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PORTER CONSULTANTS, Inc.

Radiological Protection and Environmental Services

125 ARGYLE ROAD
ARDMORE, PA. 19003

PCI-TR-323

CALCULATION OF GAMMA SKIN DOSE FOR ^{24}Na SKIN CONTAMINATION INCIDENT

April 4, 1990

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CALCULATION OF GAMMA SKIN DOSE FOR ^{24}Na SKIN CONTAMINATION INCIDENT

1.0 EXECUTIVE SUMMARY

1.1 On March 8, 1990 at 16:05 a skin contamination incident occurred at the James A. FitzPatrick Nuclear Power Plant in Lycoming, NY. The incident occurred when a technician inadvertently contaminated a small area on his left thumb pad with a concentrated solution of ^{24}Na. The contaminated area was determined to be roughly a 2 cm × 2 cm square on the affected digit. The technician was appropriately decontaminated, and the activity assayed. Preliminary calculation indicated that the skin on the thumb may have been overexposed to (primarily) β radiation.

1.2 The dose assessment to the individual consists of three parts:

1.2.1 Determining the activity on the finger.

1.2.2 Determining the β dose component.

1.2.3 Determining the γ dose component.

This report was prepared to evaluate the γ component of the dose to the tissue below the contaminated area. It should be noted that since each of the three parts of the dose assessment were performed independently, this report calculates the γ dose relative to a unit activity (1 μCi) of ^{24}Na.

1.3 The dose calculations performed for this assessment were performed primarily using the shielding code QAD-CGGP, a point kernel, combinatorial geometry shielding code using a geometric progression buildup model. This code is the latest version of the QAD-P5 code, which has been in wide use since 1967 [Ma 1967]. The current version of the code was last revised in October, 1988 and the documentation updated in March, 1989 [RSIC 1989].

1.4 A very conservative (high) dose rate conversion factor for the skin was calculated to be 165 mrad/μCi-hr at a tissue depth of 0.004 cm (4 mg/cm^2), 156 mrad/μCi-hr at 0.007 cm (7 mg/cm^2), 91 mrad/μCi-hr at 0.064 cm (64 mg/cm^2) and 27 mrad/μCi-hr at 0.500 cm (500 mg/cm^2), all averaged over 1 cm^2. The input data is enclosed as Attachment 5.1 and the assumptions used and limitations of this model are discussed in Section 2.3, below.

2.0 DESCRIPTION OF DOSIMETRY MODEL

2.1 SOURCE – RECEPTOR GEOMETRY

The contamination was modeled as a 2 × 2 cm square source located at one vertex of a 3 cm diameter cylinder of water (see Attachment 5.2). The precise geometry is unimportant for a point kernel model as long as the material and geometry between the source and receptor are accurate. The source was originally organized as a 20 × 20 array, for a total of 400 input points. However, the resulting dose rates were found to be very dependant upon the grid coordinates of the receptors due to the small source to receptor distances involved. Therefore the model was changed to a 100 × 100 array with 10,000 input points. The dose was then calculated to a point on the axis of the cylinder at several depths (0.004, 0.007,

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0.040, 0.060, 0.064, 0.067 & 0.500 cm) below the source. Additional calculations were performed to points directly below the kernels to check for ripple (see below). Finally, the dose rates for the subject problem were calculated at 0.004, 0.007, 0.064 and 0.500 cm using an 11 × 11 receptor grid covering a 1 × 1 cm area at that tissue depth. The arithmetic mean for the resulting points was used to obtain the dose rate averaged over 1 cm^2.

2.2 VALIDATION OF COMPUTER CODE

As QAD-CGGP is a well established computer code, the bench-marking consisted mainly of performing a program run with a standard input data set. The output data was identical to the benchmark data supplied with the code. Additionally, the detailed output data for the subject runs were compared to the input data and the benchmark model for consistency.

2.3 ASSUMPTIONS AND LIMITATIONS OF CODE AND MODEL

2.3.1 The main known limitation of the code is that it was not designed to model microscopic model geometries where electronic equilibrium is not established (such as the subject case). Since this results in an overestimate of the dose rates, the results are conservative.

2.3.2 A minor limitation is that the finger was modeled as a cylinder of water (see Attachment 5.2), since tissue is not an available shielding material in the code.

2.3.3 As in all point kernel models, γ ray scatter is accounted for using build-up factors for an infinite absorber. Therefore, effects, such as air scatter of γ rays back to the receptor, are not accounted for. However, due to the high γ energies involved (long mean free path lengths), the uncertainties introduced by this are minimal.

2.3.4 Finally, there are slight variations in the calculated dose rates at the shortest source to receptor distances (0.004 and 0.007 cm) between the receptor points. This was compensated for by using a large input grid (100 × 100 array) and not placing any of the receptor points directly under a source point (which greatly exaggerates the variations). The errors due to this were observed to be converging rapidly as the number of input points increased. For the data included in this report it is believed to represent only a few percent of the calculated dose rates. At the 0.64 and 0.500 cm source to receptor distances this variation was within the uncertainties of the computational method.

3.0 RESULTS

3.1 A summary of the output for the four main runs are enclosed as Attachment 5.3. The peak dose rate at a point located at a depth of 0.004 cm was calculated to be 165 mrad/μCi-hr. Peak doses calculated for 0.007, 0.064 and 0.500 cm depths were 159, 94 and 29 mrad/μCi-hr, respectively. When averaged over 1 cm^2, the average dose rate were calculated to be 162, 156, 91 and 27 mrad/μCi-hr, at the respective depths.

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4.0 REFERENCES

Malenfant, R.E.; 1967. QAD: A series of point-kernel general purpose shielding programs. LA-3572. Los Alamos Scientific Laboratory. Available from: NTIS, Springfield, VA.

Radiation Shielding Information Center. 1989. QAD-CGGP: A combinatorial geometry version of QAD-P5A, a point kernel code system for neutron and gamma-ray shielding calculations using the GP buildup factor. Oak Ridge National Laboratory, Oak Ridge, TN.

5.0 ATTACHMENTS

5.1 Input Data for QAD-CGGP Runs

5.2 Geometric Model used for QAD-CGGP Input

5.3 Dose Rate Matrix for 0.004, 0.007, 0.064 & 0.500 cm Depths

5.4 Graph of Dose Rates vs. Skin Depth

5.5 Preliminary Results of non-Charged Particle Equilibrium Dose Rate Calculations Performed by the University of Wisconsin Medical Physics Department Using the EGS-IV Monte-Carlo Computer Code

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Attachment 5.1
INPUT DATA FOR QAD-CGGP RUNS

5.1.1 0.004 cm RUN

Na-24 Gamma Skin Dose @ 0.004 cm Depth

```
100 1  100 2  1  1  2  9  1  1  2  0  0  1  1000 0
3.7E4  0.     0.     0.     0.     0.     0.
-1.0   -0.98  -0.96  -0.94  -0.92  -0.90  -0.88  -0.86
-0.84  -0.82  -0.80  -0.78  -0.76  -0.74  -0.72  -0.70
-0.68  -0.66  -0.64  -0.62  -0.60  -0.58  -0.56  -0.54
-0.52  -0.50  -0.48  -0.46  -0.44  -0.42  -0.40  -0.38
-0.36  -0.34  -0.32  -0.30  -0.28  -0.26  -0.24  -0.22
-0.20  -0.18  -0.16  -0.14  -0.12  -0.10  -0.08  -0.06
-0.04  -0.02   0.00   0.02   0.04   0.06   0.08   0.10
 0.12   0.14   0.16   0.18   0.20   0.22   0.24   0.26
 0.28   0.30   0.32   0.34   0.36   0.38   0.40   0.42
 0.44   0.46   0.48   0.50   0.52   0.54   0.56   0.58
 0.60   0.62   0.64   0.66   0.68   0.70   0.72   0.74
 0.76   0.78   0.80   0.82   0.84   0.86   0.88   0.90
 0.92   0.94   0.96   0.98   1.00
0.0    0.0002
-1.0   -0.98  -0.96  -0.94  -0.92  -0.90  -0.88  -0.86
-0.84  -0.82  -0.80  -0.78  -0.76  -0.74  -0.72  -0.70
-0.68  -0.66  -0.64  -0.62  -0.60  -0.58  -0.56  -0.54
-0.52  -0.50  -0.48  -0.46  -0.44  -0.42  -0.40  -0.38
-0.36  -0.34  -0.32  -0.30  -0.28  -0.26  -0.24  -0.22
-0.20  -0.18  -0.16  -0.14  -0.12  -0.10  -0.08  -0.06
-0.04  -0.02   0.00   0.02   0.04   0.06   0.08   0.10
 0.12   0.14   0.16   0.18   0.20   0.22   0.24   0.26
 0.28   0.30   0.32   0.34   0.36   0.38   0.40   0.42
 0.44   0.46   0.48   0.50   0.52   0.54   0.56   0.58
 0.60   0.62   0.64   0.66   0.68   0.70   0.72   0.74
 0.76   0.78   0.80   0.82   0.84   0.86   0.88   0.90
 0.92   0.94   0.96   0.98   1.00
1.     1.     1.     1.     1.     1.     1.     1.
1.     1.     1.     1.     1.     1.     1.     1.
1.     1.     1.     1.     1.     1.     1.     1.
1.     1.     1.     1.     1.     1.     1.     1.
1.     1.     1.     1.     1.     1.     1.     1.
1.     1.     1.     1.     1.     1.     1.     1.
1.     1.     1.     1.     1.     1.     1.     1.
1.     1.     1.     1.     1.     1.     1.     1.
1.     1.     1.     1.     1.     1.     1.     1.
1.     1.     1.     1.     1.     1.     1.     1.
1.     1.     1.     1.     1.     1.     1.     1.
1.     1.     1.     1.     1.     1.     1.     1.
1.     1.     1.     1.     1.
1.     1.
```

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Attachment 5.1
INPUT DATA FOR QAD-CGGP RUNS

```
1.    1.    1.    1.    1.    1.    1.    1.
1.    1.    1.    1.    1.    1.    1.    1.
1.    1.    1.    1.    1.    1.    1.    1.
1.    1.    1.    1.    1.    1.    1.    1.
1.    1.    1.    1.    1.    1.    1.    1.
1.    1.    1.    1.    1.    1.    1.    1.
1.    1.    1.    1.    1.    1.    1.    1.
1.    1.    1.    1.    1.    1.    1.    1.
1.    1.    1.    1.    1.    1.    1.    1.
1.    1.    1.    1.    1.    1.    1.    1.
1.    1.    1.    1.    1.    1.    1.    1.
1.    1.    1.    1.    1.    1.    1.    1.
1.    1.    1.    1.    1.
0   0              Square Source on Cylinder
 RCC 1  0.      0.      0.      0.      0.      3.0
      1.5
 END
 Z1    1   1
 END
1
1
11   1   8
WATE EXP
0.1119   0.8881
1.37     2.75
1.3685   2.7503
0.00154  0.00182
1        1
1.0-3.0
1.0-1.74    2.5-3.0
MeV/cm**2-sec          mrad/hr              w/g
0.0      0.0041   0.0     1   0   0   0
0.1      0.0041   0.0     1   0   0   0
0.2      0.0041   0.0     1   0   0   0
0.3      0.0041   0.0     1   0   0   0
0.4      0.0041   0.0     1   0   0   0
0.5      0.0041   0.0     1   0   0   0
0.0      0.0041   0.1     1   0   0   0
0.1      0.0041   0.1     1   0   0   0
0.2      0.0041   0.1     1   0   0   0
0.3      0.0041   0.1     1   0   0   0
0.4      0.0041   0.1     1   0   0   0
0.5      0.0041   0.1     1   0   0   0
0.0      0.0041   0.2     1   0   0   0
0.1      0.0041   0.2     1   0   0   0
0.2      0.0041   0.2     1   0   0   0
```

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Attachment 5.1
INPUT DATA FOR QAD-CGGP RUNS

```
0.3     0.0041  0.2     1   0   0   0
0.4     0.0041  0.2     1   0   0   0
0.5     0.0041  0.2     1   0   0   0
0.0     0.0041  0.3     1   0   0   0
0.1     0.0041  0.3     1   0   0   0
0.2     0.0041  0.3     1   0   0   0
0.3     0.0041  0.3     1   0   0   0
0.4     0.0041  0.3     1   0   0   0
0.5     0.0041  0.3     1   0   0   0
0.0     0.0041  0.4     1   0   0   0
0.1     0.0041  0.4     1   0   0   0
0.2     0.0041  0.4     1   0   0   0
0.3     0.0041  0.4     1   0   0   0
0.4     0.0041  0.4     1   0   0   0
0.5     0.0041  0.4     1   0   0   0
0.0     0.0041  0.5     1   0   0   0
0.1     0.0041  0.5     1   0   0   0
0.2     0.0041  0.5     1   0   0   0
0.3     0.0041  0.5     1   0   0   0
0.4     0.0041  0.5     1   0   0   0
0.5     0.0041  0.5     1   0   0   0
0.0     0.0     0.0     -1  0   0   0
```

5.1.2 0.007 cm RUN

```
Na-24 Gamma Skin Dose @ 0.007 cm Depth
100 1   100 2   1   1   2   9   1   1   2   0   0   1   1000 0
3.7E4   0.      0.      0.      0.      0.      0.
-1.0    -0.98   -0.96   -0.94   -0.92   -0.90   -0.88   -0.86
-0.84   -0.82   -0.80   -0.78   -0.76   -0.74   -0.72   -0.70
-0.68   -0.66   -0.64   -0.62   -0.60   -0.58   -0.56   -0.54
-0.52   -0.50   -0.48   -0.46   -0.44   -0.42   -0.40   -0.38
-0.36   -0.34   -0.32   -0.30   -0.28   -0.26   -0.24   -0.22
-0.20   -0.18   -0.16   -0.14   -0.12   -0.10   -0.08   -0.06
-0.04   -0.02   0.00    0.02    0.04    0.06    0.08    0.10
 0.12    0.14   0.16    0.18    0.20    0.22    0.24    0.26
 0.28    0.30   0.32    0.34    0.36    0.38    0.40    0.42
 0.44    0.46   0.48    0.50    0.52    0.54    0.56    0.58
 0.60    0.62   0.64    0.66    0.68    0.70    0.72    0.74
 0.76    0.78   0.80    0.82    0.84    0.86    0.88    0.90
 0.92    0.94   0.96    0.98    1.00
0.0     0.0002
-1.0    -0.98   -0.96   -0.94   -0.92   -0.90   -0.88   -0.86
-0.84   -0.82   -0.80   -0.78   -0.76   -0.74   -0.72   -0.70
-0.68   -0.66   -0.64   -0.62   -0.60   -0.58   -0.56   -0.54
```

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Attachment 5.1
INPUT DATA FOR QAD-CGGP RUNS

```
-0.52   -0.50   -0.48   -0.46   -0.44   -0.42   -0.40   -0.38
-0.36   -0.34   -0.32   -0.30   -0.28   -0.26   -0.24   -0.22
-0.20   -0.18   -0.16   -0.14   -0.12   -0.10   -0.08   -0.06
-0.04   -0.02    0.00    0.02    0.04    0.06    0.08    0.10
 0.12    0.14    0.16    0.18    0.20    0.22    0.24    0.26
 0.28    0.30    0.32    0.34    0.36    0.38    0.40    0.42
 0.44    0.46    0.48    0.50    0.52    0.54    0.56    0.58
 0.60    0.62    0.64    0.66    0.68    0.70    0.72    0.74
 0.76    0.78    0.80    0.82    0.84    0.86    0.88    0.90
 0.92    0.94    0.96    0.98    1.00
1.      1.      1.      1.      1.      1.      1.      1.
1.      1.      1.      1.      1.      1.      1.      1.
1.      1.      1.      1.      1.      1.      1.      1.
1.      1.      1.      1.      1.      1.      1.      1.
1.      1.      1.      1.      1.      1.      1.      1.
1.      1.      1.      1.      1.      1.      1.      1.
1.      1.      1.      1.      1.      1.      1.      1.
1.      1.      1.      1.      1.      1.      1.      1.
1.      1.      1.      1.      1.      1.      1.      1.
1.      1.      1.      1.      1.      1.      1.      1.
1.      1.      1.      1.      1.      1.      1.      1.
1.      1.      1.      1.      1.
1.      1.
1.      1.      1.      1.      1.      1.      1.      1.
1.      1.      1.      1.      1.      1.      1.      1.
1.      1.      1.      1.      1.      1.      1.      1.
1.      1.      1.      1.      1.      1.      1.      1.
1.      1.      1.      1.      1.      1.      1.      1.
1.      1.      1.      1.      1.      1.      1.      1.
1.      1.      1.      1.      1.      1.      1.      1.
1.      1.      1.      1.      1.      1.      1.      1.
1.      1.      1.      1.      1.      1.      1.      1.
1.      1.      1.      1.      1.      1.      1.      1.
1.      1.      1.      1.      1.      1.      1.      1.
1.      1.      1.      1.      1.      1.      1.      1.
1.      1.      1.      1.      1.      1.      1.      1.
1.      1.      1.      1.      1.
0   0           Square Source on Cylinder
 RCC 1  0.      0.      0.      0.      0.      3.0
      1.5
 END
 Z1    1   1
 END
1
1
11   1   8
```

