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# *News Flash*

12:05 P.M. EDT March 6, 1996 by facsimile transmission to Forum Participants/Alternates, Federal Liaisons/Alternates

# Health Physics Society Adopts Position re Low Doses of Radiation

## *Risks from Annual Doses Below 5 Rem Are Non-Existent or Too Small to Quantify*

In the March 1996 issue of the Health Physics Society newsletter, the society published its position on how radiation risk should be expressed. The position, which is reprinted below, states in short that health risks should not be quantified for radiation doses exceeding background doses by less than 5 rem (5,000 millirem) per year or 10 rem during a lifetime. Because the health risks in this range are so small, only qualitative expressions of risk are appropriate, and the qualitative expressions should emphasize the "inability to detect any increased health detriment" from exposures at these levels.

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### Health Physics Society*
### *Position Statement*

### "Radiation Risk in Perspective"

*Kenneth L. Mossman, Marvin Goldman, Frank Masse, William A. Mills, Keith J. Schiager, Richard J. Vetter*

*In accordance with current knowledge of radiation health risks, the Health Physics Society recommends against quantitative estimation of health risk below an individual dose of 5 rem in one year or a lifetime dose of 10 rem in addition to background radiation. Risk estimation in this dose range should be strictly qualitative accentuating a range of hypothetical health outcomes with an emphasis on the likely possibility of zero adverse health effects. The current philosophy of radiation protection is based on the assumption that any radiation dose, no matter how small, may result in human health effects, such as cancer and hereditary genetic damage. There is substantial and convincing scientific evidence for health risks at high dose. Below 10 rem (which includes occupational and environmental exposures), risk of health effects are either too small to be observed or are non-existent.*

Current radiation protection standards and practices are based on the premise that any radiation dose, no matter how small, can result in detrimental health effects, such as cancer and genetic damage. Further, it is assumed that these effects are produced in direct proportion to the dose received, i.e., doubling the radiation dose results in a doubling of the effect. These two assumptions lead to a dose-response relationship, often referred to as the linear, no-threshold model, for estimating health effects at radiation dose levels of interest. There is, however, substantial scientific evidence that this model is an oversimplification of the dose-response relationship and results in an overestimation of health risks in the low dose range. Biological mechanisms including cellular repair of radiation injury, which are not accounted for by the linear, no-threshold model, reduce the likelihood of cancers and genetic effects

9610080445 960326
PDR ACRS
GENERAL PDR

## Annex
## List of ICD Codes for Causes of Death Studied

| | | ICD8[a] | ICD9[b] |
|---|---|---|---|
| 1. | All causes | 000–999 | 000–999 |
| 2. | Unknown | — | — |
| 3. | All cancers | 140–207 | 140–208 |
| 4. | All except leukemia | (3)–(35) | (3)–(35) |
| 5. | Buccal and pharynx | 140–149 | 140–149 |
| 6. | Esophagus | 150 | 150 |
| 7. | Stomach | 151 | 151 |
| 8. | Small intestine | 152 | 152 |
| 9. | Colon | 153 | 153 |
| 10. | Rectum | 154 | 154 |
| 11. | Liver | 155.0–155.1 | 155.0–155.1 |
| 12. | Biliary tract | 156 | 156 |
| 13. | Pancreas | 157 | 157 |
| 14. | Nasal cavity | 160 | 160 |
| 15. | Larynx | 161 | 161 |
| 16. | Lung | 162 | 162 |
| 17. | Pleura | 163.0 | 163 |
| 18. | Bone | 170 | 170 |
| 19. | Connective tissue | 171 | 171 |
| 20. | Melanoma | 172 | 172 |
| 21. | Female breast | 174 | 174 |
| 22. | Cervix uteri | 180 | 180 |
| 23. | Other uterus | 181.182 | 179. 181. 182 |
| 24. | Ovary | 183.0 | 183.0 |
| 25. | Prostate | 185 | 185 |
| 26. | Testis | 186 | 186 |
| 27. | Bladder | 188 | 188 |
| 28. | Kidney | 189.0. 189.1 | 189.0. 189.1 |
| 29. | Brain and CNS | 191–192. 237.5–237.9. 239.6 | 191–192. 238 |
| 30. | Thyroid | 193 | 193 |
| 31. | Ill defined and secondary | 195–199 | 195–199 |
| 32. | Non-Hodgkin's lymphoma | 200. 202 | 200. 202 |
| 33. | Hodgkin's disease | 201 | 201 |
| 34. | Multiple myeloma | 203 | 203 |
| 35. | All leukemias | 204–207 | 204–208 |
| 36. | Leukemia excluding CLL | (35)–(37) | (35)–(37) |
| 37. | CLL | 204.1. 204.9 | 204.1. 204.9 |
| 38. | Acute leukemias | 204.0. 205.0. 206.0. 207.0 | 204.0. 205.0. 206.0. 207.0. 208.0 |
| 39. | Other cancers | (3)–(5–35) | (3)–(5–35) |
| 40. | Smoking-related cancers | 140–150. 161–162. 157. 188. 189.1 | 140–150. 161–162. 157. 188. 189.1 |
| 41. | Non-smoking cancers | (3)–(40) | (3)–(40) |
| 42. | All non-cancers | (1)–(3) | (1)–(3) |
| 43. | Non-malignant tumors | 210–239 | 210–229. 230.0–238.3. 238.5–239.9 |
| 44. | Circulatory diseases | 390–458 | 390–459 |
| 45. | Respiratory diseases | 460–479. 490.0–519.9 | 460–479. 487.1–519.9 |
| 46. | Liver cirrhosis | 571 | 571.2. 571.5. 571.6 |
| 47. | External causes | 800–999 | 800–999 |

