Adopting the International System of Units for Radiation Measurements in the United States

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Disclaimer

The findings and conclusions in this presentation are those of the author and do not necessarily represent the official position of the Centers for Disease Control and Prevention/the Agency for Toxic Substances and Disease Registry.

Radiological Quantities: SI and "Traditional" Units

Bq Ci rem rad Gy Sv

mrem/h Bq/kg rem/y R R/h mSv

mCi μSv pCi/g pCi/m^3

mSv/y mrem mSv/h μR/h Bq/L

nGy/h kBq/cm^2 pCi/L μCi/cm^2 MBq Bq/m^2

Authority on Units of Measurements

- 1875 Treaty established the following organizations to conduct international activities relating to a uniform system for measurements:

  - **CGPM** (*Conférence Générale des Poids et Mesures*),
    The General Conference on Weights and Measures
    - Intergovernmental governing body, meets every 4 years

  - **CIPM** (*Comité international des poids et mesures*)
    The Committee on Weights and Measures
    - Scientists and metrologists prepare and execute decisions of CGPM
    - Supervise operations of BIPM

  - **BIPM** (*Bureau international des poids et mesures*)
    International Bureau of Weights and Measures
    - Laboratory and world centre of scientific metrology, the activities include the establishment of the basic standards and scales of the principal physical quantities and maintenance of the international prototype standards.

Authority on Units of Measurements

www.icru.org

- ICRU (established in 1925 as the International X-Ray Unit Committee)
  - Develops internationally accepted recommendations regarding:
    - quantities and units of radiation and radioactivity
    - procedures suitable for the measurement and application of these quantities in diagnostic radiology, radiation therapy, radiation biology, nuclear medicine, radiation protection, and industrial and environmental activities;
    - physical data needed in the application of these procedures, the use of which assures uniformity in reporting.
  - ICRU recommendations often adopted by governments, national statutory bodies and international associations and organizations
  - Prominent U.S. involvement and leadership
    - LS Taylor (1928-69); HO Wykoff (1969-87); PM DeLuca, Jr (2006-9)

Evolution of Radiation Units (ICRU Recommendations)

QUANTITY		UNIT			DATE
Name	Symbol	Unit	Special name	Symbol	
Exposure	X	1 e.s.u. per 0.001293 g of air	röntgen	r→R	1928
Absorbed dose	D	erg g^{-1}			1950
Activity	A	3.7×10^{10} s^{-1}	curie	Ci	1953
Absorbed dose	D	100 erg g^{-1}	rad	rad	1953
Fluence	Φ	cm^{-2} or m^{-2}	(reciprocal area)	(SI)	1962
Dose equivalent	H	100 erg g^{-1}	röntgen equivalent man	rem	1971
Absorbed dose	D	J kg^{-1}	gray	Gy (SI)	1974
Activity	A	s^{-1}	bequerel	Bq (SI)	1974
Dose equivalent	H	J kg^{-1}	sievert	Sv (SI)	1977

International Commission on Radiation Units & Measurements

www.icru.org

Example: Adoption of ICRU Recommendation by BIPM

Resolution 8 of the 15th CGPM (1975)

SI units for ionizing radiation: becquerel

The 15th Conférence Générale des Poids et Mesures,

by reason of the pressing requirement, expressed by the International Commission on Radiation Units and Measurements (ICRU), to extend the use of the Système International d'Unités to radiological research and applications,
by reason of the need to make as easy as possible the use of the units for non-specialists,
taking into consideration also the grave risks of errors in therapeutic work,

adopts the following special name for the SI unit of activity:
becquerel, symbol Bq, equal to one reciprocal second.

