Relative Acceptable Societal Risks and Their Relevance to Nuclear Operations/Criticality Safety

keynote address presentation
by

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to

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Some old, new and maybe interesting stuff about

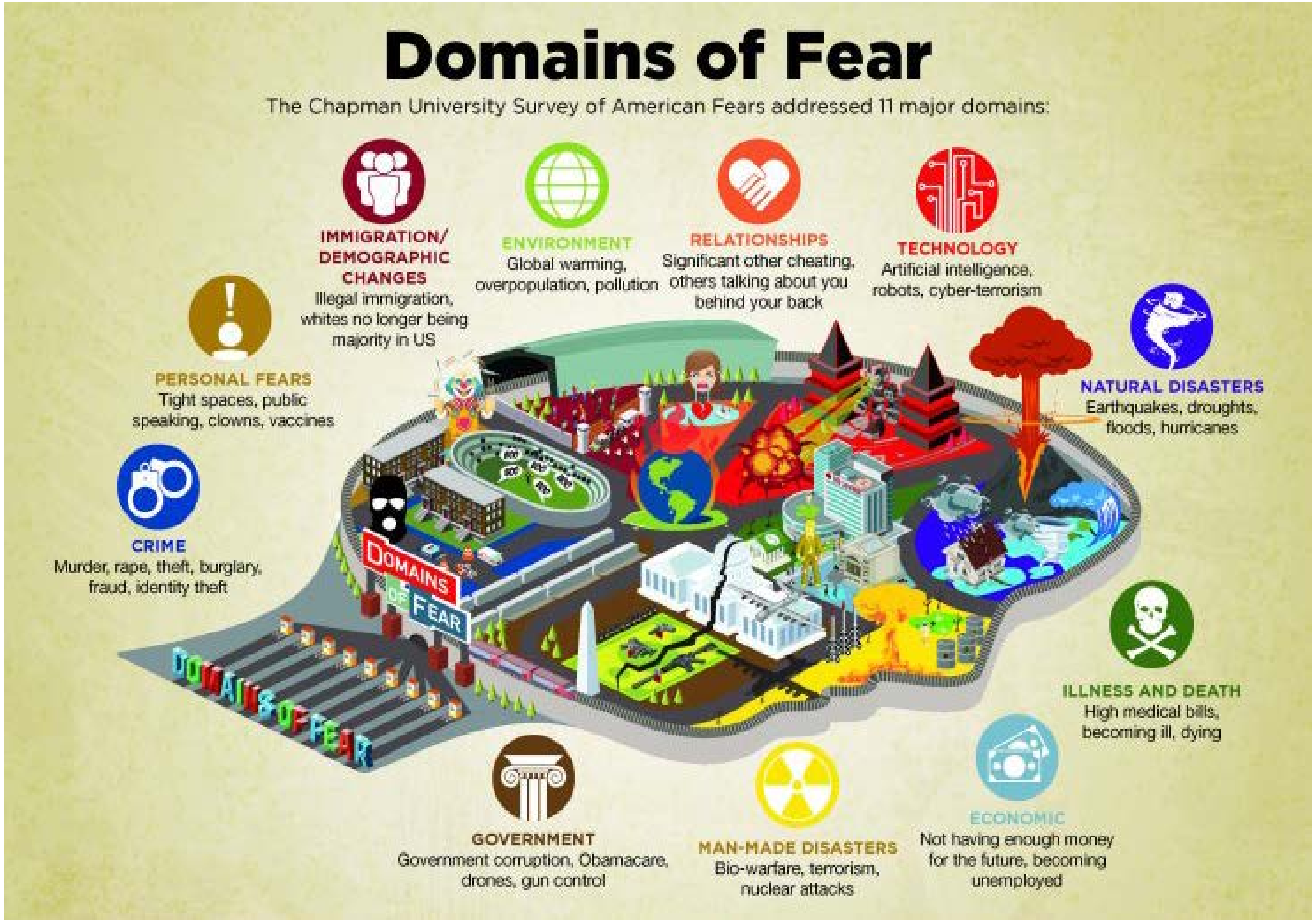
- **Fears – Personal and Societal**
- **What is and is not killing us (making us sick may be different)**
- **A few rhetorical questions**
- **Acceptable Societal Risks**
- **Relevance to nuclear criticality safety of fissionable material operations, storage, transportation, and waste disposal**