[a] *International Classification of Diseases*. 8th ed.
[b] *International Classification of Diseases*. 9th ed.
[c] Varies with facility.

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# §20.1405(d) 100 mrem/y Cap

- ✓ Too low
  - ▸ should not assume all institutional controls will fail
  - ▸ allow 500 mrem/y cap
- ✓ Too high
  - ▸ institutional controls are uncertain
  - ▸ use 15-75 mrem/y

# §20.1403 General Provisions

- ✓ EPA Drinking water standard
  - ▸ oppose
    - – prefer single dose based, all pathway standard
  - ▸ support
    - – consistent with EPA rule
- ✓ Calculation to 1000 years post decommissioning
  - ▸ use > 1000 years for long lived radionuclides
  - ▸ use < 1000 years to be consistent with 10 CFR 40 and 61
    - – 200-500 years

# §20.1407 SSABs

- ✓ Differing views
  - ▸ Support for provision
  - ▸ SSAB not always the best solution, other options should be ok
  - ▸ extend use of SSABs to unrestricted use sites
- ✓ Provide more detail
  - ▸ responsibilities
  - ▸ membership, size, qualifications, government role
  - ▸ independence from licensee
  - ▸ administrative and financial support
  - ▸ meetings
  - ▸ licensee and NRC use of SSAB recommendations

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## GUEST EDITORIAL

# The Linear, No-Threshold Model in Radiation Protection: The HPS Response

*Kenneth L. Mossman, HPS Scientific and Public Issues Committee*

In this issue of the *Newsletter*, the Scientific and Public Issues Committee publishes the long-awaited Society position statement concerning the linear, no-threshold model (LN-T) in radiation protection. In recent months, the dialogue on the appropriateness of the LN-T model as a basis for establishing radiation protection standards and practices has reached the international arena. The Society's position should add a fresh perspective to the ongoing debate.

The Committee carefully considered the many viewpoints on the LN-T model, both pro and con, expressed in the *Newsletter*. Several Society members (David Gooden, Wade Patterson, Jim Tripodes, Al Tschaeche, and Gary Zeman) attended the Committee meeting 24 July 1995 in Boston during the HPS annual meeting and added significantly to the Committee's deliberations. Although many Committee members have been thinking about the LN-T problem for some time, Wade Patterson really got the ball rolling with a presentation to the HPS Board in January 1995 at the Charleston midyear meeting. Based on Wade's presentation, the Board charged the Scientific and Public Issues Committee with developing the position statement.

This position statement is based on the premise that there is substantial and convincing evidence for health risks at high dose; however, below 10 rem, risks of health effects either are too small to be observed or are non-existent. Accordingly, the Committee concluded that quantitative risk assessment below individual doses of [illegible] should be avoided because of insufficient epidemiological data to say anything about health risk. It became clear after several drafts, and after reading many letters in the *Newsletter* on the LN-T model, that the appropriateness of the LN-T model to predict risk at low doses is not the major question. The major question is: Should we be using *any* dose-response model to predict health risks at low dose? In the absence of epidemiological data in the low-dose region, and the need to extrapolate 2-3 orders of magnitude in dose (e.g., from direct observations of cancer at 30 rem to predicted numbers of cancers at an exposure limit for the general public of 100 mrem $y^{-1}$), is it appropriate to quantify risk?

