12"	270	660	990	720	148	73	660	129	45	10
36"	27	118	118	110	18	14	101	22	12.4	5

We offer the raw data presented in Table 2 above to afford a baseline for review or additional analysis. However, to obtain useful exposure rates, this data must be corrected for the source-to-housing distance and the energy response and angular dependence of the detector, which are presented graphically in Appendix B. The instrument correction factors, obtained from these graphs are presented below in Table 3. The individual factors have been combined into a global instrument correction factor. We omitted the correction for decay during the interval between the incident and the survey as inconsequential (0.2%).

Table 3. Instrument Correction Factors		
Correction	**Efficiency**	**Correction Factor**
Instrument response through the side at approximately 650 keV	97%	1.031
Instrument response at an angle of 90□ to the radiation field.	93%	1.075
	Global Correction Factor	1.108

The measured exposure rates given in Table 2 are adjusted for the source to housing distance, and are then normalized to standard distances of 3, 12 and 36 inches using the standard rule

$$D_2 = D_1 \times \left[\frac{R_1}{R_2} \right]^2$$

where D_1 and R_1 are the distance and exposure rates at the first position and D_2 and R_2 are those at the second position. The global correction factor is then applied to compensate for detector efficiency. The corrected and normalized exposure rates are presented below in Table 4.

Table 4. Corrected and Normalized Exposure Rates.										
	Exposure Rates in milliRoentgen/hr									
Distance	**Angle in Plane Normal to Beam Axis**								**Surface**	
inches	**0□**	**45□**	**90□**	**135□**	**180□**	**225□**	**270□**	**315□**	**Back**	**Front**
3	3,507	4,910	7,715	5,330	1,206	2,034	3,507	2,343	215	24
12	491	1,201	1,801	1,310	269	133	1,201	235	82	18
36	36	156	156	146	24	19	134	29	16	7

Discussion of Survey Findings

The measurements obtained at the housing surface and at 12 inches describe a radiation field that is asymmetric and distorted from what one would expect from the customary inverse square law. In particular, we note that the pattern of measurements at 180, 225 and 270 degrees at 12 inches from the housing does not follow the pattern at those angles at the housing surface. Moreover, the measured exposure rates at 12 inches are generally at great variance with those expected from the application of the inverse square law to the surface exposure rates, after correcting for the housing radius.

These anomalies may be due to one or both of the plausible consequences of the melting and loss of lead shielding and the sledge-hammering to remove the gauge, namely displacement of the source within the housing and the creation of voids within the remaining lead shielding. Thus the source may now be much closer to the housing in a particular location and the housing radius distance correction is in gross error there and there may be little or no shielding at some positions.

However, the measurements at 36 inches follow a more regular pattern and more closely follow the inverse square law when compared to those at 12 inches. In particular, the corrected exposure rates at 36 inches and 270 degrees, which will be used extensively in the dose reconstruction, are nearly exactly 9 times those at 12 inches; whether this is physics or fortuitous cannot be determined.

Sealed Source Integrity

The melted lead shielding prevented removal of the source capsule by the usual methods so its integrity could not be directly evaluated at ADCO without incurring significant radiation exposure and the risk of contaminating the facility. However, no contamination was found in a survey at SWVA and three leak tests were all negative[1].

Copies of the leak test certificates are included as Appendix A. Note that the samples collected on 08 January 2003 indicate the general location on the damaged gauge where the sample was taken.

Dose Estimation

The Radiation Safety Officer of SWVA, Mr. Steve Powell, provided a narrative of the damaged gauge removal describing the time people spent in proximity to the gauge. A copy of this letter is included with this report as Attachment 1. Mr. Powell provided additional information regarding the incident management effort to Mr. Don Jordan of RAM Services in a telephone call on 27 January 2003. The synopsis of events below is based on his NRC letter and on notes taken by Mr. Jordan during the telephone call.

[1] Since these leak test samples were analyzed at RAM Services we can state further that there was no detectable activity at all on the samples.

