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13. **Distribution:**  
    - (a) **Name:** E. E. Bickel, T6-06  
    - **MSIN:** T6-06  
    - (b) **Name:** O. D. Berglund, S7-83  
    - **MSIN:** S7-83
    - (a) **Name:** J. R. Bristol, S7-75  
    - **MSIN:** S7-75  
    - (b) **Name:** K. R. Swallow, S5-01  
    - **MSIN:** S5-01
    - (a) **Name:** J. D. Butler, S7-05  
    - **MSIN:** S7-05  
    - (b) **Name:** J. H. Huber, R2-58  
    - **MSIN:** R2-58
    - (a) **Name:** A. R. Cannell, R1-05  
    - **MSIN:** R1-05  
    - (b) **Name:** W. L. Duffy, R1-05  
    - **MSIN:** R1-05
    - (a) **Name:** E. W. Gray, T6-06  
    - **MSIN:** T6-06  
    - (b) **Name:** C. W. Landes, S5-67  
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Tank Operations Contractor Dollar Per Person-Rem Conversion Factor Technical Basis Document

W. L. Duffy, CHP
Washington River Protection Solutions, LLC.

Richland, WA 99352
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Abstract: This technical basis provides the Tank Operations Contractor (TOC) dollar per person-rem conversion factor to be used in required optimization analyses to assure that occupational exposure is maintained As Low As Reasonable Achievable (ALARA) in developing and justifying facility designs or modifications, development or review of work processes, and the design/purchase of special tools and equipment.

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Executive Summary

This technical basis provides the Tank Operations Contractor (TOC) dollar per person-rem conversion factor to be used in required optimization analyses to assure that occupational exposure is maintained As Low As Reasonable Achievable (ALARA) in developing and justifying facility designs or modifications, development or review of work processes, and the design/purchase of special tools and equipment. Utilizing the methodology described in PNNL-6577, the value specific for TOC use was determined to be $11,000 per person-rem.
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1.0 Introduction

This document provides the technical basis for the Tank Operations Contractor (TOC) dollar per person-rem conversion factor. This factor is to be used in required optimization analyses to assure that occupational exposure is maintained As Low As Reasonably Achievable (ALARA) in developing and justifying facility designs or modifications, development or review of work processes, and the design/purchase of special tools and equipment.

2.0 Regulatory Requirements

2.1 10 CFR 835, Occupational Radiation Protection

Subpart K, Section 1002 – Facility Design and Modifications:

During the design of new facilities or modification of existing facilities, the following objectives shall be adopted:

(a) Optimization methods shall be used to assure that occupational exposure is maintained ALARA in developing and justifying facility design and physical controls.

2.2 HNF-5183, Tank Farms Radiological Control Manual

Article 128 – Facility Modifications and Radiological Design Consideration:

1. Radiological control performance is affected by human performance and engineered design features. This Manual primarily addresses the way people operate and use existing facilities and sites. General design criteria for new facilities and modifications to existing facilities are contained in 10 CFR 835 and DOE O 420.1B, “Facility Safety”. In addition, the following radiological control design criteria shall [835.1002] be adopted for new facilities or modifications to existing facilities:

a. Optimization methods shall [835.1002(a)] be used to assure that occupational exposure is maintained ALARA in developing and justifying facility design and physical controls. [RPP # 216]

3.0 Regulatory Guidance

3.1 DOE G 441.1-1C, Radiation Protection Programs Guide for Use with 10 CFR 835, Occupational Radiation Protection

Section 4.2.5, ALARA Design Review – Optimization Methodology
Optimization methods are required to assure that occupational exposure is maintained ALARA in developing and justifying facility designs or modifications and physical controls. Optimization methodology provides the technical and managerial basis for setting numerical criteria for ALARA decisions in the design of facilities, development or review of work processes, and the design/purchase of special tools and equipment. Selection of an appropriate cost-benefit factor for reducing occupational dose involves a judgment of the relative value of dose, normally in terms of dollars per rem avoided.

At sites with significant collective dose, formally documented optimization methodologies should be developed for ALARA reviews and decisions on implementation of ALARA efforts should be developed. This may be on a site or facility specific basis. Application of optimization methodologies to the ALARA process should lead to consistent, rational, repeatable decisions as to which ALARA efforts are justifiable.


