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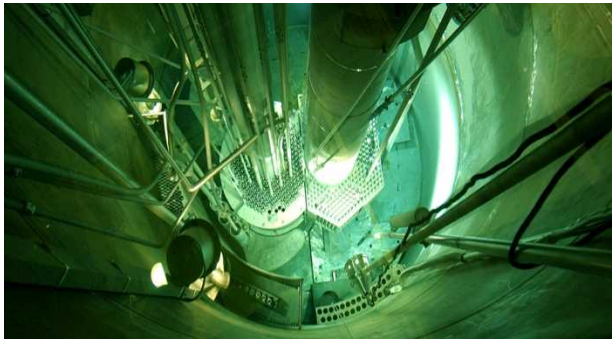

Security Risks of Nuclear and Radioactive Material at Research Reactors

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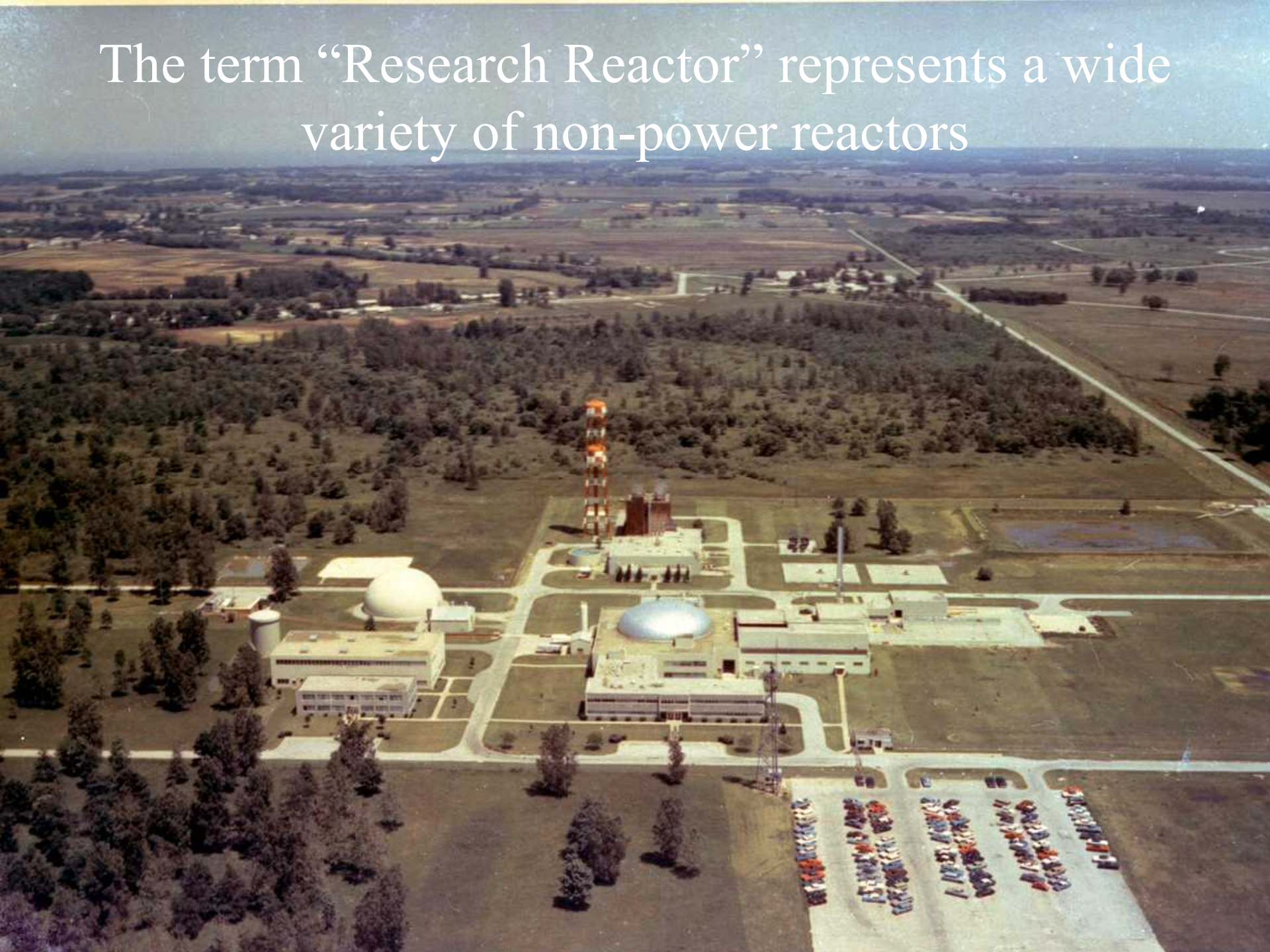
Sandia National Laboratories is a multi-program laboratory managed and operated by Sandia Corporation, a wholly owned subsidiary of Lockheed Martin Corporation, for the U.S. Department of Energy's National Nuclear Security Administration under contract DE-AC04-94AL85000.