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Attachment 5.1
INPUT DATA FOR QAD-CGGP RUNS

```
WATE EXP
0.1119   0.8881
1.37     2.75
1.3685   2.7503
0.00154  0.00182
1        1
1.0-3.0
1.0-1.74    2.5-3.0
MeV/cm*2-sec          mrad/hr              w/g
0.0     0.0071   0.0    1   0   0   0
0.1     0.0071   0.0    1   0   0   0
0.2     0.0071   0.0    1   0   0   0
0.3     0.0071   0.0    1   0   0   0
0.4     0.0071   0.0    1   0   0   0
0.5     0.0071   0.0    1   0   0   0
0.0     0.0071   0.1    1   0   0   0
0.1     0.0071   0.1    1   0   0   0
0.2     0.0071   0.1    1   0   0   0
0.3     0.0071   0.1    1   0   0   0
0.4     0.0071   0.1    1   0   0   0
0.5     0.0071   0.1    1   0   0   0
0.0     0.0071   0.2    1   0   0   0
0.1     0.0071   0.2    1   0   0   0
0.2     0.0071   0.2    1   0   0   0
0.3     0.0071   0.2    1   0   0   0
0.4     0.0071   0.2    1   0   0   0
0.5     0.0071   0.2    1   0   0   0
0.0     0.0071   0.3    1   0   0   0
0.1     0.0071   0.3    1   0   0   0
0.2     0.0071   0.3    1   0   0   0
0.3     0.0071   0.3    1   0   0   0
0.4     0.0071   0.3    1   0   0   0
0.5     0.0071   0.3    1   0   0   0
0.0     0.0071   0.4    1   0   0   0
0.1     0.0071   0.4    1   0   0   0
0.2     0.0071   0.4    1   0   0   0
0.3     0.0071   0.4    1   0   0   0
0.4     0.0071   0.4    1   0   0   0
0.5     0.0071   0.4    1   0   0   0
0.0     0.0071   0.5    1   0   0   0
0.1     0.0071   0.5    1   0   0   0
0.2     0.0071   0.5    1   0   0   0
0.3     0.0071   0.5    1   0   0   0
0.4     0.0071   0.5    1   0   0   0
0.5     0.0071   0.5    1   0   0   0
0.0     0.0      0.0   -1   0   0   0
```

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Attachment 5.1
INPUT DATA FOR QAD-CGGP RUNS

5.1.3 0.064 cm RUN

```
Na-24 Gamma Skin Dose @ 0.064 cm Depth
100 1  100 2  1  1  2  9  1  1  2  0  0  1  1000 0
3.7E4  0.     0.     0.     0.     0.     0.
-1.0   -0.98  -0.96  -0.94  -0.92  -0.90  -0.88  -0.86
-0.84  -0.82  -0.80  -0.78  -0.76  -0.74  -0.72  -0.70
-0.68  -0.66  -0.64  -0.62  -0.60  -0.58  -0.56  -0.54
-0.52  -0.50  -0.48  -0.46  -0.44  -0.42  -0.40  -0.38
-0.36  -0.34  -0.32  -0.30  -0.28  -0.26  -0.24  -0.22
-0.20  -0.18  -0.16  -0.14  -0.12  -0.10  -0.08  -0.06
-0.04  -0.02   0.00   0.02   0.04   0.06   0.08   0.10
 0.12   0.14   0.16   0.18   0.20   0.22   0.24   0.26
 0.28   0.30   0.32   0.34   0.36   0.38   0.40   0.42
 0.44   0.46   0.48   0.50   0.52   0.54   0.56   0.58
 0.60   0.62   0.64   0.66   0.68   0.70   0.72   0.74
 0.76   0.78   0.80   0.82   0.84   0.86   0.88   0.90
 0.92   0.94   0.96   0.98   1.00
0.0    0.0002
-1.0   -0.98  -0.96  -0.94  -0.92  -0.90  -0.88  -0.86
-0.84  -0.82  -0.80  -0.78  -0.76  -0.74  -0.72  -0.70
-0.68  -0.66  -0.64  -0.62  -0.60  -0.58  -0.56  -0.54
-0.52  -0.50  -0.48  -0.46  -0.44  -0.42  -0.40  -0.38
-0.36  -0.34  -0.32  -0.30  -0.28  -0.26  -0.24  -0.22
-0.20  -0.18  -0.16  -0.14  -0.12  -0.10  -0.08  -0.06
-0.04  -0.02   0.00   0.02   0.04   0.06   0.08   0.10
 0.12   0.14   0.16   0.18   0.20   0.22   0.24   0.26
 0.28   0.30   0.32   0.34   0.36   0.38   0.40   0.42
 0.44   0.46   0.48   0.50   0.52   0.54   0.56   0.58
 0.60   0.62   0.64   0.66   0.68   0.70   0.72   0.74
 0.76   0.78   0.80   0.82   0.84   0.86   0.88   0.90
 0.92   0.94   0.96   0.98   1.00
1.  1.  1.  1.  1.  1.  1.  1.
1.  1.  1.  1.  1.  1.  1.  1.
1.  1.  1.  1.  1.  1.  1.  1.
1.  1.  1.  1.  1.  1.  1.  1.
1.  1.  1.  1.  1.  1.  1.  1.
1.  1.  1.  1.  1.  1.  1.  1.
1.  1.  1.  1.  1.  1.  1.  1.
1.  1.  1.  1.  1.  1.  1.  1.
1.  1.  1.  1.  1.  1.  1.  1.
1.  1.  1.  1.  1.  1.  1.  1.
1.  1.  1.  1.  1.  1.  1.  1.
1.  1.  1.  1.  1.  1.  1.  1.
1.  1.  1.  1.  1.
1.  1.
```

Porter Consultants, Inc.
125 ARGYLE ROAD
ARDMORE, PA. 19003
215-896-5353

Attachment 5.1
INPUT DATA FOR QAD-CGGP RUNS

```
1.    1.    1.    1.    1.    1.    1.    1.
1.    1.    1.    1.    1.    1.    1.    1.
1.    1.    1.    1.    1.    1.    1.    1.
1.    1.    1.    1.    1.    1.    1.    1.
1.    1.    1.    1.    1.    1.    1.    1.
1.    1.    1.    1.    1.    1.    1.    1.
1.    1.    1.    1.    1.    1.    1.    1.
1.    1.    1.    1.    1.    1.    1.    1.
1.    1.    1.    1.    1.    1.    1.    1.
1.    1.    1.    1.    1.    1.    1.    1.
1.    1.    1.    1.    1.    1.    1.    1.
1.    1.    1.    1.    1.
0  0                Square Source on Cylinder
 RCC 1  0.     0.     0.     0.     0.     3.0
     1.5
 END
 Z1    1   1
 END
1
1
11   1  8
WATE EXP
0.1119   0.8881
1.37     2.75
1.3685   2.7503
0.00154  0.00182
1        1
1.0-3.0
1.0-1.74    2.5-3.0
MeV/cm**2-sec          mrad/hr          w/g
0.0      0.0641  0.0   1   0   0   0
0.1      0.0641  0.0   1   0   0   0
0.2      0.0641  0.0   1   0   0   0
0.3      0.0641  0.0   1   0   0   0
0.4      0.0641  0.0   1   0   0   0
0.5      0.0641  0.0   1   0   0   0
0.0      0.0641  0.1   1   0   0   0
0.1      0.0641  0.1   1   0   0   0
0.2      0.0641  0.1   1   0   0   0
0.3      0.0641  0.1   1   0   0   0
0.4      0.0641  0.1   1   0   0   0
0.5      0.0641  0.1   1   0   0   0
0.0      0.0641  0.2   1   0   0   0
0.1      0.0641  0.2   1   0   0   0
0.2      0.0641  0.2   1   0   0   0
```

Porter Consultants, Inc.
125 ARGYLE ROAD
ARDMORE, PA. 19003
215-896-5353

Attachment 5.1
INPUT DATA FOR QAD-CGGP RUNS

```
0.3     0.0641  0.2     1   0   0   0
0.4     0.0641  0.2     1   0   0   0
0.5     0.0641  0.2     1   0   0   0
0.0     0.0641  0.3     1   0   0   0
0.1     0.0641  0.3     1   0   0   0
0.2     0.0641  0.3     1   0   0   0
0.3     0.0641  0.3     1   0   0   0
0.4     0.0641  0.3     1   0   0   0
0.5     0.0641  0.3     1   0   0   0
0.0     0.0641  0.4     1   0   0   0
0.1     0.0641  0.4     1   0   0   0
0.2     0.0641  0.4     1   0   0   0
0.3     0.0641  0.4     1   0   0   0
0.4     0.0641  0.4     1   0   0   0
0.5     0.0641  0.4     1   0   0   0
0.0     0.0641  0.5     1   0   0   0
0.1     0.0641  0.5     1   0   0   0
0.2     0.0641  0.5     1   0   0   0
0.3     0.0641  0.5     1   0   0   0
0.4     0.0641  0.5     1   0   0   0
0.5     0.0641  0.5     1   0   0   0
0.0     0.0     0.0     -1  0   0   0
```

5.1.4 0.500 cm RUN

```
Na-24 Gamma Skin Dose @ 0.500 cm Depth
100 1   100 2   1   1   2   9   1   1   2   0   0   1   1000 0
3.7E4   0.      0.      0.      0.      0.      0.
-1.0    -0.98   -0.96   -0.94   -0.92   -0.90   -0.88   -0.86
-0.84   -0.82   -0.80   -0.78   -0.76   -0.74   -0.72   -0.70
-0.68   -0.66   -0.64   -0.62   -0.60   -0.58   -0.56   -0.54
-0.52   -0.50   -0.48   -0.46   -0.44   -0.42   -0.40   -0.38
-0.36   -0.34   -0.32   -0.30   -0.28   -0.26   -0.24   -0.22
-0.20   -0.18   -0.16   -0.14   -0.12   -0.10   -0.08   -0.06
-0.04   -0.02   0.00    0.02    0.04    0.06    0.08    0.10
 0.12   0.14    0.16    0.18    0.20    0.22    0.24    0.26
 0.28   0.30    0.32    0.34    0.36    0.38    0.40    0.42
 0.44   0.46    0.48    0.50    0.52    0.54    0.56    0.58
 0.60   0.62    0.64    0.66    0.68    0.70    0.72    0.74
 0.76   0.78    0.80    0.82    0.84    0.86    0.88    0.90
 0.92   0.94    0.96    0.98    1.00
0.0     0.0002
-1.0    -0.98   -0.96   -0.94   -0.92   -0.90   -0.88   -0.86
-0.84   -0.82   -0.80   -0.78   -0.76   -0.74   -0.72   -0.70
-0.68   -0.66   -0.64   -0.62   -0.60   -0.58   -0.56   -0.54
-0.52   -0.50   -0.48   -0.46   -0.44   -0.42   -0.40   -0.38
```

Porter Consultants, Inc.
125 ARGYLE ROAD
[redacted]ORE, PA. 19003
21[redacted]96-5353

Attachment 5.1
INPUT DATA FOR QAD-CGGP RUNS

```
-0.36  -0.34  -0.32  -0.30  -0.28  -0.26  -0.24  -0.22
-0.20  -0.18  -0.16  -0.14  -0.12  -0.10  -0.08  -0.06
-0.04  -0.02   0.00   0.02   0.04   0.06   0.08   0.10
 0.12   0.14   0.16   0.18   0.20   0.22   0.24   0.26
 0.28   0.30   0.32   0.34   0.36   0.38   0.40   0.42
 0.44   0.46   0.48   0.50   0.52   0.54   0.56   0.58
 0.60   0.62   0.64   0.66   0.68   0.70   0.72   0.74
 0.76   0.78   0.80   0.82   0.84   0.86   0.88   0.90
 0.92   0.94   0.96   0.98   1.00
1.    1.    1.    1.    1.    1.    1.    1.
1.    1.    1.    1.    1.    1.    1.    1.
1.    1.    1.    1.    1.    1.    1.    1.
1.    1.    1.    1.    1.    1.    1.    1.
1.    1.    1.    1.    1.    1.    1.    1.
1.    1.    1.    1.    1.    1.    1.    1.
1.    1.    1.    1.    1.    1.    1.    1.
1.    1.    1.    1.    1.    1.    1.    1.
1.    1.    1.    1.    1.    1.    1.    1.
1.    1.    1.    1.    1.    1.    1.    1.
1.    1.    1.    1.    1.    1.    1.    1.
1.    1.    1.    1.    1.
1.    1.
1.    1.    1.    1.    1.    1.    1.    1.
1.    1.    1.    1.    1.    1.    1.    1.
1.    1.    1.    1.    1.    1.    1.    1.
1.    1.    1.    1.    1.    1.    1.    1.
1.    1.    1.    1.    1.    1.    1.    1.
1.    1.    1.    1.    1.    1.    1.    1.
1.    1.    1.    1.    1.    1.    1.    1.
1.    1.    1.    1.    1.    1.    1.    1.
1.    1.    1.    1.    1.    1.    1.    1.
1.    1.    1.    1.    1.    1.    1.    1.
1.    1.    1.    1.    1.    1.    1.    1.
1.    1.    1.    1.    1.
0  0                Square Source on Cylinder
 RCC 1  0.      0.      0.      0.      0.      3.0
       1.5
 END
 Z1    1   1
 END
1
1
11   1   8
WATE EXP
```

