# Risk Comparison between Occupational and Military Radiation Dose Limit Standard

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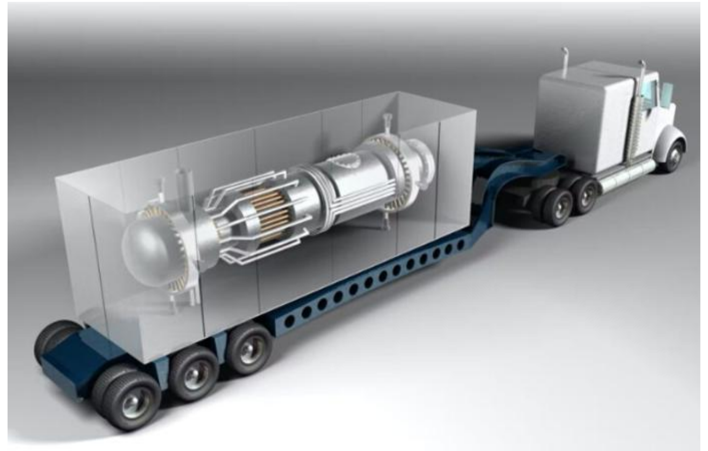
## Introduction

▣ Radiation exposure is a pivotal concern in both civilian and military sectors: while civilian nuclear workers follow ICRP-based dose limits (e.g., Publication 60/152) to minimize long-term health risks, military personnel may face ionizing radiation during both routine operations and emergency missions.

▣ The ALARA (As Low As Reasonably Achievable) principle is central to civilian radiological protection, mandating that exposure be reduced to the lowest feasible level through design, monitoring, and administrative control.

▣ Military personnel operate under the U.S. Operational Exposure Guide (OEG), which defines radiation exposure states (RES-0 to RES-3) and permits higher doses when mission success outweighs radiological risks.

▣ The emergence of deployable microreactors for military operations introduces new scenarios of occupational radiation exposure. As these HTGR-based systems are deployed closer to personnel, evaluating risk under realistic mission conditions becomes increasingly important.



▲ *Deployable Microreactors for Military Use*
*(Left: X-energy – Xe-Mobile | Right: BWXT – BANR)*

▣ This poster compares radiation risk standards across these sectors using REIC and REID models, evaluating how regulatory philosophies influence permissible dose limits and risk management strategies.


▲ *ALARA Principles*

**RES-0** The unit has not had any radiation exposure.
**RES-1** The unit has been exposed to greater than 0cGy but less than or equal to 70cGy.
**RES-2** The unit has been exposed to greater than 70cGy but less than or equal to 150cGy.
**RES-3** The unit has been exposed to greater than 150cGy.

▲ *Radiation Exposure Status Categories*

## Military Radiation Risk Framework

▣ Military employs the Operational Exposure Guide (OEG) to classify personnel radiation exposure into distinct categories (RES-0 to RES-3), based on cumulative dose and expected operational impacts.

▣ Each Radiation Exposure Status (RES) level corresponds to a defined dose range with increasing levels of risk and performance degradation.

| Risk | Dose | Expected Casualties | Performance impact | Operational Acceptability |
|---|---|---|---|---|
| Negligible Risk (RES-0) | D ≤ 50 | None | Minimal, Under 2.5% experience transient nausea or Fatigue | Acceptable for Prolonged operations in contaminated areas |
| Moderate Risk (RES-1) | D ≤ 70 | Up to 5% | Minor, Under 5% experience temporary performance degradation | Acceptable for critical missions requiring sustained effectiveness |
| Emergency Risk (RES-2~3) | D ≤ 150 | Up to 5% | Significant, Increased likelihood of radiation – induced symptoms, potential need for reassignment | Only acceptable in disaster scenarios where mission success outweighs radiation risks |

▲ *Risk Classification for Military*

▣ This framework enables military commanders to evaluate mission feasibility and adjust operational planning in real time based on unit exposure levels, balancing risk tolerance and mission urgency.

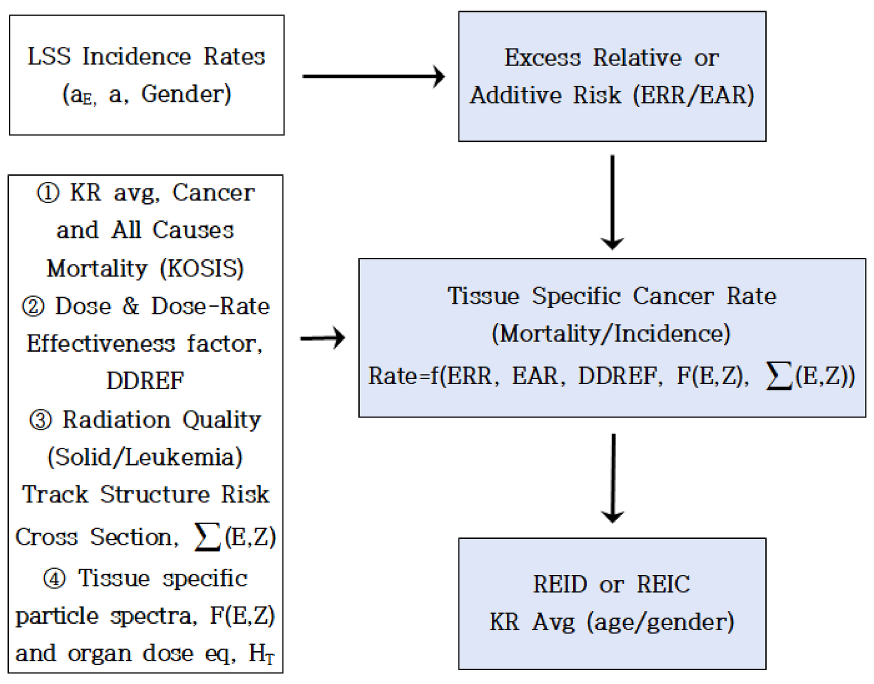
▣ Unlike civilian standards, which prioritize individual health over operational flexibility, the OEG allows elevated dose thresholds in crisis situations, provided that they are consistent with acceptable mission outcomes.