The term “Research Reactor” represents a wide variety of non-power reactors

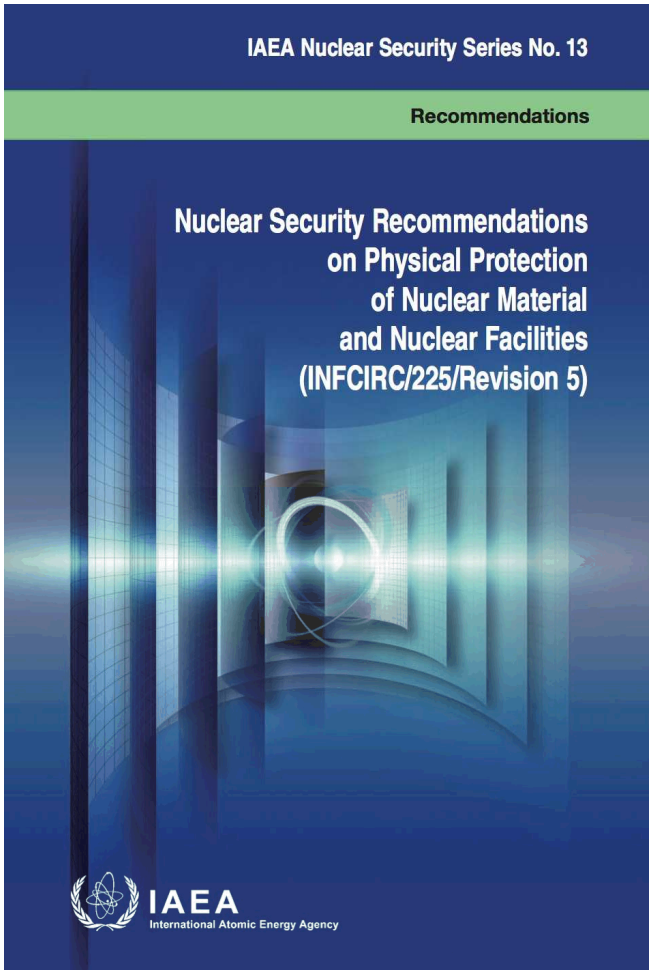


Purpose

- The purpose of the paper is:

1. To discuss the influence and **application** of international security recommendations/**guidance** on Research Reactor and Associated Facilities (RRAF)
2. To discuss the r**isk management** at RRAF and
3. How **risk** is commonly **estimated** and some potential issues with this estimation, and
4. Summarize on-going work to develop a approach to **comprehensively estimate nuclear security risk** to address these concerns

Security at Research Reactors



- Unauthorized Removal or Sabotage
- Category I, II, III
- URC, HRC

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TABLE 1. CATEGORIZATION OF NUCLEAR MATERIAL

Material	Form	Category I	Category II	Category III[f]
1. Plutonium [a]	Unirradiated[b]	2 kg or more	Less than 2 kg but more than 500 g	500 g or less but more than 15 g
2. Uranium-235 (^{235}U)	Unirradiated[b] – Uranium enriched to 20% ^{235}U or more – Uranium enriched to 10% ^{235}U but less than 20% ^{235}U – Uranium enriched above natural, but less than 10% ^{235}U	5 kg or more	Less than 5 kg but more than 1 kg 10 kg or more	1 kg or less but more than 15 g Less than 10kg but more than 1 kg 10 kg or more
3. Uranium-233 (^{233}U)	Unirradiated[b]	2 kg or more	Less than 2 kg but more than 500 g	500 g or less but more than 15 g
4. Irradiated fuel (The categorization of irradiated fuel in the table is based on international *transport* considerations. The State may assign a different category for domestic use, storage and *transport* taking all relevant factors into account.)			Depleted or natural uranium, thorium or low enriched fuel (less than 10% fissile content)[d, e]	

Note: This table is not to be used or interpreted independently of the text of the entire publication.