Reference:

- *Comptes Rendus de la 15e CGPM* (1975), 1976, p.105
- *Metrologia*, 1975, **11**(4), 179-183

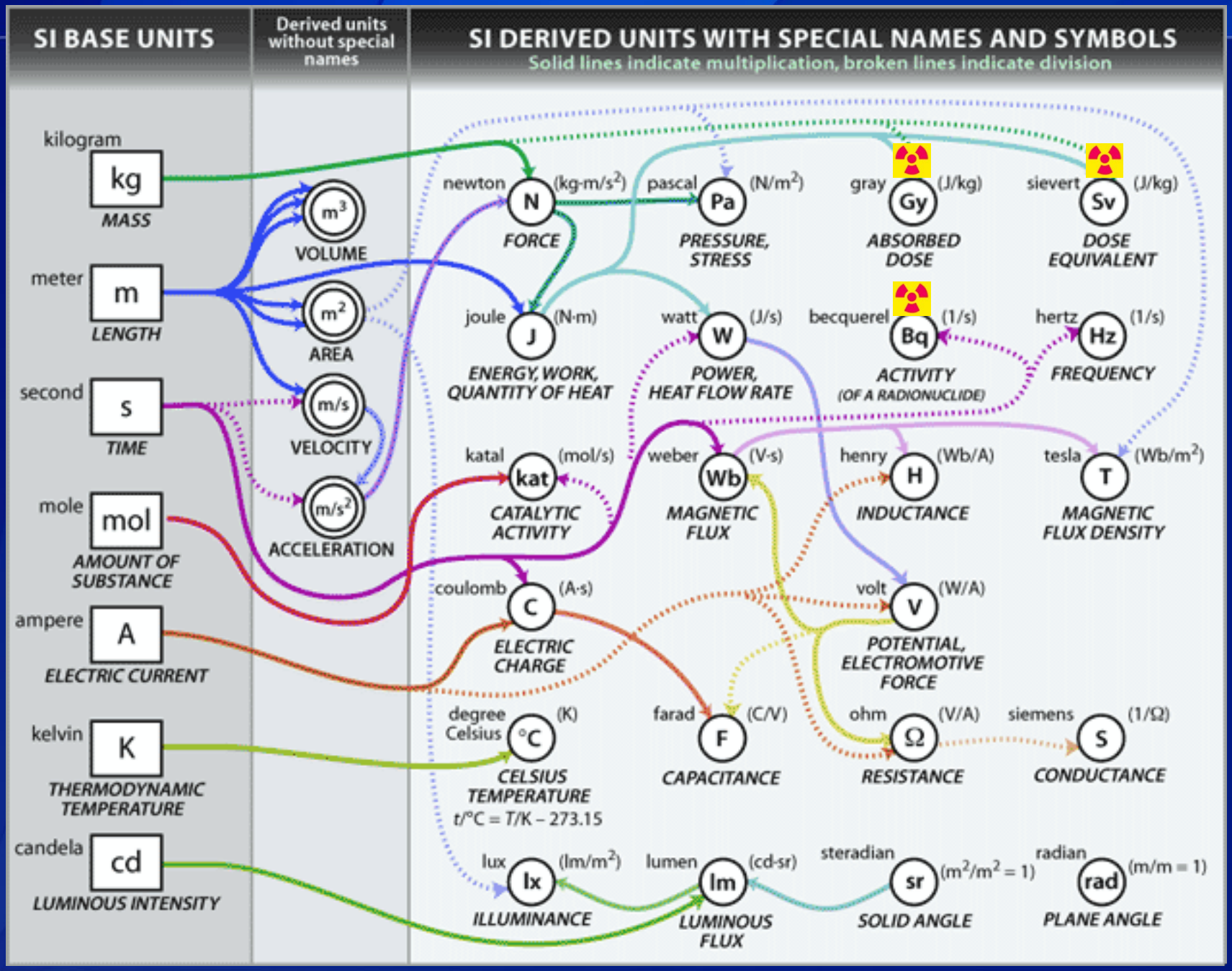
www.bipm.org/en/CGPM/db/15/8/

The Authority on Units of Measurements

- United States
  - Department of Commerce
    - National Institute of Standards and Technology (NIST)
      Formerly, the National Bureau of Standards (NBS)
      www.nist.gov
  - National Council on Radiation Protection and Measurements (NCRP)
    - Charted by Congress in 1964 (Public Law 88-376)
    - One of its stated objectives is to "develop basic concepts about radiation quantities, units and measurements, about the application of these concepts, and about radiation protection"

