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WILLIAM D. HARRINGTON
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NUCLEAR

February 15, 1984

BECo Ltr. # 84-028

Mr. Richard W. Starostecki, Director
Division of Project and Resident Programs
U. S. Nuclear Regulatory Commission
Region 1 - 631 Park Avenue
King of Prussia, Pennsylvania 19406

Docket No. 50-293
CAL No. 84-03

Response to Confirmatory Action Letter 84-03

Dear Sir:

This refers to the completed and planned actions taken by this company in regards to the incident of January 18, 1984, in which a Health Physics Technician was thought to have exceeded the regulatory limits for quarterly extremity radiation dose. The information herein submitted satisfies the commitments as mutually agreed upon and defined in Confirmatory Action Letter 84-03.

This submittal contains three elements which are:

(1) An item-by-item response to each activity discussed in Confirmatory Action Letter #84-03.

(2) A summary statement regarding the subject issues.

(3) A seven part Exposure Evaluation conducted and prepared by our Health Physics Organization.

CAL #84-03 Item No. 1

Prevent access of the individual who may have exceeded the regulatory limits for quarterly extremity radiation dose to radiation areas at Pilgrim until assignment of his personal exposure. Limit subsequent exposure accordingly.

Response

The individual was restricted from radiation areas commencing the afternoon of January 18, 1984. He was inadvertently allowed entry to radiation areas on the morning of January 20, 1984, due to the misassumption that the exposure evaluation was completed. The misassumption occurred because the extremity dose estimate figure at that time was one to two rem and, as this was not significant extremity exposure, radiation protection supervision determined that the individual could return to work. When this was discovered

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on January 20, 1984, the individual was again restricted from radiation areas until the formal exposure evaluation was completed on February 7, 1984. Based on the results of the exposure evaluation and exposure assignment, subsequent restriction from radiation areas was determined not to be necessary.

CAL Item No. 2

Establish and maintain positive health physics coverage for the work performed in the Control Rod Drive (CRD) Repair Room pending completion of the evaluation described in Item 4.

Response

On Thursday, January 19, 1984, the Chief Radiological Engineer ordered the immediate implementation of constant health physics coverage for all entries into the CRD Repair Room. (This did not apply to entries to the "A" RHR Valve Room or the Steam Tunnel which requires an individual traverse, a small section of the CRD Repair Room.) The Sr. Radiological Engineer then instructed the personnel directly responsible for providing health physics coverage on the CRD replacement job of the constant H. P. coverage requirement. In addition, an entry was made in the CRD Repair Room H. P. Log Book concerning the requirement. Subsequently, all applicable Radiation Work Permits were revised to reflect the requirement.

CAL Item No. 3

Evaluate, by January 31, 1984, the actions of all workers who may have entered the CRD Repair Room on the 23 ft. elevation of the Reactor Building between January 14 and 18, 1984. Assign resulting personnel exposure by February 15, 1984, and implement personnel exposure restrictions, as necessary, to comply with 10 CFR 20. 101.

Response

In order to evaluate the actions of all workers who may have entered the CRD Repair Room between January 14 and January 18, 1984, (inclusive), all RWP Sign-in Sheets associated with the CRD Repair Room were reviewed and all personnel that may have had access to the subject room were identified.

Sixty eight persons were identified who may have had access. All but two of these persons were interviewed, and their actions associated with the CRD Repair Room were determined and documented by two senior members of the Radiological Group's management staff. The two other persons were not interviewed because they had been laid off. Their actions were reviewed with fellow workers that accompanied them during the time identified on the RWP Sign-in Sheet. From this information it was determined that one of the individuals had not actually been in the CRD Repair Room between January 14 and January 18, 1984. The other individual was entering the "A" RHR Valve Room and at no time entered the area of the CRD Repair Room that is in question.