[a] All plutonium except that with isotopic concentration exceeding 80% in plutonium-238.

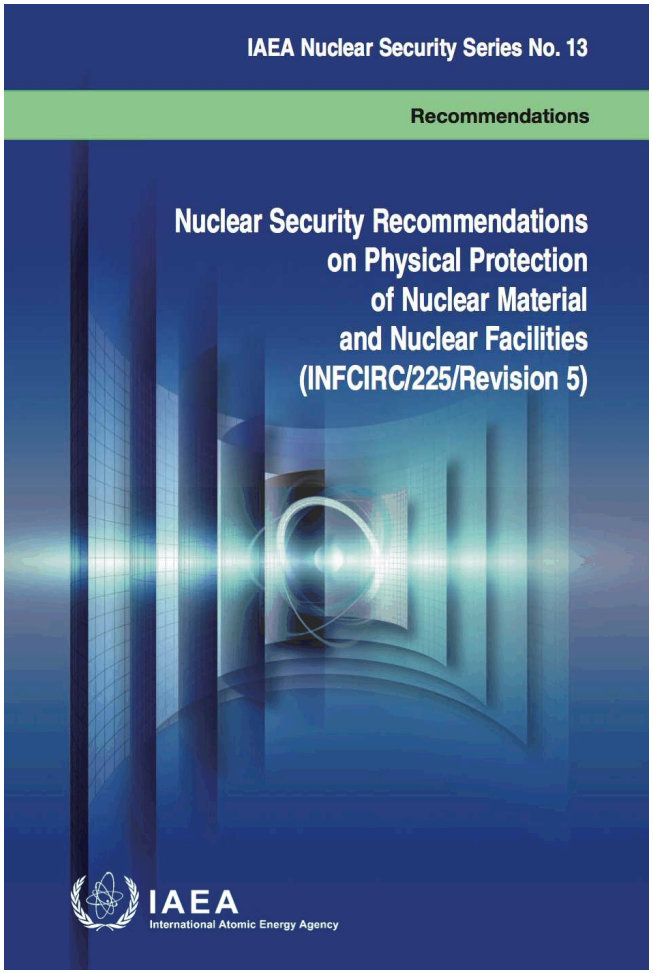
[b] Material not irradiated in a reactor or material irradiated in a reactor but with a radiation level equal to or less than 1 Gy/h. (100 rad/h) at 1 m unshielded.

[c] Quantities not falling in Category III and natural uranium, depleted uranium and thorium should be protected at least in accordance with prudent management practice.

[d] Although this level of protection is recommended, it would be open to States, upon evaluation of the specific circumstances, to assign a different category of physical protection.

[e] Other fuel which by virtue of its original fissile material content is classified as Category I or II before irradiation may be reduced one category level while the radiation level from the fuel exceeds 1 Gy/h (100 rad/h) at one metre unshielded.