      www.ncrponline.org

NCRP
National Council on Radiation Protection & Measurements



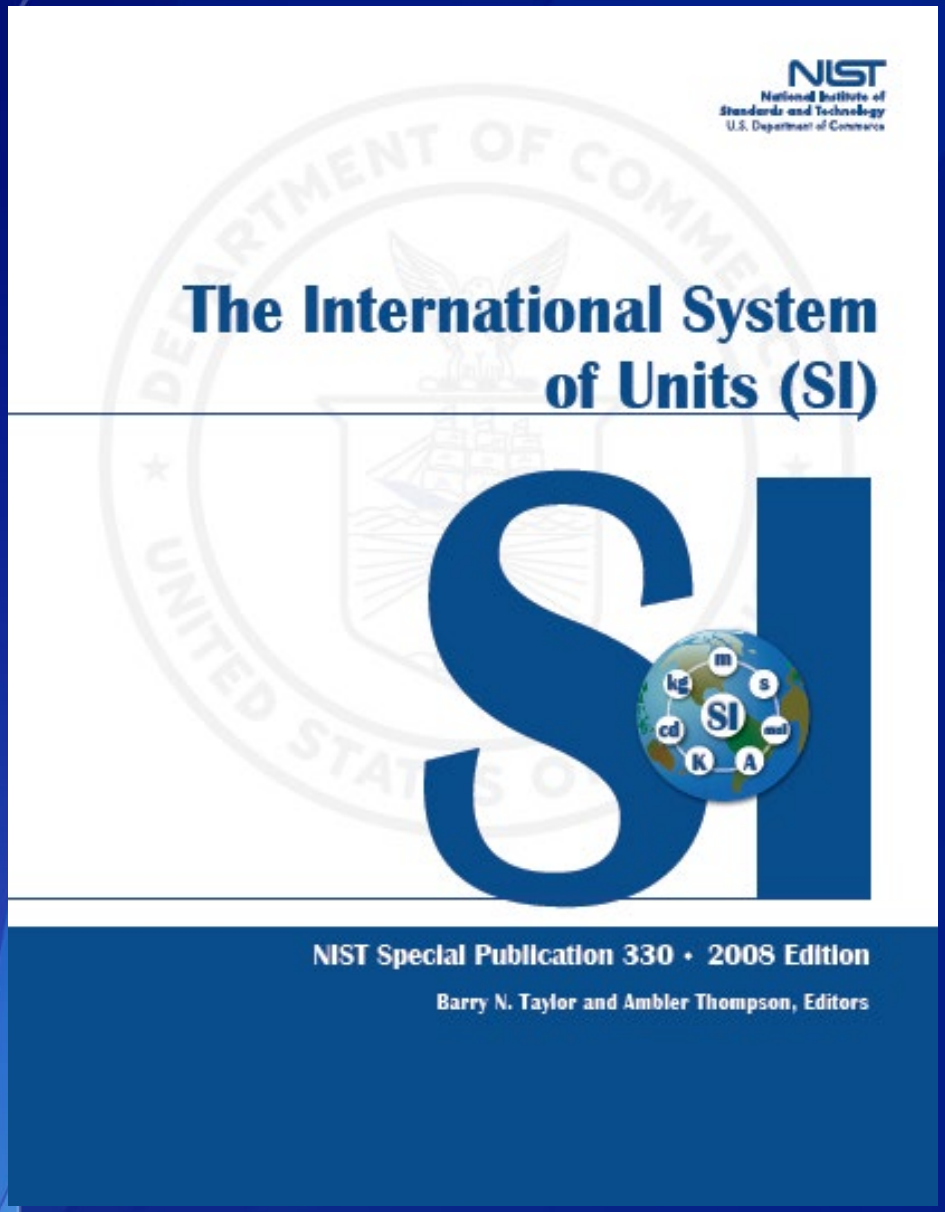
Source: http://physics.nist.gov/cuu/Units/SIdiagram.html