Fears – Personal and Societal

(America's Top Fears – 2016 Chapman University Survey of American Fears, October 11, 2016)

11 Fear Domains of 80 Specific Fears

Crime	Economic	Environment
Government	Illness & Death	Immigration & Demographic Change
Man-Made Disasters	Natural Disasters	Personal Fears
Relationships	Technology	


Domains of Fear
The Chapman University Survey of American Fears addressed 11 major domains:
IMMIGRATION/ DEMOGRAPHIC CHANGES
Illegal immigration, whites no longer being majority in US
ENVIRONMENT
Global warming, overpopulation, pollution
RELATIONSHIPS
Significant other cheating, others talking about you behind your back
TECHNOLOGY
Artificial intelligence, robots, cyber-terrorism
PERSONAL FEARS
Tight spaces, public speaking, clowns, vaccines
NATURAL DISASTERS
Earthquakes, droughts, floods, hurricanes
CRIME
Murder, rape, theft, burglary, fraud, identity theft
ILLNESS AND DEATH
High medical bills, becoming ill, dying
GOVERNMENT
Government corruption, Obamacare, drones, gun control
MAN-MADE DISASTERS
Bio-warfare, terrorism, nuclear attacks
ECONOMIC
Not having enough money for the future, becoming unemployed
DOMAINS OF FEAR
DOMAINS OF FEAR

10 most feared of 80 survey subjects include

Fear	Fear Domain	% Afraid or Very Afraid
Corrupt government officials	Government	60.6
Terrorist attack	Man-made Disasters	41
Not having enough money for the future	Economic	39.9
Terrorism	Crime	38.5
Government restrictions on firearms and ammunition	Government	38.5
People I love dying	Illness and Death	38.1
Economic/financial collapse	Economic	37.5
Identity theft	Crime	37.1
People I love becoming seriously ill	Illness and Death	35.9
The health care legislation	Government	35.5

10 median fears of the 80 listed fears

Fear	Fear Domain	% Afraid or Very Afraid
Pandemic or a major epidemic	Man-made Disasters	29.3
Corporate tracking of personal data	Technology	28.7
Extinction of plant and animal species	Environment	27.9
Pollution of drinking water	Environment	27.9
Break-ins	Crime	27.6
Widespread civil unrest	Man-made Disasters	27.6
Nuclear accident/meltdown	Man-made Disasters	27.5
Random/mass shooting	Crime	26.9
Oil spills	Environment	26.8
Collapse of the electrical grid	Man-made Disasters	26.2

10 least feared of the 80 listed fears

Fear	Fear Domain	% Afraid or Very Afraid
Germs	Personal Fears	14.9
Flying	Personal Fears	12.1
Blood	Personal Fears	11.7
Animals (dogs, rats, etc.)	Personal Fears	10.9
Significant other cheating on you	Relationships	10.2
Zombies	Personal Fears	10.2
Strangers	Personal Fears	9.8
Ghosts	Personal Fears	8.9
Clowns	Personal Fears	7.8
Others talking about you behind your back	Relationships	6.8