Module 110 – Section 2, Optimization Methods, Paragraph C, Formal (Analytical) Optimization Analysis:

In formal (analytical) optimization analyses, one must express the value of all resources, including dose, in commensurate units, or rank them in some consistent way, or both. Usually the value expression is done by assuming a dollar value for each parameter, including dose.

A formal optimization typically consists of a Cost-Benefit Analysis (CBA). In the CBA, all of the items to be considered must be expressed in the same units, usually dollars. Because of that reason, a dollar value must be given to the dose saved. The Department of Energy (DOE) has specified that this value be determined on a site-by-site basis. The Nuclear Regulatory Commission (NRC) uses a value of $2000 per person-rem. DOE evaluations to support ALARA analyses should apply monetary equivalents for a person-rem in the range from $1000 to $6000 with the nominal value of $2000.


Module 110 – Section 2, Optimization Methods, Paragraph C, Formal (Analytical) Optimization Analysis:

In formal (analytical) optimization analyses, one must express the value of all resources, including dose, in commensurate units, or rank them in some consistent way, or both. Usually the value expression is done by assuming a dollar value for each parameter, including dose.
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3.4 PNNL-6577, Department of Energy Health Physics Manual of Good Practices for Reducing Radiation Exposure to Levels that are As Low As Reasonably Achievable (ALARA)

In 1988, Pacific Northwest National Laboratory issued a revision to the DOE ALARA guide. Specifically added in this revision was a section dedicated to optimization, as the importance of including optimization techniques in an ALARA program were recognized. It echoed the DOE position that it was necessary for each operation to develop specific values for evaluating activities and actions against the ALARA criteria. Techniques and methodology for performing evaluations were provided.

3.5 NUREG-1530, Reassessment of NRC's Dollar Per Person-Rem Conversion Factor Policy

In 1995, the Nuclear Regulatory Commission completed a review and analysis of its dollar per person-rem conversion factor policy. The NRC dollar per person-rem conversion factor was calculated as the product of the value of a statistical life ($3 million in 1995 dollars) and the ICRP 60 risk coefficient for stochastic health effects, reduced to one significant digit (7.0E-04 rem⁻¹). The calculated value of $2100 per person-rem was rounded to the nearest thousand dollars and adopted at $2000 per person-rem, subject to present worth considerations and limited in scope to health effects solely. This conversion factor value is utilized to date for routine emissions, accidental releases, and 10 CFR 20 ALARA programs.

4.0 Determination of the TOC Dollar Per Person-Rem Conversion Factor

4.1 Methodology

While there is no specific or standardized direction/guidance available with regard to establishment of a dollar per person-rem conversion factor, a documented method is necessary to demonstrate the basis for such a value. The TOC has selected the methodology described in PNNL-6577 to determine a dollar per person-rem conversion factor as the sum of the health related detriment (α) and the non-health related detriment (β) of a person-rem expressed in dollars as follows:

$$ \frac{\$}{\text{Person-Rem}} = \alpha + \beta $$
To determine a TOC specific dollar per person-rem conversion factor, each of these quantities must be examined separately.

4.1.1 Health Related Detriment

The health related detriment ($\alpha$) can be determined in a number of ways. Two separate methods are presented below to illustrate the variables that affect such a value.

4.1.1.1 NUREG-1530 Value

This method simply adopts the NUREG-1530 dollar per person-rem conversion factor, $2000 per person-rem, established for health effects in 1995.

This value falls in the range of regulatory guidance published by the DOE, as described above in Section 3.2. It should be noted that utilizing this method does not account for established updates to the input parameter of value of a statistical life (VSL). As such, while use of this value would be acceptable, it is limited due to this factor.

4.1.1.2 NUREG-1530 with Updated Value of a Statistical Life

The methodology described in NUREG-1530, as described in Section 3.4, is applied with using the input parameter of value of a statistical life published by the United States Environmental Protection Agency\(^1\) and the ICRP 60 risk coefficient for stochastic health effects, rounded to one significant digit. The product of these two values produces a dollar per person-rem conversion factor as follows:

\[
\frac{\$}{\text{Person-Rem}} = \frac{7.9 \times 10^6}{\text{Person-Rem}} \times \frac{7.0 \times 10^{-4}}{\text{Person-Rem}}
\]

\[
= \frac{7.9 \times 10^6 \times 7.0 \times 10^{-4}}{\text{Person-Rem}}
\]

\[
= \frac{5530}{\text{Person-Rem}}
\]

\(^1\)United States Environmental Protection Agency. 2010. EPA 240-R-10-001, Guidelines for Preparing Economic Analyses. Section 7.2.11, p. 7-8.
The resultant value determined from this method falls in the range of regulatory guidance published by the DOE, as described above in Section 3.2. The value represents a solid estimate for the health related detriment component for the value of a person-rem since it accounts for an updated value of a statistical life and utilizes the DOE endorsed ICRP risk coefficient for stochastic health effects.

