THE INFLUENCE OF NCRP ON RADIATION PROTECTION IN THE U.S.: REGULATION AND GUIDANCE

Twelfth Annual Warren K. Sinclair Keynote Address

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Annual Meeting of NCRP

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OUTLINE

- Introduction
- U.S. Advisory Committee on X-ray and Radium Protection 1929 – 1946
- National Committee on Radiation Protection 1946 – 1964
  - AEC to NRC
  - FRC to EPA
  - FEMA to DHS
  - AEC to DOE
  - NASA
  - States – CRCPD
  - Non-Regulatory Bodies
- Future
Representatives from several countries met before the Second International Congress of Radiology in Stockholm in July 1928 to discuss radiation protection problems and possibly prepare some initial x-ray protection recommendations.

For the United States, Lauriston S. Taylor was designated as representative from the National Bureau of Standards.

The responsibility fell to Taylor to organize a national committee to deal with the protection problems faced at that time in the U. S.

In 1929, the Advisory Committee on X-ray and Radium Protection was established with L. S. Taylor acting as chairman.

There were 7 members in addition to Taylor from the American Roentgen Ray Society, the Radiological Society of North America, the American Medical Association, and X-ray Equipment Manufacturers.
The Committee provided guidance for protection of persons exposed to radiation in the research and medical communities.

In 1931, the Advisory Committee proposed the first formal standard for protecting people from radiation sources, NBS Handbook 15.

- The recommended limit on dose rate was expressed as 0.1 roentgen per day.

Over the next 12 years several handbooks were published that determined radiological protection in the U. S.

Prior to 1946 there was no Federal agency with responsibility for radiation protection.
<table>
<thead>
<tr>
<th>NCRP Report No (NBS HB No.)</th>
<th>Title</th>
<th>Date</th>
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<tbody>
<tr>
<td>1 (15)</td>
<td>X-ray protection (Superseded by HB 20)</td>
<td>1931</td>
</tr>
<tr>
<td>2 (18)</td>
<td>Radium protection for amounts up to 300 mg (Superseded by HB 23)</td>
<td>1934</td>
</tr>
<tr>
<td>3 (20)</td>
<td>X-ray protection (Superseded by HB 41)</td>
<td>1936</td>
</tr>
<tr>
<td>4 (23)</td>
<td>Radium protection (Superseded by HB 54)</td>
<td>1938</td>
</tr>
<tr>
<td>5</td>
<td>Safe handling of radioactive luminous compounds</td>
<td>1941</td>
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</table>
In 1946 the Advisory Committee was expanded and renamed National Committee on Radiation Protection.

Dr. Taylor was approved as Chairman and seven sub-committees were established to develop reports which would continue to be published as NBS Handbooks.

Fifteen reports were published between 1946 and 1958.
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<th>NCRP Report No (NBS HB No.)</th>
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<tbody>
<tr>
<td>6 (41)</td>
<td>Medical X-ray protection up to two million volts (Superseded by HB 60)</td>
<td>1949</td>
</tr>
<tr>
<td>7 (42)</td>
<td>Safe handling of radioactive isotopes</td>
<td>1949</td>
</tr>
<tr>
<td>8 (48)</td>
<td>Control and removal of radioactive contamination in laboratories</td>
<td>1951</td>
</tr>
<tr>
<td>9 (49)</td>
<td>Recommendations for waste disposal of phosphorus-32 and iodine-131 for medical users</td>
<td>1951</td>
</tr>
<tr>
<td>10 (51)</td>
<td>Radiological monitoring methods and instruments</td>
<td>1952</td>
</tr>
<tr>
<td>11 (52)</td>
<td>Maximum permissible amounts of radioisotopes in the human body and maximum permissible concentrations in air and water</td>
<td>1953</td>
</tr>
<tr>
<td>12 (53)</td>
<td>Recommendations for the disposal of carbon-14 wastes</td>
<td>1953</td>
</tr>
<tr>
<td>13 (54)</td>
<td>Protection against radiations from radium, cobalt-60, and cesium-137</td>
<td>1954</td>
</tr>
<tr>
<td>14 (55)</td>
<td>Protection against betatron-synchrotron radiations up to 100 million electron volts</td>
<td>1954</td>
</tr>
<tr>
<td>15 (56)</td>
<td>Safe handling of cadavers containing radioactive isotopes</td>
<td>1953</td>
</tr>
<tr>
<td>16 (58)</td>
<td>Radioactive-waste disposal in the ocean</td>
<td>1954</td>
</tr>
<tr>
<td>17 (59)</td>
<td>Permissible dose from external sources of ionizing radiation</td>
<td>1954</td>
</tr>
<tr>
<td>18 (60)</td>
<td>X-ray protection</td>
<td>1955</td>
</tr>
<tr>
<td>19 (61)</td>
<td>Regulation of radiation exposure by legislative means</td>
<td>1955</td>
</tr>
<tr>
<td>20 (63)</td>
<td>Protection against neutron radiation up to 30 MeV</td>
<td>1957</td>
</tr>
<tr>
<td>21</td>
<td>Safe handling of bodies containing radioactive isotopes</td>
<td>1958</td>
</tr>
</tbody>
</table>
Title 10, Atomic Energy, Part 20 (10 CFR Part 20), Standards for Protection Against Radiation (AEC 1957).