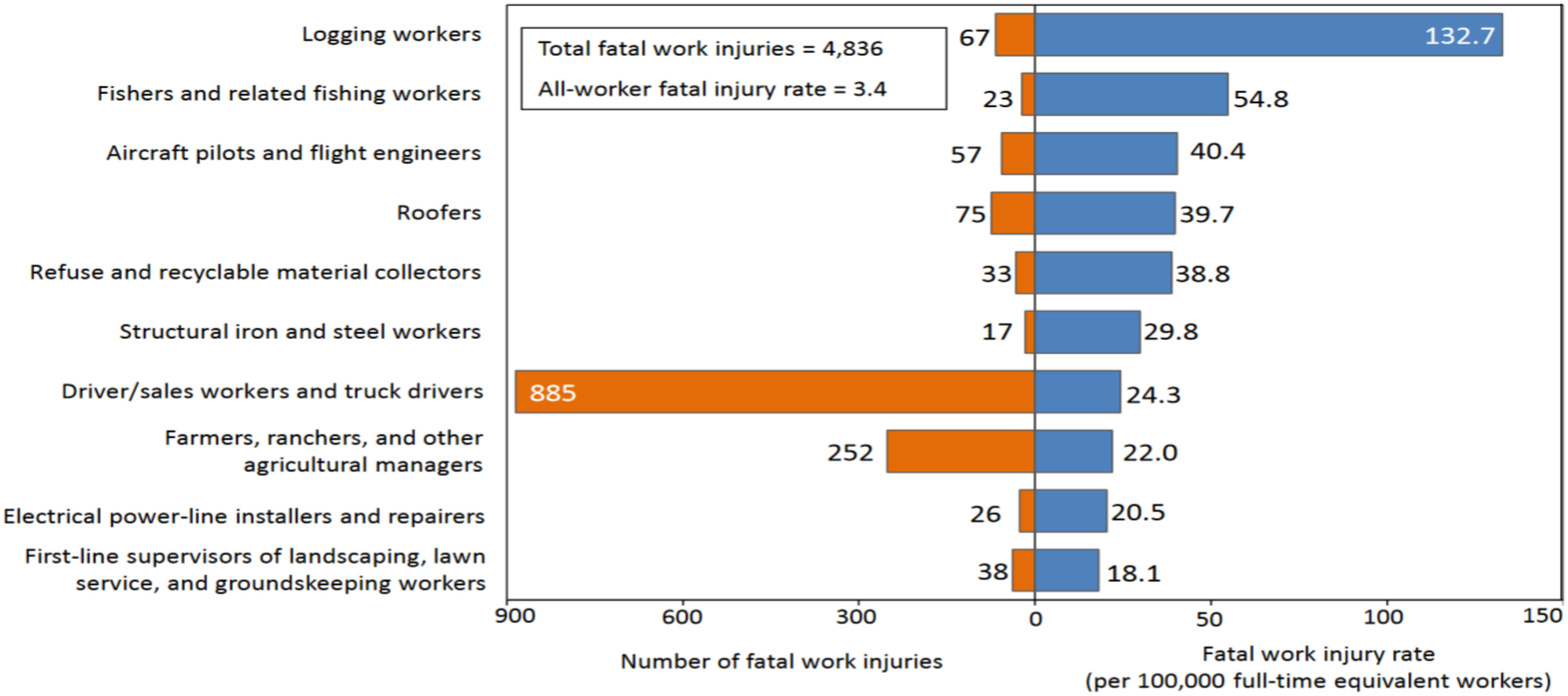
How do those fears relate to what is and <u>is not</u> killing us?

What is and is not killing us (making us sick may be different)

[deaths/yr-100,000 employees](total employee deaths/yr){deaths/yr-US Population}

All on the jobs [3.4](4836){$1.5x10^{-5}$}

(US Bureau of Labor Statistics Census of Fatal Occupational Injuries – 2016)



Hazardous/Risky Jobs

[deaths/yr-100,000 employees] (total employee deaths/yr) {deaths/yr-US Population}

All on the jobs [3.4] (4836) {$1.5x10^{-5}$}

(US Bureau of Labor Statistics Census of Fatal Occupational Injuries – 2016)

Top 10 Dangerous Jobs

1. Logging workers [133] (67) {$2.0x10^{-7}$}
2. Fishers and related fishing workers [55] (23) {$7.1x10^{-8}$}
3. Aircraft pilot and flight engineers [40] (57) {$1.8x10^{-7}$}
4. Roofers [40] (75) {$2.3x10^{-7}$}
5. Refuse and recyclable material collectors [39] (33) {$1.0x10^{-7}$}
6. Structural iron and steel workers [30] (17) {$5.3x10^{-8}$}
7. Drivers/sales workers and truck drivers [24] (885) {$2.7x10^{-6}$}
8. Farmers, ranchers, and other agricultural managers [22] (252) {$7.8x10^{-7}$}
9. Electrical power-line installers and repairers [21](26){$8.0x10^{-8}$}
10. Construction laborers [16] (235) {$7.3x10^{-7}$}