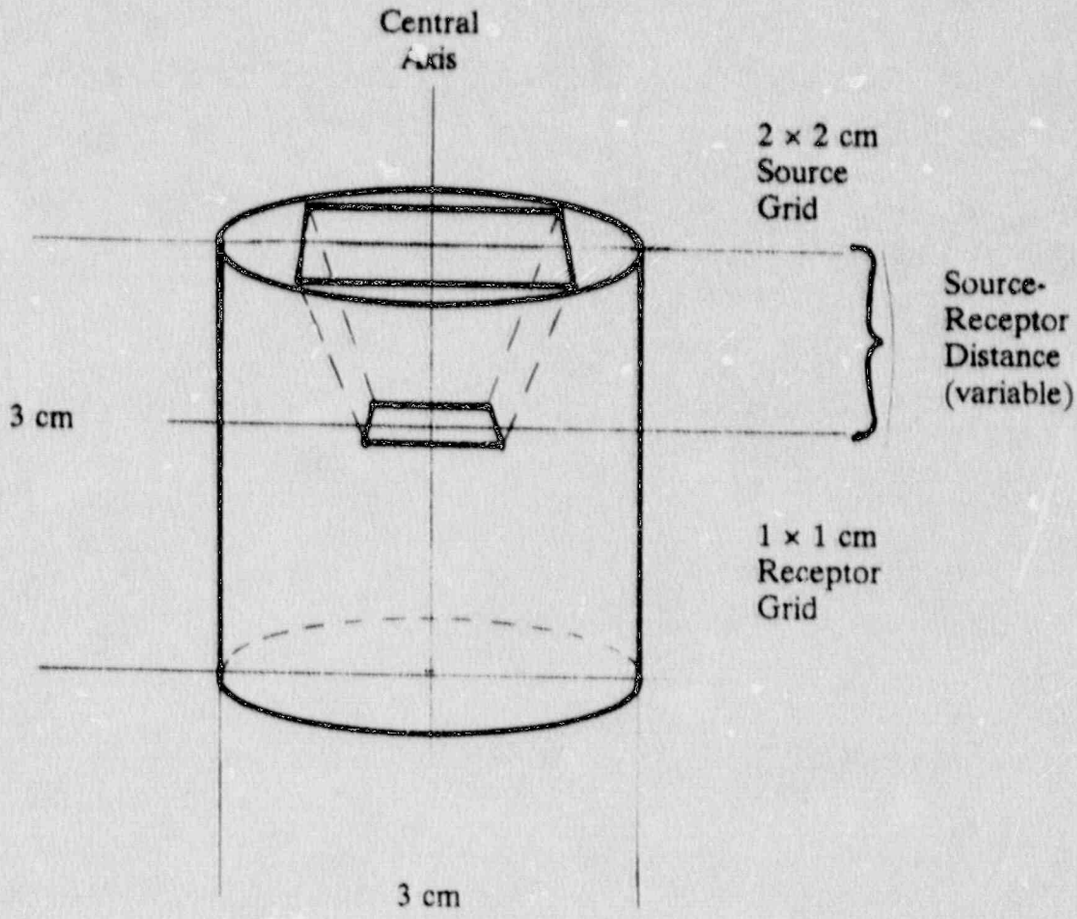
Porter Consultants, Inc.
125 ARGYLE ROAD
ARDMORE, PA. 19003
215-896-5353

Attachment 5.1
INPUT DATA FOR QAD-CGGP RUNS

```
0.1119   0.8881
1.37     2.75
1.3685   2.7503
0.00154  0.00182
1        1
1.0-3.0
1.0-1.74    2.5-3.0
MeV/cm**2-sec          mrad/hr                w/g
0.0      0.5001  0.0   1   0   0   0
0.1      0.5001  0.0   1   0   0   0
0.2      0.5001  0.0   1   0   0   0
0.3      0.5001  0.0   1   0   0   0
0.4      0.5001  0.0   1   0   0   0
0.5      0.5001  0.0   1   0   0   0
0.0      0.5001  0.1   1   0   0   0
0.1      0.5001  0.1   1   0   0   0
0.2      0.5001  0.1   1   0   0   0
0.3      0.5001  0.1   1   0   0   0
0.4      0.5001  0.1   1   0   0   0
0.5      0.5001  0.1   1   0   0   0
0.0      0.5001  0.2   1   0   0   0
0.1      0.5001  0.2   1   0   0   0
0.2      0.5001  0.2   1   0   0   0
0.3      0.5001  0.2   1   0   0   0
0.4      0.5001  0.2   1   0   0   0
0.5      0.5001  0.2   1   0   0   0
0.0      0.5001  0.3   1   0   0   0
0.1      0.5001  0.3   1   0   0   0
0.2      0.5001  0.3   1   0   0   0
0.3      0.5001  0.3   1   0   0   0
0.4      0.5001  0.3   1   0   0   0
0.5      0.5001  0.3   1   0   0   0
0.0      0.5001  0.4   1   0   0   0
0.1      0.5001  0.4   1   0   0   0
0.2      0.5001  0.4   1   0   0   0
0.3      0.5001  0.4   1   0   0   0
0.4      0.5001  0.4   1   0   0   0
0.5      0.5001  0.4   1   0   0   0
0.0      0.5001  0.5   1   0   0   0
0.1      0.5001  0.5   1   0   0   0
0.2      0.5001  0.5   1   0   0   0
0.3      0.5001  0.5   1   0   0   0
0.4      0.5001  0.5   1   0   0   0
0.5      0.5001  0.5   1   0   0   0
0.0      0.0     0.0   -1  0   0   0
```

Porter Consultants, Inc.
125 ARGYLE ROAD
ARDMORE, PA. 19003
215-896-5353

Attachment 5.2
GEOMETRIC MODEL USED FOR QAD-CGGP INPUT



Porter Consultants, Inc.
125 ARGYLE ROAD
ARDMORE, PA. 19003
215-896-5353

Attachment 5.3
OUTPUT DATA SUMMARY FROM QAD-CGGP RUNS

Average Gamma Dose Rate (mrad/uCi-hr) @ 0.004 cm Depth

Receptor Coordinates (cm)		X -0.5	-0.4	-0.3	-0.2	-0.1	-0.0	0.1	0.2	0.3	0.4	0.5
	0.5	157.0	158.5	159.5	160.2	160.5	160.6	160.5	160.2	159.5	158.5	157.0
	0.4	158.5	160.0	161.0	161.7	162.1	162.2	162.1	161.7	161.0	160.0	158.5
	0.3	159.5	161.0	162.1	162.8	163.2	163.3	163.2	162.8	162.1	161.0	159.5
	0.2	160.2	161.7	162.8	163.5	163.9	164.1	163.9	163.5	162.8	161.7	160.2
	0.1	160.5	162.1	163.2	163.9	164.3	164.5	164.3	163.9	163.2	162.1	160.5
Y	-0.0	160.6	162.2	163.3	164.1	164.5	164.6	164.5	164.1	163.3	162.2	160.6
	-0.1	160.5	160.0	163.2	163.9	164.3	164.5	164.3	163.9	163.2	160.0	160.5
	-0.2	160.2	161.0	162.8	163.5	163.9	164.1	163.9	163.5	162.8	161.0	160.2
	-0.3	159.5	161.7	162.1	162.8	163.2	163.3	163.2	162.8	162.1	161.7	159.5
	-0.4	158.5	162.1	161.0	161.7	162.1	162.2	162.1	161.7	161.0	162.1	158.5
	-0.5	157.0	162.2	159.5	160.2	160.5	160.6	160.5	160.2	159.5	162.2	157.0
Column Average	=	159.3	161.1	161.9	162.6	163.0	163.1	163.0	162.6	161.9	161.1	159.3

Peak Reading = 164.6   Overall Average = 161.7   Average/Peak = 98.2%   Corner/Peak = 95.4%

Porter Consultants, Inc.
125 ARGYLE ROAD
ARDMORE, PA. 19003
215-896-5353

Attachment 5.3
OUTPUT DATA SUMMARY FROM QAD-CGGP RUNS

Average Gamma Dose Rate (mrad/uCi-hr) @ 0.007 cm Depth

Receptor Coordinates (cm)		X -0.5	-0.4	-0.3	-0.2	-0.1	-0.0	0.1	0.2	0.3	0.4	0.5
	0.5	151.1	152.5	153.5	154.2	154.5	154.6	154.5	154.2	153.5	152.5	151.1
	0.4	152.5	154.0	155.0	155.7	156.1	156.2	156.1	155.7	155.0	154.0	152.5
	0.3	153.5	155.0	156.1	156.8	157.2	157.3	157.2	156.8	156.1	155.0	153.5
	0.2	154.2	155.7	156.8	157.5	157.9	158.1	157.9	157.5	156.8	155.7	154.2
	0.1	154.5	156.1	157.2	157.9	158.4	158.5	158.4	157.9	157.2	156.1	154.5
Y	-0.0	154.6	156.2	157.3	157.3	158.5	158.6	158.5	157.3	157.3	156.2	154.6
	-0.1	154.5	156.1	157.2	157.9	158.4	158.5	158.4	157.9	157.2	156.1	154.5
	-0.2	154.2	155.7	156.8	157.5	157.9	158.1	157.9	157.5	156.8	155.7	154.2
	-0.3	153.5	155.0	156.1	156.8	157.2	157.3	157.2	156.8	156.1	155.0	153.5
	-0.4	152.5	154.0	155.0	155.7	156.1	156.2	156.1	155.7	155.0	154.0	152.5
	-0.5	151.1	152.5	153.5	154.2	154.5	154.6	154.5	154.2	153.5	152.5	151.1
Column Average	=	153.3	154.8	155.9	156.5	157.0	157.1	157.0	156.5	155.9	154.8	153.3

Peak Reading = 158.6   Overall Average = 155.6   Average/Peak = 98.1%   Corner/Peak = 95.3%

Porter Consultants, Inc.
125 ARGYLE ROAD
ARDMORE, PA. 19003
215-896-5353

Attachment 5.3

OUTPUT DATA SUMMARY FROM QAD-CGGP RUNS

Average Gamma Dose Rate (mrad/uCi-hr) @ 0.064 cm Depth

Receptor Coordinates (cm)		X: -0.5	-0.4	-0.3	-0.2	-0.1	-0.0	0.1	0.2	0.3	0.4	0.5
	0.5	86.1	87.6	88.6	89.2	89.6	89.7	89.6	89.2	88.6	87.6	86.1
	0.4	87.6	89.1	90.1	90.8	91.1	91.3	91.1	90.8	90.1	89.1	87.6
	0.3	88.6	90.1	91.1	91.8	92.2	92.4	92.2	91.8	91.1	90.1	88.6
	0.2	89.2	90.8	91.8	92.5	93.0	93.1	93.0	92.5	91.8	90.8	89.2
	0.1	89.6	91.1	92.2	93.0	93.4	93.5	93.4	93.0	92.2	91.1	89.6
Y	-0.0	89.7	91.3	92.4	93.1	93.5	93.6	93.5	93.1	92.4	91.3	89.7
	-0.1	89.6	91.1	92.2	93.0	93.4	93.5	93.4	93.0	92.2	91.1	89.6
	-0.2	89.2	90.8	91.8	92.5	93.0	93.1	93.0	92.5	91.8	90.8	89.2
	-0.3	88.6	90.1	91.1	91.8	92.2	92.4	92.2	91.8	91.1	90.1	88.6
	-0.4	87.6	89.1	90.1	90.8	91.1	91.3	91.1	90.8	90.1	89.1	87.6
	-0.5	86.1	87.6	88.6	89.2	89.6	89.7	89.6	89.2	88.6	87.6	86.1
Column Average	=	88.4	89.9	90.9	91.6	92.0	92.1	92.0	91.6	90.9	89.9	88.4

Peak Reading = 93.6 Overall Average = 90.7 Average/Peak = 96.9% Corner/Peak = 92.0%

Attachment 5.3
OUTPUT DATA SUMMARY FROM QAD-CGGP RUNS

Average Gamma Dose Rate (mrad/uCi-hr) @ 0.500 cm Depth

Receptor Coordinates (cm)		X: -0.5	-0.4	-0.3	-0.2	-0.1	-0.0	0.1	0.2	0.3	0.4	0.5
	0.5	24.5	25.3	26.0	26.4	26.6	26.7	26.6	26.4	26.0	25.3	24.5
	0.4	25.3	26.2	26.8	27.3	27.3	27.6	27.3	27.3	26.8	26.2	25.3
	0.3	26.0	26.8	27.5	28.0	28.2	28.3	28.2	28.0	27.5	26.8	26.0
	0.2	26.4	27.3	28.0	28.4	28.7	28.8	28.7	28.4	28.0	27.3	26.4
	0.1	26.6	27.5	28.2	28.7	29.0	29.1	29.0	28.7	28.2	27.5	26.6
Y	-0.0	26.7	27.6	28.3	28.8	29.1	29.2	29.1	28.8	28.3	27.6	26.7
	-0.1	26.6	27.5	28.2	28.7	29.0	29.1	29.0	28.7	28.2	27.5	26.6
	-0.2	26.4	27.3	28.0	28.4	28.7	28.8	28.7	28.4	28.0	27.3	26.4
	-0.3	26.0	26.8	27.5	28.0	28.2	28.3	28.2	28.0	27.5	26.8	26.0
	-0.4	25.3	26.2	26.8	27.3	27.3	27.6	27.3	27.3	26.8	26.2	25.3
	-0.5	24.5	25.3	26.0	26.4	26.6	26.7	26.6	26.4	26.0	25.3	24.5
Column Average	=	25.8	26.7	27.4	27.9	28.1	28.2	28.1	27.9	27.4	26.7	25.8

Peak Reading = 29.2 Overall Average = 27.3 Average/Peak = 93.4% Corner/Peak = 83.9%

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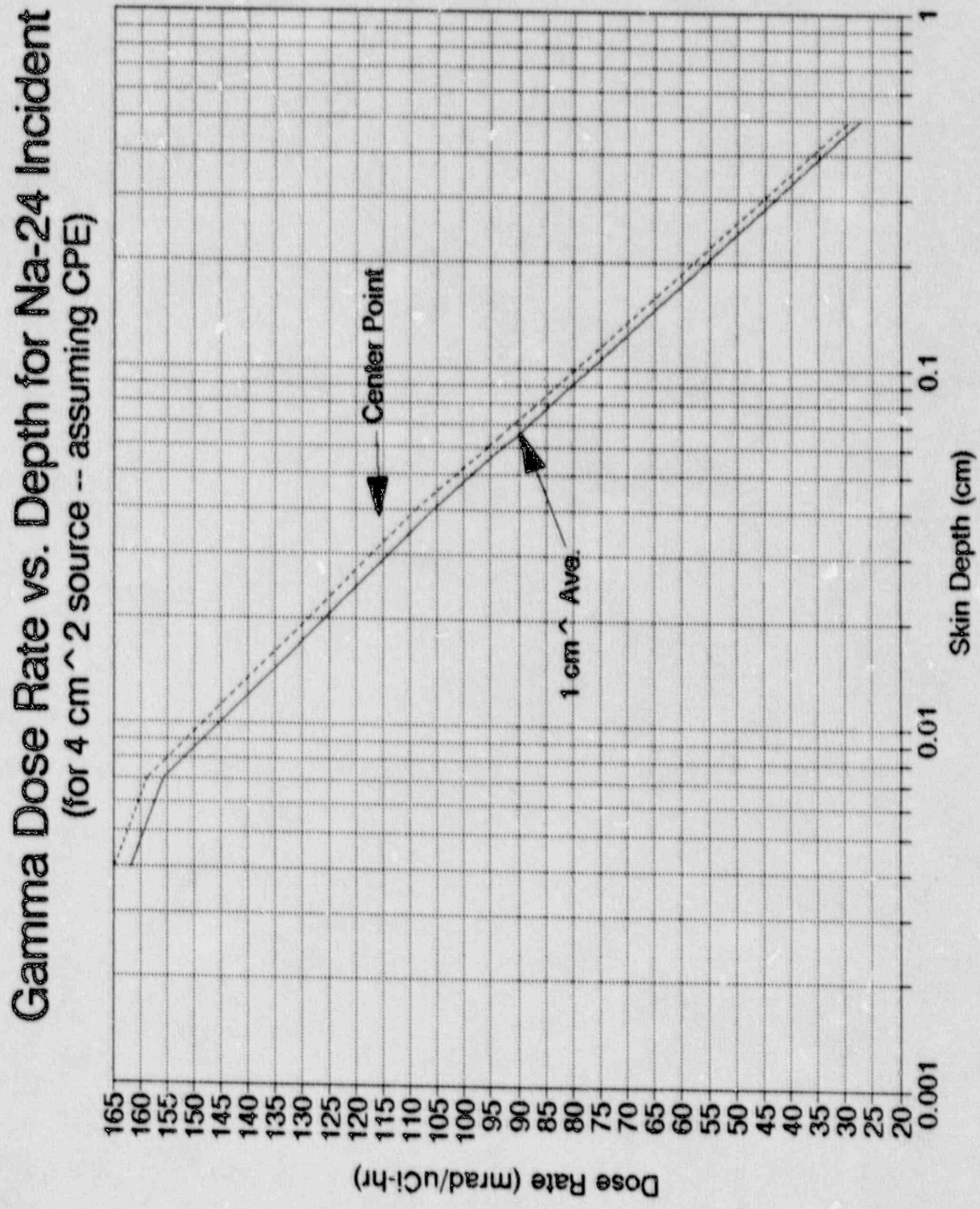
Attachment 5.4



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Attachment 5.5
PRELIMINARY RESULTS OF NON-CHARGED PARTICLE EQUILIBRIUM DOSE RATE CALCULATIONS PERFORMED BY THE UNIVERSITY OF WISCONSIN MEDICAL PHYSICS DEPARTMENT USING THE EGS4 MONTE-CARLO COMPUTER CODE

1.0 In the body of this report it is acknowledged that the dose rates calculated represent conservative estimates of the actual γ dose received. This is mainly due to the fact that the computer code used to perform the calculations assumes that charged particle equilibrium exists in the absorber materials. In fact, due to the extremely short source to receptor distances involved in the subject incident. this is not a valid assumption. A review of current literature revealed that there was no simple approach to correcting this limitation.