Security at Research Reactors



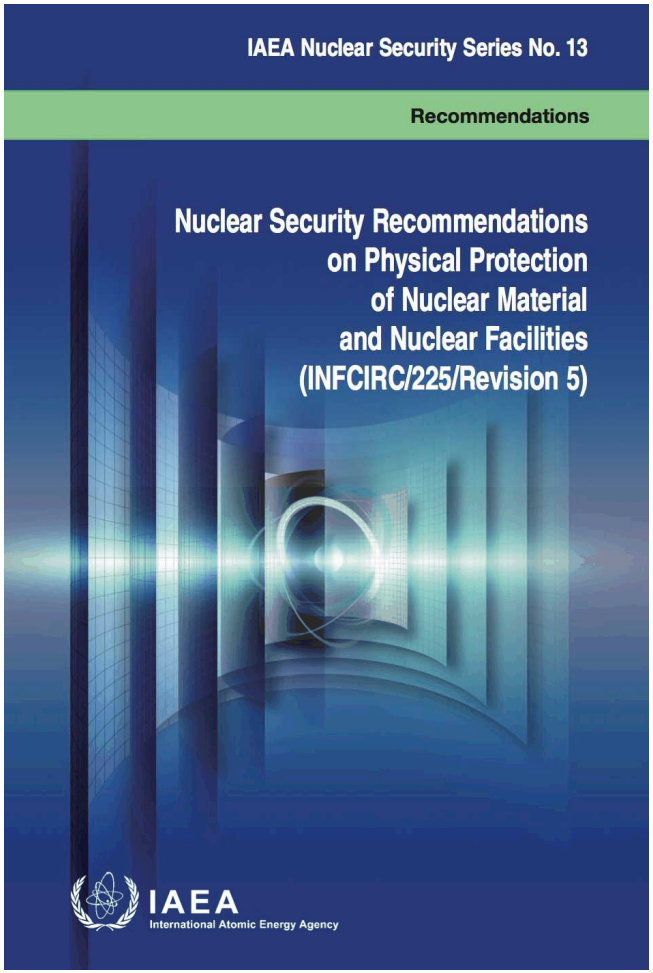
The security risk posed by Research Reactors is commonly represented by:

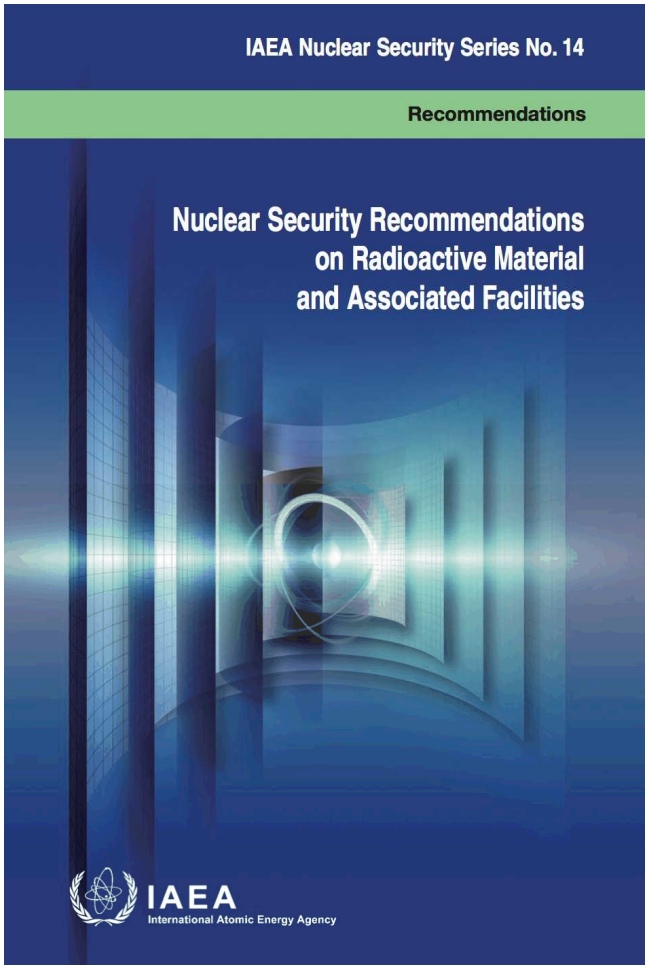
- the category of nuclear material for theft