<u>BUT</u>, what <u>is</u> killing our US Population

845 deaths/100,000 people from all causes taken from death certificates

[deaths/yr-100,000 people] (total deaths/yr) {deaths/yr-US population}

(US Centers for Disease Control and Prevention – National Center for Health Statistics, 2016)

Top 10 causes of death

1. **Diseases of heart (heart disease)**
   [196] (633,842) {2.0×10^{-3}}
2. **Malignant neoplasms (cancer)**
   [184] (595,930) {1.8×10^{-3}}
3. **Chronic lower respiratory diseases**
   [48] (155,041) {4.8×10^{-4}}
4. **Accidents**
   [46] (146,571) {4.5×10^{-4}}
5. **Cerebrovascular diseases (stroke)**
   [44] (140,323) {4.3×10^{-4}}
6. **Alzheimer's disease**
   [34] (110,561) {3.4×10^{-4}}
7. **Diabetes mellitus (diabetes)**
   [25] (79,535) {2.5×10^{-4}}
8. **Influenza and pneumonia**
   [18] (57,062) {1.8×10^{-4}}
9. **Nephritis, nephrotic syndrome and nephrosis (kidney disease)**
   [16] (49,959) {1.5×10^{-4}}
10. **Intentional self-harm (suicide)**
    [14] (44,193) {1.4×10^{-4}}

Causes of accidental deaths

(US Centers for Disease Control – Deaths: Final Data for 2014, tables 9, 18)

[deaths/yr-100,000 people] (total deaths/yr) {deaths/yr-US population}

- Total Deaths [42.6] (135,928) {4.3×10^{-4}}
- Falls [10.0] (31,959) {1.0×10^{-4}}
- Motor vehicle [10.6] (33,736) {1.1×10^{-4}}
- Poisoning [13.2] (42,032) {1.3×10^{-4}}

Fears relate to real and false concerns about our well being

- Avoidance of actual hazard risks are variable at:
  - Work
    - Corporate/business procedures/training
    - Physical equipment hazard barriers
    - Regulatory requirements/impositions
  - Home/daily life
    - Public information and encouragement
  - Environment
    - Public domain
    - ?
- Do the foregoing “killers” demonstrate acceptable societal risks?

Questions for your consideration

regarding the foregoing information

- What risks would you judge acceptable for yourself, society, and regulators for nuclear criticality safety and accidents considering the observed:
  - Fears
  - Risk Data
  - Judgements about risk for safety (i.e., risk acceptance)
- What do you perceive your obligations are for advancing your judgments about safety?
- What actions would you consider to make positive changes, if any?

To be reconsidered later – maybe

Relevance of personal and societal risk to nuclear criticality safety

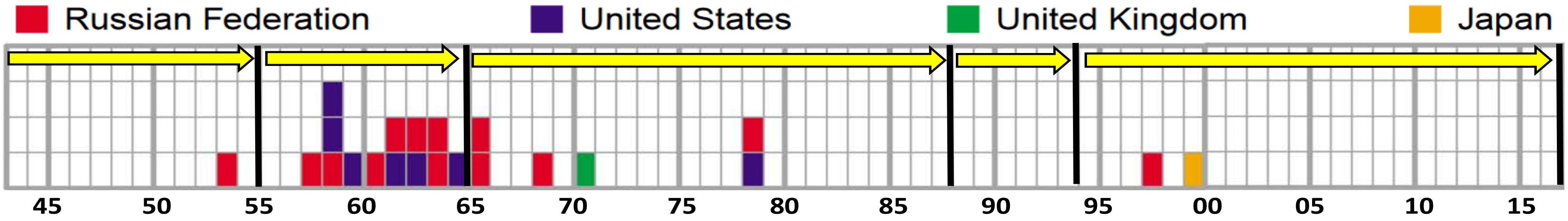
- **"Risk"** = Frequency of harm * magnitude of harm
  (measurable or estimable)
- **"Safety"** = Judgment and/or opinion of risk acceptability
  (not measurable - sensed)