The individual known to have handled the chip was interviewed immediately after Radiological Group management personnel were notified of the incident. He was also interviewed by Radiological Group management personnel several times throughout the course of the investigation. Four people who were determined to be those most likely to have handled the chips or knowledgeable about anybody possibly handling the chips were initially interviewed by January 20, 1984. Three of these individuals were interviewed by a Senior Health Physics Technician assigned to the CRD replacement project. He reported the results of this interview to the Sr. ALARA Engineer. The fourth individual was interviewed by the Sr. ALARA Engineer. Of the sixty-six people, in total who were interviewed, the majority of the interviews occurred on January 25 and 26, 1984. It should be noted that at no time during the entire interview process was there any indication that an individual handled the chips other than the individual known to have handled the chips on January 18, 1984.

Of the sixty-six people interviewed, only five people indicated coming in physical contact with the bucket with the chips in it. (This does not include the individuals who "created" the bucket during a control drive disassembly on January 14, 1984. All of these individuals used long-handled tools and wore extremity dosimetry). Both the extremity and whole body exposures were evaluated for these individuals. The results of the evaluations indicated that one of the five individuals potentially received a maximum of 30 mrem to the hands. The whole body exposure (as indicated by each individual pocket dosimeter and TLD) was determined to be representative of the actual exposure received after evaluation of the geometry between the bucket, the various parts of the whole body and the location of the dosimetry on the body, while the bucket was being handled each time. As a result of this evaluation, it has been determined that exposure already assigned by the routine TLD and pocket dosimeter monitoring program was accurate.

The evaluation of the actions of all workers was completed by January 27, 1984.

<u>CAL Item No. 4</u>

Evaluate the health physics controls used for the work in the CRD Repair Room between January 14 and 18, 1984. Include in this evaluation, as a minimum: (a) the adequacy of the information provided to workers relative to the hazards associated with the radioactive material in the CRD Repair Room; and (b) the adequacy of the radiation surveys performed, the radiation work permit used, source controls, and the personnel dosimetry supplied to the workers involved.

<u>Response to Item No. 4</u>

An evaluation of the health physics controls used for the work in the CRD Repair Room between January 14 and 18, 1984, was performed. There were three primary components to this evaluation. The first component was an in-

intensive review by the Radiological Group management staff of the controls that were in place. The second component was interviews with the Health Physics personnel directly responsible to implement the health physics coverage for work in the CRD Repair Room during this period. The third component was interviews with the personnel working in the CRD Repair Room during this period. (The interviews referred to are the same interviews referred to in Response No. 3 above. The questionnaire used for the interviews was structured to elicit information concerning the health physics coverage as well as information concerning the chips and the bucket.) Based on the results of the evaluation, it was determined that the health physics coverage was adequate and that one improvement was desirable. This improvement was the requirement for constant health physics coverage for all work in the CRD Repair Room. This improvement was identified very early in the evaluation and was immediately implemented as described in the Response to Item No. 2 above.

Referring specifically to each of the items listed in CAL Item No. 4, the following is submitted:

a) "adequacy of the information provided to workers relative to the hazards associated with the radioactive material in the CRD Repair Room"

Based on the interviews with workers, those who worked in the vicinity of the bucket were either aware of the high dose rates from the bucket specifically, or of the dose rates in the room and that they were not to be in that area unless they had to. (Some workers indicated they were not aware of the bucket or the high dose rates in the vicinity of the bucket. These workers, though, were those whose assignment in the room did not require them to go in that part of the room.) When asked if the H. P. Technician signing them in on the RWP knew of the task they were to perform and the areas of the room to be entered, they replied in the affirmative. Therefore, it has been determined that the information provided to the workers was adequate except for one instance which we identified. This instance involved the entry to the CRD Repair Room on the morning of January 18, 1984. The individuals were not told about the bucket and its associated dose rates. These individuals did move the bucket and remove some CRD components from it and were not aware of the associated dose rates.