The position statement recommends the use of qualitative expressions of risk below 5 rem in one year or 10 rem in a lifetime (above background). Clearly, there are many ways in which risk can be expressed qualitatively. For example, assume an individual receives a whole body dose of 10 mrem. The following is an appropriate qualitative expression of the risk:

*The amount of radiation received is about 10 times lower than the allowable dose to individual members of the general public in one year. A radiation dose of this magnitude has not been associated with any adverse health effects and the risk is generally considered to be negligible.*

Although the position statement does not specifically address the appropriateness of the LN-T model at low doses, national and international bodies such as

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ED Volume 24, Number 20

# Is Slightly Dirty Clean Enough? DOE Thinks So

BY GEORGE LOBSENZ

The Energy Department, frustrated by regulatory inaction on a key "how clean is clean" issue, is planning to issue an internal order outlining procedures to determine when slightly radioactive but valuable surplus DOE materials can be sold to outside companies for recycling overseas.

DOE officials also were pushing for a White House meeting this week to confer with Environmental Protection Agency and Nuclear Regulatory Commission officials on ways to rejuvenate a lagging interagency effort to craft broader deregulatory standards for minimally contaminated materials. However, the planned meeting was cancelled late Tuesday.

The proposed DOE order, now scheduled for release in March, would establish "free release criteria" for the sale of contaminated surplus materials—mainly various metals—that could bring the department tens of millions of dollars in revenue. Sale of the metal also would eliminate or reduce costs for continued storage of those materials at DOE sites.

DOE's decision to issue the order now is prompted in part by a contemplated sale of tons of contaminated nickel from DOE to Scientific Ecology Group (SEG), a Westinghouse subsidiary heavily involved in DOE waste management activities. The surplus nickel is left over from uranium enrichment operations and is being managed by DOE's Oak Ridge, Tenn., office.

The order is designed to clear away health and legal questions now blocking sale of the nickel, which SEG plans to resell for reuse in Spain, according to DOE officials.

The proposed rule also

(Continued on page 4)

## Budget Impasse Prompts Murkowski To Introduce New USEC Bill

Seeking a way around the budget impasse, Senate lawmakers have introduced a bill to privatize the United States Enrichment Corp.

Sen. Frank Murkowski (R-Alaska), chairman of the Energy and Natural Resources Committee, along with Sens. Pete Domenici (R-N.M.), Bennett Johnston (D-La.) and Wendell Ford (D-Ky.), last Friday introduced a proposal to privatize the government-owned enrichment business; the language of the bill is virtually identical to the USEC language that was attached to the fiscal 1996 budget reconciliation bill that was vetoed by President Clinton Dec. 6.

And with high-level budget negotiations sputtering, getting the reconciliation bill passed in its entirety is looking increasingly improbable.

As such, Murkowski said in introducing the measure that he is prepared to take his chances either with a stand-alone bill, or attaching the USEC language "to any other legislative vehicle."

The privatization effort was set in motion by the Energy Policy Act of 1992, which required the federal government to move toward selling the entity by 1995.

—PAMELA NEWMAN

# *Markey Draft Proposes Trade: Retail Wheeling For PURPA Reform*

BY MARY O'DRISCOLL

**Rep. Ed Markey (D-Mass.) is floating an electric utility deregulation bill that calls for national standards for electric competition and repeals PURPA's mandatory purchase requirements where such competition exists.**

The bill, based on a proposal originally drafted by the National Independent Energy Producers, was to have been introduced to coincide with Thursday's scheduled House energy and power subcommittee hearing on the Public Utility Regulatory Policies Act.

But insiders said Tuesday afternoon the bill's introduction probably would be put off until supporters could muster s[illegible]th bipartisan support and get approval from some competition-minded electric utilities that back the concept but are balking at the proposal's divestiture language.

The proposal comes as some industry insiders are trying to build momentum for consideration of an electricity restructuring bill sometime this year. However, the odds of serious consideration of such a bill are slim as presidential election years are noted more for their lack of congressional accomplishments than anything else—and this year's budget debate is expected to take up much of Congress' time.

For that and other reasons, such as the Federal Energy Regulatory Commission's pending open access rule, lack of consensus among the many electric power industry participants and the Energy Department's reluctance to move on anything this year, many

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# Is Slightly Dirty Clean Enough?... (Continued from page one)

would establish a review process under which other DOE contaminated material sales could move forward. However, department officials said the rulemaking only would cover internal transfers between DOE sites or sales to companies intending to market materials overseas.

In order to offer contaminated DOE materials for domestic recycling, DOE officials said EPA and NRC must complete action on regulations setting *de minimis* levels for release of slightly contaminated materials into U.S. commerce.

The problem has been that the EPA-NRC *de minimis* initiative has been bogged down by controversy and funding constraints at both agencies.