- NCRP Report No. 17 (NBS Handbook 59, 1954), Permissible Dose from External Sources of Ionizing Radiation;
- Included the insert to accompany NBS Handbook 59 (1957) that added recommendations on cumulative occupational and population exposure limits.
  - $5 \times (\text{age} - 18) \text{ rem yr}^{-1}$ and 3 rem per 13 wk for head, trunk, active blood forming organs, lens, and gonads;
  - $10 \times (\text{age} - 18) \text{ rem yr}^{-1}$ and 6 rem per 13 wk for skin:
    - 25 rem per 13 wk for the extremities;
  - 15 rem yr$^{-1}$ for internal exposure of individual organs;
  - Population limit of 5 rem in 30 yr in addition to background and medical exposure;
  - Small groups of the public, a limit of 0.5 rem yr$^{-1}$.
Formed in 1959 (Public Law 86-373) to provide a Federal policy on human radiation exposure.

Report No. 1 of the Federal Radiation Council was published in May 1960 to provide a Federal policy on human radiation exposure:

“The recommendations of the NCRP have received wide acceptance in the United States.”

NCRP Report. Nos. 13 (1954), 17 (1954), 18 (1955) and 22 (1959) are cited as forming the basis for the FRC Radiation Protection Guide (RPG) and Radioactivity Concentration Guides (RCG) and subsequent Protective Action Guides (PAG).
<table>
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<tr>
<th>NCRP Report No. (NBS HB No.)</th>
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<tbody>
<tr>
<td>22 (69)</td>
<td>Maximum permissible body burdens and maximum permissible concentrations of radionuclides in air and in water for occupational exposure</td>
<td>1959</td>
</tr>
<tr>
<td>23</td>
<td>Measurement of neutron flux and spectra for physical and biological applications</td>
<td>1960</td>
</tr>
<tr>
<td>24</td>
<td>Protection against radiations from sealed gamma sources</td>
<td>1960</td>
</tr>
<tr>
<td>25 (75)</td>
<td>Measurement of absorbed dose of neutrons and of mixtures of neutrons and gamma rays</td>
<td>1961</td>
</tr>
<tr>
<td>26</td>
<td>Medical x-ray protection up to three million volts</td>
<td>1961</td>
</tr>
<tr>
<td>27 (79)</td>
<td>Stopping powers for use with cavity chambers</td>
<td>1961</td>
</tr>
<tr>
<td>28</td>
<td>A manual of radioactivity procedures</td>
<td>1961</td>
</tr>
<tr>
<td>29</td>
<td>Exposure to radiation in an emergency</td>
<td>1962</td>
</tr>
<tr>
<td>30 (92)</td>
<td>Safe handling of radioactive materials</td>
<td>1964</td>
</tr>
<tr>
<td>31</td>
<td>Shielding for High Energy Accelerator Installations</td>
<td>1964</td>
</tr>
</tbody>
</table>
Director of NBS recommended that the Committee seek a means for completely independent establishment and operation.

Joint Committee on Atomic Energy: “U. S. Government was dependent upon an unofficial and independent committee, the NCRP, to establish the protection standards.”

Proposal that the NCRP be established under a Congressional Charter.

Charter under Public Law 88-376, 1964, set out its organization and objectives and established its independence from government control.