4.1.2 Non-Health Related Detriment

PNNL-6577 recommends that the non-health related detriment (\(\beta\)) consider replacement cost of workers who are no longer able to work in radiological areas due to approaching of administrative control levels. The Department of Energy – Office of River Protection (DOE-ORP) Administrative Control Level (ACL) is 2 Rem. As such, the non-health related detriment (\(\beta\)) can be determined by a ratio of the replacement cost of a radiological worker ($/Person) and the DOE-ORP ACL (Rem) as follows:

\[
\frac{\$}{\text{Person-Rem}} = \frac{\text{Replacement Cost ($/Person)}}{2 \text{ Rem}}
\]

Based on input from the Baseline Management and Training organizations, it is estimated that the average radiological worker requires 200 hours of training at a cost of approximately $52/hour. As such, the replacement cost of a worker is taken to be $10,400.

Input of this value into the equation listed above results in:

\[
\frac{\$}{\text{Person-Rem}} = \frac{\$10,400/\text{Person}}{2 \text{ Rem}} = \frac{\$5200}{\text{Person-Rem}}
\]

4.1.3 Total Detriment

Utilizing the methodology described in PNNL-6577 to determine a dollar per person-rem conversion factor as the sum of the health related detriment (\(\alpha\)) and the non-health related detriment (\(\beta\)) of a person-rem expressed in dollars results in the following:

\[
\frac{\$}{\text{Person-Rem}} = \alpha + \beta
\]

\[
\frac{\$}{\text{Person-Rem}} = \$5530 + \$5200 = \$10,730
\]
4.2 Department of Energy Contractor Comparison

The dollar per person-rem conversion factor used by other Department of Energy contractors was benchmarked as a method for comparison and contrast the values determined above. The results of this benchmarking effort are displayed in Table 4-1.

**Table 4-1: DOE Contractor Dollar Per-Person Rem Conversion Factors**

<table>
<thead>
<tr>
<th>Contractor</th>
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<tr>
<td>Argonne National Laboratory</td>
<td>$10,000</td>
</tr>
<tr>
<td>Bechtel National – Hanford Site</td>
<td>$7000 – 70,000</td>
</tr>
<tr>
<td>CH2M Hill Plateau Remediation Company – Hanford Site</td>
<td>$10,000</td>
</tr>
<tr>
<td>Mission Support Alliance – Hanford Site</td>
<td>$20,000</td>
</tr>
<tr>
<td>Nevada Test Site</td>
<td>$7000 – 70,000</td>
</tr>
<tr>
<td>Pacific Northwest National Laboratory</td>
<td>$16,700</td>
</tr>
<tr>
<td>Savannah River Site</td>
<td>$8500</td>
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This benchmarking effort clearly demonstrates that dollar per-person rem conversion factors vary across the DOE complex. The basis of these values is inconsistent, with some based purely on contractor management decision, while others are based on complex calculations to derive a value. While inconsistency is apparent, it can be demonstrated that the value determined in Section 4.2 is reasonable and is not an outlier from the data presented.

5.0 Results and Conclusion

While there is no specific or standardized direction/guidance available with regard to establishment of a dollar per person-rem conversion factor, a documented method is necessary to demonstrate the basis for such a value. Utilizing the methodology described in PNNL-6577 to determine a dollar per person-rem conversion factor, a value specific for TOC use was determined. Given the uncertainty inherent to any approach to determine this value, it is reasonable to adopt a dollar per person-rem conversion factor rounded to the nearest thousand dollars. Thus, this technical basis document defines that $11,000 per person-rem be used in developing and justifying facility designs or modifications, development or review of work processes, and the design/purchase of special tools and equipment.

\[
\frac{$}{\text{Person-Rem}} = 11,000
\]
6.0 References