Summary of the Incident

At approximately 12:45 p.m. on 16 December 2002 a tundish accidentally spilled molten steel onto a Kay Ray Model 7060SD gauge[2], S/N 29662 containing 500 mCi of Cs-137 as of 31 January 1991 and which was installed on the side of a mold. The area was immediately evacuated and remedial efforts were undertaken by four SWVA employees, who will be identified as Employees A, B, C, and D in this report in order to maintain the confidentiality of their potential radiation exposures. They are identified in Attachment 2 to this report.

Of these four, Employee B was present on the scene at a distance where the radiation levels were at background levels, as measured by Employee A with a Bicron micromax survey meter, and did not participate directly in the effort to remove the damaged gauge.

Employee A measured dose rates of 5000 microrem per hour at six feet from the damaged gauge prompting the evacuation of the area and the conservative removal procedures. Note that this is the maximum limit of the instrument.

Employees A, C, and D removed the gauge intact from the mold using a cutting torch with a 6 foot extension and a sledgehammer. Each person spent 3 minutes in proximity to the gauge either cutting and/or hammering and then retired to a safe distance to be replaced by the next person. Each "cycle" in the removal effort consisted of 3 turns of cutting or hammering by each person for a total of 9 minutes in proximity to the gauge during the cycle. The cycle was repeated 4 times for a total exposure time of 36 minutes near the gauge. The workers retired to a safe distance for 10 – 15 minutes between turns and took longer breaks at a greater distance between cycles. Of the 36 minutes spent near the gauge by each employee, approximately 24 minutes were spent cutting and the remaining 12 minutes hammering. Each employee seems to have taken an equal part in the effort.

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[2] This gauge was identified incorrectly as S/N 93K047 in the original incident report and on subsequent leak tests. Mr. Wiza of RAM Services verified the correct S/N, 29662, by examining the identification plate on the damaged gauge.