2.0 As part of the review effort, PCI contacted Dr. Herbert Attix, author/editor of several noted texts on dosimetry. Dr. Attix, who is currently on the faculty of the University of Wisconsin (UW), referred us to one of his associates, Dr. Thomas R. Mackie to provide asssistace. Dr. Mackie, a medical health physicist, is actively engaged in work related this problem. Dr. Markie indicated that they had a computer code available, EGS4, that could be used to perform the desired calculations.

3.0 EGS4 is a Monte-Carlo code developed at the Stanford Linear Accelerator Center which can be used to describe the transport of γ rays and the resulting scattered electrons through material. The code has been ported to a Sun® workstation at UW and required run times in the neighborhood of 12 hrs. to perform the desired calculations.

4.0 The preliminary results of the UW calculations indicate that the dose at 0.005 cm depth is ~15% of the dose at 0.200 cm depth (13.32 mrad/μCi-hr at 0.005 cm vs. 68.6 mrad/μCi-hr at 0.200 cm). Table 1 is a printout of the output data (in 10^{-12}Gy/cm^2/dis.) and Figure 1 is a plot of the resultant data. These preliminary results indicate that the γ dose rate calculated by QAD-CGGP at 0.004 and 0.007 cm may be high by a factor of 10 when charged particle equilibrium is accounted for.

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EGS4 Simulation of Na-24 surface contamination

Absorbed dose per unit area per unit decay. **Units: Gy x E(-12)/cm^2/disintegration**

A	B	C	D=B*C	E	F	G=E*F	H=(B+E)/2	I=H/2
Depth	1.369 MeV			2.754 MeV			Total Dose	Total Dose
cm	Data	Rel Error	Abs Error	Data	Rel Error	Abs Error	Uncorrected	Corrected *
0.005	1.0470	0.3550	0.3479	0.5850	0.3150	0.1855	1.56589	0.7845
0.015	1.1290	0.1900	0.2145	0.9804	0.2550	0.2500	2.1094	1.0647
0.025	1.6390	0.2150	0.3522	1.0970	0.2450	0.2688	2.7350	1.3878
0.035	2.3720	0.1570	0.3724	1.2020	0.1850	0.2272	3.5740	1.7870
0.045	2.7640	0.0580	0.1603	1.7240	0.1150	0.1983	4.4880	2.2440
0.055	2.2780	0.1380	0.3144	2.4480	0.1430	0.3501	4.7260	2.3630
0.065	2.6680	0.1050	0.2802	2.2620	0.1220	0.2760	4.9310	2.4655
0.075	1.9420	0.1300	0.5125	2.7450	0.0530	0.1455	6.6870	3.3438
0.085	4.2840	0.1340	0.5741	2.6960	0.0970	0.2615	6.9800	3.4900
0.095	3.7740	0.0860	0.3246	3.3150	0.1150	0.3812	7.0890	3.5445
0.105	4.8150	0.1020	0.4707	3.6990	0.1280	0.4735	8.3140	4.1570
0.115	5.3770	0.1340	0.7205	3.9530	0.0970	0.3834	9.3300	4.6650
0.125	5.6220	0.1250	0.7028	4.5390	0.1220	0.5538	10.1610	5.0805
0.135	5.3760	0.0800	0.4301	5.1330	0.1010	0.5184	10.5090	5.2545
0.145	5.6890	0.0760	0.4323	4.7810	0.0680	0.3251	10.4690	5.2345
0.155	5.2980	0.1100	0.5829	4.3650	0.0870	0.3798	9.6640	4.8320
0.165	5.3480	0.0720	0.4571	4.3630	0.0820	0.3578	10.7110	5.3555
0.175	5.1950	0.0740	0.3844	4.8370	0.0990	0.4789	10.0320	5.0160
0.185	5.3520	0.0930	0.3519	5.4640	0.0920	0.5027	10.7960	5.3980
0.195	5.2260	0.0720	0.3763	4.9560	0.0770	0.3816	10.1820	5.0910

* To reduce the calculation time, decaying photons from the contaminant on the phantom surface were forced to be directed initially into the phantom. Thus the dose per decay is on the average twice as large as would be calculated had the full 4π geometry been used and is accounted for in column I.

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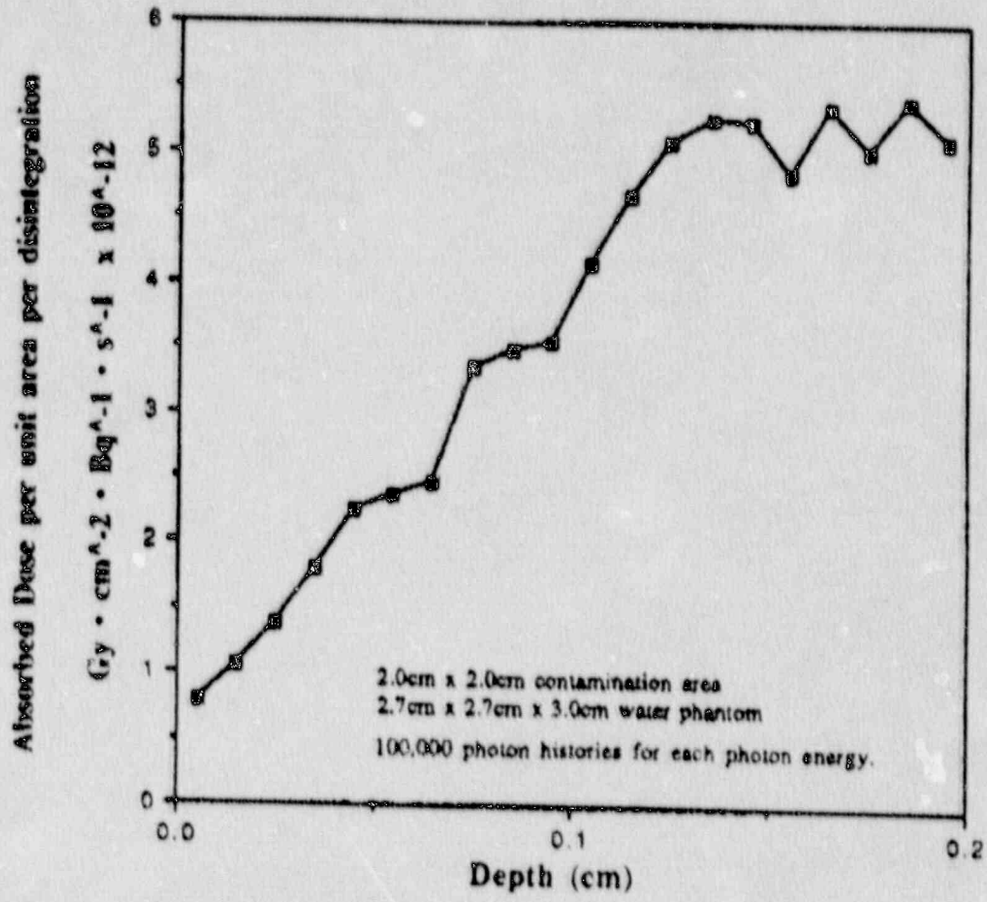
ATTACHMENT 5.5

FIGURE 1

Na-24 Depth Dose (EGS4)



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Radiological Protection and Environmental Services

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REPORT OF BETA-GAMMA DOSIMETRY ASSOCIATED WITH CONTAMINATION OF A WORKER'S THUMB AT THE JAMES A. FITZPATRICK NUCLEAR POWER PLANT

April 3, 1990

Prepared for:

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James A. FitzPatrick Nuclear Power Plant
New York Power Authority
Lycoming, New York 13093

Prepared by:

Sydney W. Porter, Jr. CHP
President

Reviewed by:

John Sykes III
Consultant Health Physicist

NOTE: Identification of Worker's names and Social Security Numbers are available to authorized personnel from NYPA

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REPORT OF BETA GAMMA DOSIMETRY ASSOCIATED WITH CONTAMINATION OF A WORKER'S THUMB AT THE JAMES A. FITZPATRICK UCLEAR POWER PLANT

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1.0 INTRODUCTION

On March 8, 1990, Worker P inadvertently contaminated his right glove and cross contaminated a 4 cm^2 area of the skin (pad) of the left thumb with ^{24}Na.

Porter Consultants, Inc. (PCI) was requested on 3/12/90 to perform an independent, in depth evaluation of the dose to the worker's left thumb due to the ^{24} Na contamination incident. On 3/13/90 Mr. Sykes of PCI performed a preliminary review of the initial on-site dose calculation. Mr. S.W. Porter, Jr., CHP, was requested to personally assess the situation and arrived in Oswego late on 3/13/90. Early on 3/14/90 Mr. Porter initiated an independent time and motion review of the circumstances before, during, and following the March 8, 1990 contaminating event. Mr. Porter then coordinated the preparation of special ^{24}Na calibration standards for recalibration of all instrumentation utilized in the dose assay. Mr. Porter personally calibrated the specific survey instruments utilized for the dose assessment. All documents generated by J.A. FitzPatrick Plant associated with this contamination incident (through 3/15/90) were carefully reviewed by Mr. Porter.

2.0 EXECUTIVE SUMMARY

2.1 Our most accurate dose assessment for Worker P is 16.335 rads β and .728 rads γ (total of 17.06 rads per cm^2) to the live tissue of the skin of the left thumb. This is the highest square centimeter dose to an area just under 64 mg/cm^2 of stratum corneum (dead skin). A special series of computer runs were performed to determine the gamma portion of the dose (Reference 1). The beta dose was calculated by both the Cross (Reference 2) and the VARSKIN (Reference 3) methods and indicated agreement to within a few percent.

2.2 The NRC on site inspection team (O'Connell and Chawaga) requested that the dose be calculated at a depth of 0.007 cm (7mg/cm^2). This dose is 48.2 rads β + 0.57 rads γ to yield a total of 48.8 rads per cm^2. For this contamination incident, it is biologically and anatomically inappropriate to calculate the dose to an area below only 7 mg/cm^2 of stratum corneum.

2.3 This dose to the skin of the left thumb is well below the threshold for any observable skin effects (Ref. 4). Medical personnel verified this by observing no first or second wave erythema (reddening of the skin) on Worker P.

2.4 The best estimate of the thickness of the dead layer of the skin is ~64 mg/cm^2 for the reasons given in Paragraph 3.5.

2.5 There was no significant absorption of ^{24}Na through the stratum corneum as demonstrated by the lack of ^{24}Na in both the whole body counts and the urine radiobioassay (Attachments 7.11, 7.12 and 7.13). Refer to paragraph 3.5 of this document for further information concerning penetration of $^{24}NaNo_3$ through the stratium corneum.

2.6 The most probable cause of this incident is a combination of worker error (not strictly following procedures), and incomplete worker training (failure to instruct workers concerning magnitude of hazards involved with the procedure).

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2.7 RECOMMENDATIONS

2.7.1 Review lessons learned from this incident with all operational and appropriate support personnel. (This includes a review of what should have been covered in the ALARA Pre-Plan Meeting for the ^{24}Na Feedwater Flow Test.)

2.7.2 All Health Physics and Chemistry Professionals and Senior Technicians should attend a Professional Enrichment Course concerning β hazards and associated β assay and dosimetry.

2.7.3 The Skin Decontamination Procedure (Personnel Decontamination RPP-2 of 3/6/89) should be revised to include the requirement to obtain medical permission to utilize agents other than soap, water and surgical scrubs (i.e. Potassium Permanganate/Sodium Bisulfate or stronger solutions). The "Medical Assistance" section should encourage the person having difficulty in decontaminating to obtain medical assistance.

3.0 REVIEW OF THE CIRCUMSTANCES CONCERNING THE CONTAMINATION INCIDENT

3.1 TIME AND MOTION STUDY

Mr. Porter interviewed Worker P, and then performed a time and motion study of the contaminating event to independently verify all of the times involved associated with the exposure of Worker P. A $^{24}Na\ NO_3$ solution vial, identical to that utilized on 3/8/90, was given to Worker P for the time and Motion Studies. The results of this debriefing are contained in Attachment 7.1.

3.2 INTERVIEW OF H.P. TECHNICIAN (WORKER B.A.) PERFORMING ASSAY AND CHEMICAL DECONTAMINATION OF WORKER P's LEFT THUMB

A lengthy interview of the H.P. Technician who performed the assays brought out many facts that were not completely documented at that time. At Mr. Porter's request, this Technician (Worker BA) documented all the points discussed in Attachment 7.2. This document includes two very helpful diagrams.

3.3 AREA OF CONTAMINATION ON LEFT THUMB

The determination of the total area of contamination was performed by Workers JS and MM. Attachment 7.3 resulted from debriefing these men. This documents the method and results of this survey (a 2 cm by 2 cm area of contamination on Worker P's left thumb pad).

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3.4 DOSE ASSESSMENT WORK SHEET

The Dose Assessment Work Sheet (Attachment 7.4) reflects all of the dose assays discussed in Attachments 7.1 and 7.2. This work sheet has been revised many times as better information became available. The most significant amendments were the survey meter specific calibration constants for a 2 cm x 2 cm ^{24}Na source and the point kernal calculation of the gamma dose.

3.5 ESTIMATING THE STRATUM CORNEUM THICKNESS OF WORKER P's LEFT THUMB AND DISCUSSION OF UPTAKE VIA SKIN ABSORPTION.

3.5.1 Dr. David D. O'Brien, Jr. estimated that the stratum Corneum for Worker P to be between 60 and 67.3 mg/cm^2 after decontamination efforts. Refer to Attachment 7.10 for a copy of his letter.

3.5.2 The lack of any detectable ^{24}Na in the bloodstream (whole body counts) demonstrates that there was no significant absorption of ^{24}Na through the stratum corneum. The minimum detectable quantity of ^{24}Na with a whole body count is 2 nanocuries. This is less than 1/1500 of the original ^{24}Na on the left thumb. Refer to Attachments 7.11 and 7.12.

3.5.3 The lack of ^{24}Na absorption through the stratum corneum to the blood stream is further demonstrated by the lack of any ^{24}Na in Worker P's urine. The urine sample was a composite taken from 2100 hours on 3/8/90 to 0600 hours on 3/9/90 and included the early morning voiding. The MDA for ^{24}Na is approximately 2 x 10^{-7} μCi/cc of urine for the 25 minute count utilized in the Liquid Bioassay count of Worker P's urine (Refer to Attachment 7.13).

3.5.4 Another fact that reinforces this point is that virtually all the ^{24}Na was removed within 2½ days. The total stratum corneum exfoliation time for the thumb pad is in excess of 20 days (Ref. 5). If significant penetration of the ^{24}Na into the 64 mg/cm^2 of the stratum corneum had occurred, then the decontamination could not have been complete in only 2½ days.

3.5.5 The horny layer of the thumb pad is practically impervious to low molecular weight electrolytes such as $NaNO_3$(according to Dr. A. Kleegman, Professor of Research Dermatology, University of PA Medical School) (Reference 11).

4.0 PREPARATION OF CALIBRATION STANDARDS AND SURVEY INSTRUMENT ASSAY FOR LEFT THUMB CONTAMINATION OF WORKER P

4.1 SPECIAL CALIBRATION STANDARDS

It was necessary to prepare two special ^{24}Na calibration sources that closely approximated the geometry of the contaminated left thumb. (Refer to Attachment 7.3.) One source was prepared on a round 2.5 cm diameter thin filter paper (4.9 cm^2). The other source was

prepared on a 2 cm x 2 cm square thin filter paper. A thin filter paper standard is preferable to a metal planchet because it more closely resembles the backscatter properties of the skin. The sources were given a preliminary γ spectrometry assay using an HPGe detector system on their day of preparation (3/14/90). Refer to Attachment 7.5. It became apparent that a special assay geometry needed to be established at a reasonable distance away from the sample. Thus, a 10 cm distance from the detector geometry was established on 3/15/90. Both ^{24}Na calibration standards were then counted, and the activity corrected for decay back to the time that all the assay instruments were calibrated with each of these two sources. The assay of both sources is 2.06 μCi of ^{24}Na on 1900 hours of 3/14/90. Refer to Attachment 7.6.