Several problems were identified that contributed to these individuals not knowing the dose rates associated with the bucket. First, a survey of the CRD Repair Room had been performed on the previous shift which indicated the location of the bucket and the dose rates. All copies of the survey (the survey forms are multi-part) erroneously were placed in the "Supervisor's Review" box in the Health Physics office. One copy should have been placed in the RWP folder. In addition, the Health Physics Technician briefing the three workers prior to their entry had not been informed during shift turnover about the bucket. He did review the RWP folder, but the survey from the previous shift was not present. The Health Physics Technician did not know about the bucket; therefore, could not inform the three workers of its presence. A lack of adequate communications, both written and verbal, was the cause of this inadequacy in the health physics coverage.

A memo has been issued by the Chief Radiological Engineer to all Health Physics personnel stressing the requirement for complete shift turnovers and proper communications between Health Physics personnel.

b) "the adequacy of radiation surveys performed"

An evaluation of all of the surveys performed in the CRD Repair Room from January 14 to January 18, 1984, was performed. All surveys reviewed indicate at least the higher does rates in the vicinity of the bucket and most surveys specifically indicated the presence of the bucket and its associated dose rates. Based on the results of this evaluation, the radiation surveys performed in the room during this period were determined to be adequate.

c) "the radiation work permit used"

An evaluation of the Radiation Work Permit (RWP) used as well as all RWP's covering work in the CRD Repair Room was performed. Based on this evaluation it was determined that the RWP's and the requirements they imposed were adequate and that one improvement should be implemented. This improvement is the requirement for constant health physics coverage as described in the Response to Item No. 2 above.

d) "source control"

An evaluation of the source controls being implemented in the CRD Repair Room was performed. Based on the results of this evaluation, it was determined that the source control was adequate and that improved source control would also be achieved by the required constant health physics coverage as described in the Response to Item No. 2 above. This evaluation did identify one instance of inadequate source control during the entry to the CRD Repair Room by three individuals on the morning of January 18, 1984. The cause for this instance is provided in the response to Section "b" above as it is directly related to the inadequate briefing to the workers. The memo referred to in Section "b" and the required constant health physics coverage will prevent the recurrence of this event.

e) "the personnel dosimety supplied to the workers involved"

An evaluation of the personnel dosimety supplied to the workers involved was performed. This evaluation also included personnel dosimetry supplied to all workers at PNPS.

This evaluation involved the review, in particular, of the use of both extremity dosimetry and the use of whole body dosimetry. Specific extremity monitoring at PNPS is normally accomplished by securing a regular TLD to the extremity to be monitored. (A self-reading dosimetry is also normally secured to the same area). In particular, when the extremity to be monitored is the hand, the TLD is secured to the wrist. If the surface dose rates are such that a portion of the hand is likely to receive a significantly higher does than the wrist, long-handled tools are employed so that the does rates to all parts of the hand are essentially the same. Similar techniques are utilized when necessary for each of the extremities. Whole body monitoring at PNPS is normally accomplished by wearing a TLD badge and

self-reading dosimeter on the front of the trunk of the body, usually the waist or chest area. However, when a specific situation involves a potential for a portion of the whole body to receive a significantly higher dose than that to the area where the badge is normally worn, either the TLD badge and self-reading dosimeter are worn at the area of expected highest dose or TLD badges and dosimeters are worn at more than one area of the whole body and the individual's dose is assigned after analysis of all of the TLD badge results.

Based on the results of this evaluation, it was determined that personnel dosimetry supplied to workers in the specific incident being discussed and to all radiation workers at PNPS is adequate and reflects the state of the art of personnel dosimetry.

Summary

The results of the investigation performed subsequent to this incident indicated that (1) there was an error in judgement in which a trained and qualified individual improperly handled highly radioactive material (2) there were several breakdowns in communication including a sole reliance on log books to transmit data which more appropriately should have also been reflected in the appropriate RWP's and (3) there is the need to reemphasize, to all Health Physics personnel, the unique radiological hazards associated with physically small, high dose rate sources due to the inaccuracies associated with "contact" dose rates as measured by conventional survey instruments.