DOE officials had hoped to discuss ways to refloat the NRC-EPA *de minimis* initiative at a meeting that the White House Council on Environmental Quality had initially scheduled for Thursday. The meeting was cancelled late Tuesday, however, due to lack of consensus on the need for such a meeting.

The department now will attempt to lead by example by issuing its more circumscribed order on "free release of contaminated materials," according to a DOE document.

"The DOE order on free release is a reasonable and thorough framework that represents an important U.S. government prototype for addressing volumetric radioactive contamination," the document said. "This approach offers a reasonable 'path forward' that shows the DOE is taking an initiative to deal with the *de minimis* impasse."

The order effectively would clear for outside sale those surplus DOE metals or materials with radioactivity levels between one and 30 millirems. DOE officials said that range was roughly equivalent to the general 15 millirem deregulatory standard being considered by EPA and NRC.

"Once the [free release] criteria [are] met it is the vendor's responsibility, not the department's, to fully comply with pertinent international, federal and state regulations regarding disposition of radioactive-contaminated materials," the DOE document said.

The document said the same criteria and procedures were given a successful trial run recently in the transfer of surplus contaminated copper from DOE's Oakland, Calif., field office for recycle in Asia.

DOE officials believe the order will provide the department with more legal backing to proceed with surplus material sales. In particular, the order is supposed to shield DOE from any liability concerns relating to release of slightly contaminated materials into general commerce.

"With the free release criteria, the DOE has a direct and meaningful safeguard, once the materials are transferred to the private sector," the DOE document said.

However, department officials said there is some doubt about the extent of legal protection that an internal safety order can provide the department. They said a broader EPA-NRC rulemaking would be much more effective in that regard.

The officials also said they plan to seek public comment on the internal DOE free release order in hopes of further clarifying key issues needing resolution.

## 1995 A Record-Setting Year For Wind Energy

The numbers are in, and 1995 was a record-setting year for the wind energy industry, according to the American Wind Energy Association.

Worldwide, installed windpower capacity climbed to more than 5,000 megawatts in 1995, a 1,300 MW increase from 1994, AWEA said.

Most of this increase occurred outside the U.S., according to AWEA. Specifically, said AWEA Executive Director Randall Swisher, the fastest growth in wind energy is occurring in Germany, Spain and India. "Less than 5 percent of new construction in 1995 occurred in the United States. Wind energy technology is taking off while the American market remains stuck in neutral."

In 1990, Swisher added, nearly 80 percent of the world's installed wind capacity was sited in the United States; by 1995 the U.S.' share of the market had fallen to less than 50 percent.

## *ABB Wins $400 Million Korean Power Contract*

ABB said Monday that it has been awarded a $400 million contract from Korea Electric Power Corporation to build a 2,000 megawatt combined cycle power plant in South Korea.

Under the terms of the contract, ABB will supply Kepco with eight of the company's high-performance GT24 sequential combustion gas turbines, plus their associated heat recovery steam generators, steam turbines, electricity generators, power plant control systems and auxiliary equipment.

When operating, the plant is expected to achieve an overall fuel efficiency of nearly 60 percent.

Construction of the plant, to be built in Poryong, Korea, is scheduled to begin in April. The plant is expected to begin generating electricity within 15 months, and be complete in 27 months.

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# The HEALTH PHYSICS SOCIETY'S Newsletter

Volume XXIII, Number 6 June 1995


## IN THIS ISSUE



## Innovative Research Needed

*Marvin Goldman, Ph.D., Professor Emeritus*

The traditionally accepted linear, no-threshold hypothesis as a dose-response model for carcinogenesis is increasingly being questioned. This model dates back to the genetic radiation studies on the fruit fly by H. J. Müller in the 1920s. Genetic effects were found to be linearly related to dose over many orders of magnitude.

Later, as somatic effects such as carcinogenesis became evident, the linear hypothesis was extended to carcinogenic effects. It was reasonable to assume that since the "primordial" lesion appears to be in the DNA, that the same proportionality would exist for carcinogenic as well as genetic effects.

Although the "initial sub-lesions" in the nucleus may be proportional to dose, it is not certain at this point that cancer development follows a linear dose relationship over many orders of magnitude. Most of our solid radiation cancer data is derived over a single order of magnitude (around 0.5 Gy to 5 Gy). At higher doses survival is compromised and few survive the latent period. At lower doses the possible excess incidence is difficult to quantify.

Since our main human data base on low-LET exposures is almost entirely from acute, high-dose rates, i.e. the A-bomb survivors and medical therapy patients, we have little to go on for low-dose rates other than the consistently non-linear relationship for all radiogenic tumors in experimental animals. Since the observation is not in humans, it is all but ignored.

