Plenary Session
Consistency in Radiation Protection Standards

NCRP and International Consistency in Radiation Protection Standards

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National Council on Radiation Protection & Measurements
Vanderbilt University

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Sacramento, CA -- July 23, 2012
Dade Moeller
1927-2011

- Scientist
- Leader
- Author
- Gentleman
- Teacher
- Father

- US Navy
- Georgia Tech, NC State
- USPHS: ORNL, LANL, NERHL
- Harvard School Public Health
- HPS President
- Dade Moeller & Assoc

NERHL
Dade Moeller 1927- 2011

2008 NCRP Taylor Lecturer
Outline
NCRP and International Consistency in Radiation Protection Standards

- Similarities / Consistencies
- Differences
- Does it Matter?
- Issues of Importance
- Some Suggestions
- NCRP Initiatives
ICRP 103 (2007)

Revolution, Evolution, Evilution?

- Opportunity – Harmony, Alignment, Consistency, Consolidation, Improve, Address the New
- Awareness because of Fukushima, CT scans, terrorist concerns
United States has been an Integral Part of ICRP

<table>
<thead>
<tr>
<th>Period</th>
<th>Position</th>
<th>Name</th>
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<tbody>
<tr>
<td>1928-69</td>
<td>Main Commission, Chairman</td>
<td>Lauriston Taylor</td>
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<tr>
<td>1950-72</td>
<td>Main Commission, C2</td>
<td>Karl Z Morgan</td>
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<td>1950-58</td>
<td>Main Commission, vChair</td>
<td>Gino Failla</td>
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<td>1969-80</td>
<td>Main Commission, C1</td>
<td>Art Upton (ICRP 26)</td>
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<td>1973-2001</td>
<td>Main Commission, vChair</td>
<td>Charlie Meinhold (ICRP 60)</td>
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<td>1977-96</td>
<td>Main Commission, C1</td>
<td>Warren Sinclair (ICRP 60)</td>
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<td>1989-2005</td>
<td>Main Commission, C3</td>
<td>Fred Mettler (ICRP 103)</td>
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<td>1997-</td>
<td>Main Commission</td>
<td>John Boice (ICRP 103)</td>
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<td>2004-12</td>
<td>Main Commission, C1</td>
<td>Julian Preston (ICRP 103)</td>
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<tr>
<td>2012-</td>
<td>Main Commission, C1</td>
<td>Bill Morgan</td>
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Because NCRP’s Congressional Charter states that the NCRP will cooperate with ICRP, it should not be surprising that recommendations are similar, though not exactly the same.

Differences reflect the aspects of radiation application and exposure circumstances unique to the United States.
Better Alignment is Possible
Because we Have the Same Goals and Principles

GOAL: Protect Workers, Public and the Environment

Fundamental Principles

- Justify the Exposure
- Optimize Protection (ALARA)
- Dose Limits
Avoid Deterministic Effects

- Ulcer
- Hair Loss
- Cataracts
- Hair Loss
- Beta burns
## Dose Limits (Occupation)

<table>
<thead>
<tr>
<th></th>
<th>ICRP 60</th>
<th>ICRP 103</th>
<th>NCRP 116</th>
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<tbody>
<tr>
<td><strong>Effective Dose</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Annual</td>
<td>20 mSv y(^{-1}) averaged 5 y, not to exceed 50 mSv in any single year</td>
<td>Same</td>
<td>50 mSv</td>
</tr>
<tr>
<td>Cumulative</td>
<td></td>
<td>10 mSv x Age (y)</td>
<td></td>
</tr>
<tr>
<td><strong>Equivalent Dose</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lens of Eye</td>
<td>150 mSv y(^{-1})</td>
<td>20 mSv y(^{-1}) averaged 5 y, not to exceed 50 mSv in any single year</td>
<td>150 mSv y(^{-1})</td>
</tr>
<tr>
<td>Skin</td>
<td>500 mSv y(^{-1})</td>
<td>Same</td>
<td>500 mSv y(^{-1})</td>
</tr>
<tr>
<td>Extremities</td>
<td>500 mSv y(^{-1})</td>
<td>Same</td>
<td>500 mSv y(^{-1})</td>
</tr>
</tbody>
</table>

*2011 Statement* ICRP and NCRP recommendations have yet to be fully implemented in the U.S.
Recommendations of the NCRP and ICRP are based on radiation effects on human populations.