One potential problem resulted from inadequate communications between health physics personnel; however, adequate communications would not have prevented this incident. The communications problem has since been corrected. The individual in an interview following the occurrence, was questioned as to what he would have prescribed if someone had wanted to remove an unknown source from a bucket and he properly stated the requirements which he would impose. This incident is analogous to an experienced electrician touching an energized wire because he neglected to check it properly first, or an experienced carpenter cutting off a thumb or finger while operating a saw, or an experienced mechanic losing a finger or hand because he put them into operating equipment. In these cases, the people are adequately trained and experienced personnel but still, for inexplicably intangible reasons, they neglect or forget their training and experience and make a serious judgemental error which may lead to actual bodily injury. In all examples, which have occurred many times, individuals failed to take a known precautionary step they have taken many times previously. Finding a solution to totally prevent these types of situations may not be possible.

We trust this submittal will meet with your approval and we are prepared to meet and further discuss this incident, our subsequent restorative actions or any other aspect involved to facilitate your review.

Respectfully submitted,

W D Harrington

W. D. Harrington

Attachment(s)

EXPOSURE EVALUATION OF INCIDENT OF JANUARY 18, 1984

I. Overview of Incident

II. Quantification of Sources

III. Geometry of Event

IV. Time of Exposure

V. Relevant Information from Personnel Interview

VI. Estimate of Exposure - Gamma

VII. Estimate of Exposure - Beta

I. OVERVIEW OF INCIDENT

On January 18, 1984 a Health Physics Technician identified a white plastic bucket in the CRD Repair Room with a notably high dose rate on contact with the outside of the bucket. The reported measured contact dose rate on the surface of the bucket was 10R/hr.

In an attempt to reduce exposures to personnel working in the room the HP Tech decided to identify, segregate and transfer the source(s) of these radiation levels to a lead pig.

The technician removed the suspected sources of radiation, several small metal chips, from the bucket by hand, surveyed each, and placed them in the lead pig. During this transfer dose rates well in excess of the original measurement of 10R/hr were observed when individual metal chips were held essentially in contact with the survey instrument.

Due to the fact that dose rates appeared to increase greatly as the distance from the source to survey instrument decreased it appeared that true contact dose rates to the individual's fingers might be greatly in excess of the survey instrument reading. Therefore an investigation was instituted to determine the true contact dose rates, exposure times and resulting extremity exposure.

The results of this investigation indicate with certainty the individual in question received no more than 4.56 Rem gamma dose and negligible beta exposure resulting from contact with the sources identified as having been handled. Indeed, all the sources present in the lead pig if handled simultaneously, could not have resulted in a gamma exposure greater than 10.41 Rem.

The appropriate extremity exposure to assign for this incident is 4.56 Rem gamma with negligible beta contribution due to the thickness of the gloves worn during the incident.

II. QUANTIFICATION OF SOURCES

In an effort to accurately determine the contact dose rates several tests were performed. First the radioactive chips were retrieved from the lead pig and individually placed in true contact with a TLD chip. The time of exposure was carefully measured and the location of the mutual chip relative to the TLD chip was carefully maintained. The source chip and receptor chip were truly in contact except that two intervening layers of plastic and one layer of cotton were used to simulate the technician's gloves.

Each source chip was exposed to three different TLD chips for known time periods (except for chip #7 which was exposed only twice). Exposure times were all greater than 5 minutes thereby minimizing errors in time measurement. Each TLD was read out in a conventional manner.

The raw results of these measurements are contained on attachment A and the corrected (background subtracted) and averaged results are contained on attachment B.

In addition, to assess any beta dose contribution and to verify the energy of the gamma radiation a Ge-Li analysis of a fraction of one of the source chips was also performed. The results are presented on attachment C. These results confirm the assumption that Co-60 comprises essentially all of the

activity contributing to the exposure. The results also serve to identify the maximum beta energy present as 0.314 Mev. which has a smaller range than required to penetrate the 95 mg/cm^2 thickness of the gloves and dead skin layer (see attachment D).