Since direct epidemiological studies cannot be expected to verify effects at doses which are small fractions of background radiation, we may have to wait for the biomolecular explanation of tumorigenesis steps from initiation to promotion to manifestation for our answer.

As long as there seem to be many steps in the model, I am prepared to entertain the hypothesis that the true universal carcinogenesis curve is curvilinear with an initial shallow slope and the equivalent of a saturation plateau at high levels. Each of the molecular and cellular "steps" that contribute to the data which generate such curves may have its own probability distribution and it may not be linear. The sum of these step probabilities also may not be a straight line – it is just as likely to be sigmoid!

Let's stop debating what we believe and hope for, and put the linear, no-threshold hypothesis to sound, solid scientific scrutiny and objective testing. It is time for innovative research! We need to do a complete review of the available data, and as well employ our newer molecular tools in unique research to better understand the radiation carcinogenesis process. ■

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**Publication Deadline**

Almost everything the Managing Editor receives by the 20th of June will be printed in the August issue.

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## EDITORIAL

### Dose-Response Model Reactions Bring Surprises

Two notable surprises occurred as responses came in to my editorial in the April issue of the *Newsletter*. The biggest surprise is that responders held very closely to the 500-word limit for submissions and that this limit did not seem to hamper authors. Responses seem cogent and complete.

The second surprise is that the viewpoints are all so one-sided. Almost all refute the linear, no-threshold (LNT) paradigm. We had unvisd responses from both "sides" of this issue, so don't know how to interpret the lack of reaction from the LNT supporters.

It certainly is a controversial topic. Almost as controversial, we found, is how to punctuate the name of our model under discussion. Submissions had at least three different styles. Health physics publications editors decided it should be "linear, no-threshold."

The 22 responses received by the 1 May deadline appear in the next 14 pages of the *Newsletter*. Regular *Newsletter* materials start on page 17. The first several in the special section give some of the history of the linear, no-threshold model. The next few discuss molecular and cellular implications. The remainder are of a more general nature and are arranged, as much as possible, to look nice on a page. Due to the historical nature of some of the articles, traditional units have been retained.

What use will be made of this special issue of the *Newsletter*? First of all, we hope it will be interesting to read.

Secondly, we have already sent the articles to Ken Mossman, Chairman, Scientific and Public Issues (SPI) Committee, Health Physics Society (HPS). Ken was directed by the Board to prepare a HPS position paper on the subject following a recommendation to this effect by Wade Patterson at the midyear meeting of the Board in Charleston.

Ken expects to have a rough draft of this position paper ready for review by the SPI Committee at the July meeting in Boston. The Committee will decide on the deposition of the paper at that time.

Under consideration will be whether to submit it to the NCRP. The NCRP plans to initiate a new Scientific Committee 1-6, Basis for the Linearity Assumption. It is expected that work on this Committee will begin in the middle of the year. Chairing the Committee will be Arthur C. Upton.

The paper may also be submitted to the National Academy of Sciences as input to the next committee assigned to update the evaluation of low-level effects.

In addition to submitting this special issue to the SPI Committee, what other plans do we have? It is expected that this issue will get a lot of other people excited about the topic and that they will want to put their words on paper. We will continue to entertain submissions. Keep the body of your paper to ≤500 words, use references where necessary and follow the style set by *Health Physics*. Avoid duplicating what others have already said.

This special issue put a heavy work load on our small-but-dedicated *Newsletter* staff. Sharon typed until her hands were numb around deadline time. She also introduced needed consistency in the references for the articles. Mary assisted in copy editing and formatting the special section.

Associate Editor Andy Hull provided ideas and names of persons to be invited for submissions. Associate Editor Steve Garry carefully proofed all of the submissions. Thanks to all.

*Gen Roessler* ■

# — Special Issue —
# Radiation Dose-Response Model

## Through Space and Time... to the Linear, No-Threshold Paradigm

*Ronald L. Kathren*

It is perhaps not without significance to note that for virtually all health physicists and radiation biologists in active practice today, the linear, no-threshold dose response for low dose and low-dose rate radiations has, throughout their entire careers, been the foundation of radiation protection standards applied in our efforts to protect people and the environment from the harmful effects of radiation. It thus may come as a surprise to some, particularly those who have begun their careers in recent years, to learn that the linear, no-threshold model and its offspring, ALARA and the nontruncated application of collective dose, have not always served as the basis for radiation protection standards.