4.2 Calibration of Survey Instruments Utilized to Assay Thumb

Since the actual geometry of the 2 cm x 2 cm ^{24}Na contaminated area was somewhere between a square and a circle, it was decided to manufacture two sources (one round and one square), and to calibrate all assay instruments with both sources. The calibration of both the RSO-50 and the RO-5 Ion Chamber Survey Meters was performed on 3/14/90 by S. W. Porter, Jr. and G. J. Vargo together. Subsequent counting of the two Calibration Standards (Attachment 7.6) showed both sources to be 2.06 μCi at 1900 hours on 3/14/90. This data allowed accurate calculation of the specific response of the RSO-50 (Attachment 7.7) and of the RO-5 (Attachment 7.8). The digital response of the RO-5 open window was averaged over 20 measurements, and the closed window (which fluctuated less) was averaged over 10 measurements. The response of the two ion chamber survey meters utilized in the initial assays of Worker P, are as follows:

RSO-50 = 34.0 mrad/μCi-hr. at 1/8" open window
RO-5 = 41.6 mrad/μCi-hr. at 1/2" open window

The GM Tube Frisker (HP-210 Probe + Ludlum 177 Ratemeter)was calibrated on 3/14/90 with excessive dead time (>100,000 c/m) at the distances needed (contact and 0.5 inches). Thus, this calibration was delayed until 3/20/90 to allow enough decay for a reasonable calibration, unaffected by detector dead time. The calibration factor for the HP-210 Frisker is approximately 600,000 c/m/μCi (calculated on the basis of Attachment 7.9).

5.0 CONCLUSIONS

1. The effects of 17 (or even as much as 49) rads to a small area (4 cm^2)to the live skin of the thumb is radiobiologically insignificant. This was demonstrated by the lack of any medically observable effects (as per Dr. O'Brien's observations). The threshold for skin erythema is 200 to 300 rads for a human with very radiosensitive skin (Reference 4).

2. There was no systemic uptake of ^{24}Na into Worker P's body as demonstrated by both the Whole Body Counts and the Urine Radiobioassay (Attachments 7.11, 7.12 & 7.13).

3. The most likely dose to the live skin of Worker P's left thumb is 17.03 rads (beta and gamma)/cm^2 at 64 mg/cm^2 depth. The choice of a target area of 1 cm^2 for averaging dose to the skin, although current as to regulatory guidance, is highly questionable biologically. The

newest (February, 1990) draft recommendations of ICRP (Reference 6), which is a revision to ICRP 26, recommends averaging dose over 100 cm^2 of skin for non-stochastic effects. For stochastic effects, ICRP recommends averaging dose over the entire skin (Reference 6).

4. The choice of measuring dose at 64 mg/cm^2 comes from both the observations of Dr. O'Brien (Attachment 7.10) and the statement of a research dermatologist who specializes in skin absorption (Paragraph 3.5.5).

5. The beta dose calculations at 0.064 cm depth (64 mg/cm^2) from ^{24}Na deposited over 4 cm^2 of skin agree very well between the Cross methodology (Reference 2) and the Varskin Code (Reference 3). The gamma dose calculations at depths less than electronic equilibrium (~0.5 cm) are subject to some of interpretation. The assumption of electronic equilibrium in the QAD-CGGP Code (Reference 1) yields a conservatively high dose at depths less than 0.5 cm. The PCI dose calculations were run utilizing a source of 200,000 point kernals to smooth out point to point variations. The SLAC code EGS-4 was run so that lack of electronic equlibrium is taken into account.

6.0 REFERENCES

1. PCI-Technical Report 323, Calculation of Gamma Skin Dose for ^{24}Na Skin Contamination Incident, March 27, 1990.

2. Cross, W. G., Tables of Beta Dose Distribution, Atomic Energy of Canada Limited, Report AECL-2793, 1967.

3. Traub, R. J., Reese, W. D. et al, Dose Calculation for Contamination of Skin Using the Computer Code (VARSKIN),, NUREG-CR-4418, August, 1987, NRC, Washington, D. C.

4. C. S. Potten, Radiation and Skin, Published by Taylor and Frances, Philadelphia, 1985.

5. International Commission on Radiation Protection, Report #23, Report of the Task Group on Reference Man, 1974, published by Pergamon Press.

6. International Commission on Radiological Protection, Recommendations of the Commission - February, Draft, 1990, ICRP/90/G-01k, 1990-02-09.

7. NYPA, JAFNPP. Radiological Incident Report. RIR# 90-019. Dated: 3-8-90, 16:25.

8. NYPA, JAFNPP. Draft. Chronology of events for sodium-24 contamination incident.

9. NYPA, JAFNPP. Radiation Protection Operating Procedure. Personnel Decontamination. RPP-2 Rev 7. 3/6/89.

10. NYPA, JAFNPP. Memo dated 3/15/90. From: George J. Vargo. To: File. Subject: Extremity dose assessment - OR-90-057/RIR-90-19.

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11. Private communication between Dr. Kleegman and S. W. Porter, Jr. on 3/22/90.

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Attachment 7.1

3/14/90 SWP Notes

DEBRIEFING OF WORKER P

(H.P. Tech, 6 years of H.P. experience at FitzPatrick Plant, Nuclear Navy ELT for 6 yrs.)

Contaminating Event

16:05 hours on 3/8/90

Personnel Dosimetry

Ring TLD on inner ring fingers of both hands, plus a Panasonic 4 element TLD on chest next to a direct reading dosimeter (DRD).

TLD left hand 51 mR
(chip wet) dried in dessicant for 1.5 days

TLD right hand 1.2 mR?
(chip wet) dried in dessicant for 1.5 days

chest TLD (30 mR prior) 50 for job (Total of 80).
DRD was 5 mR (The walls of the DRD absorb essentially all β radiation from ^{24}Na.

Time and Motion Study Results for Capping Procedure

4 sec. at 1.5 R/hr
gives approx. 1.2 mR while capping ^{24}Na vial with right hand

Overall Timing After Contaminating Event

3/8/90

16:05 (within 1 min. of contaminating event) - exit work area.
16:10 went through portals - alarm
16:11 finished with HP 210 probe - alarmed for left hand.
16:13 shower (pocket of pants contaminated, socks contaminated), minor contamination at hand fingers
16:25 shower, hand decon
17:15 decon
} numbers at ½" from detector

3/9/90

06:15 Frisked - RO-5 S/N 69 - by self (Worker P)
10:00 Frisked - RO-5 S/N 69 - by H.P. Supvsr J.S.
12:05 Frisked - RO-5 S/N 69 - by self (Worker P)
15:00 Frisked - RO-5 S/N 69 - by self (Worker P)

3/10/90

all measurements by self Worker P Decons with #1 Ivory bar soap.

S.W. Porter, J.

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Attachment 7.2

3/15/90

WORKER P'S CONTAMINATION INCIDENT of 3/8/90

Incident Recall by Worker B.A. (x6738)

Incident began 16:25 hrs.

- Commenced initial survey and encountered several problems;
- The cross contamination of my left hand from the frisker handle. My left hand palm was contaminated to 1800 cpm at this time. I just put gloves on to continue the survey and deconned the handle.

NOTE:At this time the H.P. shift technician N. S. and the H.P. technician covering the job, P.D., commenced a detailed survey of all applicable areas involved in this event.

- The level of contamination required that I utilize an RSO-50 (serial number 616) instead of the hand held frisker to complete the survey.
- Surveyed the clothing and found multiple contamination locations (See attached figure).
- Instructed Worker P to remove pants, shoes, and socks.
- Performed a survey of the skin on Worker P's left thigh.

  The dose rate on the skin exceeded the dose rate on his pants.
- Instructed Worker P to remove all of his clothing. Finger rings taken for decon 1625-1630 hrs.
- Performed a survey on the skin of his whole body using the hand held frisker, excepting those areas where the frisker was off scale. The RSO-50 was used for those cases where the frisker was off scale.

The results are as follows to the best of my recall:

- Area 1 Worker P's left thumb 120 mrad/hr open window uncorrected, 4.0 mr/hr closed window. To about 50,000 cpm on the finger tips of the left hand.
- Area 2 Worker P's right finger tips and thumb were contaminated to about 12,000 cpm.
- Area 3 Worker P's left thigh 20 mrad/hr open window (uncorrected), 1.7 mr/hr closed window.
- Area 4 Worker P's left waist about 4,000 cpm.
- Area 5 Worker P's left mid chest about 6,000 cpm.
- There was no facial contamination.

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Attachment 7.2

This survey was brief and only to obtain an overall picture of the total extent of the contamination. I felt that at this time (1630 to 1635) that an initial decon should begin immediately. These initial contamination readings were taken at about 1/8" from the zone of contamination. While Worker P was in the shower, I deconned my left palm and verified that the decon area and frisker was not contaminated.

The first shower was completed at about 1640 (cool water and soap the decon agent)
Results after the shower as follows:
All main body contamination was deconned to less than 100 cpm (areas 3, 4, 5 of attached figure). This was verified by having Worker P use the portal (hands out outside the portal) with H.P. Supervisor J.S. and myself being the hands.

No noticeable change on Worker P's hands at this point.

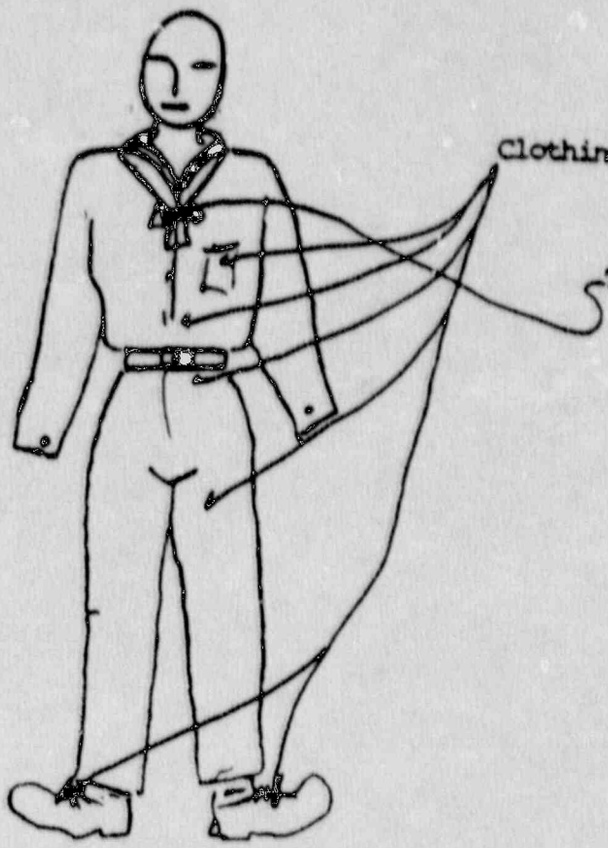
At this time 1645 to 1700 hrs, Worker P deconned his hands with soap, water, and soft nail brush. Between the three washings no appreciable drop in dose rates on the hands. Major contamination (area 1) was still at about 90 mrad/hr open window uncorrected using the RSO-50. Worker P's hands prior to decon start were very reddened and chapped from working out of doors at home and still looked that way. The only exception was that the callused areas were softening up.

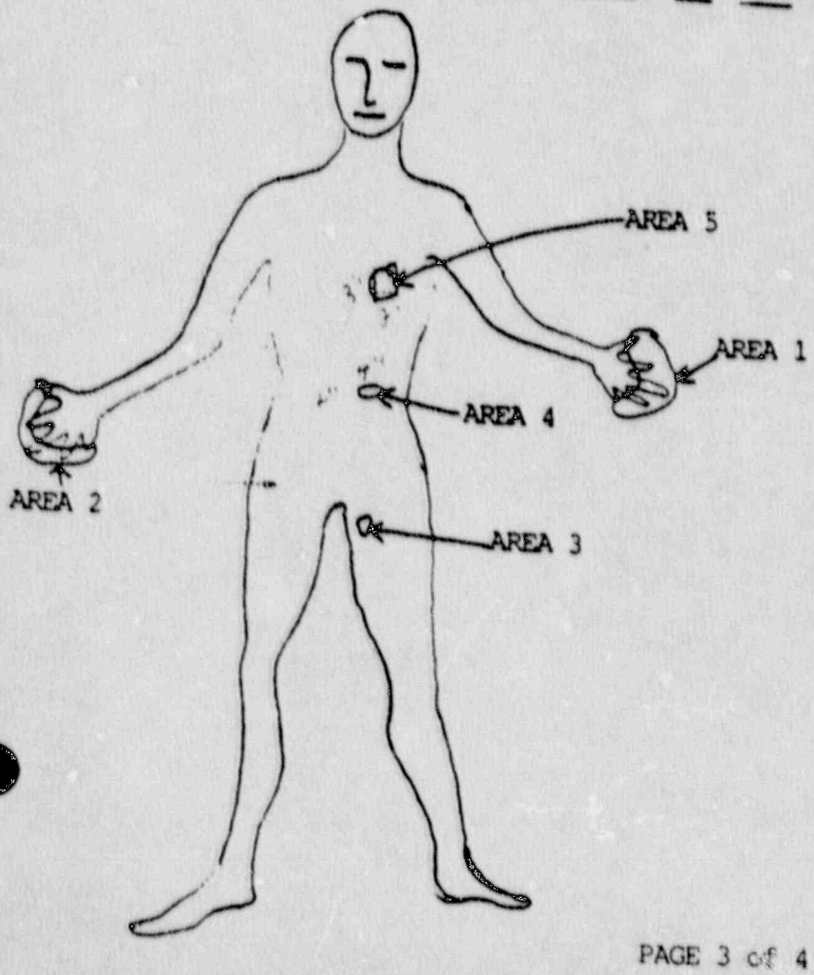
At about 1810 hrs. with H.P. Supervisor J.S. reading PDP-11 (DOSE ASSESSMENT) to me, I switched the instrument for dose rates to an RO-5 with " collar in place (serial no. 69 used) to be able to use the procedure correctly. To survey Worker P's thumb and verify the dose rate at ", I had a second person (J.S. or T.B.) verify the distance was properly maintained. The dose rate was 48 mrad/hr open window (uncorrected) and 1.7 mr/hr closed window. The finger tips of the hands stayed about the same. But I did not think to shield Worker P's thumb so these results were questionable.

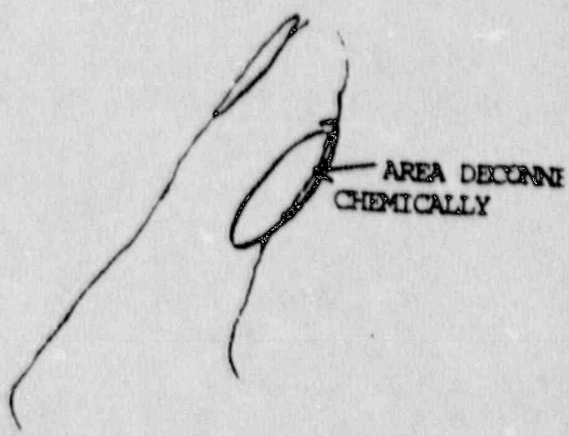
From around 1830 to 1930 hrs. Worker P soaked his hands in a solution of saturated NaCl solution to attempt an ion exchange. During the process I periodically checked his hand with no evident change. The solution in the beaker did have a dose rate of 20 - 30 cpm by frisker when this attempt at decon stopped.