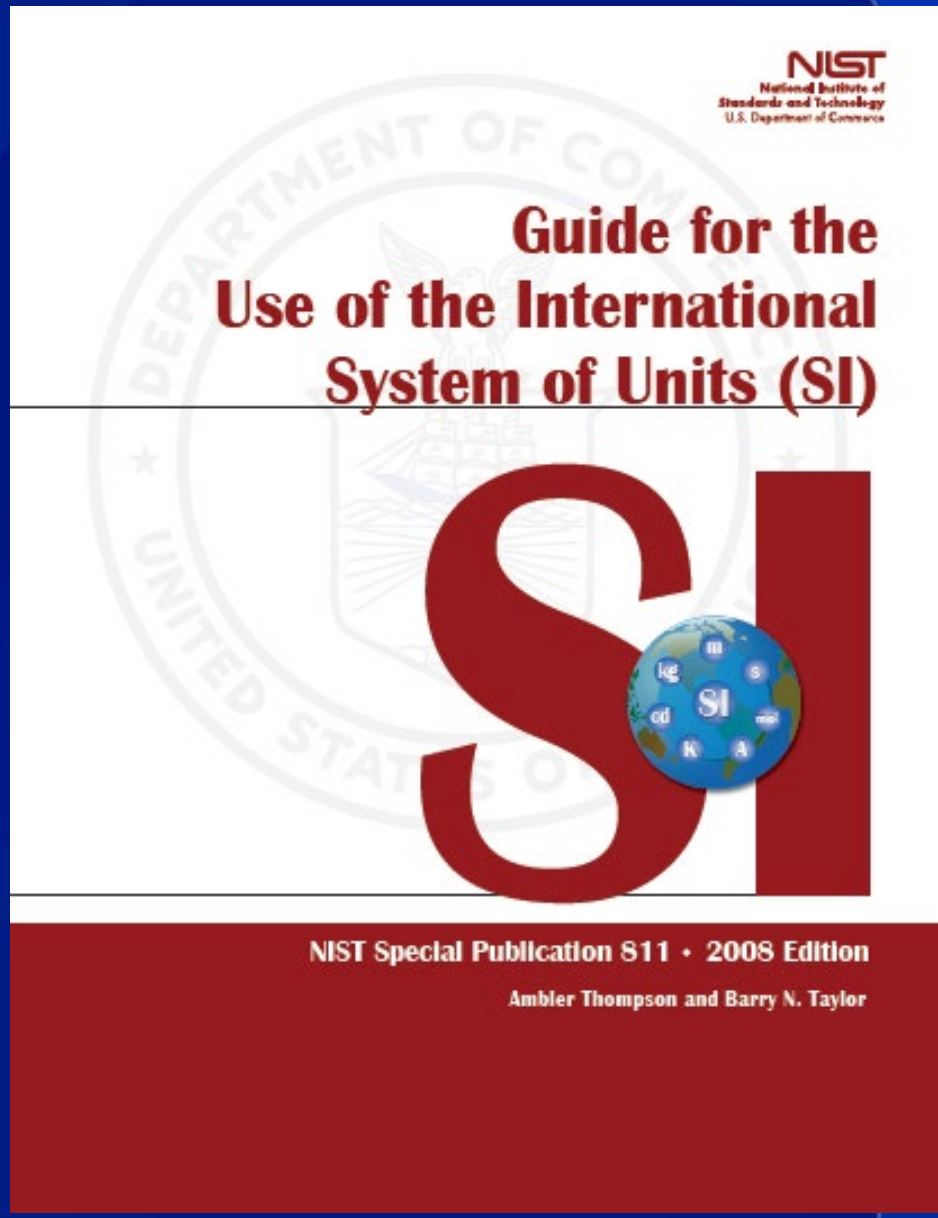
SI Brochure: The International System of Units (SI)
[8th edition, 2006; updated in 2014]

Non-SI Units recognized

- Section 4.1: Non-SI units accepted for use with the SI, and units based on fundamental constants
  - Units of historical importance in established literature
  - Units deeply embedded in the history and culture of the human race

- Section 4.2: Other non-SI units not recommended for use
  - Of historical interest or still used in specialized fields
  - CIPM can see no case for continuing to use these units in modern scientific and technical work.
    - Units of *curie, rad, rem,* and *roentgen* included in this category!

