Examining Self-Protection Requirements: Methods to Improve the Security of HEU Materials

Presentation at the
International Symposium on Nuclear Security Vienna, 2 April 2009

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Outline

- HEU fuel cycle inventories
- Current protection of HEU materials:
  - self protection standards: what should they be?
  - are they being followed?
- Evaluating physical protection and self-protection:
  - irradiated reactor fuel
  - spent radioisotope production targets
- Improving physical protection of highly enriched uranium in irradiated materials: short- and long-term solutions

Civilian HEU Uses

Photo: HEU-powered icebreakers, Murmansk, Russia

- Research and test reactors
- Critical assemblies
- Medical isotope production
- Fast reactors
- Icebreakers
- Space propulsion (past, future?)

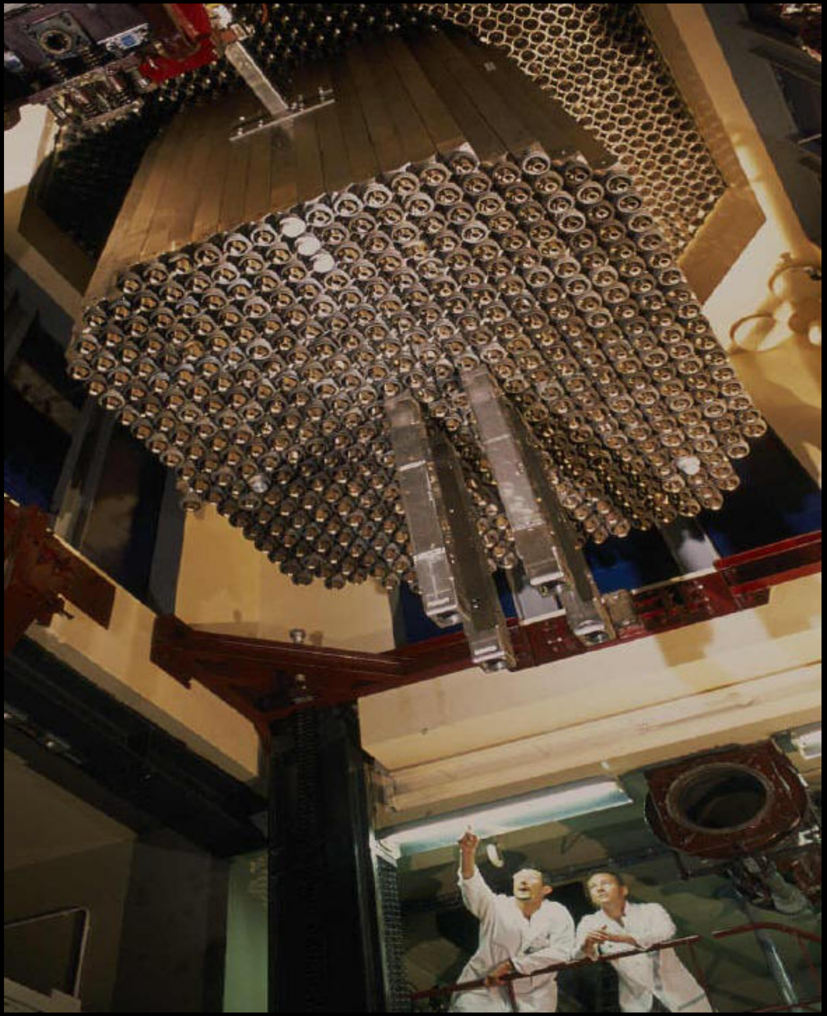
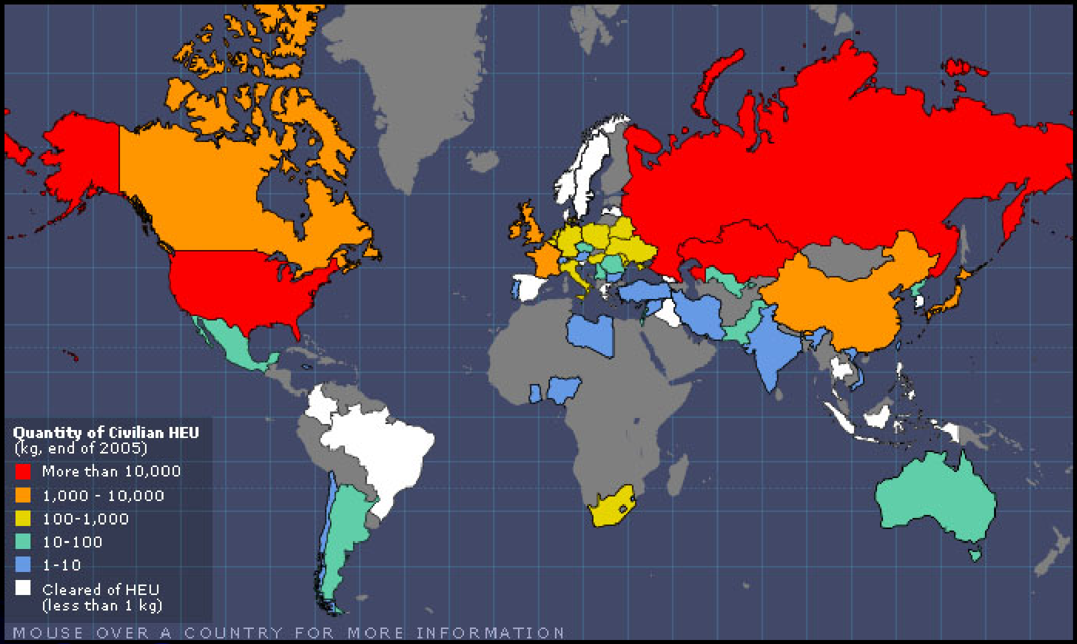