An activity, hazard, or thing, is safe if its risks are judged/opined to be acceptable

List of some significant nuclear criticality accidents events and their outcomes

Accident Date	Processing Facility	Significant Radiation Exposures	Fatal Exposures
1958 Jun 16	Oak Ridge Y-12 Plant	8	0
1958 Dec 30	Los Alamos Scientific Laboratory	3	1
1959 Oct 16	Idaho Chemical Processing Plant	0	0
1961 Jan 25	Idaho Chemical Processing Plant	0	0
1962 Apr 07	Hanford Works	3	0
1964 Jul 24	United Nuclear Fuels Recovery Plant	3	1
1978 Oct 17	Idaho Chemical Processing Plant	0	0

Chronology of Process Criticality Accidents over the period of 1943 – 2017*



Standards/regulations impacting administrative and operational activities

1943 – 1955: **Reliance on theorists and experimentalists knowledgeable of critical experiment results**

1955 – 1964: **Informal meetings of US AEC facility specialists issuing *Nuclear Safety Guide* (classified, LA-2063 in 1956), *Nuclear Safety Guide* (unclassified, TID-7016 in 1961), issuance of US AEC Manual Chapter 0530 *Nuclear Criticality Safety* (1961), and later the issuing *Safety Standard for Operations with Fissionable Materials Outside Reactors* (ASA N6.1-1964)**

1964 – 1977: **Transition to US ERDA adopting Manual Chapter 0530 *Nuclear Criticality Safety***

1969 – 2014: **Issuance of *Nuclear Criticality Safety in Operations with Fissionable Materials Outside Reactors* (ANSI N16.1-1969, Rev-1975, ANSI/ANS-8.1-1983, Rev-1998, Rev-2014)**

1977 – 2017: **Transition to US DOE renaming regulation to DOE Order 0530 *Nuclear Criticality Safety***

1984 – 2017: **Issuance of ANSI/ANS-8.19-1984, Rev-1996, Rev-2014**

1988 – 2017: **Price Anderson Amendment Act and Appointment of DOE Secretary Adm. J. D. Watkins, etc.**

1994 – 2017: **Initiation of 10CFR830 and promulgation of US DOE Orders, Standards, Guides (e.g., Orders 5480.30, 420.1; Standards-1020, -1027, -1120, -1173, -1158, -3007, - 3009, Guides 421.1-2A, Handbooks-3010: etc. and partial endorsement of ANSI/ANS-8.xx standards by US DOE and NRC)**

1998 – 2017: **US NRC partial endorsement of ANSI/ANS-8.xx standards**

***Taken from TP McLaughlin, et al, A Review of Criticality Accidents 2000 Revision, LA-13638, May 2000**

- **People and organizations have worked toward the prevention of nuclear criticality accidents since 1943**

- **The work includes transitions of scientific, professional and regulatory input and oversight**

Examples of cost effectiveness for pre-1988 and pre-2017 application for US DOE non-reactor nuclear facilities

(Based on personal observations/guesstimates for a single facility)