In fact, the linear hypothesis is a relative latecomer. Initially following the discovery of x rays and radioactivity, the general belief was that radiation exposure was not harmful. This euphoria quickly gave way to the increasing reports from both experimental work and field observations in humans to the more sober conclusion that too great an exposure could, indeed, result in some sort of damage. Thus, although by 1905 it was generally recognized that too great an exposure could result in acute frank effects (today we call them deterministic), it was not until 1925 – three full decades after the discovery of x rays – that the first protection standard was proposed. The standard was based on the so-called skin erythema dose and implicitly (and indeed its proposer, Arthur Mutscheller, so stated) carried with it the concept of a dose which, if not exceeded, would permit such damage as might occur to be repaired, or, in other words, a *tolerance dose*.

The concept of the tolerance dose held for nearly three decades. It served the Manhattan District workers well, and seemed to provide an adequate margin of safety. Indeed, 40, or even 30, years ago the prevalent belief was that one could be exposed at the maximum permissible dose (then 15 rem whole body per year) continuously over a 50-year working lifetime with no demonstrable ill effect. But in the 1950s, the linear, no-threshold model was adopted, based in no small measure on the Nobel prize winning work of Herman Müller which showed a clear linearity between dose and induction of genetic mutations in fruit flies with no apparent threshold, and to 1959 testimony by Caltech geneticist E.B. Lewis, who proposed before Congress the ALARA protection philosophy based on genetic effects. Initially, the linear hypothesis was chosen because of its mathematical simplicity, and the fact that of all the dose response curve choices, it provided an *upper limit* on the risk to the exposed individual.

Largely within the past two decades, the linear, no-threshold model has assumed increasing regulatory importance and is now generally applied in radiation risk studies. In an effort to ensure the safety of the worker and the general public, evidence contradictory to a linear, no-threshold model is rejected out of hand by otherwise responsible scientists and regulators, leading to acceptance of the model as a fundamental law or paradigm, rather than as a hypothesis or theory. What we know (or should know) and bear in mind in our standards-setting process is that the linear, no-threshold hypothesis does not apply to all radiation dose responses, and that for some effects there may in fact be a threshold, or a nonlinear response.

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## History: The Linear, No-Threshold Model

*David S. Gooden*

The linear, no-threshold model for radiation injury evolved during the Cold War's era of intense above-the-ground testing of nuclear weapons. In the 1950s, $^{90}Sr$ and $^{137}Cs$ from fallout were known to exist in small amounts in milk and other foods. There was a fear that exposure to these and other radioactive materials would compromise our nation's genetic pool. This fear was based on the belief that genetic injury was a linear, no-threshold phenomenon. The belief was attributed to experimentation with the fruit fly (Drosophila). However, Dr. H.J. Müller, the Nobel Prize winner for genetic work with the fruit fly, said in his 1927 article that

> "while the figures are not quite conclusive, they make it probable that, within the limits used, the number of recessive lethals does not vary directly with x-ray energy absorbed, but more nearly with the square root of the latter...should this proportionality be confirmed, we should have to conclude that these mutations are not caused directly by a single quanta of x-ray energy that happens to be absorbed at some critical spot (emphasis added)" (Müller 1927).

This clearly is an early statement for *sublinearity*, not

linearity. The *UNSCEAR 1958 Report* claimed no genetic damage, even in the fruit fly, below what could be called a 25 rad threshold (UNSCEAR 1958). This value is within the range of other apparent "threshold" doses identified in other diseases such as radiogenic leukemia in the atomic bomb survivors (UNSCEAR 1994). Hereditary injury due to radiation exposure of humans has not been identified at all.

Also in the 1950s, a physician, E.B. Lewis, contributed to the belief in a linear, no-threshold paradigm for radiation injury. Lewis claimed that radiation-induced leukemia was a linear, no-threshold phenomenon. This is not the case (UNSCEAR 1994). It is now known that radiogenic hereditary injury and leukemia, the two premises on which the linear, no-threshold model was originally based, are not linear, no-threshold phenomena.

In spite of the loss of early foundations, the linear, no-threshold model continues to persist because once it was put into place, it was maintained by value systems (*science policy*), not science fact.* Through usage, the model became an article of faith and competing models of radiation injury were excluded from consideration. The model influences all of our radiation safety actions and all our related health and safety regulations. It is time to evaluate our science policy to see if it serves us well, based on our science facts.

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*L.A. Sagan, address to the 1992 International Conference on Low Dose Irradiation and Biological Defense Mechanisms, Kyoto, Japan. Sagan noted that Thomas Kuhn, in his seminal work, The Structure of Scientific Revolutions, pointed out that most scientists are not seekers after truth, but rather are technicians who are taught to unquestioningly adopt certain models or paradigms. Their scientific endeavors, therefore, are limited to modifying only the details of the paradigms and the paradigms themselves are rarely challenged. Kuhn states that scientists "censor" information that is inconsistent with the paradigm. He believes that in the absence of concrete scientific findings the influence of personal and community values (which scientists share) contributes to the construction of paradigms.

