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SARAN-CHLOROPEL PLASTIC SUIT WORKER DOSE RATES FROM AIRBORNE TRITIUM EXPOSURE - FIRST EXPOSURE HOUR (U)

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WESTINGHOUSE SAVANNAH RIVER COMPANY

INTER-OFFICE MEMORANDUM

APRIL 20, 1993 ESH-HPT-93-0127

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SARAN-CHLOROPEL PLASTIC SUIT WORKER DOSE RATES FROM AIRBORNE TRITIUM EXPOSURE - FIRST EXPOSURE HOUR (U)

Introduction

Radiological Engineering was requested [1] to develop Tritium Stay Time Chart dose rates [2] for the 9 mil Saran-Chloropel (CPE) plastic suit for a period of one hour or less. Assumptions utilized in previous calculations [2] were revised to better address the first hour of exposure in the suit for emergency situations.

Summary/Recommendations

Based upon available empirical data [3] and the following discussion, Saran-CPE Suit Tritium Stay Time Chart dose rates are presented in the attached table. Since the millirem per minute values are based on only the first hour of exposure, this table should not be used in conjunction with stay times originally calculated [2]. This table must be used with extreme caution and careful consideration when estimating doses for high HTO air concentration exposures.

Limitations

Caution must be exercised in estimating stay times in HTO concentrations greater than 0.2 μCi/cc or 20,000E-05 μCi/cc. At concentrations greater than this value, the protection afforded by the Saran-CPE suit may be compromised. Performance testing at Los Alamos National Laboratory (LANL) [4] showed the fit factor (commonly refered to as the protection factor from in-leakage) for this suit to be 10,000 under laboratory test conditions. At HTO concentrations greater than 0.2 μCi/cc, individuals may be exposed to HTO concentrations in excess of a DAC due to in-leakage. Dose rate calculations used to develop the attached chart account for only HTO permeation of the suit, not HTO in-leakage.

The millirem per minute values are only valid during the first hour of exposure. After breakthrough occurs (at 95 minutes for the Saran-CPE suit), the protection afforded by the suit rapidly decreases by 77% within a 30 minute period.

In extremely high HTO air concentrations, sufficient egress air and possible suit tears must also be considered. The LANL performance

testing [4] showed that 1% of room air concentrations could be reached within the suit in 50 seconds after loss of breathing air. In extremely high HTO concentrations, this could mean dose rates in excess of 100 Rem/min if breathing air were to be lost.

Discussion

The original dose rates for the Saran-CPE suit were based on a "Saran Reduction Factor" (SRF). The original SRF of 6.3 was calculated as the ratio of the 12 mil PVC suit breakthrough time to the 9 mil Saran-CPE suit breakthrough time [2]. This SRF did not account for the difference in permeation rates prior to breakthrough of each suit.

To account for this difference, an average permeation rate for each suit, was calculated for the first hour of exposure prior to breakthrough of the Saran-CPE suit. The ratio of the average permeation rates for each suit were then applied to the 12 mil PVC suit dose rates to determine the 9 mil Saran-CPE suit dose rates.

Bases for the calculation of the revised dose rates follow in the Bases/Assumptions section. Additional information can be found in Radiological Engineering's Job Folder LTB0115.

Bases/Assumptions

The lower limit of detection for HTO during the permeability tests [3] was 0.006 μCi/ml. The area of the test material over which permeation takes place is 5.07 cm^2.

12 mil PVC Permeation Rate For 1st Hour of Exposure

Prior to 12 mil PVC suit breakthrough (BT), the average permeation rate is:

$$\frac{0.006\ \mu Ci}{ml} \times \frac{2\ ml\ chamber}{15\ min\ for\ BT} \times \frac{1}{5.07\ cm^2} \times \frac{60\ min}{1\ hr} = 9.47E\text{-}03 \mu Ci/cm^2\text{-}hr$$

After 12 mil PVC suit BT, the average permeation rate is 0.07 μCi/cm^2-hr [3].