At 1930 to 2030 hrs. with no evident results from previous decons on the hands, I used the unshielded probe from an E-530 to locate the main dose area of Worker P's left thumb. This area (see figure) of skin was in good condition and after discussing it with Supervisor, decided to decon the area using Potassium Permangenate and Bisodium Sulfate. After completion of this decon process, the skin was in good condition and the dose rate of 40 mrad/hr open window (uncorrected) with the RO-5 at ". With this minor decrease, considering the half life of the isotope and the potential chemical damage to Worker P's thumb, we stopped the decon attempts. At 20:30 hours, 2000 to 3000 c/m remained on tips of right finger.

(signed) B.A.

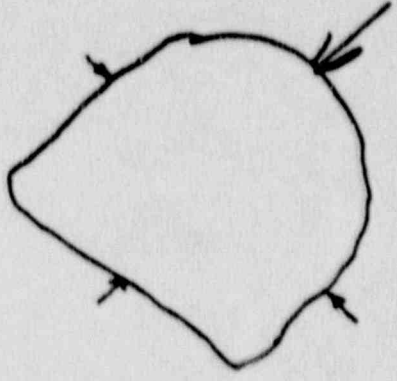

Clothing contamination areas
Tops of dosimitry also contaminated


AREA 5
AREA 1
AREA 4
AREA 2
AREA 3


AREA DECONNI
CHEMICALLY

[redacted] thigh area was contaminated in a [redacted] manner about 1"-2" below the base of his pocket.

Just about this size and shape



Scott was wearing cords

3.5cm x 3.5cm [redacted]

From the time of survey to shower was ≤ 10 mins [redacted]

80 000 cpm

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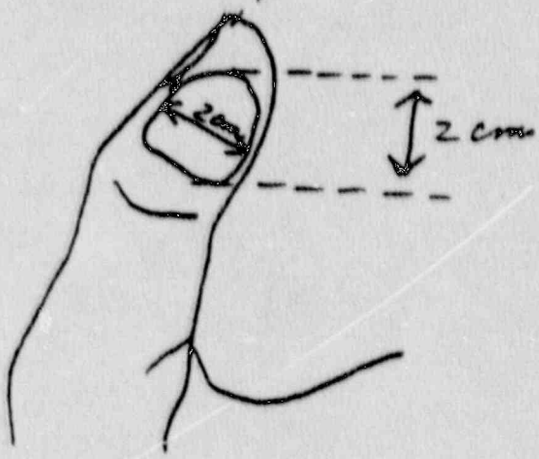
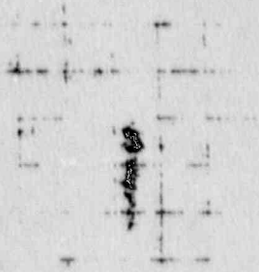
ATTACHMENT 7.3

3/10/90 @ 1000 hours

Using a [redacted] model 177 frisker and the hot particle collimator the contaminated area of (WORKER P's) thumb (left thumb) was defined as the following diagram:





SIGNED:
MM
JS

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Attachment 7.4

DOSE ASSESSMENT: RES TECHNICIAN Na-24 CONTAMINATION EVENT

t1/2	15.03 hr
lambda	0.046 1/hr
te	21.64 hr

Dose Constants:	Varskin	Gamma @ 0.007 cm	Varskin	Gamma @ 0.064 cm
	2.205	0.156 rad/uCi-hr	0.747	0.091 rad/uCi-hr

Date	Time	DT hr	Cum hr	OW mrad/hr	GM cpm	Ion Ch Act uCi	uCi-hr	Instrument Used
03/08	16:05	NA	NA	NA		NA	NA	
03/08	16:25	0.33	0.3	120		3.531	1.18	RSO-50
03/08	17:15	0.83	1.2	90		2.649	2.21	RSO-50
03/08	18:10	0.92	2.1	48		1.154	1.06	RO-5
03/08	19:30	1.33	3.4	48		1.154	1.54	RO-5
03/08	20:30	1.00	4.4	40		0.961	0.96	RO-5
03/08	21:00	0.50	4.9	34		0.817	0.41	RO-5
03/08	22:00	1.00	5.9			0.780	0.78	
03/08	23:00	1.00	6.9			0.745	0.75	
03/08	24:00	1.00	7.9			0.712	0.71	
03/09	01:00	1.00	8.9			0.679	0.68	
03/09	02:00	1.00	9.9			0.649	0.65	
03/09	03:00	1.00	10.9			0.620	0.62	
03/09	04:00	1.00	11.9			0.592	0.59	
03/09	05:00	1.00	12.9			0.565	0.57	
03/09	06:00	1.00	13.9			0.540	0.54	
03/09	07:00	1.00	14.9			0.515	0.52	
03/09	08:00	1.00	15.9			0.492	0.49	
03/09	09:00	1.00	16.9			0.470	0.47	
03/09	09:30	0.50	17.4	18	120,000	0.433	0.22	
03/09	10:30	1.00	18.4			0.413	0.41	
03/09	12:05	1.58	20.0	14	80,000	0.336	0.53	
03/09	13:00	0.92	20.9			0.321	0.29	
03/09	14:00	1.00	21.9			0.307	0.31	
03/09	15:00	1.00	22.9			0.293	0.29	
03/09	16:00	1.00	23.9			0.280	0.28	

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03/09	17:00	1.00	24.9			0.267	0.27
03/09	18:00	1.00	25.9			0.255	0.26
03/09	19:00	1.00	26.9			0.244	0.24
03/09	20:00	1.00	27.9			0.233	0.23
03/09	21:00	1.00	28.9			0.222	0.22
03/09	22:00	1.00	29.9			0.212	0.21
03/09	23:00	1.00	30.9			0.203	0.20
03/09	24:00	1.00	31.9			0.193	0.19
03/10	01:00	1.00	32.9			0.185	0.18
03/10	02:00	1.00	33.9			0.176	0.18
03/10	03:00	1.00	34.9			0.168	0.17
03/10	04:00	1.00	35.9			0.161	0.16
03/10	05:00	1.00	36.9			0.154	0.15
03/10	06:00	1.00	37.9			0.147	0.15
03/10	07:00	1.00	38.9	4.5	60,000	0.108	0.11
03/10	08:00	1.00	39.9			0.103	0.10
03/10	09:00	1.00	40.9			0.099	0.10
03/10	10:00	1.00	41.9			0.094	0.09
03/10	11:00	1.00	42.9			0.090	0.09
03/10	12:00	1.00	43.9			0.086	0.09
03/10	13:00	1.00	44.9			0.082	0.08
03/10	14:00	1.00	45.9			0.078	0.08
03/10	15:00	1.00	46.9			0.075	0.07
03/10	16:00	1.00	47.9			0.071	0.07
03/10	17:00	1.00	48.9			0.068	0.07
03/10	18:00	1.00	49.9			0.065	0.07
03/10	19:00	1.00	50.9			0.062	0.06
03/10	20:00	1.00	51.9			0.059	0.06
03/10	21:00	1.00	52.9			0.057	0.06
03/10	22:00	1.00	53.9			0.054	0.05
03/10	23:00	1.00	54.9			0.052	0.05
03/10	24:00	1.00	55.9			0.049	0.05
03/11	01:00	1.00	56.9			0.047	0.05
03/11	02:00	1.00	57.9			0.045	0.05
03/11	03:00	1.00	58.9			0.043	0.04
03/11	04:00	1.00	59.9			0.041	0.04
03/11	05:00	1.00	60.9			0.039	0.04
03/11	06:00	1.00	61.9			0.037	0.04
03/11	07:00	1.00	62.9			0.036	0.04

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03/11	08:00	1.00	63.9			0.034	0.03
03/11	09:00	1.00	64.9	0.6	6,000	0.014	0.01

Ultimate Decay [D(0)*1.44T] = 0.312

uCi-hr = 21.867 using ion chamber data

Ion chamber calibration data

	OW	CW	net	BCF
RO-5A #69	77.8	2.8	75.0	2.9
RO-5A #108	77.0	2.5	74.5	2.9
RSO-50 #617	44.0	2.0	42.0	4.0
RSO-50 #602	60.0	2.0	58.0	3.6

Na-24 counting standard

Counting time	03/10/90	19:25	32942.80	
Sampling time	03/10/90	19:25	32942.80	
		DT	0.00	
Correction factor			1.00	
Measured activity			2.125	uCi
Corrected activity			2.125	uCi

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Ion chamber correction factors obtained 03/14/90

RSO-50 S/N 616 Source-Cham Dist	Uncorrected mR/uCi-hr OW	CW	OW	CW
0.125 in	70	3	34	1.5
0.500 in	55	2	27	1.0

Round source 0.5 in OW mR/hr	CW mR/hr	Square source 0.5 in OW mR/hr	CW mR/hr	RO-5 S/N 69
86.2	2.1	85.6	2.1	0.500
86.2	2.1	85.5	2.2	
86.7	2.3	84.8	2.1	
86.5	2.2	85.3	2.1	
86.4	2.2	84.9	2.1	
86.6	2.2	84.7	2.1	
86.7	2.3	84.2	2.2	
86.7	2.3	85.0	2.2	
86.8	2.1	84.5	2.0	
86.0	2.0	84.6	2.3	
86.8		84.8		
86.9		84.2		
86.5		84.8		
86.4		84.2		
86.3		83.9		
87.1		83.6		
87.1		84.8		
87.7		84.1		
87.8		85.3		
87.0		84.8		
87.5				
X 86.8	2.2	X 84.7	2.1	

2.06 uCi
42.12 mrad/uCi-hr

2.06 uCi
41.11 mrad/uCi-hr

Average Instrument Response 41.61 mrad/uCi-hr

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Cumulated activity 21.867 uCi-hr

Depth cm	Beta rad	Gamma rad	Total rad/cm^2
0.007	48.216	3.411	51.628
0.064	16.335	1.990	18.324

New York Power Authority

CHEMISTRY LABORATORY REPORT

System/Sample I.D.: NA-24 ANALYSIS / INVESTIGATION

Sample Date/Time: 3/14/90 / Analyses Date/Time: 3/14/90 /

RESULTS:

NA-24 SOURCE 0.5 mL diluted to 1000.0 mL
9.27 uCi/mL ACTIVITY (SEE ATTACHED)
DECAYED TO SAMPLE DILUTION TIME
NA-24 SOURCE 0.3 mL ABSORBED / EVAPORATED ≅ 2.78 uCi
INTO 0.45 micron FILTER 2.5 cm DIAMETER ≅ 13.48
7.30 uCi/mL ACTIVITY (SEE ATTACHED) @ 17:05 hrs
DECAYED TO FINAL 0.100 mL PIPETTE ON TO
FILTER

NA-24 SOURCE 0.3 mL ON 2 cm SQUARE 3/14/90 @ 1712

	OPEN WINDOW	CLOSED	B⁻ CORRECT
RO5A #69	88.4 mRAD/HR	2.4 mR/HR	258 mRAD/HR
RSO-50 #622	60.0 mRAD/HR	2.5 mR/HR	224 mRAD/HR

NA-24 SOURCE 0.3 mL ON 2.5 cm DIAMETER 0.45 MICRON FILT. 3/14/90 @ 1741

	OPEN WINDOW	CLOSED	B⁻ CORRECT
RO5A #69	92.4	2.7	269.1 mRAD/HR
RSO-50 #622	60.0	3.0	229.3 mRAD/HR

WEIGHT OF (5) 10 × 10 cm SURGEON GLOVES 7.1320 gm
7.1320 ÷ 5 ≅ 1.4264 gm / SURGEON GLOVE 10 × 10 cm

Radiological and Environmental Services Department
James A. FitzPatrick Nuclear Power Plant

ATTACHMENT 7.6 PCI-TR-324

New York Power Authority

CHEMISTRY LABORATORY REPORT

System/Sample I.D.: UA24 ANALYSIS / INVESTIGATION

Sample Date/Time: 3/15/90 / _____ Analyses Date/Time: 3/15/90 /

3/15/90 - ANALYZED 0.3 ML ON RUNO FILTER AND
(A.M.) SQUARE FILTER ON #3 GELI USING FRESH
CALIBRATION ON 47MP SHELF 2 (10 CM)
WITH VARIOUS BASELINE COUNT TIMES. ANALYZED
FOR BOTH uCi/ml AND uCi/FILTER.

RESULTS

(1) FILTER PREPARED AT 1705 3/14 ~~RECOUNTED~~
RECOUNTED COUNT PERFORMED 3/14 @ 1807 WITH
NEW 47MP-2 EFF.

SAMPLE TIME: 13.48 hrs = 8.37 uCi
" 13.48 = 2.51 uCi/filter on 3/14
" 17.05 = 2.16 uCi/filter 3/14

(2) FILTER PREPARED AT 1705 3/14 RECOUNTED
- 3/15 @ 09:47 - 47MP-2 EFF.

SAMPLE TIME 13.48 = 8.88 uCi
" 13.48 = 2.66 uCi/filter
" 17.05 = 2.74 uCi/filter

(3) SQUARE FILTER PREPARED AT 17:12 3/14 COUNTED
3/15 @ 10:04

SAMPLE TIME 13.48 = 8.91 uCi
" 13.48 = 2.67 uCi/filter
" 17.05 = 2.29 uCi/filter
19:00 = 2.06 uCi/filter

SEE ATTACHED PRINTOUTS

ATTACHMENT 7.7

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[illegible]

PCI-FORM-12
Revision 0
February 15, 1988

CERTIFICATE OF CALIBRATION

TEST EQUIPMENT		INSTRUMENT INFORMATION	
Standard Source	Activity & Date		
① 2.5cm Round ^{24}Na Filter Paper Source	2.06uCi at 1900 hrs	Instrument Mfr.	BICRON
② 4 cm sq. ^{24}Na Filter Paper Source	2.06uCi at 1900 hrs	Model RSO-50	Serial No. 616
		External Probe NONE	Serial No. ---
		Cal. Procedure	SPECIAL

INSTRUMENT CALIBRATION INFORMATION

	Instrument Range	Calibration Standard Value	Instrument Response Per uCi Response	Cal.	Time of Cal.
1	① at 1/8" O W	2.06 uCi	34 mR/hr-uCi	70 mR/hr	1900 hrs 3/14/90
2	① at 1/8" C W	"	1.5 mR/hr-uCi	3 mR/hr	" "
3	① at 1/2" O W	"	27 mR/hr-uCi	55 mR/hr	" "
4	① at 1/2" C W	"	1 mR/hr-uCi	2 mR/hr	" "
5	② at 1/8" O W	"	34 mR/hr-uCi	70 mR/hr	" "
6	② at 1/8" C W	"	1.5 mR/hr-uCi	3 mR/hr	" "
7	② at 1/2" O W	"	30 mR/hr-uCi	62 mR/hr	" "
8	② at 1/2" C W	"	1 mR/hr-uCi	2 mR/h	" "
9					
10					
11					
12					
13					
14					
15					

Calculation of Results

ADDITIONAL TESTS

Type of Test	Results	Test Date	Next Test Due Date

Comments: Special calibration to determine the response of the RSO-50 to a contaminated (4 cm^2) thumb of a worker.

Instrument Calibrated by: S.W. Porter, Jr. and George Vargo

Calibration date: 3/14/90; 18:30 hrs to 19:30 hrs. Next Calibration due: N/A

Reviewed by: S.W. Porter, Jr. Date: 3/20/90

S.W. Porter, Jr., CHP

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215-896-5353

PCI-FORM-12
Revision 0
February 15, 1988

CERTIFICATE OF CALIBRATION

TEST EQUIPMENT		INSTRUMENT INFORMATION	
Standard Source	Activity and Date		
(1) Round 2.5 cm² ^{24}Na Filter Paper	2.06 uCi at 1900 hrs.	Instrument Mfr.	EBERLINE
		Model RO-5	Serial No. 69
(2) Square 4 cm² ^{24}Na Filter Paper	2.06 uCi at 1900 hrs	External Probe NONE	Serial No. ---
		Cal. Procedure	SPECIAL

INSTRUMENT CALIBRATION INFORMATION

3/14/90
Time of Cal. = 1900 hrs

	Instrument Range	Calibration Standard Value	Instrument Response Per uCi response	Cal.	
1	(1) at 1/2" CW	2.06 uCi ^{24}Na	42.1 mrem/hr-uCi	86.8 mR/hr	avg of 20 meas.
2	(1) at 1/2" CW	2.06 uCi ^{24}NA	1.1 mrem/hr-uCi	2.2 mR/hr	avg of 10 meas.
3	(2) at 1/2" CW	2.06 uCi ^{24}Na	41.1 mrem/hr-uCi	84.7 mR/hr	avg of 20 meas.
4	(2) at 1/2" CW	2.06 uCi Na	1.0 mrem/hr-uCi	2.1 mR/hr	avg of 10 meas.
5					
6					
7					
8					
9					
10					
11					
12					
13					
14					
15					

Calculation of Results

ADDITIONAL TESTS

Type of Test	Results	Test Date	Next Test Due Date

Comments: Special Calibration to determine the response of the RO-5 to a contaminated (4 cm²) thumb of a worker.