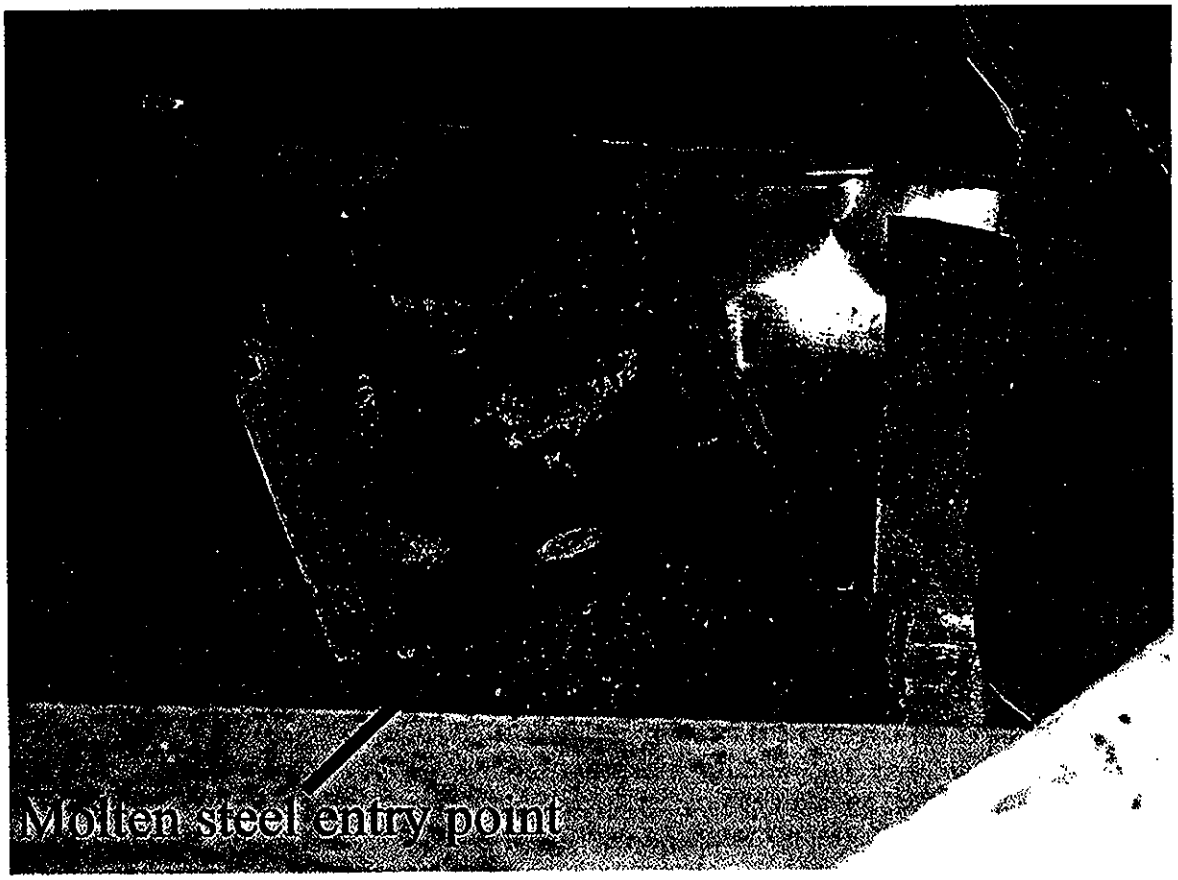

Figure 2. Damaged Gauge in Steel Box at SWVA

Before the removal operation began, a hoisting strap was placed around the gauge using a remotely operated crane, which also took up the slack once the strap was in place. Consequently, nobody seems to have approached very close to the gauge (i.e., closer than 3 feet) or to have handled it directly. When the gauge was freed, the crane was used to place the gauge into a box made of 2-inch thick steel and approximately 3 X 3 feet X 2 ½ feet high. During this operation, all employees left to a safe distance and the crane was operated remotely from a distance of 60 feet, where Employee A measured the dose rate as essentially background. The gauge was placed in the steel box shutter end down and additional lead sheets were placed over the area with the highest radiation level.

The steel box was then transported by forklift from the incident location to a remote site, which was secured with appropriate warnings. Employee D operated the forklift and Employee A measured the dose rate in the cab at the operator's seat during this operation at 300 microrem per hour. A re-enactment of the transport operation was timed at 3 minutes and 15 seconds.

Two sheets of lead had been placed on the bottom of the box and others around the sides before the gauge was deposited. After the gauge was placed in the box, Employee A dropped additional sheets of lead by hand over the gauge. Employee A then surveyed the outside of the box to identify any hot spots and, finding some, Employee A rearranged the lead sheets by hand to cover those spots. A total of 10 sheets of lead measuring 24 inches by 24 inches by 1/8 inch were used. Employee A estimated that it took less than 2 minutes to add the lead, survey the box, and rearrange the shielding and that whilst arranging the lead his hand would have been 12 to 18 inches from the gauge.

A total of about 3 hours elapsed from the start of remedial operations until the gauge was finally secured in its shielding box at the remote site.

While cutting the attachments of the gauge, people worked to the "right" of the gauge as it was installed and in a crouched position, as the gauge was mounted about 24 inches from the deck level on which they stood. This appears to correspond to 270□ in the radiation survey coordinates. While hammering, they worked from behind and above the gauge, facing the "back" of the gauge.

At a visit to the site by Mr. Wiza of RAM Services on January 9 – 10, the removal effort was partly re-enacted with the implements originally employed. Distances between the gauge and each employee were measured. The shortest distance for the cutting operation, 4 feet 1 inch, was measured between Employee C's hand and the gauge location. In this position, Employee C's body was 4 feet 10 inches from the gauge. These minimum distances will be used in the dose estimation for all three employees.

Employees worked closer to the damaged gauge while hammering, but this distance was not measured during the re-enactment and so must be estimated. Mr. Powell stated that the sledgehammer had about a 3-foot handle and so we will use this distance to estimate the whole body exposure during this phase of the operation, although it is probable that this distance would have been significantly greater since the hammer would have been held at arm's length.