OR

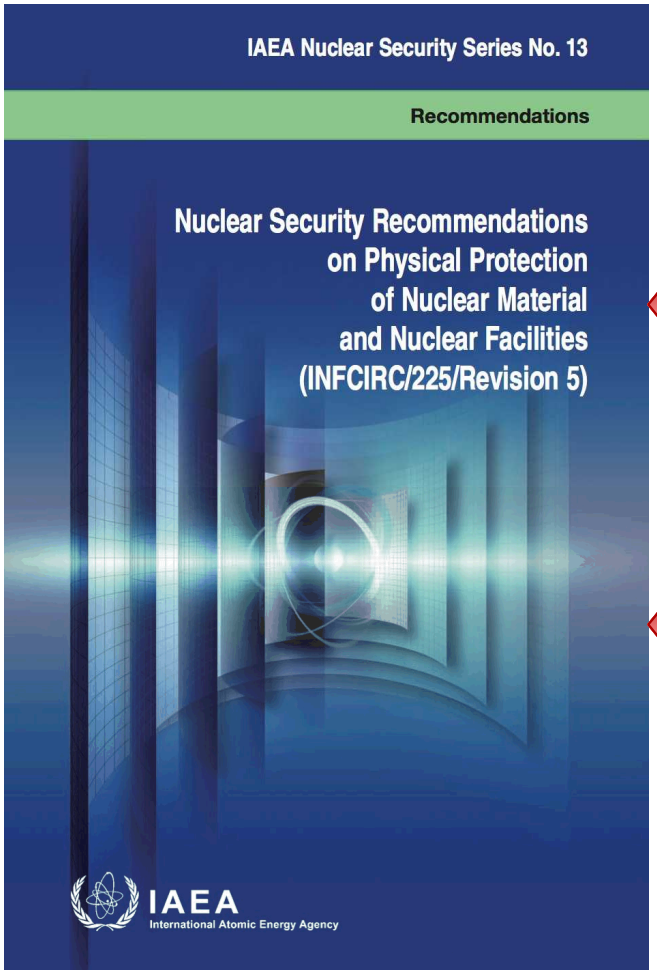
- the thermal power of the reactor for sabotage