The total permeation during the first hour is:

$$0.25hr(9.47E\text{-}03\mu Ci/cm^2\text{-}hr) + 0.75hr(0.07\mu Ci/cm^2\text{-}hr) = 5.49E\text{-}02\mu Ci/cm^2$$

9 mil Saran-CPE Suit Permeation Rate For 1st Hour of Exposure

Prior to 9 mil Saran-CPE suit BT, the average permeation rate is:

$$\frac{0.006\ \mu Ci}{ml} \times \frac{2ml\ chamber}{95\ min\ BT} \times \frac{1}{5.07cm^2} \times \frac{60\ min}{1\ hr} = 1.49E\text{-}03\ \mu Ci/cm^2\text{-}hr$$

The total permeation during the first hour is:

1 hr X 1.49E-03 $\mu Ci/cm^2$-hr = 1.49E-03 $\mu Ci/cm2$

SRF During 1st Hour of Exposure

$$SRF(1hr) = \frac{\text{12mil PVC permeation}}{\text{9mil Saran-CPE permeation}} = \frac{5.49E\text{-}02\ \mu Ci/cm^2}{1.49E\text{-}03\ \mu Ci/cm^2} = 36.85$$

This indicates that prior to breakthrough, the 9 mil Saran-CPE suit provides about thirty-seven times more protection than the 12 mil PVC suit. After breakthrough, this protection rapidly plummets to about a factor of two.

The Revised Stay Time Chart dose rates shown in the attached table assume the following:

- There is no leakage into the suit other than from permeation.
- Permeation of the suit begins immediately upon exposure to a HTO atmosphere.
- The surface area of the 12 mil PVC suit and the 9 mil Saran-CPE suit are equivalent.
- Personnel will be limited to 1 hour stay time or less when using this dose rate chart.
- Permeation is only for HTO vapor in contact with the suit. Permeability (and consequently the stay times) of the suit changes if the HTO contacts the suit in any other form (i.e. water, oil, Freon, etc.).
- Gloves on the suit are equivalent or less permeable to HTO than the suit material.
- A minimum air flow rate of 5-6 scfm is maintained during suit use. Calculations do not address additional dilution of suit air concentrations due to the increased volume of air supplied to the suit (18-20 scfm).

References

[1] Telecon between H. J. Stafford and L. T. Burckhalter on 4/19/93.
[2] ESH-HPT-93-0126, **Technical Bases For Plastic Suit Reduction Factors Against Airborne Tritium Exposure**, L. T. Burckhalter / E. J. Kvartek to A. S. Morrison, Rev. 1, 4/19/93.
[3] Chemical Permeation Report DCN: 86-256-047-01, **Tritiated Water and Mixtures Containing Tritiated Water Versus Four Suit Materials**, Radian Corporation, 2/19/86.
[4] **Savannah River Plant Airline-Type Supplied Air Tritium Suit**, Los Alamos National Laboratory.

Airborne Concentration uCi/cc	Airborne Concentration x E-5 uCi/cc	mrem/min*		
0.001	100	1.60E-04		
0.005	500	8.01E-04		
0.01	1000	1.60E-03		
0.02	2000	3.21E-03		
0.03	3000	4.83E-03		
0.04	4000	6.45E-03		
0.05	5000	8.08E-03		
0.06	6000	9.71E-03		
0.07	7000	1.13E-02		
0.08	8000	1.30E-02		
0.09	9000	1.46E-02		
0.1	10000	1.63E-02		
0.2	20000	3.31E-02		
0.3	30000	5.06E-02		
0.4	40000	6.86E-02		
0.5	50000	8.72E-02		
0.6	60000	1.06E-01		
0.7	70000	1.26E-01		
0.8	80000	1.47E-01		
0.9	90000	1.68E-01		
1	100000	1.90E-01		
2	200000	4.51E-01		
3	300000	8.03E-01		
4	400000	1.27E+00		
5	500000	1.89E+00		
6	600000	2.69E+00		
7	700000	3.72E+00		
8	800000	5.05E+00		
9	900000	6.74E+00		
10	1000000	8.89E+00		
20	2000000	9.86E+01		
30	3000000	8.21E+02		
40	4000000	2.05E+03		
50	5000000	2.56E+03		
60	6000000	3.07E+03		
63.2	**6320000**	3.24E+03		
NOTE: Kanne Monitors Overrange at 63.2 uCi/cc or 6,320,000E-5 uCi/cc				
5Q Limits: <10 rem Recover Victim, <25 rem Protect Health & Safety,				
<50 rem Reasonable Chance to Save a Life,50 - 100 rem Strong				
Probability to Save a Life, >100 rem Protect Life & Public Safety				
* - based on first hour of exposure				