ICRP recommends a dose limit of 100 mSv in 5 years (not to exceed 50 mSv in a single year) – essentially, 20 mSv yr\(^{-1}\).

NCRP recommends an annual limit of 50 mSv yr\(^{-1}\) and that cumulative dose should not exceed age times 10 mSv.

The NRC standard is currently 50 mSv yr\(^{-1}\). Routine practice of maintaining ALARA did not support additional reduction in the dose limits at the time with 97% workers receiving < 20 mSv yr\(^{-1}\).

The goal is to translate the need to limit cumulative exposure (for which ICRP and NCRP are in general alignment) within the regulatory framework (for which recommendations seem to differ).
Deviations – Not Necessarily Inconsistencies

- NCRP has outlined its position with regard to international and U.S. standards and regulations in NCRP Report 116.
- Deviations from ICRP recommendations exist because of the desire for greater flexibility in the United States.
- Differences in the regulatory approaches include the need for substantial stakeholder involvement in the United States.
- A more extensive process for making changes (and evaluating impact).
The impact (e.g., feasibility, practicality, burden) of changing regulations based on incremental improvements in knowledge on radiation effects should be balanced by the potential health benefits and value of enhancing international consistency of radiation exposure guidance.

The position in the United States is somewhat complicated because various agencies are involved with radiation protection regulation and guidance:

- U.S. Nuclear Regulatory Commission
- U.S. Environmental Protection Agency
- U.S. Department of Energy
- Occupational Safety and Health Administration.
Why Change?

- New scientific data have been published since ICRP 60 and NCRP 116.
- The estimates of cancer risk attributable to radiation exposure have not changed greatly in the past 17 years.
- The estimated risk of heritable effects is currently lower than before.
- The new data provide a firmer basis on which to model risks and assess detriment.

ICRP Publication 103

Table 1. Detriment-adjusted nominal risk coefficients ($10^{-2}$ Sv$^{-1}$) for stochastic effects after exposure to radiation at low dose rate.

<table>
<thead>
<tr>
<th>Exposed population</th>
<th>Cancer Present$^1$</th>
<th>Publ. 60</th>
<th>Heritable effects Present$^1$</th>
<th>Publ. 60</th>
<th>Total Present$^1$</th>
<th>Publ. 60</th>
</tr>
</thead>
<tbody>
<tr>
<td>Whole</td>
<td>5.5</td>
<td>6.0</td>
<td>0.2</td>
<td>1.3</td>
<td>5.7</td>
<td>7.3</td>
</tr>
<tr>
<td>Adult</td>
<td>4.1</td>
<td>4.8</td>
<td>0.1</td>
<td>0.8</td>
<td>4.2</td>
<td>5.6</td>
</tr>
</tbody>
</table>
An Opportunity to Align and to Compliment and to Consolidate

- New data on the biological effects of ionizing radiation include new information on cataracts, heart disease and non-cancer
- New technologies – Medical Imaging, modular reactors, airport screening
- Awareness of population exposures (indoor radon; flight crews; CT scans)
- Concern over nuclear incidents, accidents, terrorist actions
- Recognition that the world has changed – there is a safety culture
Dose limits for the eye is an important issue raised based on new data on health effects. It is encouraging that ICRP Recommendations 103 has generated debate and discussions within the United States.

Although uncertainty remains, the absorbed dose threshold for circulatory disease may be as low as 0.5 Gy to the heart. Doses to patients of this magnitude could be reached during complex interventional procedures, and therefore particular emphasis should be placed on optimization in these circumstances (ICRP 2011).
Impact – New Technologies