Reports published in the early years of the Council were influential in the practice of radiation protection and led to the safe use of radioactive materials and radiation producing devices. These included recommendations for protection in:

- Research and Educational Institutions,
- Medical Practices, and
- Shielding Specification and Design for Accelerator, X-ray and Gamma-ray Facilities.
NATIONAL COUNCIL ON RADIATION PROTECTION AND MEASUREMENTS: THE FIRST 25 YEARS

Early NCRP Reports

Shielding Specification and Design Report No. 31, 33, 34

Medical Practices Report No. 33, 34, 35, 37

Research and Education Report No. 32
Changes in U. S. Regulatory Structure:

In December 1970, the FRC and its functions were transferred to the new Environmental Protection Agency (EPA).

By 1977 the Atomic Energy Commission responsibilities had been divided and assigned to the Nuclear Regulatory Commission (NRC) and the Department of Energy (DOE).
In 1975 NCRP reviewed its recommendations in Report No. 39 and determined that no changes were necessary: Report No. 43, 1975.

Recommendations of ICRP, Publ. No. 26, 1977 were used by EPA, NRC and DOE to establish the radiation protection regulations that are currently in effect in the U.S.

Although NCRP issued its updated recommendations in Report No. 91 in 1987, the report appeared too late to be used in the further development of the regulations issued by the EPA, NRC and DOE.

By its 25th anniversary in 1989, the NCRP report number had reached 103.
NC RP REPORTS: 1930-1990

Number of NC RP Reports

- 1930-1934: 0 reports
- 1935-1939: 3 reports
- 1940-1944: 0 reports
- 1945-1949: 1 report
- 1950-1954: 7 reports
- 1955-1959: 2 reports
- 1960-1964: 9 reports
- 1965-1969: 2 reports
- 1970-1974: 7 reports
- 1975-1979: 21 reports
- 1980-1984: 16 reports
- 1985-1989: 22 reports

Note: The number of reports varies significantly by decade, with a peak in the 1975-1979 period.
Radiation protection recommendations of ICRP (1991) and NCRP (1993) have yet to be fully implemented in the United States.

NRC in 10 CFR 35 Medical Use of Byproduct Material (2002 and 2012) relies upon information provided in several NCRP reports:

- No. 102, 1989: Medical radiation equipment design, performance and use;
- No. 105, 1989: Protection for allied health personnel;
- No. 107, 1990: ALARA;
- No. 111, 1991: Emergency plans;
- No. 123, 1996: Assessment of radiation exposure; and
NRC in the Federal Register (2002) specified a revision in the skin dose limit based on NCRP documents:

- Report No. 106, 1989: Limit for Exposure to ‘‘Hot Particles’’ on the Skin;
- Report No. 130, 1999: Biological Effects and Exposure Limits for ‘Hot Particles’; and
- Statement No. 9, 2001: Extension of the Skin Exposure Limit for Hot Particles to Other Sources of Skin Irradiation.
U.S. NRC
REGULATORY GUIDES

- Guide 8.13, 1999, Prenatal Exposure
- Guide 8.18, 2011, ALARA at medical institutions
- Guide 8.21, 1979, Surveys at processing & manufacturing plants
- Guide 8.29, 1996, Risks from occupational exposure:
- Guide 8.31, 2002, ALARA at uranium facilities
- Guide 8.40, 2010, Measuring effective dose equivalent
EPA was given responsibility for:

- The promulgation of environmental standards, and
- The development of national radiation protection guidance for Federal and State agencies.

First revision of the 1960 Federal guidance for occupational exposure was published in January 1987:

- ICRP Publ. 26 (1977), but also
- ALARA, both ICRP and NCRP in Report No. 43, 1975.

EPA has issued standards and guidance documents that rely on NCRP recommendations.
1991 – Manual of Protective Action Guides and Protective Actions for Nuclear Incidents:
- NCRP Report No. 22, 1959: Maximum permissible body burdens and concentrations of radionuclides.
- NCRP Report No. 39, 1971: Basic radiation protection criteria, and
- NCRP Report No. 52, 1977 Cs – 137: from the environment to man.

2013 – DRAFT Protective Action Guides and Planning Guidance for Radiological Incidents:
- NCRP Report No. 138, 2001: Terrorist events involving radioactive material and
- NCRP Report No. 165, 2010: Responding to a radiological or nuclear terrorism incident.