The radiation coming directly through the "back" of the gauge is at comparatively moderate levels. However, given the likely position of a worker relative to the mounted gauge while hammering, it would appear that this exposure rate might be suitable for the lower legs while the exposure rate coming from the top (0□) of the gauge is more appropriate for calculating hand and body exposure during this operation.[3]

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[3] On 30 January we attempted to measure the radiation levels that are more realistic for this operation, namely from behind and above the gauge as it was installed. However, lead shot already had been placed inside the damaged gauge housing, thereby preventing this measurement without excessive exposure to remove this shielding.

Dose Estimation Basis

Based on the narrative provided, we employ the following assumptions in our calculations:

1. The 3 workers directly involved in the incident remediation spent a total of 36 minutes in proximity to the damaged gauge.
2. Cutting operations required 24 minutes.
3. Hammering required 12 minutes.
4. While operating the cutting torch all employees' hands were 49 inches from the gauge.
5. While operating the cutting torch all employees' torsos were 58 inches from the gauge.
6. While cutting, they were in the field measured at 270□ in the survey coordinates.
7. While hammering, both their hands and torsos were 36 inches from the gauge.
8. While hammering, they were exposed to the field measured at 0□.
9. When taking breaks between turns at cutting and hammering, they moved to a "safe" distance where the dose rates were either background or less than 1 milliroentgen per hour. Exposures accumulated during these periods are expected to be inconsequential when compared with the exposure during removal efforts and the uncertainty in that exposure.
10. Exposures accumulated operating the crane or forklift are inconsequential for the reasons given in Item 9 above.
11. While adjusting the shielding, Employee A's hand was exposed to the maximum field at 12 inches for 1 minute while rearranging the shielding.
12. While adjusting the shielding, Employee A's body was exposed to the maximum field at 24 inches for 2 minutes.
13. Exposure rates at distances greater than 36 inches will be scaled from the normalized measurements at 36 inches using the inverse square law.
14. Exposure rates at distances closer than 36 inches will be scaled from the normalized measurements at 3 or 12 inches as appropriate.
15. Skin and lens of the eye doses are the same as the whole body doses.

16. Employee B received no exposure above background during the incident.

In Table 5 below we present the exposure rates and exposure accumulated during the various operations involved in the removal of the damage gauge. We calculate the exposure rates at the operating distances described in the Assumptions using the inverse square law with the 36-inch exposure rates of Table 4 as a basis. Exposures are then computed from these calculated exposure rates and the time spent in the various operations. The time and distance estimates are presented in the list of assumptions above.

Table 5. Estimated Exposures During Various Operations

Operation	Position	Dose Location	Distance inches	Time minutes	Exposure Rate milliRoentgen/hr	Exposure milliRoentgen
Cutting with torch	270□	Body	58	24	51.6	20.6
Cutting with torch	270□	Hand	49	24	72.3	28.9
Hammering	0□	Body	36	12	36.0	7.2
Hammering	0□	Hand	36	12	36.0	7.2
Rearranging Shielding	12" Maximum	Body	24	2	450.3	15.0
Rearranging Shielding	12" Maximum	Hand	12	1	1,801	30.0

The exposures for each operation in which an employee participated are added together and presented below in Table 6. Since it was assumed that each contributed equally in the cutting and hammering operations, the exposures for Employees A, C, and D are all equal for these operations and the only distinction is that Employee A moved the lead shielding within the steel box.

Table 6. Estimated Employee Radiation Exposures in milliRoentgen.

Operation	Employee A		Employee C		Employee D	
	Body	Hand	Body	Hand	Body	Hand
Cutting	20.6	28.9	20.6	28.9	20.6	28.9
Hammering	7.2	7.2	7.2	7.2	7.2	7.2
Shielding	15.0	30.0				
Total exposures	42.8	66.1	27.8	36.1	27.8	36.1

Discussion of Calculated Employee Exposures

We believe that the calculated exposures in Table 6 represent plausible maximum bounds on the exposure each may have actually received. Since the Radiation Safety Officer carefully timed the operations close to the gauge, the duration of the exposures appears to be a well known quantity.