Security at Research Reactors



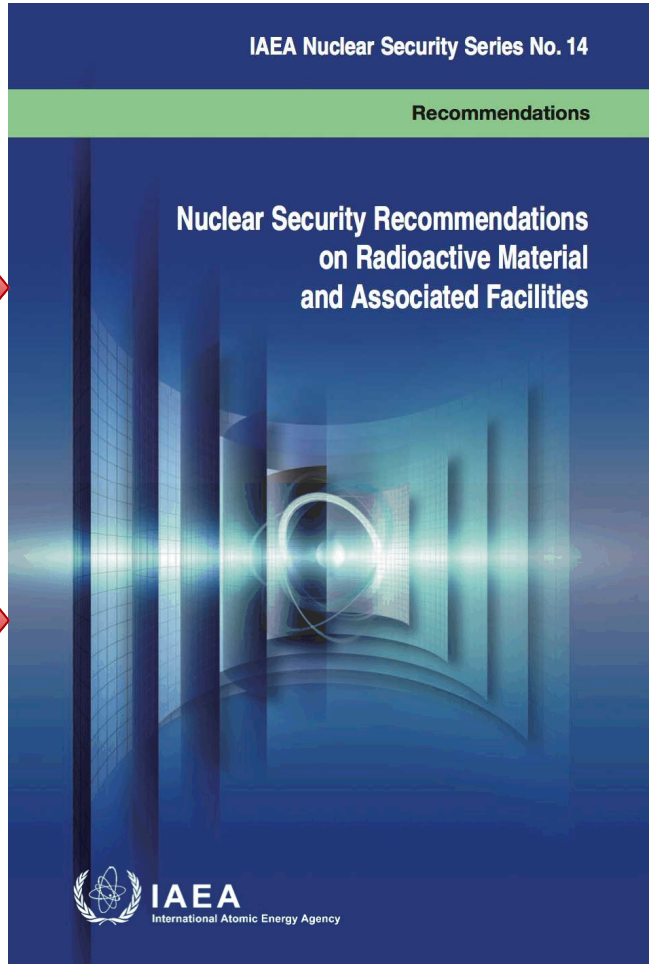


Security at Research Reactors

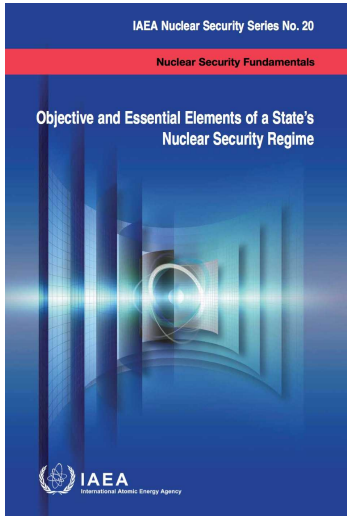


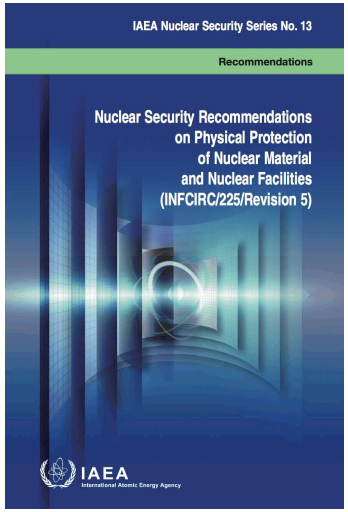
Irradiated Fuel

Irradiated Uranium Targets



Guidance on Risk Management





Objectives and Essential Elements of Nuclear Security Regime

*"…nuclear security regime uses **risk informed approaches**… which take into account:"*

- ***threat***
- ***attractiveness*** *and vulnerability of material*
- ***characteristics*** *of material*
- ***consequences***

Physical Protection of Nuclear Material and Nuclear Facilities

"***Risk*** *can be* ***managed*** *by:"*

- *reducing* ***threat***
- *improving* ***security*** *effectiveness*
- *reducing* ***consequences***

Probabilistic Risk

Probabilistic Risk is the product of ***Consequence Severity*** and ***Probability of Occurrence***

$$Risk = C * P_o$$

Risk estimate is usually performed for the highest consequence inventory on the site,

- *Usually the reactor fuel or core*
- *This estimate becomes the defacto security risk for the entire site*
- *However, it is not a trivial task to gather data to estimate risk.*

Nuclear Security Risk at RRAF

- **Research Reactors are commonly co-located with other research or production facilities, such as:**
  - **Waste Treatment and Interim Storage**
  - **Fuel Fabrication**
  - **Radioisotope production**
  - **Gamma Sterilization**

Sources: Wikipedia

Developing an Estimate of Comprehensive Security Risk at RRAF

- Diverse Targets
- Consequences not comparable
- Different Attractiveness

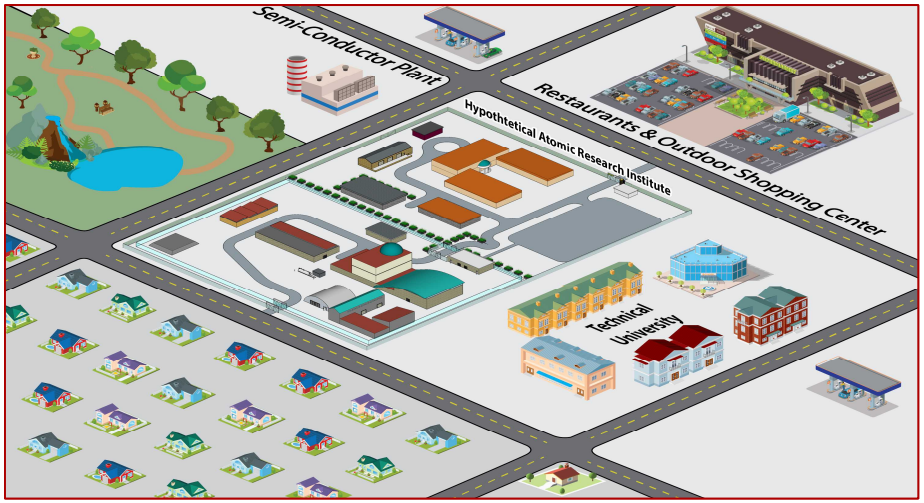
- Proper Security Resource Allocation
- Effective, Cost-Efficient Security System

Comprehensive Security Risk involves:

1. Identifying each target that could lead to unacceptable consequence on RRAF
2. Understanding the security risk posed by each target
   - Potential Consequence
   - Attractiveness
   - Threat
3. Combining the individual risk estimates into a comprehensive, RRAF-wide security risk

IAEA CRP Project

- Develop a Methodology to Estimate Comprehensive Security Risk for a RRAF



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Identify Possible Targets

Estimate Consequence Severity of each

Estimate Risk of each target

Combine Dis-similar Consequence Risks

- Security Risk at a RRAF is complex due to the diverse targets, consequences, and attractiveness
- Current Approaches may not sufficiently estimate Site-wide security risk
- CRP in place to attempt to develop an approach