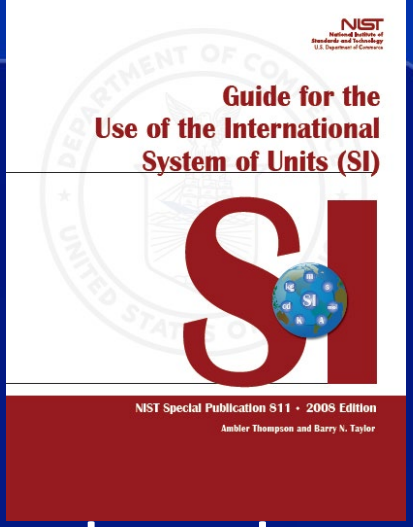




www.nist.gov/pml/pubs/sp330/

www.nist.gov/pml/pubs/sp811/

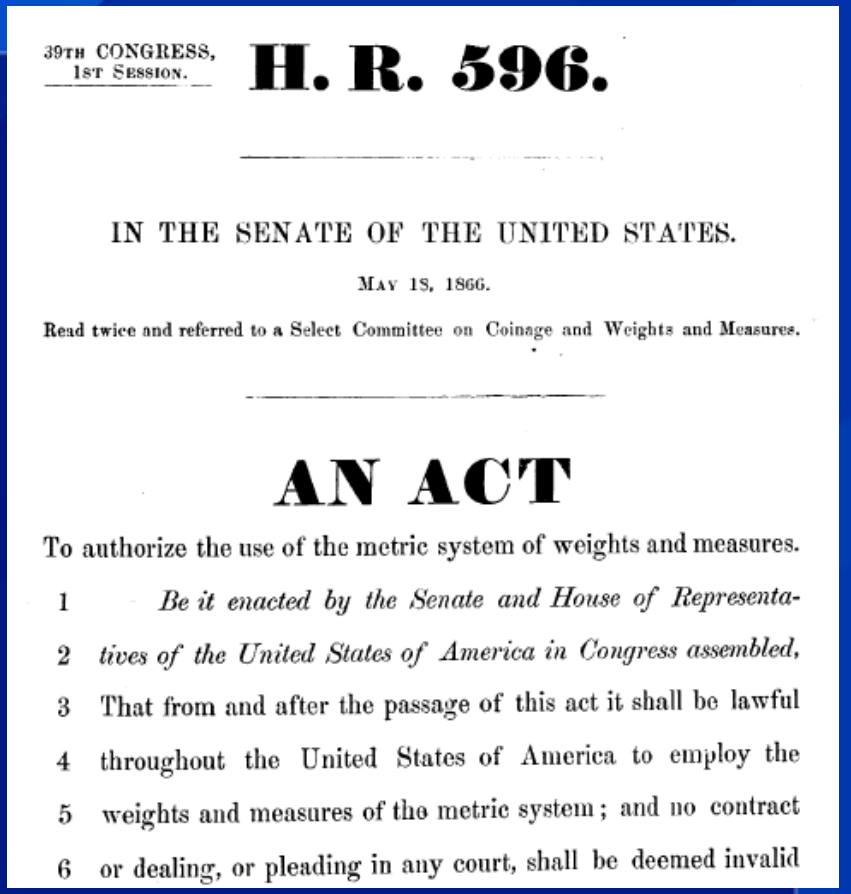
On Non-SI Units



- Recognizes units of curie, roentgen, rad, and rem "since they are in wide use in the United States, especially in regulatory documents dealing with health and safety."
- Nevertheless, this *Guide* strongly discourages the continued use of the curie, roentgen, rad, and rem.