By employing long-handled tools in the cutting and hammering operations, the work was done at a distance where small changes in distance do not result in large changes in the exposure rate. A six inch change in distance from 48 inches results only in about a 30% change in the exposure rate. Therefore, errors in the gross estimates of operating distance will not affect the exposure estimates greatly.

While the radiation field varies strongly with position at short distances, apparently due to the missing and displaced shielding, it does begin to even out at the working distances. Since we have employed the maximum plausible exposure rates (e.g., they did work from the right and not the left) we believe that the measured radiation profile describes the radiation field with sufficient accuracy for these purposes.

The major uncertainty in our calculations appears to be extremity exposure received by Employee A while moving the lead sheets when the gauge was stored in the steel box. During this operation, his hand could have been much closer to the source that the assumed 12 inches, in which case the exposure rate would have been dramatically greater. We believe that we have compensated partly for this uncertainty by overestimating the time required and by ignoring the shielding effects of the lead sheets which were in place. We note, however, that even had Employee A held his hand on the gauge housing for one minute at the location of maximum exposure rate, he would have only received about 100 mR of extremity exposure, which is well within regulatory limits.

Appendix A. Leak Tests of the Damaged Gauge.

Steven Powell
Steel of West Virginia
P.O. Box 2547
Huntington, WV 25726

SEALED SOURCE LEAK TEST CERTIFICATE

Assay No.	17542	NEXT LEAK TEST DUE	DISPOSAL
Company	Steel of West Virginia	Location	
Contact Person	STEVEN POWELL	Telephone	304-696-8234

Source Description

Customer Reference		
	Source 1	**Source 2**
Manufacturer	Kay Ray	
Model Number	7060SD	
Serial Number	29662	
Isotope	Cs-137	
Original Activity	500 mCi	
Assay Date	(not specified)	
Date source wiped	8-JAN-2003	

ADDITIONAL DESCRIPTION: CORRECTION:
S/N PREVIOUSLY GIVEN INCORRECTLY AS S93K0407

LEAK TEST ANALYSIS

SAMPLE ACTIVITY	LESS THAN 0.005 □Ci	ANALYSIS DATE	9-Jan-2003
ANALYSIS MINIMUM DETECTABLE ACTIVITY			1.44E-05 □Ci
ANALYST	DON JORDAN		

Steven Powell
Steel of West Virginia
P.O. Box 2547
Huntington, WV 25726

SEALED SOURCE LEAK TEST CERTIFICATE

Assay No.	17621	Next Leak Test Due	DISPOSAL
Company	Steel of West Virginia	Location	
Contact Person	STEVEN POWELL	Telephone	304-696-8234

Source Description

Customer Reference	Source 1	Source 2
Manufacturer	Kay Ray	
Model Number	7060SD	
Serial Number	29662	
Isotope	Cs-137	
Original Activity	500 mCi	
Assay Date	Oct-93	
Date source wiped	9-JAN-2003	

Additional Description: SHUTTER END DAMAGED
CORRECTION: S/N PREVIOUSLY GIVEN INCORRECTLY AS S93K0407

Leak Test Analysis

Sample Activity	LESS THAN 0.005 □Ci	Analysis Date	13-Jan-2003
Analysis Minimum Detectable Activity			1.44E-05 □Ci
Analyst	DON JORDAN		

Steven Powell
Steel of West Virginia
P.O. Box 2547
Huntington, WV 25726

SEALED SOURCE LEAK TEST CERTIFICATE			
Assay No.	17622	Next Leak Test Due	DISPOSAL
Company	Steel of West Virginia	Location	
Contact Person	STEVEN POWELL	Telephone	304-696-8234

Source Description		
Customer Reference		
	Source 1	Source 2
Manufacturer	Kay Ray	
Model Number	7060SD	
Serial Number	29662	
Isotope	CS-137	
Original Activity	500 mCi	
Assay Date	Oct-93	
Date source wiped	9-JAN-2003	
Additional Description:	TOP INSIDE OF DAMAGED HOUSING CORRECTION: S/N PREVIOUSLY GIVEN INCORRECTLY AS S93K0407	