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## Changes in an Isolated Molecule Versus Human Health Effects

*R.G. Thomas*

There is little doubt that ionizing radiation will induce some change in an organic molecule. In other words, if one were to place an *in vitro* dish of biologically active molecules, say proteins, in the beam of a radiation source, and if measurement were made of all subtle changes in that molecule, then a radiobiological effect would be recorded on that molecule.

The common sense question that should follow such an event is: Does that subtle change in an isolated molecule have any relationship to some health effect in an irradiated person?

The linear extrapolation dogma is not based upon scientific or epidemiological evidence of radiation-induced health effects. We have a complicated system in the human body, complicated by all sorts of intricate machinery such as the immune system, designed to protect us.

Subtle molecular changes observed *in vitro* generally have no extrapolative powers to the human being because of the human repair process; they can only be scientifically based if proven to be related. Molecular biologists tend to show a radiation effect upon their favorite molecular or cellular system, with the implication that a related health effect should be considered in radiation protection criteria.

We know of no human cancer cases resulting from doses of radiation below at least 0.2 Gy (20 rad). Why are we worrying about what happens as zero dose is approached? Why are we sufficiently mentally insufficient to even consider guidance doses of 0.01 mSv (1 mrem) $yr^{-1}$, in the range where it cannot be measured?

If we are that concerned, what are we to do about natural background, which can vary by 1-3 mSv $yr^{-1}$, depending upon geography? (The frightful part of this latter is that some day, some person who considers him/herself an epidemiologist, is going to find some biologically related effect that is endemic to the people of Estes Park, Colorado, that is not found in Baltimore, Maryland, and the Press and the zero dose-zero effect people in our litigious society will eat it up.)

The plea here is for common sense. Is it ever going to be possible for influential people to recognize that an effect on a molecule, which may extrapolate linearly to the zero dose-zero effect point, is meaningless when it comes to setting standards for radiation, where no cancerous effects have been seen below rather sizeable doses? The answer unfortunately is no; there is too much job security and notoriety at stake.

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# The Cell Dose Approach Uncovers the Probability of a "Threshold" for Late Tissue Response at Exposures to Low Doses of Ionizing Radiation

*Ludwig E. Feinendegen*

Risk of detriment to biological systems from exposure to ionizing radiation is conventionally related to absorbed dose in the irradiated tissue.

This approach does not take into consideration the microscopic distribution of energy deposition events from tracks of ionizing particles (referred to here as hits) in tissue, nor does it relate to the multicellular structure of tissue.

Cells are the elemental units of life in tissue and respond as entire microorganisms, i.e. as a whole, to physiological or pathological interventions. Responses of hit cells underlie tissue detriment. Late effects, such as cancer and genetic mutations in germ cells with hereditable diseases in the offspring, arise from single cells.

At low values of absorbed dose or dose rate only single cells are hit per defined time interval, and the quantities of absorbed energy per cell (referred to here as cell doses, or hit sizes) conform to a spectrum that is typical for a given radiation quality.

At low-level exposure, absorbed dose to tissue thus is inadequate for assessing effects of radiation in hit cells potentially causing cancer or genetic mutations. The use of the relative biological effectiveness (RBE) or the quality factor of a radiation only partially corrects for the discrepancy between the values of absorbed dose to tissue and that to hit cells in that tissue when assessing risk from low-dose exposure (Feinendegen et al. 1994).

Individual cells in tissue respond in various ways to having been hit. According to experimental evidence, one response may lead to a permanent alteration in the DNA with the consequence of malignant transformation, with a probability of about $10^{-4}$ per x-ray hit (Feinendegen 1990).

Other responses may, with a probability closer to one, involve the cells in temporarily improving on the one hand their defense – for example against metabolically produced aggressive oxygen-containing radicals (Feinendegen et al. 1987; Feinendegen et al. 1988; Hohn-Elkarim et al. 1990) - - and on the other hand their capacity of repair – for example of DNA damages incurred from such radicals or other toxic agents (Wolff et al. 1988; Wolff 1992).

Also, hit cells may be induced to apoptosis and thus eliminate damages carried by them (Kondo 1993). Cells of the immune system have been reported to be stimulated, resulting in an improved surveillance in tissue against malignant cells or against potentially toxic agents (Makinodan 1992). The ratios of probabilities of some of these responses have been shown to change in favor of benefit with decreasing dose to the cells (Feinendegen et al. In Press).