Photo: Cadarache critical assembly.
Source: M. Salvatores, presentation at Oslo Symposium

HEU fuel cycle inventories



http://www.nti.org/db/heu/map.html

➢Security levels are generally lower than at military facilities

Civil HEU Use:

~ 50 metric tons of HEU in civilian facilities worldwide (8 tons in safeguarded facilities, Dec. 31, 2007)*

➢Estimated on the basis of capacity, one year of operations at civilian reactors uses > 750 kg, in addition to large quantities in other types of facilities such as CAs

➢Huge stocks at fuel cycle facilities will remain as long as there are facilities that need this fuel

*320 SQs reported in IAEA Annual Report, 2008

Current protection of HEU materials

- Convention on the Physical Protection of Nuclear Material (CPPNM) and INFCIRC/225 provide general recommendations, not specific guidance.

- Idea that 1 Gy/hr (100 rem/hr) is “self-protecting” is questionable, yet few sites even meet current security recommendations:

  - There is no regular monitoring of radiation levels to determine if stockpiles are no longer “self-protecting”

  - IAEA and CPPNM call for basing physical protection on “the state’s current evaluation of the threat.” But even in locations with similar threat assessments, great variation in security provisions and requirements have been found

What is “self protection”?

- Current standards derived from health effects
  - Safety is important, but not the same thing as security

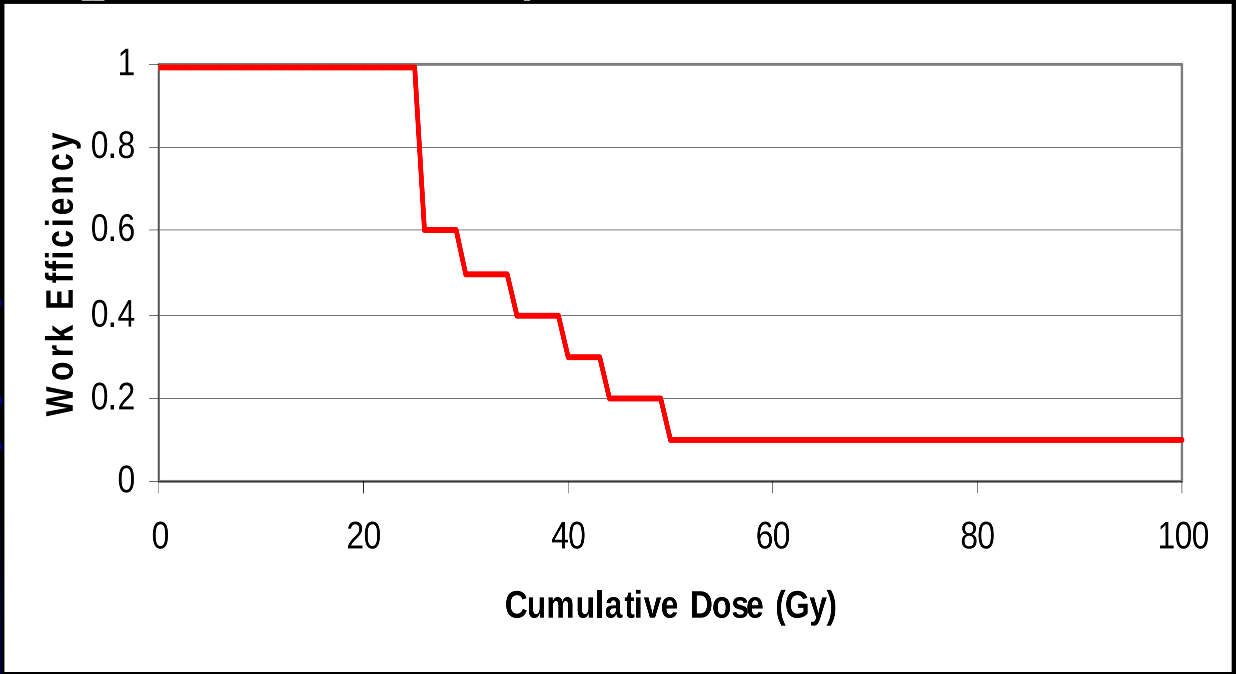
- 2005 Oak Ridge National Laboratory study used a security-based definition of “self protection” –