- NCRP Report No. 161, 2008: Management of contaminated persons;
- NCRP Report No. 165, 2010: Responding to a radiological or nuclear terrorism incident;
- NCRP Report No. 166, 2010: Population monitoring and radionuclide decorporation, and
U.S. EPA


- NCRP Report No. 100, 1989: Exposure of the U.S. population from diagnostic medical radiation;
- NCRP Report No. 102, 1989: Medical X-ray protection;
- NCRP Report No. 116, 1993: Limitation of Exposure to Ionizing Radiation;
- NCRP Report No. 133, 2000: Procedures performed outside the radiology department;
- NCRP Report No. 145, 2003: Radiation protection in dentistry;
- NCRP Report No. 147, 2004: Structural shielding design for medical x-ray imaging facilities;
- NCRP Report No. 148, 2004: Radiation protection in veterinary medicine; and
- NCRP Report No. 172, 2012: Reference levels and achievable doses in medical and dental imaging: recommendations for the United States;

2008: Planning guidance for protection and recovery following radiological dispersal device (RDD) and improvised nuclear device (IND).
   - NCRP Report No. 116, 1993: Limitations of exposure;
   - NCRP Report No. 138, 2001: Terrorist events involving radioactive material; and
   - NCRP Commentary No. 19, 2005: Preparing emergency responders for nuclear and radiological terrorism.

2010: Planning guidance for a response to a nuclear detonation added two additional reports.
   - NCRP Report No. 161, 2008: Management of contaminated persons;
   - NCRP Report No. 165, 2010: Responding to a radiological or nuclear terrorism incident.
1981: DOE Order 5480.11, Radiation Protection for Occupational Workers.

1993: 10 CFR part 835, Occupational Radiation Protection.


1988: Example of DOE guidance document: Health physics manual of good practices for accelerator facilities, which included references to NCRP.

- NCRP Report No. 47, 1976: Structural shielding design;
- NCRP Report No. 51, 1977: Radiation protection design guidance;
- NCRP Report No. 79, 1984: Neutron radiation;
- NCRP Report No. 58 (2nd Ed.), 1985: Radioactivity measurements;
- NCRP Report No. 81, 1985: Radionuclide contamination;
- NCRP Report No. 88, 1986: Radiation alarms and access control; and

- NCRP Report No. 53, 1977: Dose limits for the embryo and fetus;
- NCRP Report No. 59, 1978: Operational radiation safety program;
- NCRP Report No. 61, 1978: Training for radiographers;
- NCRP Report No. 65, 1980: Management of persons contaminated with radionuclides;
- NCRP Report No. 71, 1983: Operational radiation safety training;
- NCRP Report No. 91, 1987: Limits for exposure;
- NCRP Report No. 106, 1989: Limit for exposure to hot particles on the skin;
- NCRP Report No. 112, 1991: Calibration of survey instruments; and
1989: Radiation protection program for space exploration
  ▶ NCRP Report No. 98, 1989: Radiation received in space activities;

Guidance for activities in low earth orbit
  ▶ NCRP Report No. 142, 2002: Operational radiation safety program for astronauts in low-Earth orbit; and
  ▶ NCRP Commentary No. 23, 2014: Radiation protection for space activities.

Extending space missions beyond low Earth orbit

NCRP addressed the specific topic of the potential effect of individual genetic susceptibility on risk to astronauts from radiation exposure
Formed as part of the implementation of Public law 90-602, "Radiation Control for Health and Safety Act of 1968".

Suggested State Regulations for the Control of Radiation, most recent publication 2014.

Part D: Standards for protection against ionizing radiation

Part X: Therapeutic radiation machines
- NCRP Report No. 49, 1976: Structural shielding design for x-ray equipment;
- NCRP Report No. 69, 1981: Dosimetry of x-ray and gamma ray beams for radiation therapy;
- NCRP Report No. 79, 1984: Neutron contamination from electron accelerators;
- NCRP Report No. 144, 2003: Radiation protection for particle accelerators; and
- NCRP Report No. 151, 2005: Structural shielding design for megavoltage accelerator facilities.
Guidance Documents:

- **2001**: Quality Control Recommendations for Diagnostic Radiography.

- **2004**: Implementation Guidance for Regulation and Licensing of TENORM.