LEAK TEST ANALYSIS			
Sample Activity	LESS THAN 0.005 □Ci	Analysis Date	13-Jan-2003
Analysis Minimum Detectable Activity			1.44E-05 □Ci
Analyst	DON JORDAN		

Appendix B. Survey Instrumentation

Designer and Manufacturer of Scientific and Industrial Instruments

CERTIFICATE OF CALIBRATION

LUDLUM MEASUREMENTS, INC.
POST OFFICE BOX 810 PH. 915-235-5494
501 OAK STREET FAX NO. 915-235-4672
SWEETWATER, TEXAS 79556, U.S.A.

CUSTOMER ADCO SERVICES INC. ORDER NO. 280277/264016

Victoreen Model 450P Serial No. 1412

Model Serial No.

Cal Date 29-May-02 Cal Due Date 29-May-03 Cal Interval 1 Year Meterface DIGITAL

Check mark ☑ applies to applicable instr. and/or detector IAW mfg. spec. T. 73 °F RH 44 % Alt 699.6 mm Hg

☐ New Instrument Instrument Received ☐ Within Toler +-10% ☐ 10-20% ☑ Out of Tol ☐ Requiring Repair ☐ Other-See comments

☑ Mechanical ck ☐ Meter Zeroed ☐ Background Subtract ☐ Input Sens. Linearity
☐ F/S Resp. ck ☐ Reset ck. ☐ Window Operation ☐ Geotropism
☐ Audio ck ☐ Alarm Setting ck ☐ Batt. ck. (Min. Volt) ____ VDC
☐ Calibrated in accordance with LMI SOP 14.8 rev 12/05/89 ☑ Calibrated in accordance with LMI SOP 14.9 rev 02/07/97.

Instrument Volt Set ____ V Input Sens ____ mV Det. Oper. ____ V at ____ mV Threshold Dial Ratio ____ = ____ mV

☐ HV Readout (2 points) Ref./Inst. ____ / ____ V Ref./Inst. ____ / ____ V

COMMENTS:

Gamma Calibration: GM detectors positioned perpendicular to source except for M 44-9 in which the front of probe faces source.

RANGE/MULTIPLIER	REFERENCE CAL. POINT	INSTRUMENT REC'D "AS FOUND READING"	INSTRUMENT METER READING*

*Uncertainty within ± 10% C.F. within ± 20%

Range(s) Calibrated Electronically

	REFERENCE CAL. POINT	INSTRUMENT RECEIVED	INSTRUMENT METER READING*		REFERENCE CAL. POINT	INSTRUMENT RECEIVED	INSTRUMENT METER READING*
Digital Readout	2 R/hr	1.98 R/h	1.98 R/h	Log Scale			
	200 mR/hr	189 mR/h	189 mR/h				
	20 mR/hr	19.5 "	19.5 "				
	2 mR/hr	1.86 "	1.86 "				
	200 µR/hr	190 µR/h	186 µR/h				

Ludlum Measurements, Inc. certifies that the above instrument has been calibrated by standards traceable to the National Institute of Standards and Technology, or to the calibration facilities of other International Standards Organization members, or have been derived from accepted values of natural physical constants or have been derived by the ratio type of calibration techniques. The calibration system conforms to the requirements of ANSI/NCSL Z540-1-1994 and ANSI N323-1978. State of Texas Calibration License No. LO-1963

Reference Instruments and/or Sources:
Cs-137 Gamma S/N ☐ 1162 ☑ G112 ☑ M565 ☑ 5105 ☐ T1008 ☐ 1879 ☐ E552 ☑ E551 ☐ Neutron Am-241 Be S/N T-304

☐ Alpha S/N ☐ Beta S/N ☐ Other

m 500 S/N ☐ Oscilloscope S/N ☐ Multimeter S/N

Calibrated By: Duane Jackson Date 29-May-02

Reviewed By: Rhonda Harm Date 4 Jun 02

This certificate shall not be reproduced except in full, without the written approval of Ludlum Measurements, Inc.
FORM C22A 10/31/2001