  “the incapacitation inflicted upon a recipient from inherent radiation emissions in a time frame that <u>prevents the recipient from completing an intended task</u>”

Photo: disk of HEU at Russian critical facility
Source: A. Glaser & F. von Hippel, “Thwarting Nuclear Terrorism,” Scientific American, *Feb. 2006*

2005 ORNL Study on Incapacitation

- The Oak Ridge study determined that a "dose rate of **100 Gy/hr** (10,000 rad/h) at 1 m was … the level that significantly affected performance of the perpetrator & offered limited self-protection (in the range of minutes)"



COATES, C. et al, Radiation Effects on Personnel Performance Capability and a Summary of Dose Levels for Spent Research Reactor Fuels", ORNL/TM-2005/261, Dec. 2005.

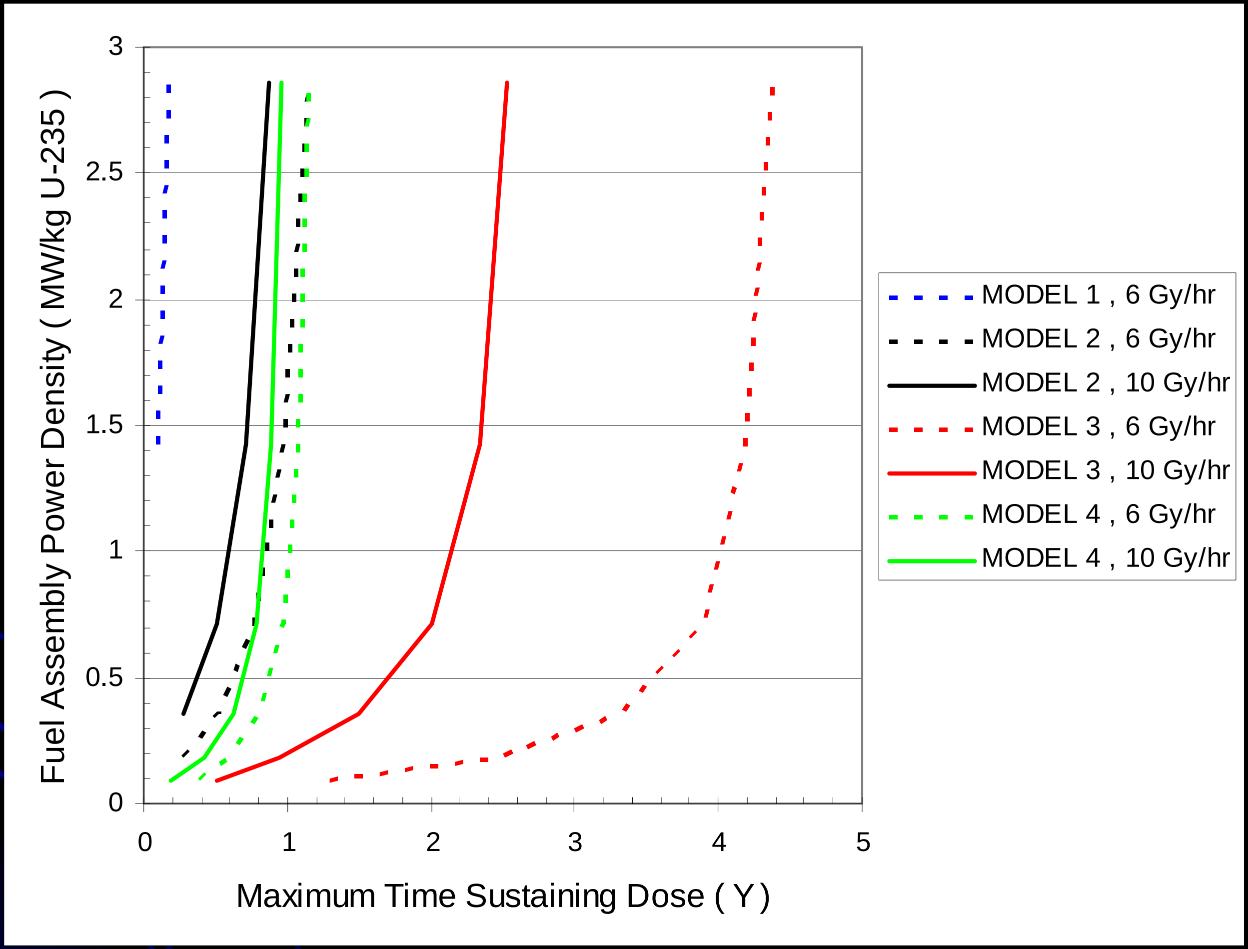
What should be considered "self protecting"?