- **Time considerations:** 33 yrs (1955 to 1988), 29 yrs (1988 to 2017), 62 yrs (1955 to 2017)
- **$\mathbf{Cost_0}$** – (i.e., 2017 – 1955) **= 6 FTEs/yr**
- **$\mathbf{Cost_1}$** – (6 FTEs)(33 yrs) [i.e., 1988 – 1955] + (~30 FTEs)(29 yrs) [i.e., 2017-1988]
  = 1068 FTEs/62 yrs **= 17.2 FTEs/yr**
- **$\mathbf{Cost_2}$** – (i.e., 2017 – 1955) **= 30 FTEs/yr**
- **$\mathbf{E_{0,1,2}}$**, $\text{Effectiveness}_{0,1,2}$ – (62 yrs/7 accidents) **= 8.86 accident-free years**
- **$\mathbf{C_0/E_0}$** = (6 FTEs/yr)/(8.86 accident-free yrs) **= (0.68 FTEs/yr)/accident-free year**
- **$\mathbf{C_1/E_1}$** = (17.2 FTEs/yr)/(8.86 accident-free yrs) **= (1.94 FTEs/yr)/accident-free year**
- **$\mathbf{C_2/E_2}$** = (30 FTEs/yr)/(8.86 accident-free yrs) **= (3.39 FTEs/yr)/accident-free year**

Hokey?

- YES!

Correct the assumption(s), misapplication(s) and derive your own result/conclusion

Consider a conjectured fatality rate for US FM handlers in 2017 based upon the 1955 – 2017 experiential data

Assume:

- 2 fatal exposures to criticality accidents over 62 yrs = 0.032 fatalities/yr
- 30 FM handler workforce per facility
- 7 facilities in US
- 210 FM handlers potentially exposed per year in US

Results:

- [deaths/yr-100,000 employees] = [(deaths/yr)/(hours worked by all FM handlers per yr)](200,000,000) =

	US FM Handlers	US Overall	Loggers
[deaths/yr-100,000 employees]	**[14.7]** deaths/yr-100,000 employees	**[3.4]**	**[133]**
(total employee deaths/yr) =	**(3.2×10^{-2})** employee deaths/yr	**(4836)**	**(67)**
{deaths/yr-US Population} = 0.032 deaths/yr-3.26×10^{8} =	**{9.8×10^{-11}}** deaths/yr-US Pop.	**{1.48×10^{-5}}**	**{2.0×10^{-7}}**

- (total employee deaths/yr) =
- {deaths/yr-US Population} = 0.032 deaths/yr-3.26×10^{8} =

Again – apply your own assumptions for your own results!

Science, Risk, Safety And Their Limits: The Regulator's Dilemma

(Alvin M. Weinberg, Issues in Science and Technology, Vol. 2, No. 1 (FALL 1985), pp. 59-72)

- Public emphasis has shifted from visible/demonstrable problems with statistical evidence

to

- Invisible/low-concentration pollutants and hazards with limited to no statistical evidence

Historic regulatory influences

(Terry F. Yosie (EPA), Risk Assessment in Setting National Priorities, Plenum Press, pg 1-11, 1989)

- Assuming facilities operate at full capacity
- Using hazard emission rates that do not account for technology or controls that yield lower emissions
- Using dispersion models for “model” sources rather than for specific facilities
- Assuming that target individuals spend all of their time, out doors, in the path of emissions
- Relying on Maximum Exposed Individuals in lieu of population risks
- Using a “one hit” model that assumes that a single particle of a substance can cause cancer and predicts that risk is proportional to dose at lower levels of exposure
- Assuming linearity at low doses in a multistage model
- Using surface area over body weight
- Counting both benign and malignant tumors
- Using data from the most sensitive animal species

A 1988 review of the impact of a Chernobyl-like event described such Regulatory Influences

(C. Whipple and C. Starr, "Nuclear Power Safety Goals in Light of the Chernobyl Accident," NUCLEAR SAFETY, Vol. 29, No. 1)

"The recently adopted Nuclear Regulatory Commission safety goals [Aug. 1986] include a proposed plant performance guideline limiting the frequency of large releases of radioactive materials. Analysis indicates that the proposed plant guideline is potentially far more restrictive than the health objectives:" goes well beyond previously established health objectives, and is not supported on cost-benefit grounds. ***The Chernobyl accident, which caused no offsite prompt fatalities, has cast doubt on the operational significance of the safety goal health objectives. <u>The proposed guideline is responsive to concerns that the health objectives do not limit the frequency of accidents sufficiently</u>."***

Inferred meaning – safety goals are predicated upon more than health concerns

By 1997 realities were still poorly publicized

(K. Becker, "Economic, Social And Political Consequences In Western Europe," IAEA accession No. XA9745887, 1997)

" ***Consequences of the Chernobyl accident are fortunately far less substantial as it has been frequently predicted and claimed in the media:***

1. There have been so far about 30 identifiable premature deaths due to acute radiation syndrome (less frequent estimates are somewhat higher up to 100 - 200 when including partially radiation-related cases).