AC Inst. Only ☐ Passed Dielectric (Hi-Pot) and Continuity Test ☐ Failed

Figure 3. Survey Instrument Calibration Certificate

Detector	300 cc volume air ionization chamber, pressurized to 6 atmospheres Conductive plastic chamber wall: 200 mg/cm^2 thick
Warm-Up Time	Less than one minute for initial operation when the instrument is in temperature equilibrium with the surrounding area and about 4 minutes for readings less than 20 μR/h in a 10 μR/h or less background
Drift	After seven minutes operation, 0.04 mR/h equivalent, or less.
Response Time	Time measured from 10% to 90% of final value for a step increase/decrease in radiation rate such that a range change does not occur: **0 to 500 μR/h (0 to 5 μSv/h) range** 5 seconds. **0 to 5 mR/hr (0 to 50 μSv/h) range** 2 seconds. **0 to 50 mR/h (0 to 500 μSv/h) range:** 1.8 seconds. **0 to 500 mR/h (0 to 5 mSv/h) range** 1.8 seconds. **0 to 5 R/h (0 to 50 mSv/h) range** 1.8 seconds. **NOTE:** In a pulsating field, the instantaneous rate should not exceed 5 R/h for proper integration. Instantaneous exposure rate is still limited to 5 R/h.
Precision	Within 5% of reading.
Readout	**Liquid Crystal Display.** Contains an analog bar graph with a permanent scale on the display and a 2 1/2 digit display. **Analog Display.** The bargraph consists of 100 segments, 2 1/2 inches long, the scale has five major divisions; the appropriate value for the operating range of the instrument will appear below the scale **Digital Display.** The digital display is 2 1/2 digits followed by a significant zero digit depending on the operating range of the instrument. The leading 1/2 digit is blank, or a "1", or a "0" for clarity. Units of measure appear to the right of the digital display. Appropriate multipliers also appear on the display **Units** As indicated under Range, programmable in R/h or Sv/h. Appropriate multipliers also appear on the display **Auto-On Backlight.** Turns on when ambient light is less then twilight conditions.
External Controls	ON/OFF button, MODE button.
Automatic Features	Ranging and zeroing are fully automatic.
Environmental Effects	**Operating Temperature Range.** -4 ° to +122 °F (-20 ° to +50 °C) **Relative Humidity Range.** 0 to 100%, non-condensing **Geotropism** Less than 1%
Dimensions (L x W x H)	8.5 in. x 4.5 in. x 7 in. (21 cm x 11.4 cm x 18 cm)
Weight	Approximately 2 lbs., 0 oz. (0.91 kg)
Batteries	Two 9V transistor batteries provide over 200 hours continuous operation. Five Lithium batteries provide chamber bias voltage of 105V (10 yr. life expectancy).

Figure 4. Selected Victoreen Specifications. [Victoreen at 1-3]

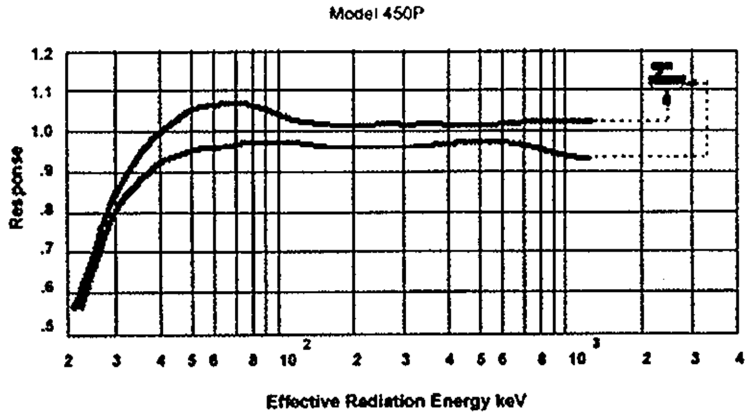

Figure 5. Victoreen Ion Chamber Energy Response. [Victoreen, at 1-5]

