A REGULATORY PERSPECTIVE ON WHETHER THE SYSTEM OF RADIATION PROTECTION IS FIT FOR PURPOSE

Michael Boyd

U.S. Environmental Protection Agency

Origins of the System of Radiation Protection

- 1925 – First International Congress of Radiology (London) established what was to become the ICRU
  - Also in 1925, Mutscheller and Sievert recommended maximum permissible dose from x-rays and radium equal to 10% of an erythema dose (~ 300 -700 mGy/y)
- 1928 – ICRP originated at Second International Congress of Radiology (Stockholm)
  - First radiation protection recommendations adopted
  - ICRU definition for roentgen led to consensus on a tolerance dose for x-rays (later redefined to cover higher voltage x-rays and radium gamma rays)

Critical Turning Points

- ICRP Publication 2 (1959) introduced the concepts of maximum permissible body burden and critical organ dose for managing intakes of radionuclides
- ICRP Publication 26 (1977)
  - Distinguished between stochastic and non-stochastic effects
  - Introduced effective dose equivalent and collective dose
  - Introduced the system of dose limitation based on principles of justification, optimization, and limitation (these ideas had been around since at least 1960)

Evolution of the System of Protection

- Publication 60
  - Recommendations expanded to include consideration of waste disposal, protection during emergencies, and indoor radon
  - Process-based system distinguished between practices and interventions
  - Dose equivalent becomes equivalent dose; effective dose equivalent becomes effective dose; and, Q becomes W_R (among other changes)

Evolution of the System of Protection

- Publication 103
  - Moves from process-based to situation-based system
    - Planned exposure situations
    - Emergency exposure situations
    - Existing exposure situations
  - Distinguishes between source-related protection using constraints and reference levels and individual-related protection using dose limits

Meanwhile, in the United States

ICRP Publication 26 (Jan. 17, 1977) adopted 4 days after EPA issues ICRP 2-based nuclear fuel cycle regulations (Jan. 13, 1977)

ICRP Publication 60 adopted Nov. 1990.

U.S. NRC's new ICRP 26-based standards for radiation protection are effective May 21, 1991

ICRP Publication 103 published in 2007.

U.S. DOE issues ICRP 60-based worker protection standards in 2007

But, change may be coming

- EPA is considering updating its nuclear fuel cycle regulations and will be asking the public to comment on whether this update is needed and whether ICRP 103 recommendations should be a part of the revised regulations
- NRC staff is developing a recommendation for the Commission on whether or not to update their standards for radiation protection and whether to incorporate ICRP 103 recommendations
- Now could be the best opportunity in over 30 years for the U.S. to harmonize its system of radiation protection with that of ICRP, including adopting SI!

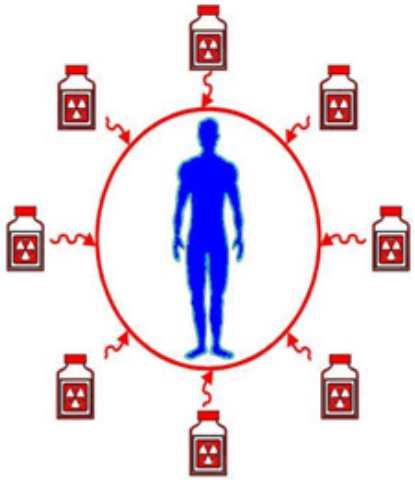
Is ICRP 103 Fit for Purpose?

- ICRP recommendations have generally reflected the needs of the day
  - Initially, protecting radiologists and radium users from deterministic effects
  - Then, meeting the demands for protection of the nuclear workforce
  - More recently, expanding protection for individual members of the public to include radon exposure guidance, medical reference doses, etc.
- Improvements to the system of protection have not only kept pace with science and technology, but also with evolving societal demands for equitable protection of all individuals and increased protection for sensitive sub-populations (children, pregnant women)

Fit for Purpose?: Limits and Constraints

- Regulators prefer numerical limits – bright lines where below the line is okay and above the line is not
- Regulators would rather regulate single sources of exposure to everyone than all sources to anyone
- An ICRP 103 constraint is thus easily translated into a regulatory source "limit"
- Is this a misinterpretation of the ICRP's intent?

Limits and Constraints

Dose Limits	Constraints and Reference Levels
Protect individual workers from occupational exposure and the Representative Person from public exposure	
	
From all regulated sources in planned exposure situations	From a source in all exposure situations

May be difficult to quantify and enforce.

Relatively easy to quantify and enforce.

Collective Dose

- Regulators have used collective dose as a quantitative tool for –
  - Determining when a practice or process is optimized,
  - Evaluating alternative site cleanup remedies, and
  - Performing legally required cost benefit assessments

Collective Dose in ICRP 103

- ICRP 103 has de-emphasized collective dose as a quantitative tool in favor of a disaggregated and more qualitative approach for optimization
- ICRP thus discourages summing seemingly trivial doses over large populations for estimating health effects
- Is this advice compatible with the linear no-threshold model for estimating dose response?