2. Of the approximate 700 childhood thyroid cancers that may be attributable to radioiodine emissions, 90 - 95% are curable (many are treated in Western Europe, in particular Germany).

3. No increases in leukemia or other types of cancer, or genetic defects, have so far been detected, nor are they likely based on the evaluation of the Hiroshima and Nagasaki data.

4. There have been no detectable radiation-related effects in Western Europe, or other countries outside the former western Soviet Union."

Public, news media, and scientist problems regarding the identification of <u>Risk</u> and <u>Safety</u>

- Public distinction between and understanding of risk and safety
  - Interpretations of adverse events intensely influenced by news media and special interest factions
  - Skewed by interest in personal and/or societal safety (not necessarily bad), sensationalism and the macabre
  - Impacted by gullibility and/or wishful thinking (internalizing social media)
- News Media
  - Disproportionate coverage (justifiable early alert, encouragement to pay attention?)
  - Make and sell stories of likely interests to the public (free press, capitalism, personal interests?)
  - Alert the public (historical value, pending issues, status of events and government action)
- Scientists fear of being misconstrued (justifiably?)
  - Accurate use of technical language frequently is misinterpreted
  - Lack of "full" knowledge about an immerging hazard gets viewed as clandestine behavior

General public's knowledge about 12 science-related topics - % answers correct

(C. Funk, S.K. Goo, "A Look at What the Public Knows and Does Not Know About Science," Pew Research Center, 30 September 2015)

Earth's core is its hottest layer (with labeled image) – **86%**

Uranium is needed to make nuclear energy/weapons – **82%**

A comet has icy core and tail of gas and dust (photo) – **78%**

Ocean tides are created by gravitational pull of moon – **76%**

Jonas Salk developed polio vaccines (set of four photos) – **74%**

Distinguish definition of astrology from astronomy – **73%**

Radio waves are used to make/receive cellphone calls – **72%**

A light-year is a measure of distance – **72%**

Can interpret a scatterplot chart (graph) – **63%**

Identify how light passes through magnifying glass (set of images) – **46%**

Amplitude or height determines loudness in a sound wave – **35%**

Water boils at lower temperature at high altitudes – **34%**

A minority of 29% of Americans and 16% among American Association for the Advancement of Science members consider the country's K-12 STEM education to be among the best in the world.

Questions

- How proactive should old and/or new project knowledge be shared with advocates, adversaries, and public for support of nuclear criticality safety applications?
- If new to your public, what, why, when, how, where and who should provide, defend, object to the knowledge about disposal of low-levels of radioactive materials; e.g.,
  - the potential, as ridiculous as it may be, for criticality following disposal of uranium at low-level waste facilities: blended with moist, loamy, sandy, acidic soils, arid, rocky, salty/basic soils, etc.?
  - the radiation dose consequences from a postulated criticality occurring in a low-level waste disposal facility?
- What other circumstances (e.g., economics, health, accessibility, etc.) might also impact concerns about risks and safety?

More questions for consideration while recalling foregoing information

- What risks would you judge should be accepted by you, society, and regulators for the application and practice of nuclear criticality safety?

- What do you perceive your obligations are for advancing your judgments about safety?

- What actions would you consider to make positive changes, if any?

Relevance to nuclear criticality safety?

It is up to every one of us to influence rational thought about risk and safety as well as regulatory and public acceptance of our nuclear enterprise

Can we not see the possibilities around us?

We might miss the “Easy Solution”

Thanks to all of you this morning!

Best wishes are offered for your futures.

Calvin M. Hopper