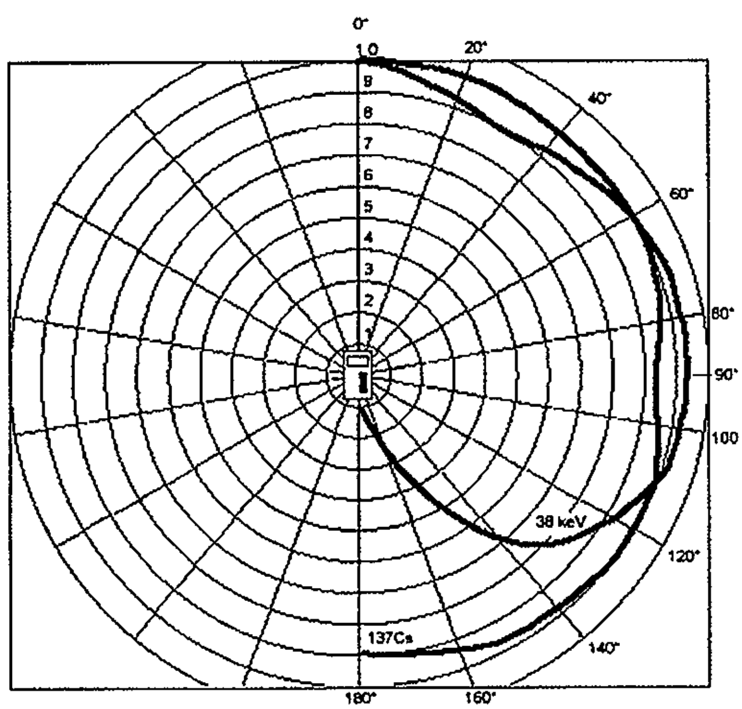

Figure 6. Victoreen Angular Response. [Victoreen, at 1-6]

Appendix C. References

Victoreen **Victoreen Operation and Instruction Manual, Ion Chamber Survey Meter, Model 450P & 450P-DE-SI,** Part No 450P-1, Revision 3, Victoreen Inc., May 2000

Attachment 1. RSO Narrative of the Incident

Nuclear Regulatory Commission
Washington D.C.

Steel of West Virginia
U. S. Nuclear Regulatory Commission
License #47-16310-02

Nuclear Regulatory Occurrence Number 39455

On December 16, 2002, Steel of West Virginia had an accidental movement of a tundish, which caused a molten stream to penetrate the outer jacket of a radioactive source (500 millicurie cesium 137). The molten metal stream, after penetrating the outer metal jacket, eroded some of the lead shielding around the encapsulated source causing a leakage of radioactive activity. This activity occurred between 12:45 and 1:00 pm.

As soon as the known possibility of a radiation leakage occurred, Steel of West Virginia evacuated the work area of all personnel. Immediately the area was surveyed with a Bicron micromax radiation detector. Radiation leakage was detected and lead shielding was applied to reduce the amount of exposure. The exposure rate was 5,000 microrims at six feet from the source on three sides. This was the maximum reading on the Bicron micromax unit. At this time we treated this as a worse case scenario.

Three Steel of West Virginia personnel ([redacted]) started removing the source from its mounting bracket. This team revolved around a schedule of: 3 minutes in the effected area-10 to 15 out- four times in a cycle. This cycle was repeated 3 times after a 20minute break between each cycle.

From a remote operated crane, the source was then placed shutter down in a lead lined steel box. The box had 2" thick steel plates on all sides. There were about 10 lead sheets (3ftx3ftx1/8) encapsulated around the source.

Readings were taken three feet from the edge of the box. One side was less than 20 microrims, the other three sides were about100 microrims.

The box with the source was placed in a remote area and roped off with caution tape. After additional steel plating was added, the area outside the caution tape, when checked, registered less than 35 microrims.

At this time we did a survey of the effected area and found no remedial radiation on either the casting deck or upper spray chamber area. No reading above normal background was cited in any of the effectual areas.

Steve Powell
Steel of West Virginia