Instrument Calibrated by: S.W. Porter, Jr. and George Vargo

Calibration date: 3/14/90; 18:30 hrs to 19:30 hrs. Next Calibration due: N/A

Reviewed by: S.W. Porter, Jr., CHP Date: 3/20/90

Services Department

James A. FitzPatrick
Nuclear Power Plant

ATTACHMENT 7.9

PCI-TR-324

RECEIVED
MAR 2 1 1990
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New York Power Authority

CHEMISTRY LABORATORY REPORT

System/Sample I.D.: ^{24}Na COUNTING / CALIBRATION STANDARDS

Sample Date/Time: 3/14/90 / 1348 (STDS. PREPARED.) Analyses Date/Time: 3/20/90 / 1615

GM PROBE (HP-210) MEASUREMENTS TAKEN WITH LUDLUM MODEL 177 S/N 384

	GEOMETRY (COUNT RATE - cpm)				
STANDARD	①	②	③	④	
ROUND	1800	1500	180*	1050	
SQUARE	2100	1700	900	1050	
BACKGROUND	50	50	50	50	

① "CONTACT" WITH SOURCE ON BLOTTER PAPER ON LAB BENCH

② 0.125" (0.312 cm) DISTANCE W/O COLLIMATOR

③ 0.125" (0.312 cm) DISTANCE W/ 0.564 cm RADIUS COLLIMATOR.

④ 0.5" (1.27 cm) DISTANCE

* MULTIPLE ATTEMPTS GAVE SAME RESULT; CHECKED BOTH SIDES OF MYLAR - THIS VALUE REPRESENTS HIGHEST READING.

DECAY CORRECTION: SOURCES STANDARDIZED 3/14/90 @ 1900

ROUND SOURCE 2.06 μCi SQUARE SOURCE 2.06 μCi

DECAY FACTOR $\Delta t = 141$ hr $e^{-\lambda t} = 1.48E-3$

SOURCE ACTIVITIES:

ROUND 3.05E-3 μCi SQUARE 3.05E-3 μCi

NOTE - NO EVIDENCE OF CONTAMINATION IN SOURCE CONTAINERS (PETRI DISHES, WRAPPING, ETC.)

BY: G.J. VARGO, J.A. JOLINI, W. HAMBLIN

David D. O'Brien, M.D.
22 W. Oneida St.
Oswego, New York 13126

March 14, 1990

George J. Vargo, Ph.D.
New York Power Authority
James A. FitzPatrick Nuclear Power Plant
P.O. Box 41
Lycoming, New York 13093

Dear Dr. Vargo:

I have reviewed the contamination problem of WORKER P occuring on March 8, 1990, with regard to radioactive sodium 24 to his left thumb.

WORKER P has received considerable decontamination, according to your statement, and all evidence of contamination has been removed.

I examined WORKER P on March 13, 1990. My examination reveals markedly highly keratanization of both palms and thumbs. There is no evidence of physical injury, (including eyrethema). The left thumb has obviously been scrubbed considerably with removal of considerable amounts of keratinized layer, but continues to still have a very thick stratum corneum.

I have reviewed the reference tables in the Report of Task Group on Reference Man, ICRP Publication No. 23, pages 46-54.

It is clearly evident from the reference table No. 6, that WORKER P is at the high end of the stratum corneum layer (i.e. 673) and I would estimate his layer to be at least 600-673μm (even after decontamination efforts).

If I may be of further assistance to you, please contact me.

Very truly yours,

David D. O'Brien Jr., M.D.
Nuclear Medical Consultant
New York Power Authority

New York Power Authority J.A. Fitzpatrick Nuclear Plant
Whole Body Count VAX/VMS Dose Analysis Report V1.1

9-MAR-1990 13:06:19

Configuration : SYS$SYSDEVICE:[USER]POINTONSCOTT_LOWER.CNF;1
Analyses by : PEAK V15.2,PEAKEFF V2.2,ENBACK V1.3,NID V2.2,MINACT V2.0
Analyses by : WBCDOSE V1.1
Sample title : SPECIAL COUNT
Employee name : WORKER P
Employee ID num. : 139-38-1272 WBC ID number :
TLD badge number : 28 Seat height :
Uptake date : 9-MAR-1990 13:00:25 Acquisition date : 9-MAR-1990 13:00:25
Organ name : Lower Torso Operator initials: MTM
Detector name : Lower Torso Detector geometry: WBC Chair
Elapsed live time: 0 00:05:00.00 Elapsed real time: 0 00:05:00.16 0.1%
Sensitivity : 5.00 Gaussian : 50.00
Energy tolerance : 20.00 keV Half life ratio : 8.00

********** Lower Torso Results ********** NaI

Post-NID Peak Search Report

It	Energy	Area	Bkgnd	FWHM	Channel	Left	Pw	%Err	Fit	Nuclides
0	1434.00	510	246	73.43	179.71	159	39	8.4		

Whole Body Short Report

Lower Torso totals: 0.000E+00

********** Lungs Results ********** NaI

Post-NID Peak Search Report

It	Energy	Area	Bkgnd	FWHM	Channel	Left	Pw	%Err	Fit	Nuclides
0	1436.15	338	175152.39	179.09	159	37	10.6			

Whole Body Short Report

Lungs totals: 0.000E+00

********** Thyroid Results ********** NaI

Post-NID Peak Search Report
***** No peaks found *****

Mary Bolton (Detector) Chair Design

Whole Body Short Report

Name : WORKER P

Acquisition date : 9-MAR-1990 12:00:25

Thyroid totals: 0.000E+00

All organ totals : 0.000E+00

Reviewed by:

Mark Hollabaugh
Signature

3/13/90
Date

New York Power Authority J.A. Fitzpatrick Nuclear Plant
Whole Body Count W/X/YMS Dose Analysis Report V1.1

13-MAR-1990 07:15:33

Configuration : EVS$SYS:EV1CB.CUSTPROG]WBC_LOWER.CNF;1
Analyses by : PEAK V1.5,PEAKEFF V2.2,ENBACK V1.3,NID V2.2,MDMDT V2.0
Analyses by : WBCDOSE V1.1
Sample title : MAIN EXIT CLOTHED
Employee name : WORKER P
Employee ID num. : 139-38-1272 WBC ID number :
FID badge number : 39 Seat height :
Update date : 11-MAR-1990 07:09:37 Acquisition date : 13-MAR-1990 07:09:37
Organ name : Lower Torso Operator initials: RE
Detector name : Lower Torso Detector geometry: WBC Chair
Elapsed live time: 0 00:05:00.00 Elapsed real time: 0 00:05:00.15 0.0%
Sensitivity : 5.00 Gaussian : 50.00
Energy tolerance : 20.00 keV Half life ratio : 2.00

********** Lower Torso Results **********

Post-NID Peak Search Report

It	Energy	Area	Bkgnd	FWHM Channel	Left	Pw %Err	Fit	Nuclides
0	1444.70	464	244	64.15 180.24	159	42 9.0		K-40

Whole Body Short Report

Nuclide	Energy	Activity (uCi)	1-Sigma Error	1-Sigma % Error	%MPOB	Flg
K-40	1460.81	1.149E-01	1.036E-02	9.0	0.00	

Lower Torso totals: 1.149E-01

********** Lungs Results **********

Post-NID Peak Search Report

It	Energy	Area	Bkgnd	FWHM Channel	Left	Pw %Err	Fit	Nuclides
0	1477.13	142	91	40.79 186.45	177	24 14.9		K-40

Whole Body Short Report

Nuclide	Energy	Activity (uCi)	1-Sigma Error	1-Sigma % Error	%MPOB	Flg
K-40	1460.81	5.467E-02	8.162E-03	14.9	0.00	

Lungs totals: 5.467E-02

********** Thyroid Results **********

Post-NID Peak Search Report
***** No peaks found *****

Thyroid totals: 0.000E+00

All organ totals : 1.696E-01

Reviewed by:

Signature

Date

GDR/HP PEAK SEARCH RESULTS Version 2.1

New York Power Authority
J. A. FitzPatrick Nuclear Plant

WORKER P LIQUID BIO Analyzed by: BB
File ID: EXIT

Sampling Start Date:	03/09/90 10:53	Sampling Stop Date:	03/09/90 10:53
Sample Duration:	.00 Hrs	Sample Size:	1.000E+03 ml
Yield:	100.0000 %	Current Date:	03/09/90 11:19
Counting Start Date:	03/09/90 10:53	Live Time:	1500 sec
Decay time:	.00 Hrs	Clock Time:	1500 sec

Detector #: 4
Energy(keV)= 2.88E-01+ 9.98E-01*Ch+ 1.06E-06*Ch^2+ 0.00E+00*Ch^3 03/09/90 09:05

FWHM(kev) = 1.56E+00+-3.09E-02*En+ 1.40E-03*En^2+ 0.00E+00*En^3 11/06/89 08:24
(Where En=SQRT(Energy in keV))

PEAK SEARCH RESULTS

Peak Sensitivity: 2.00 Search Start/End: 0/2048

PK. #	ENERGY (keV)	CENTROID CHANNEL	NET COUNTS	UN-CERTAINTY	C.L. COUNTS	BKG COUNTS	CH IN PEAK	FWHM (keV)	FLAG

~ 24 hr wind

GDR/HP L I B R A R Y S E A R C H S U M M A R Y Version 2.1

WORKER P LIQUID BIO Reported by: BB
File ID: EXIT

Library File: . . . . . .LWJLIB.LIB (Liq. Filter & Filtrate Isotopic Lib)

LIBRARY SEARCH RESULTS

Library Match Resolution 2.00

PK. #	ENERGY (keV)	NET COUNTS	ISOTOPE	EXPECTED NET CNTS	% OF PKS. FOUND	% ABN. FOUND	SCORE	FLAG

03/09/89 11:17 BB Page 3.F4

GDR/MP MUCLIDE ANALYSIS SUMMARY Version 2.1

New York Power Authority
J. A. FitzPatrick Nuclear Plant

WORKER P) LIQUID BIO Reported by: BB
File ID: EXIT

Library File: . . . . . .LWJLIB.LIB (Liq. Filter & Filtrate Isotopic Lib)
MPC/LLD File: . . . . . .LQSLLD.MPC (Soluble Liquid Filtrate Samples)

Detector #: 4
Efficiency File: . . . . . 1LLLSiD04.EFF (1 LITER POLY BOTTLE)

Eff.=1/(3.20E+00*En^-1.52E+00 + 1.07E+03*En^ 8.42E-01) 05/17/89 05:29
(Where En = Energy in MeV)

Nuclide	Group	Energy (keV)	MEASURED or MDA CONCENTRATION Concentration (uCi/ml)		Less-Than Level Conc	Peaks Found	LLD REQUIRED	LLD MET?
CE-144		133.54	< 8.83E-07	MDA	3.23E-07	0 of 1	5.E-05	Yes
CE-141		145.44	< 2.10E-07	MDA	8.96E-08	0 of 1	5.E-05	Yes
I-131		364.48	< 1.75E-07	MDA	6.21E-08	0 of 1	1.E-06	Yes
CS-137		661.65	< 1.58E-07	MDA	4.84E-08	0 of 1	5.E-07	Yes
MO-99		739.58	< 1.60E-06	MDA	4.52E-07	0 of 3	5.E-05	Yes
[illegible]-134		795.85	< 2.99E-07	MDA	8.80E-08	0 of 6	5.E-07	Yes
[illegible]-58		810.76	< 1.70E-07	MDA	7.51E-08	0 of 2	5.E-07	Yes
MN-54		834.83	< 2.01E-07	MDA	1.07E-07	0 of 1	5.E-07	Yes
FE-59		1099.22	< 4.98E-07	MDA	1.65E-07	0 of 2	5.E-07	Yes
ZN-65		1115.52	< 1.13E-07	MDA	1.80E-07	0 of 1	5.E-07	Yes
CO-60		1332.49	< 2.38E-07	MDA	1.63E-07	0 of 2	5.E-07	Yes

TOTAL MEAS. ACT. : 0.00E+00 +- 0.00E+00 uCi/ml

****

M P C C H E C K

MPC FILE: LQSLLD.MPC

****

Nuclide	uCi/ml	MPC	% MPC
TOTAL:	0.00E+00		0.00E+00

NEW YORK POWER AUTHORITY

JAFNPP TRAINING DEPARTMENT

FORMAL TRAINING HISTORY. AS OF: 9/22/88 PAGE: 1 JAF310

SCOTT WORKER P ←→ SSAN: 139-38-1272 DEPT: RES TRAINING CATEGORY: RADIATION & ENVIRONMENTAL TECHNICIAN TRAINING ITP#: 7 RANGE: 1/01/87 TO 12/31/87

COURSE TOPIC: RADIATION OVEREXPOSURE INCIDENT - CAUSES & CORRECTIVE ACTION
LESSON PLAN: URIR 87-43
OBJECTIVE: SEE ADDITIONAL TEXT
REFERENCE#: SEE ADDITIONAL TEXT
DESCRIPTION: SEE ADDITIONAL TEXT
INSTRUCTOR: VARIOUS
LOCATION: JAFNPP

FREQ: 1 EVAL: SAT PROG CODE: 10-7.7
DATES: 3/02/87
ATTND: 1.5 .0 .0 .0 .0
ABSNT: .0 .0 .0 .0 .0
GRAD1: SAT
GRAD2:
GRAD3:

COURSE TOPIC: MISSING CONTROL ROD ROLLER GUIDE BALL
LESSON PLAN: RES-JRES-87-086
OBJECTIVE: INFORM STAFF AND IMPROVE PERFORMANCE OF JOB TASKS
REFERENCE#: MEMO JRES-87-086, EAS 28-0387 LOST PARTS ANAL. OF CRD BALL
DESCRIPTION: REQUIRED READING
INSTRUCTOR: NONE
LOCATION: JAFNPP

FREQ: 1 EVAL: N/A PROG CODE: 10-7.11
DATES: 3/09/87
ATTND: .0 .0 .0 .0 .0
ABSNT: .0 .0 .0 .0 .0
GRAD1: N/A
GRAD2:
GRAD3:

COURSE TOPIC: RES DEPARTMENT PROCEDURES AND PROGRAMS ←
LESSON PLAN: RES-3-5-87
OBJECTIVE: INFORM STAFF AND IMPROVE JOB PERFORMANCE
REFERENCE#: RES-DSO-08 (REV.0) SUPERVISORY OVERSIGHT OF RADIOLOGICAL WRK
DESCRIPTION: REQUIRED READING
INSTRUCTOR: NONE
LOCATION: JAFNPP

FREQ: 1 EVAL: N/A PROG CODE: 10-7.11
DATES: 3/13/87
ATTND: .0 .0 .0 .0 .0
ABSNT: .0 .0 .0 .0 .0
GRAD1: N/A
GRAD2:
GRAD3:

COURSE TOPIC: RES DEPARTMENT PROCEDURES & PROGRAMS ASSIGNED 4-10-87
LESSON PLAN: RES-4-10-87
OBJECTIVE: INFORM STAFF AND IMPROVE JOB PERFORMANCE
REFERENCE#: AMMONIA OUTGASSING OF DRYWELL INSULATION DURING STARTUP
DESCRIPTION: REQUIRED READING
INSTRUCTOR: NONE
LOCATION: JAFNPP