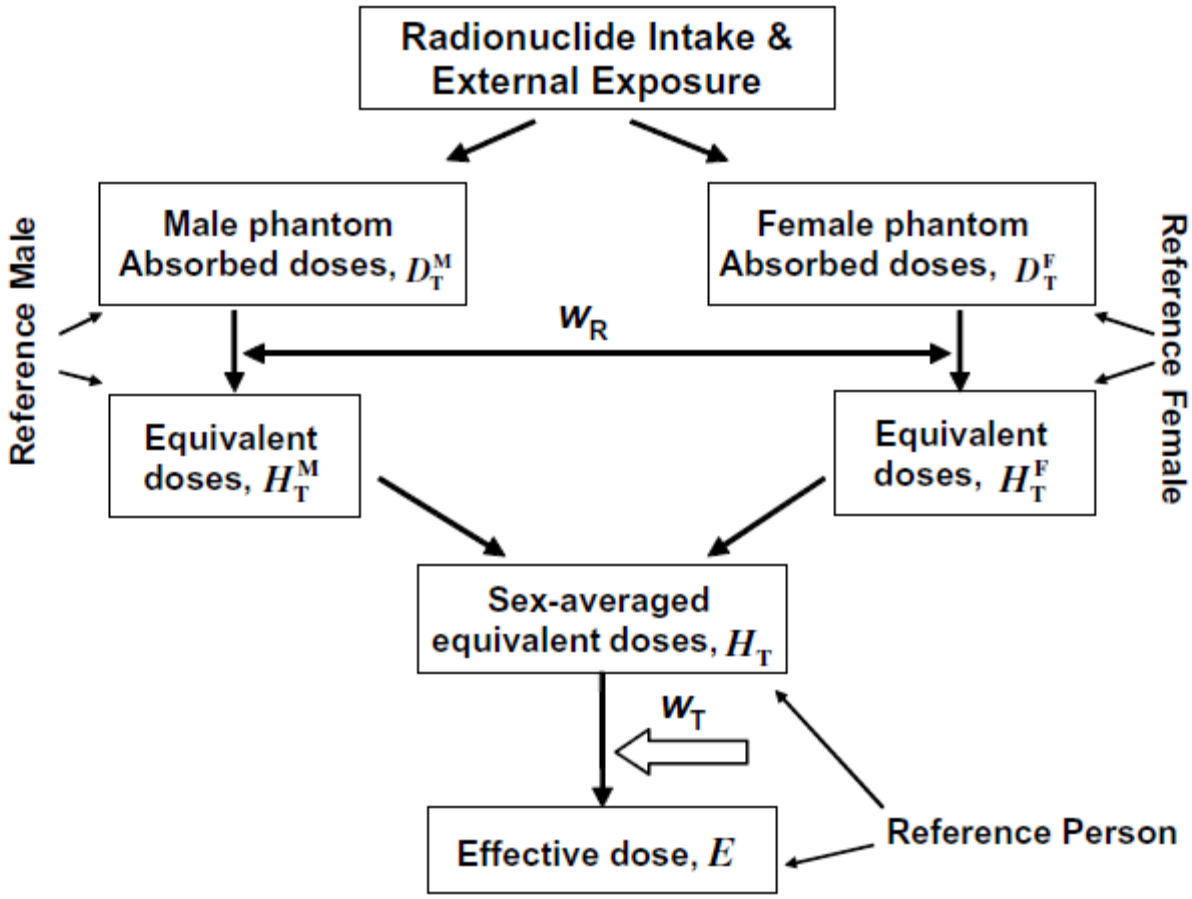
Reference Persons

- Internal dosimetry requires knowledge of basic anatomical and physiological data
- 1949 Chalk River Conference on Permissible Dose
  - First ICRP definition for "Standard Man"
- 1975 – ICRP Publication 23 updates the concept to "Reference Man"
- Emphasis was on calculating internal doses to adult radiation workers (typically male at that time)

A Reference Person

- 2003 – Publication 89 gives anatomical and physiological data for 6 ages (newborn, 1, 5, 10, and 15 year-olds, and adult) for males and females
  - Reference Man terminology retained, but in the sense of "reference human"
- 2007 – Publication 103 defines a reference person as the average of the adult male and the adult female using computational voxel phantoms adjusted to ICRP Pub. 89 data

Reference Person



Doses to Children

- Age-specific effective doses from intakes of radionuclides are available for children at 5 ages (ICRP Publication 72)
  - Committee 2 will be updating this information
- Age-specific external dose coefficients will soon be available for these radionuclides
- But, the definition for effective dose given in Publication 103 uses W_t that are independent of age and sex

Regulatory Challenge

- EPA is responsible for setting standards for radioactivity in the general environment
- Adult dose conversion factors were all that were available when current dose-based regulations were written
- Stakeholders will rightly expect consideration of age and gender differences when setting new exposure standards for the general population
- How to do it?

Possible Solutions

- Age-averaged dose conversion factors (DCFs) could be calculated for chronic intake and exposure to radionuclides at environmental levels
  - Age-specific DCFs would still be used for assessing doses from larger acute intakes
- Media-specific radionuclide concentrations could be set that correspond to acceptable age-averaged risk objectives
  - EPA has published age-averaged risk coefficients

Reference Person: Summary

- Further guidance from ICRP on assessing lifetime doses to the general population and setting dose constraints for chronic childhood exposures (e.g., occurring from birth to age 15) would be welcome
- The tools needed to address this challenge already exist or will be available in the near future (using age-specific voxel phantoms)

Emergency Response

- There is some difference of opinion regarding when an emergency situation becomes an existing situation
  - Acceptable doses are at least 10-fold lower for existing situations
  - For example, prolonged controllable exposures at the upper end of the emergency exposure band (100 mSv/y) would generally not be acceptable to the public
- Publication 111 has provided useful clarification, but more may be needed

Summary

- Is the ICRP system of radiation protection fit for purpose?
  - Yes!
  - However, there will always be room for improvement, clarification, and consideration of new scientific data
- As EPA considers updating older regulations, we look forward to the next generation of implementing guidance from ICRP (and NCRP!)