- Current recommendation:1 Gy/hr at 1 m
- U.S. diplomats have proposed: 10 Gy/hr at 1 m
- ORNL proposals: 100 Gy/hr at 1 m

Absorbed Dose	Prodromal stage
> 10 Gy (> 1000 rads) **(some symptoms may occur as low as 6 Gy or 600 rads)**	• Symptoms: anorexia, severe nausea, vomiting, cramps, and diarrhea. • Onset occurs within a few hours after exposure. • Stage lasts about 2 days.
> 50 Gy (5000 rads) **(some symptoms may occur as low as 20 Gy or 2000 rads)**	• Symptoms: extreme nervousness and confusion; severe nausea, vomiting, and watery diarrhea; loss of consciousness; burning sensations of the skin. • Onset occurs within minutes of exposure. • Stage lasts for minutes to hours.

CENTERS FOR DISEASE CONTROL AND PREVENTION, Acute Radiation Syndrome: A Fact Sheet for Physicians, http://www.bt.cdc.gov/radiation/arsphysicianfactsheet.asp

Are self-protection recommendations being met? -- Evaluating irradiated reactor fuel



The maximum time at which a dose rate of 6 and 10 Gy/hr is produced by fuel elements of different uranium masses, burnup and % HEU for varying power density

Spent radioisotope production targets

- Isotope waste is particularly vulnerable: <u>very highly enriched & lightly irradiated</u>
- Argonne study (Spring 2007): irradiated target material can be contact handled in 3 years:
  - for acid-dissolution waste, the dose rate after 3 years is 1.5 mrem/hr per g of HEU at 1 m
  - for alkaline-digested HEU, the dose rate is 0.5 mrem/hr per g.

George Vandegrift and Edward Fei, "Mo-99 Production Using LEU," presented at the INMM Annual Meeting, Tucson, Arizona, July 2007

Recommendation for new, simpler methods to estimate self protection (1)

Should be based on **time since irradiation**

- Dose rates calculated on the basis of reactor type, burnup, and cooling time can be the basis for new recommendations for the physical protection of irradiated nuclear fuels.
- Instead of radiation levels (which may not be monitored), recommendations can specify the time by which irradiated materials should be moved into higher-security storage facilities (meeting security requirements for unirradiated materials of the same type).

Recommendation for new, simpler methods to estimate self protection (2)

INFCIRC/225 and other relevant guidelines, national and international, for Category I materials should be updated to include:

- A list of recommended engineering measures—such as more doors, longer hallways or other barriers (such as access barriers over reactor cores) to increase delay time or tamper-proof radiation monitors & intrusion detection systems to reduce warning time that a theft is in process
- A description of adequate guard forces and response teams, including a recommendation for force-on-force testing

Improving physical protection of HEU in irradiated materials: the long-term solution

- Top-security storage for HEU materials not in use (equivalent to the security provided for weapons)
- Timelines for moving irradiated materials into these storage facilities
- Minimization of HEU use at civilian sites wherever possible

Thank you!

Australia’s OPAL reactor: world-class research tools, and designed for radioisotope production using LEU fuel, LEU targets