Although the HP Technician remembered handling only 3 to 5 separate chips during three different transfer movements, 8 chips were found in the shielded container. To ensure a thorough evaluation, dose rate measurements were made on all 8 chips (the two smallest chips were taken together as one).

III. GEOMETRY OF EXPOSURE

This exposure event was unusual in that the sources of radiation were of unusually small dimensions as shown in attachment E. These dimensions are small when compared with the size of the probe or sensitive volume of conventional survey instruments.

As a result, dose rates considered to be "contact" as measured by a survey instrument, underestimated the true contact dose rate by a factor of from 20 to 55 with 55 being the case for the smallest source chip (see attachment F).

To obtain accurate contact dose rate measurements a detection device with dimensions comparable to the source and with no intervening casing or housing was placed in true contact with the source chip. This device was a personnel dosimeter chip, 1/8" X 1/8" X .035". This arrangement closely approximated the true source-receptor geometry during the exposure period. Two layers of rubber and one of cotton representing the protective clothing worn by the individual were the only material intervening between the source and receptor. Continuous pressure was applied during the measurement to ensure source-receptor contact.

IV. TIME OF EXPOSURE

Due to the unusually high dose rates an accurate estimate of the exposure time was vital in assessing dose. The individual who actually handled the radioactive chips participated in a time-motion study performed under accurately simulated and controlled conditions. The individual wore a respirator and 3 pairs of gloves during this study and recreated the physical arrangement of pertinent objects (source bucket, extender survey instrument and lead pig) as accurately as possible. The individual repeated his physical motions during the period in question ten times during this simulation. Each series of motions involved the movement of three simulated source chips from the source bucket, to the survey instrument and into the lead pig. The results of this time-motion study are presented in attachment G. The average total time of contact exposure to the source chips was 8.02 seconds.

V. RELEVANT INFORMATION FROM PERSONNEL INTERVIEW

The Health Physics technician involved in the exposure was interviewed on several occasions. He was able to identify from pictures with considerable confidence, those chips he had handled on the day of the incident. He identified the chip moved on the first motion as either chip #3 or #7 (both chips have similar shapes), on the second motion as either chip #2 or #4 (also similar in shape) and on the third motion as chip #5 (actually two small chips). He was also quite sure of the physical locations of the source bucket, survey instrument and lead pig since he had pre-planned the activity to limit exposure. He was also confident about the path and duration of his motions.

Although he had originally reported dose rates as high as 300r/hr on a chip(s) as measured by his survey instrument, he admitted that he had not allowed the meter to stabilize at any specific reading but that he had ob-

served the meter needle "heading toward 300R", at which time he threw the source chip(s) into the lead pig.

The technician stated that he had no reason to believe that the lead pig was empty when he started putting chips into it. Therefore some chips must have been present in the pig from some prior activities.

VI. ESTIMATE OF EXPOSURE - GAMMA

The final exposure estimate considers the highest credible contact dose rates, the time of contact exposure and number of chips moved. Since the technician was able to identify the chip moved on the first motion as possibly being either of two chips, the chip with the highest dose rate was considered. The same situation occurred for the second motion. The chips moved on the third motion were positively identified as the two smallest of the group.

Gamma contact dose rates on each chip moved (the last two small chips are considered as one) were multiplied by the time of contact (less than 3 seconds on each move) and added, to obtain the total contact exposure as follows:

0.505R/sec X 3 sec.	=	1.52 R
0.783R/sec X 3 sec.	=	2.35 R
0.230R/sec X 3 sec.	=	0.69 R
TOTAL	=	4.56 R

Indeed, even if the individual involved had handled all of the pieces found in the lead pig (which is unlikely if not incredible) he would have received no more than 10.41 Rem to the extremity from Gamma radiation.