▣ The OEG also provides guidance for mitigating acute radiation effects, ensuring that even under high-risk conditions, exposure remains managed within structured, mission-aligned limits.

## Quantitative Risk Assessment Methodology

▣ Radiation risk in this study is assessed using the ICRP's standardized framework for estimating cancer incidence (REIC) and mortality (REID) resulting from ionizing radiation exposure.

▣ The REIC model integrates organ-specific cancer incidence rates with survival probabilities after exposure, factoring in age at exposure, attained age, and radiation dose.




▲ *ICRP-based REID Calculation Flow*

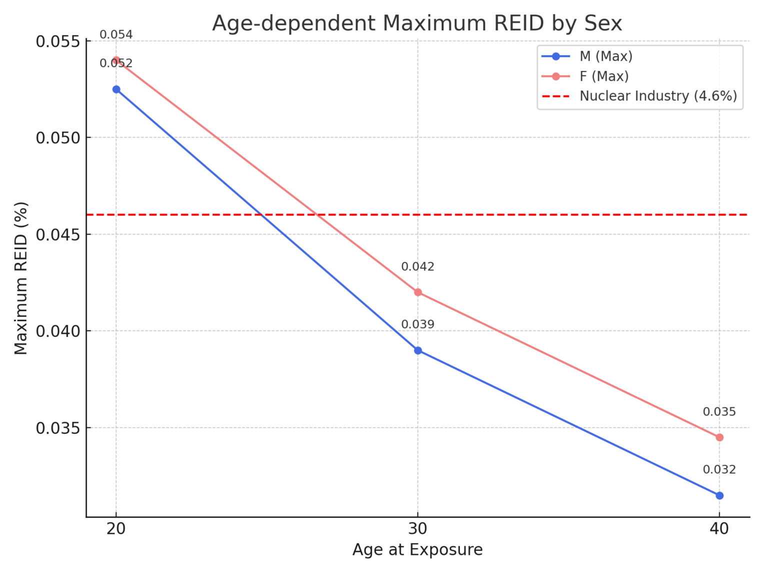
▣ Risk modeling is performed using both Excess Relative Risk (ERR) and Excess Absolute Risk (EAR) formulations, which quantify the proportional and absolute increase in cancer risk compared to unexposed populations.

▣ Organ/tissue-specific parameters are adopted from epidemiological studies including the Life Span Study (LSS) of atomic bomb survivors and pooled international cohorts.

▣ National demographic data (KOSIS) and cancer fatality rates (SEER program) are combined to derive age- and gender-specific REID values applicable to Korean adults, under both occupational and military exposure scenarios.

## Results and Comparative Analysis

▣ REID values were calculated for various age groups using ICRP models, revealing that younger individuals exhibit significantly higher lifetime cancer risks due to longer post-exposure latency and greater cumulative susceptibility.




▲ *Age-Dependent REID*

▣ Under RES-1 conditions (D ≤ 70 cGy), calculated REID remains below 2.5% across all age groups, while RES-2 exposures (70 < D ≤ 150 cGy) approach or exceed 5% for individuals in their 20s, particularly among females.

▣ In comparison, long-term occupational exposure in the nuclear industry—modeled as 20 mSv/year over a 46-year career—results in REID values below 4.6%, consistent with international safety thresholds.

▣ Although military exposures may result in higher short-term doses, they are typically limited in duration and frequency, and are governed by the OEG framework to avoid unacceptable long-term health consequences.

▣ Furthermore, while radiological risk is higher in combat scenarios, it remains secondary to acute threats such as explosives or ballistic trauma, highlighting the contextual nature of military health risk assessments.

## Conclusions

▣ Civilian and military radiation exposure standards reflect fundamentally different priorities: long-term health protection versus mission-oriented flexibility.

▣ The OEG framework allows higher short-term dose acceptance in military operations, provided it supports mission success and remains within controlled risk levels.

▣ Age-specific REID analysis underscores the need for protective dose policies for younger personnel in both sectors.

▣ Effective radiation risk management requires a balance between regulatory compliance, real-time decision-making, and operational feasibility.