Timeline

- 1866 – The Metric Act of 1866 legally recognized the metric system of measurement in the U.S.



39TH CONGRESS, 1ST SESSION.

H. R. 596.

IN THE SENATE OF THE UNITED STATES.

MAY 18, 1866.

Read twice and referred to a Select Committee on Coinage and Weights and Measures.

AN ACT

To authorize the use of the metric system of weights and measures.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That from and after the passage of this act it shall be lawful throughout the United States of America to employ the weights and measures of the metric system; and no contract or dealing, or pleading in any court, shall be deemed invalid

- 1975 – The Metric Conversion Act (Public Law 94 – 168) declared the Metric system the preferred system of weights and measures for United States trade and commerce.

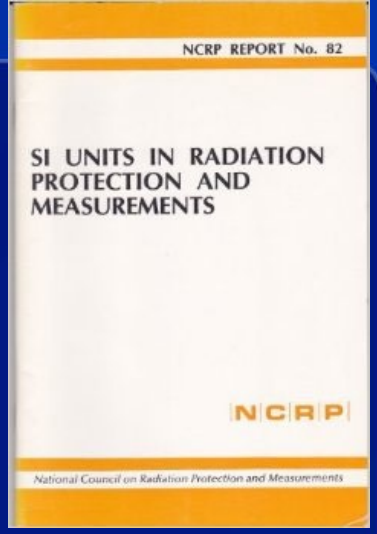
Timeline

- 1975 – Formal international adoption of SI derived units with special names for radiological quantities (10-year transition period.)
- 1977 – ICRP began exclusive use of SI units.
- 1984 – Journal Health Physics required all manuscripts to use the SI units (with traditional units in parentheses during a transition period).
- 1985 – NCRP published Report No.82, recommended a further transition period to be completed by December 1989. [NCRP itself has been using SI exclusively.]
- 1991 – Executive Order 12770 signed by President George H.W. Bush and Federal Register Notice of Metric Conversion Policy for Federal Agencies.

Timeline

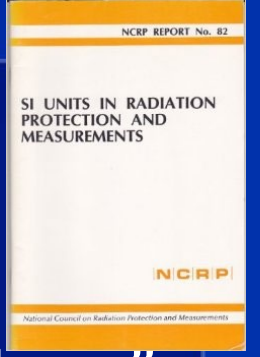
- 1992 – Nuclear Regulatory Commission (NRC) published its Metrication Policy (57 FR 46202). The policy "supports and encourages the use of the metric system of measurement by licensed nuclear industry."
- 1996 –Nuclear Regulatory Commission reaffirmed its Metrication Policy and considered "its conversion to the metric system is complete."
- 1998 – NIST Federal Register Notice (Volume 63, No. 144:40334–40340) discourages continued use of the curie, roentgen, rad, and rem.
- 2008 – NIST Special Publications 330 and 811 strongly discourages the continued use of the curie, roentgen, rad, and rem.
- 2012 – Health Physics Society position statement on exclusive use of SI units to express radiological quantities.
- 2013 – HPS Publications and website implement "SI only" policy.

NCRP Report No. 82
SI Units in Radiation Protection and Measurements
(1985)



- Considered and discussed many concerns regarding the adoption of SI units for radiological quantities.
- Called for a gradual adoption of SI units in the United States over a five-year transition period. (complete by Dec 1989)
- Solicited “the cooperation of all in making this transition, which experience indicates is less formidable than many suppose.”

NCRP Report No. 82



- "Some will find the transition more difficult than others."
- "It will be easier to change now rather than later."
- "The cost of switching in the near future will be less than the cost of switching at any later time."
- Available "evidence in other countries does not indicate that safety is jeopardized by the introduction of a new unit system."

This was written 30 years ago!

Federal Register / Vol. 61, No. 119 / Wednesday, June 19, 1996 / Notices 31169

Nuclear Regulatory Commission

Conversion to Metric System; Policy Statement

- Supports and encourages the use of the metric system by licensed nuclear industry.
- Will publish new documents in dual units, SI (English)
- Documents specific to a licensee will be in the system of units employed by the licensee.
- Only documents applicable to all licensees will contain dual units.