VII. ESTIMATE OF EXPOSURE - BETA

The thickness of the rubber and cotton gloves together (88 mg/cm^2) along with the thickness of the dead skin layer (7 mg/cm^2) limited beta exposure to insignificant values.

ATTACHMENT A

RAW EXPOSURE DATA

	MREM	Hot Chip #	Time-On	Time-Off	TLD #	Net Time
	171880	1	10:50	10:56	218651	5'-01"
	146730	1	10:57	11:02	218503	5'-01"
	135510	1	11:03	11:08	217248	5'-01"
	240350	2	11:09	11:14	218690	5'-01"
	237040	2	11:14	11:20	102689	5'-02"
	230770	2	11:21	11:25	218866	5'-01"
	151330	3	11:26	11:31	027799	5'-13"
	157900	3	11:32	11:37	028015	5'-01"
	152760	3	11:37	11:42	099349	5'-00"
	204800	4	11:42	11:47	218581	5'-01"
	205290	4	11:47	11:52	114145	5'-01"
	200350	4	11:53	11:58	099398	5'-01"
Note (1)	76060	5	11:59	12:04	218260	5'-02"
	64573	5	12:04	12:09	217144	5'-01"
	67350	5	12:10	12:15	114428	5'-00"
	121690	6	12:15	12:20	103317	5'-01"
	122080	6	12:20	12:25	102979	5'-01"
	120950	6	12:26	12:31	026693	5'-01"
	118020	7	12:32	12:37	113670	5'-01"
	103190	7	12:38	12:43	217744	5'-01"

(1) Two slivers considered as 1 chip.

(2) Control TLD #114262 read 30 mrem.

ATTACHMENT B

CORRECTED EXPOSURE DATA

Chip #	TLD #	Net Dose (Rem)	Net Time (Sec)	Dose Rate (Rem/Sec)
1	218651	171.850	301	0.571
1	218503	146.700	301	0.487
1	217248	135.480	301	0.450
			Average	0.503 Rem/sec
				(1811 Rem/hr)
2	218690	240.320	301	0.798
2	102689	237.010	302	0.785
2	218866	230.740	301	0.767
			Average	.783 Rem/sec
				(2819 Rem/hr)
3	027799	151.300	313	0.483
3	028015	157.870	301	0.524
3	099349	152.730	300	0.509
			Average	0.483 Rem/sec
				(1818 Rem/hr)
4	218581	204.770	301	0.680
4	114145	205.260	301	0.682
4	099398	200.320	301	0.666
			Average	0.676 Rem/sec
				(2434 Rem/hr)
5	218260	76.030	302	0.252
5	217144	64.543	301	0.214
5	114428	67.320	300	0.224
			Average	0.230 Rem/sec
				(828 Rem/hr)

ATTACHMENT B

CORRECTED EXPOSURE DATA - Page 2

Chip #	TLD #	Net Dose (Rem)	Net Time (Sec)	Dose Rate (Rem/Sec)
6	103317	121.660	301	0.404
6	102979	122.050	301	0.405
6	026693	120.920	301	0.402
			Average	0.404 Rem/sec
				(1454 Rem/hr)
7	113670	118.000	301	0.392
7	217744	103.160	301	0.343
			Average	0.368 Rem/sec
				(1325 Rem/hr)

TOTAL OF AVERAGE VALUES OF REM/SEC = 3.469 Rem/sec

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DECAY TIME (MIN):  1
CALIB CURVE #...:  3
DILUTION FACTOR.:  1
DEAD TIME (%)...:  5
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ATTACHMENT C

Ge-Li Analysis of a Chip

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(+-KEV=1.5, #SIG=1.5, #SMOOTHS=1)