Computed Tomography

Calendar Year

62 Million in 2006
85 Million in 2011
Initiative to Reduce Unnecessary Radiation Exposure from Medical Imaging

February 2010

Center for Devices and Radiological Health

U.S. Food and Drug Administration

2008-09 NEXT Survey: Cardiac Catheterization

Cumulative Air Kerma

<table>
<thead>
<tr>
<th>Air Kerma (Gy)</th>
<th>Percent of Cases</th>
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<tbody>
<tr>
<td>&lt;3</td>
<td>40</td>
</tr>
<tr>
<td>3-5</td>
<td>35</td>
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<tr>
<td>5-14</td>
<td>20</td>
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<td>15-19</td>
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<td>20-24</td>
<td>10</td>
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<tr>
<td>25-29</td>
<td>5</td>
</tr>
<tr>
<td>30-33</td>
<td>5</td>
</tr>
<tr>
<td>34-50</td>
<td>0</td>
</tr>
<tr>
<td>&gt;50</td>
<td>0</td>
</tr>
</tbody>
</table>

Data Sources:
- 0.05 Gy (Avg. Cardiac Cath)
- 2.2 Gy (Coronary Micro)
Exposures in Medicine

NCRP REPORT No. 168

RADIATION DOSE MANAGEMENT FOR FLUOROSCOPOICALLY-GUIDED INTERVENTIONAL MEDICAL PROCEDURES

2011

ICRP

Annals of the ICRP

ICRP Publication 117
Radiological Protection in Fluoroscopically-Guided Procedures Performed Outside the Imaging Department
Medical Exposures Deserve Continued Attention

NCRP Report No. 172

Reference Levels and Achievable Doses in Medical and Dental Imaging: Recommendations for the United States

Coming Soon

RADIATION PROTECTION FOR PROCEDURES PERFORMED OUTSIDE THE RADIOLOGY DEPARTMENT

2000
Impact – New Technologies

A Reflection on You
The technology of X-rays for whole-body scanning in airports involves tiny doses of radiation and technology to record how it bounces off the skin. Here’s how it differs from medical X-rays.

Transmission X-rays, such as
TYPICAL DOSE: 4 millirems

Backscatter X-rays, such as
TYPICAL DOSE: .005 millirem

Sources: Health Physics Society; American Science and Engineering Inc.
Personal suggestions would be to consider:

- (1) unification of terminology – mSv should replace rem, effective dose (or total effective dose) should replace TEDE, etc. – we need to speak the same language for scientists and the public;
- (2) leapfrog ICRP 60 and start with ICRP 103 when considering updating recommendations that are based on ICRP 26 or earlier reports;
- (3) modify the radiation weighting factors based on the latest ICRP biokinetic models and evaluations;
- (4) re-evaluate lens of the eye dose limits;
Thoughts to Harmonize/Align

- (5) collective dose should not be used to attribute hypothetical numbers of cancer deaths from tiny doses;
- (6) continued focus on need for change and implications of change (with stakeholder involvement): such as in industry (radiographers) and in medicine (interventional radiologists, cardiologists, emergency department physicians) and effects on job performance and/or patient care;
- (7) be involved, when asked to serve on ICRP or NCRP committees, make a difference.
NCRP Initiatives/Contemplations

- Update NCRP 116 Recommendations
- Update NCRP 136 Evaluation of the LNT Model
- Integration of Epidemiology with New Biology for estimation of risk
- Update NCRP 126 Uncertainties in Risk Estimates used in Radiation Protection
- Guidance in Medicine such as Diagnostic Reference Levels and CT use in Emergency Departments
- Coordinate Studies on Low Dose Rate Effects
The Major **Issue** in Radiation Epidemiology and Radiation Protection?

What is the level of risk when exposure received gradually over time and not briefly?
One Million U.S. Radiation Workers and Veterans

- Manhattan Project Workers
- Atomic veterans
- Nuclear utility workers
- Medical and other occupational
- Possible – Other Military

Concluding Remark

- **Common philosophy**: radiation protection is based on justification, dose limitation and the application of ALARA (optimization), economic and social factors being taken into account (NCRP 1993, 1998).

- **ALARA** is “simply the continuation of good radiation-protection practices which traditionally have been effective in keeping the average individual exposures for monitored workers well below the limits” (NCRP 1993).

- As the needs for radiation protection change in the 21st century there is a need for constant improvements, constant vigilance and continued cooperation and alignment with the world. Let’s “Come Together”
Radiation Dose and Impacts on Exposed Populations

S.Y. Chen & Bruce A. Napier, Co-chairs

March 11-12, 2013

Bethesda, Maryland