FREQ: 1 EVAL: N/A PROG CODE: 10-7.11
DATES: 4/13/87
ATTND: .0 .0 .0 .0 .0
ABSNT: .0 .0 .0 .0 .0
GRAD1: N/A
GRAD2:
GRAD3:

COURSE TOPIC: ACCIDENT CHEMISTRY CONSIDERATIONS ←
LESSON PLAN: RES-34-4
OBJECTIVE: PER LP RES-34-4
REFERENCE#: CHEMISTRY RESPONSE TO EMERGENCY AND ABNORMAL EVENTS
DESCRIPTION:
INSTRUCTOR: R. J. DENEVE
LOCATION: JAFNPP

FREQ: 1 EVAL: N/A PROG CODE: 10-7.7
DATES: 4/27/87
ATTND: 8.0 .0 .0 .0 .0
ABSNT: .0 .0 .0 .0 .0
GRAD1: N/A
GRAD2:
GRAD3:

COURSE TOPIC: RCS CHEMISTRY TRANSIENTS ←
LESSON PLAN: RES-34-1
OBJECTIVE: PER LP RES-34-1
REFERENCE#: CHEMISTRY RESPONSE TO EMERGENCY AND ABNORMAL EVENTS
DESCRIPTION:
INSTRUCTOR: R. J. DENEVE
LOCATION: JAFNPP

FREQ: 1 EVAL: PASS PROG CODE: 10-7.7
DATES: 4/28/87
ATTND: 8.0 .0 .0 .0 .0
ABSNT: .0 .0 .0 .0 .0
GRAD1: 92
GRAD2:
GRAD3:

COURSE TOPIC: DOSIMETRY RECORDS, CALIBRATION & SPECIAL PURPOSE DOSIMETERS
LESSON PLAN: RES-25-3-6
OBJECTIVE: PER L.P. # RES-25-3 4 & 6
REFERENCE#:
DESCRIPTION:
INSTRUCTOR: J. V. WIEROWSKI
LOCATION: JAFNPP

FREQ: 1 EVAL: PASS PROG CODE: 10-7.2
DATES: 4/29/87 4/30/87
ATTND: 8.0 8.0 .0 .0 .0
ABSNT: .0 .0 .0 .0 .0
GRAD1: N/A 96
GRAD2:
GRAD3:

NEW YORK POWER AUTHORITY

JAFNPP TRAINING DEPARTMENT

FORMAL TRAINING HISTORY. AS OF: 9/22/88 PAGE: 2 JAF310

COTT WORKER P SSAN: 139-38-1272 TRAINING CATEGORY: RADIATION & ENVIRONMENTAL TECHNICIAN TRAINING
DEPT: RES ITP#: 7 RANGE: 1/01/87 TO 12/31/87

COURSE TOPIC: INSPECTION REPORT 50-333/87-07 ←
LESSON PLAN: RES-3-14-87 — FREQ: 1 EVAL: N/A PROG CODE: 10-7.5.6
OBJECTIVE: INFORM STAFF & IMPROVE PERFORMANCE — DATES: 6/15/87
REFERENCE#: NRC INSPECTION REPORT 50-333/87-07 — ATTND: .0 .0 .0 .0 .0
DESCRIPTION: REQUIRED READING — ABSNT: .0 .0 .0 .0 .0
INSTRUCTOR: SELF STUDY — GRAD1: N/A
LOCATION: JAFNPP — GRAD2:
GRAD3:

COURSE TOPIC: RES DEPT PROCEDURES & PROGRAMS ISSUED 3/25/87
LESSON PLAN: RES-3-25-87 — FREQ: 1 EVAL: N/A PROG CODE: 10-7.5.6
OBJECTIVE: INFORM STAFF & IMPROVE PERFORMANCE — DATES: 6/15/87
REFERENCE#: RPOP-01 (REV.4) REFUELING FLOOR RADIATION PROTECTION COVERA — ATTND: .0 .0 .0 .0 .0
DESCRIPTION: REQUIRED READING — ABSNT: .0 .0 .0 .0 .0
INSTRUCTOR: SELF — GRAD1: N/A
LOCATION: JAFNPP — GRAD2:
GRAD3:

COURSE TOPIC: RES DEPARTMENT PROCEDURES & PROGRAMS ASSIGNED 3-7-87
LESSON PLAN: RES-3-7-87 — FREQ: 1 EVAL: N/A PROG CODE: 10-7.11
OBJECTIVE: INFORM STAFF AND IMPROVE JOB PERFORMANCE — DATES: 6/15/87
REFERENCE#: SEE ADDITIONAL TEXT — ATTND: .0 .0 .0 .0 .0
DESCRIPTION: REQUIRED READING — ABSNT: .0 .0 .0 .0 .0
INSTRUCTOR: NONE — GRAD1: N/A
LOCATION: JAFNPP — GRAD2:
GRAD3:

COURSE TOPIC: RES PROCEDURES AND PROGRAMS ISSUED 6/11/87
LESSON PLAN: RES-6-11-87A — FREQ: 1 EVAL: N/A PROG CODE: 10-7.5.6
OBJECTIVE: INFORM STAFF AND IMPROVE PERFORMANCE — DATES: 6/15/87
REFERENCE#: SEE ADDITIONAL TEXT — ATTND: .0 .0 .0 .0 .0
DESCRIPTION: REQUIRED READING — ABSNT: .0 .0 .0 .0 .0
INSTRUCTOR: SELF STUDY — GRAD1: N/A
LOCATION: JAFNPP — GRAD2:
GRAD3:

COURSE TOPIC: RES PROCEDURES AND PROGRAMS ISSUED 6/11/87
LESSON PLAN: RES-6-11-87B — FREQ: 1 EVAL: N/A PROG CODE: 10-7.5.6
OBJECTIVE: INFORM STAFF AND IMPROVE PERFORMANCE — DATES: 6/15/87
REFERENCE#: SEE ADDITIONAL TEXT — ATTND: .0 .0 .0 .0 .0
DESCRIPTION: REQUIRED READING — ABSNT: .0 .0 .0 .0 .0
INSTRUCTOR: SELF — GRAD1: N/A
LOCATION: JAFNPP — GRAD2:
GRAD3:

COURSE TOPIC: RES PROCEDURES AND PROGRAMS ISSUED 6/11/87
LESSON PLAN: RES-6-11-87C — FREQ: 1 EVAL: N/A PROG CODE: 10-7.5.6
OBJECTIVE: INFORM STAFF AND IMPROVE PROFICIENCY — DATES: 6/15/87
REFERENCE#: SEE ADDITIONAL TEXT — ATTND: .0 .0 .0 .0 .0
DESCRIPTION: REQUIRED READING — ABSNT: .0 .0 .0 .0 .0
INSTRUCTOR: SELF STUDY — GRAD1: N/A
LOCATION: JAFNPP — GRAD2:
GRAD3:

COURSE TOPIC: AUXILIARY SYSTEMS CHEMISTRY/PLANT EFFLUENTS
LESSON PLAN: RES-EFFLUENTS — FREQ: 1 EVAL: PASS PROG CODE: 10-7.8
OBJECTIVE: EO'S 1 THRU 7 FROM RES-34-2, & ALL OF RES-35-2&3 — DATES: 7/20/87
REFERENCE#: SPDES PERMIT, RETS, RES-34-2, RES-35-2, RES-35-3 — ATTND: 8.0 .0 .0 .0 .0
DESCRIPTION: LECTURE, EXAM — ABSNT: .0 .0 .0 .0 .0
INSTRUCTOR: DENEVE — GRAD1: 92
LOCATION: JAFNPP — GRAD2:
GRAD3:

ATTACHMENT 7.14

NEW YORK POWER AUTHORITY — JAFNPP TRAINING DEPARTMENT

FORMAL TRAINING HISTORY. — AS OF: 9/22/88 — PAGE: 3 — JAF310

DOTT WORKER P — SSAN: 139-38-1272 — DEPT: RES — TRAINING CATEGORY: RADIATION & ENVIRONMENTAL TECHNICIAN TRAINING — ITP#: 7 — RANGE: 1/01/87 TO 12/31/87

COURSE TOPIC: CHEM LAB EXPLOSION
LESSON PLAN: RES-SER-10-87
OBJECTIVE:
REFERENCE#: INPO SER 10-87
DESCRIPTION: REQUIRED READING
INSTRUCTOR:
LOCATION: JAFNPP

FREQ: 1 EVAL: N/A PROG CODE: 10-7.11
DATES: 7/20/87
ATTND: .2 .0 .0 .0 .0
ABSNT: .0 .0 .0 .0 .0
GRAD1: N/A
GRAD2:
GRAD3:

COURSE TOPIC: RESIN INTRUSION INTO REACTOR COOLANT
LESSON PLAN: RES-SER-16-87
OBJECTIVE: RECOGNITION OF RESIN INTRUSION VIA WATER CHEMISTRY
REFERENCE#: INPO SER 16-87
DESCRIPTION: SELF-STUDY
INSTRUCTOR: N/A
LOCATION: JAFNPP

FREQ: 1 EVAL: N/A PROG CODE: 10-7.11
DATES: 7/20/87
ATTND: .6 .0 .0 .0 .0
ABSNT: .0 .0 .0 .0 .0
GRAD1: N/A
GRAD2:
GRAD3:

COURSE TOPIC: RADIATION PROTECTION STANDARDS & REGULATIONS ←
LESSON PLAN: RES-17-1
OBJECTIVE: PER LP RES-17-1
REFERENCE#: PER LP RES-17-1
DESCRIPTION: LECTURE
INSTRUCTOR: J. WIEROWSKI
LOCATION: JAFNPP

FREQ: 1 EVAL: PASS PROG CODE: 10-7.2
DATES: 7/22/87 7/23/87
ATTND: 3.2 7.0 .0 .0 .0
ABSNT: .0 .0 .0 .0 .0
GRAD1: N/A 100
GRAD2:
GRAD3:

COURSE TOPIC: THERMOLUMINESCENT DOSIMETER CALIBRATION
LESSON PLAN: RES-25-4-L1
OBJECTIVE: DEVELOP DOSIMETRY OPERATION SKILLS PER LP RES-25-4-L1
REFERENCE#: PER LP # RES-25-4-L1
DESCRIPTION: LABORATORY EXERCISE
INSTRUCTOR: J. WIEROWSKI
LOCATION: JAFNPP

FREQ: 1 EVAL: SAT PROG CODE: 10-7.2
DATES: 7/22/87
ATTND: 4.0 .0 .0 .0 .0
ABSNT: .0 .0 .0 .0 .0
GRAD1: N/A
GRAD2:
GRAD3:

COURSE TOPIC: MISSING CONTROL ROD ROLLER GUIDE BALL
LESSON PLAN: RES-JRES-87-086
OBJECTIVE: INFORM STAFF AND IMPROVE PERFORMANCE OF JOB TASKS
REFERENCE#: MEMO JRES-87-086, EAS 28-0387 LOST PARTS ANAL. OF CRD BALL
DESCRIPTION: REQUIRED READING
INSTRUCTOR: NONE
LOCATION: JAFNPP

FREQ: 2 EVAL: N/A PROG CODE: 10-7.11
DATES: 7/23/87
ATTND: .2 .0 .0 .0 .0
ABSNT: .0 .0 .0 .0 .0
GRAD1: N/A
GRAD2:
GRAD3:

COURSE TOPIC: REMOVAL OF PERMALI SHIELDING MATERIAL FROM N-1 AND N-2
LESSON PLAN: RES-MOD-F187009
OBJECTIVE: INFORM TECHNICIANS OF PLANT MODS AFFECTING RAD. PROTECTION
REFERENCE#: MOD PACKAGE F187009
DESCRIPTION: REQUIRED READING, DISCUSSION
INSTRUCTOR: J. WIEROWSKI
LOCATION: JAFNPP

FREQ: 1 EVAL: N/A PROG CODE: 10-7.11
DATES: 7/23/87
ATTND: .3 .0 .0 .0 .0
ABSNT: .0 .0 .0 .0 .0
GRAD1: N/A
GRAD2:
GRAD3:

COURSE TOPIC: INSPECTION REPORT 50-333/87-06 AND ENFORCEMENT ACTION
LESSON PLAN: RES-NRC-87-06
OBJECTIVE: INFORM PLANT STAFF
REFERENCE#: INSPECTION REPORT 50-333/87-06, ENFORCEMENT/VIOLATION 87-07
DESCRIPTION: REQUIRED READING
INSTRUCTOR: N/A
LOCATION: JAFNPP

FREQ: 1 EVAL: N/A PROG CODE: 10-7.11
DATES: 7/23/87
ATTND: .3 .0 .0 .0 .
ABSNT: .0 .0 .0 .0 .
GRAD1: N/A
GRAD2:
GRAD3:

Porter Consultants, Inc.
125 ARGYLE ROAD
ARDMORE, PA. 19003
215-896-5353

Attachment 7.15

DOSE TO RIGHT HAND OF WORKER P (a rough calculation)

A. General Data

1. Left thumb pad contamination of 3.5 μCi ^{24}Na was transferred during removing right hand glove with bare left hand. Left thumb most likely touched tip of right hand glove (thumb and right index finger) (Worker P Statement).

2. Highly contaminated right hand glove remained on right hand for about 5 minutes (Worker P Statement).

3. Worker P was wearing on right hand - cotton glove 10 mg/cm^2 (one)
surgeon's glove 14 mg/cm^2 (one)

4. Worker P right thumb pad stratium corneum is about same thickness as left thumb pad (64 mg/cm^2).

B. Calculations

1. Assume a conservative 5% transfer of contamination from right hand to left hand. Assume right hand thumb also had a contamination area of 4 cm^2.

2. Then right hand contained 70 μCi ^{24}Na for 5 minutes, or 3.5 μCi-hr.

3. From above A.3 and A.4 above, the total absorption over line skin is 10 + 14 + 64 = 88 mg/cm^2.

4. At 88 mg/cm^2 the dose rate conversation factor for beta dose is 2.95 rads/hr/μCi/cm^2. If this source is distributed over 4 cm^2, then this conversion factor becomes 0.74 rads/hr/μCi/cm^2.

5. $\therefore$ 3.5 μCi-hr x 0.74 rads/hr/μCi = 3 rads of beta. If one assumes 10% additional gamma dose, then the beta gamma = 3.3 rads to the right thumb pad (or fingertips).
(Note, if a dead layer thickness of only 7 mg/cm^2 is assumed, then this rough calculation of dose to right thumb becomes 3.5μCi-hr x 1.3 = 4.6 rads beta.

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ARDMORE, PA. 19003
215-896-5353

Attachment 7.16

DOSE TO GONADS FROM ^{24}Na CONTAMINATION ON LEFT THIGH OF WORKER P

A. General Data

1. Area of Contamination: 3.5 cm x 3.5 cm (thigh under front pocket)

2. Distance from center of contaminated area to closest external surface of gonad: 3 inches (7.62 cm).

3. Contaminated measurements at 16.25 hrs on 3/8/90 was : 20 mrad/hr open window with an RSO-50 survey meter, 1.7 mrad/hr closed window with an RSO-50 survey meter.

4. Time of contamination was not earlier than 16:05 hrs on 3/8/90
Time of complete decontamination was before 16:35 hrs on 3/8/90, ∴ assume a 0.5 hour residence time of the contamination on the thigh area.

5. The inherent shielding of the male gonad is 300 mg/cm^2.

B. Calculations

1. Total of μCi of ^{24}Na on thigh area = 0.6

2. 0.6μCi for 0.5 hr = 0.3 μCi-hr

3. Gamma Dose from ^{24}Na: Γ = 18.4 R-cm^2/hr - mCi, thus = 0.32 mR/μCi-hr.

4. Total gamma dose to closest gonad ≈0.1mrad

5. The beta dose to the sperm is calculated by assuming a 3 inch distance plus 300 mg/cm^2 inherent shielding.

6. The beta dose constant through 300 mg.cm^2 plus 3 inch distance = 0.09 rad/hr/μCi of ^{24}Na/cm^2.

7. The total beta dose = 0.3 μCi-hr x 0.09 rad/hr/μCi ≈27mrad.

8. Total beta-gamma dose to gonad is much less than 27 mrad (assumes all contamination is in a 1 cm^2 area of skin which is very conservative).