SAMPLE DESCRIPTION..: CRD SLIVER
CC&RP OPERATOR......: MITCHELL
DATE & HOUR SAMPLED.:
DATE & HOUR ANALYZED: 1-26-84,1418

COUNT (YES/NO) ? Y
SET I/O DEVICE TO REMOTE, PRESET TIME TO 0 0
COLLECT TIME (SEC) ? 1000
NOW COUNTING
COUNT DONE
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GAMMA SPECTROGRAPHIC ANALYSIS

CHANNEL	NET AREA(COUNTS)	ENERGY(KEV)	ISOTOPES
1055.17	321.	488.19	
1445.53	399.	667.21	I-132
1662.66	368.	766.76	NB-95
1714.51	375.	790.52	
1809.65	3767.	834.14	NB-98,KR-88,MN-54
1876.19	411.	864.64	CO-58
2165.33	412.	997.14	
2548.06	72521.	1172.48	CO-60
2895.64	62839.	1331.67	CO-60
3498.83	57.	1607.80	
3821.87	65.	1755.62	LA-142

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RADIONUCLIDE ANALYSIS

COLLECT TIME (SEC)..: 1000

ISOTOPE		ACTIVITY	+- 2 SIG	
~~NB-95~~		~~1.52787E-03 UC/~~SAMPL +-	1.17702E-03	(77.04 %)
MN-54	3.7	1.69374E-02 UC/SAMPL +-	1.48626E-03	(8.77 %)
CO-60	96.3	4.44102E-01 UC/SAMPL +-	3.49146E-03	(0.79 %)

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ISOTOPE	THEORETICAL	MEASURED	DIFFERENCE
NB-95	765.79	766.76	0.97
MN-54	834.83	834.14	-0.69
CO-60	1332.49	1331.67	-0.82

STANDARD DEVIATION= 0.83

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ATTACHMENT D

ANALYSIS OF THICKNESS OF PROTECTIVE GLOVES

Rubber Swatch ($16\ in^2 = 103.23\ cm^2$)

$$\frac{4003.60\ mg}{103.23\ cm^2} = 38.78\ mg/cm^2$$

Cotton Swatch ($13.75\ in^2 = 88.71\ cm^2$)

$$\frac{888.60\ mg}{88.71\ cm^2} = 10.02\ mg/cm2$$

Thickness of Dead Skin Layer = $7\ mg/cm^2$

Net thickness of protective layer = $38.78 \times 2 + 10.02 + 7 = 94.58\ mg/cm^2$

ATTACHMENT E

APPROXIMATE AREAS AND VOLUMES OF CHIPS

Chip #	Length	Width	Thickness	Area	Volume
1	1 3/8	3/8	1/16"	1.125 in^2	.0322 in^3
2	3/4	1/2	1/16	0.875	.0234
3	1 7/8	1/4	1/16	1.000	.0293
4	1	3/8	1/16	0.844	.0234
5*	3/8	3/8	1/16	0.375	.0088
6	1 3/8	1/4	1/16	0.750	.0215
7	1 3/8	1/4	1/16	0.750	.0215

* Totals for two chips

ATTACHMENT F

MEASURED GAMMA DOSE RATES

1 Chip #	2 Contact Dose Rate with Extender - R/hr	3 Contact Dose Rate with TLD R/hr	4 Ratio 3/2	
1	90	1811	20.1	
2	110	2819	25.6	
3	75	1818	24.2	
4	100	2434	24.3	
5 *	15	828	55.2	Smallest Chip
6	70	1454	20.8	
7	50	1325	26.5	

* Actually the two smallest chips taken together.

ATTACHMENT G

RESULTS OF TIME-MOTION STUDY

2 pairs of Rubber Gloves

1 pair of Cotton Gloves

Face Mask

January 25, 1984: 3:15 - 3:45 approx.

Run #	Net Sec. for 3 Moves
1	7.77
2	7.37
3	8.33
4	8.05
5	7.69
6	8.08
7	8.46
8	7.97
9	8.33
10	8.17

$\overline{X}$ = 8.022 sec.   S = .355 sec.

Min = 7.37   Max = 8.46