Federal Register / Vol. 61, No. 119 / Wednesday, June 19, 1996 / Notices 31169

Nuclear Regulatory Commission

Conversion to Metric System; Policy Statement

- All event reporting and emergency response communications between licensees, the NRC, and State and local authorities will be in the English system of measurement.

- The purpose of this notice is to inform the public of the Commission's decision that its Statement of Policy on Conversion to the Metric System does not need to be modified, that it considers this policy final, and that its conversion to the metric system is complete.

Fukushima Nuclear Reactor Radiation Crisis: A National Review of the U.S. Domestic Public Health and Medical Response

- Report by the Association of State and Territorial Heath Officials (ASTHO), 2012

  www.radiationready.org

- “The difference in radiation units used in the US and other countries was a source of confusion.”

U.S. and International Response

- Information provided by Japanese authorities, IAEA, WHO, UNSCEAR, … were all in SI units.
  - Professional community in the rest of the world views "traditional" units as archaic, obsolete, and outdated.
- Most print and television media used SI units .
- Unit conversion, although generally straightforward, introduces unnecessary opportunities for numerical errors when safety and credibility are at stake.
- Difference in units complicated communications between radiation subject matter experts, other professionals involved in the response, and members of the general public. [CM Miller, *Health Phys.* 102(5): 584-8, 2012]

HEALTH PHYSICS SOCIETY

EXCLUSIVE USE OF SI UNITS TO EXPRESS RADIOLOGICAL QUANTITIES

POSITION STATEMENT OF THE HEALTH PHYSICS SOCIETY*

Adopted: February 2012

"The continued use of traditional, yet outdated, units to express radiological quantities in the United States can have significant repercussions with regard to effective response to radiation emergencies."

1975-2015

- We now have evidence accumulated over decades of use – that is *exclusive use* - of SI units in nearly all countries in the world.

- These countries, many with well-established nuclear industries, have effected the transition to SI units successfully, without compromising health and safety, and have demonstrated that complete conversion to current international units is certainly practical and doable.

- Furthermore, there has not been any indication of any difficulty in research, practice, or in teaching or educating their young scientists.

http://hps.org/documents/SIunits_ps025-0.pdf

Continued use of the outdated traditional units:

- Hinders the exchange and interpretation of information even among radiation safety professionals, especially during a radiation emergency,
- Provides an unnecessary barrier to public communication, and
- Perpetuates the use of these units by future generations of radiation safety professionals who are not conversant in the current scientific and internationally adopted radiological units.

HPS Position Statement http://hps.org/documents/SIunits_ps025-0.pdf

Bureau International des Poids et Mesures

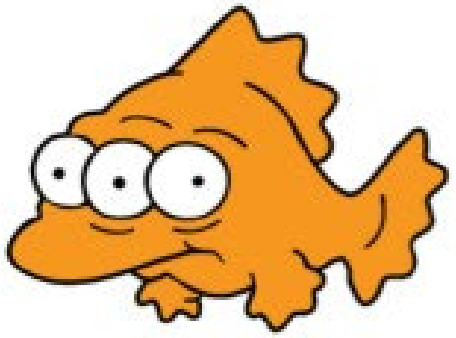
- The SI is the only system of units that is universally recognized, so that it has a distinct advantage in establishing a dialogue over the whole world.

http://www.bipm.org/en/publications/si-brochure/

SIMPSONS GUIDE TO RADIATION

Bequerel [Bq]
How brightly your Cesium glows

Gray [Gy]
How brightly Cesium will make you glow



Sieverts [Sv]
How many extra eyes will you have after glowing?

Source: http://9gag.com/gag/aM1d7XX/simpsons-guide-to-radiation-unit

Thank You

For more information please contact Radiation Studies Branch, CDC

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Telephone, 1-770-488-3800
E-mail: rsbinfo@cdc.gov Web: emergency.cdc.gov/radiation