- **2006**: Handbook for Responding to a Radiological Dispersal Device.
  - NCRP Commentary No. 19, 2005: Preparing emergency responders.

- **2010**: Planning Guidance for the Response to a Nuclear Detonation.
  - NCRP Report No. 116, NCRP Report No. 138, NCRP Commentary No. 19; and
  - NCRP Report No. 165, 2010: Responding to a radiological or nuclear terrorism incident.
NON-REGULATORY BODIES
NATIONAL ACADEMY OF SCIENCES

K-L. D. Gottfried & G. Penn, Editors

Committee on an Assessment of CDC Radiation Studies.

Committee to Assess Health Risks from Exposure to Low Levels of Ionizing Radiation.

Committee for Evaluation of Space Radiation Cancer Risk Model.

Committee for Evaluation of Space Radiation Cancer Risk Model.
American Association of Physicists in Medicine (AAPM)

NON-REGULATORY BODIES

AAPM Reports

NCRP Report No. 33, 35, 39, 54, 57, 66
NCRP Report No. 39, 45, 54, 64, 77
NCRP Report No. 49
NCRP Report No. 160 Comm. No. 16
NCRP Report No. 102, 107
NCRP Report No. 99, 105, 107, 122
NCRP Report No. 49
NCRP Report No. 49
NCRP Report No. 95
NCRP Report No. 18
NCRP Report No. 58
NON-REGULATORY BODIES

American College of Radiology

- ACR Practice Parameter For The Performance Of Screening And Diagnostic Mammography (2013).
- ACR-AAPM Practice Parameter For Diagnostic Reference Levels And Achievable Doses In Medical X-Ray Imaging (2014).
  - NCRP Report No. 168, 2010: Fluoroscopically-guided interventional medical procedures; and
Examination Preparation Guide

Basic science
NCRP Report No.
82, 92, 100, 101, 104, 115, 121, 128, 130, 136

Physics
NCRP Report No.
57, 97

Nonionizing Radiation
NCRP Report No.
74, 86, 119

Environmental studies
NCRP Report No.
50, 62, 93, 94, 103

Emergency planning
NCRP Report No.
65, 138

Radiation protection
NCRP Report No.
88, 105, 116, 117, 120, 127, 144, 145

Basic science
NCRP Report No.
82, 92, 100, 101, 104, 115, 121, 128, 130, 136

Physics
NCRP Report No.
57, 97

Nonionizing Radiation
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74, 86, 119

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NCRP Report No.
50, 62, 93, 94, 103

Emergency planning
NCRP Report No.
65, 138

Radiation protection
NCRP Report No.
88, 105, 116, 117, 120, 127, 144, 145
Non-Regulatory Bodies
Health Physics Society - Position Statements

  - NCRP Report No. 138, 2001
  - NCRP Report No. 139, 2002
  - NCRP Report No. 116, 1993
- Update on Perspectives and Recommendations on Indoor Radon (2009).
  - NCRP Report No. 160, 2009

- Occupational Radiation Safety Standards and Regulations Are Sound (2010).
  - NCRP Report No. 93, 1987
  - NCRP Report No. 116, 1993
  - NCRP Report No. 126, 1997
- Exclusive Use Of SI Units To Express Radiological Quantities (2012).
  - NCRP Report No. 82, 1985
- Uncertainty In Risk Assessment (2013).
  - NCRP Report No. 171, 2012
Common theme: Radiation protection must be based on the principals of justification, dose limitation and the application of ALARA.

The effectiveness of operating under the basic principles of radiation protection is demonstrated across all occupations in the U.S. in which exposure to radiation is possible. (NCRP Report No. 160).

NCRP recommendations and guidance documents have had a great influence on the application and implementation of these principles, and protection of the population while permitting the beneficial use of technologies that may lead to radiation exposure.
NCRP Council Committee 1 (CC-1): update the bases of the System of Protection against Radiation for the United States, and the fundamental recommendations to limit exposures and their subsequent consequences.

- inform about all sources of ionizing radiation exposure;
- include sources and exposures that were not specifically addressed in previous recommendations;
  - patients exposed in diagnostic and interventional medical procedures,
  - caregivers for patients treated with radioactive materials,
  - voluntary participants who may be exposed to ionizing radiation in medical research,
  - workers and the general public exposed to naturally occurring radiation sources including those enhanced by technology, and
- exposure to non-human species in the environment.