The response of tissue to low-dose exposure must be viewed as a net consequence of multiple cellular responses in the irradiated tissue (Feinendegen 1991); the algebraic sum of cells that experience a temporary protection against spontaneous malignant transformation, and that, after malignant transformation, are eliminated by a stimulated immune system, may outweigh the sum of cells that sustain a radiation-induced malignant transformation at a given dose.

In view of the demonstrated increase of the ratio benefit to detriment in hit cells with decreasing dose to the cells, the relationship between probability of detriment in tissue and tissue-absorbed dose is predicted to deviate from linearity toward a "threshold" with decreasing doses.

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## Dose, Response, and Biological Level

*Charles A. Sondhaus*

Is response a linear function of radiation dose, or must dose exceed a threshold to produce a response? This depends on how dose and response are specified. Organisms and their tissues are cell systems; both dose and response can be defined at either cell or tissue level. Conventionally measured, (absorbed) dose is the mean value of aggregate energy deposited in unit mass of tissue by many discrete ionizing events (hits). Each hit deposits a different amount of energy, and occurs randomly in individual cells. Microscopic dose in cell targets is highly variable; it does not equal the mean value until every cell is hit repeatedly (Booz and Feinendegen 1988).

At the low doses and dose rates from natural background or involved in protection, photon and secondary electron fluences do produce many events in each cell. However, most single photon events are not energetic enough to cause observable responses; to do so, multiple events must occur almost simultaneously in a given target. Conversely, equal doses from heavy charged particles or neutrons are distributions that include many events large enough to cause cell responses; however, few cells in the irradiated tissue are hit even once (Bond et al. 1988).

The probability of any cell response depends on event size. It remains very small for small hits, then increases rapidly and becomes quite high for large enough events, as shown by the "hit size effectiveness function (HSEF)" (Sondhaus et al. 1990). Yet few, if any, responses result unless single hits deposit enough energy to overcome free radical removal and DNA repair mechanisms (Feinendegen et al. In Press).

A given radiation produces the same relative distribution of single event sizes at any low dose level. The probability per unit fluence of causing a given cell response can be derived by convoluting this distribution with the HSEF. It differs, for example, by three orders of magnitude between $^{60}$Co gamma photons and low-energy fast neutrons.

The number of aberrant cells that result from a given fluence of any radiation will thus increase linearly with increasing fluence, at least in the low-level region. However, appreciable numbers of responses will not begin to appear until the number of sufficiently energetic events exceeds some specific value. Accordingly, a dose level should exist below which the number of aberrant cells produced in an irradiated cell population remains so small that a functioning immune surveillance system may eliminate most, if not all, of them.

Thresholds may therefore occur on two levels: in cells, where single events may not deposit enough energy to cause responses, and in tissue, where the resulting number of aberrant cells may remain small enough to be controlled by the immune system. A level of irradiation should therefore exist below which no effects on tissues or organisms are expressed (Cronkite 1990).

There is evidence for the plausibility of this hypothesis. A prime example is the slow-but-successful evolution of complex organisms under the constant cosmic and terrestrial background irradiation that has existed throughout their long history on earth.

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## The Linear, No-Threshold Model Fails Badly in the Low-Dose Region

*Bernard L. Cohen*

There is no experimental evidence for a linear, no-threshold dose-response relationship for radiation-induced cancer in the low dose, low-dose rate region of the vast majority of applications. (In this region, "linear-quadratic" reduces to "linear, no-threshold.")

The only basis is in this theory: a cancer is initiated by a single particle of radiation interacting with a single cell nucleus, so the cancer risk is proportional to the number of particles of radiation, which is just proportional to the dose. However, this very simple theory ignores the effects of repair processes which prevent the vast majority of initiating events from developing into cancers.

If the efficiency of these repair processes is affected by radiation, the simple theory obviously becomes invalid, and any reason for accepting a linear, no-threshold relationship collapses.

It is now indisputably clear that small doses of radiation do indeed affect the efficiency of repair processes. The best evidence for this is the "adaptive response" which is the topic of a forthcoming ICRP Report. Numerous papers on this are contained in Sugahara et al. 1992, and a brief review is given in Cohen 1994.

A typical result stated in one of these papers is that a 1 rem dose several hours before a 200 rem dose reduces the cancer risk from the latter by about 35 percent, which is

interpreted as an increase in production of repair enzymes by the 1 rem dose. Another supporting finding is that 1-5 rem of radiation strongly stimulates the immune system, which may also be protective against development of cancer.

Thus there is no evidence, experimental or theoretical, to support a linear, no-threshold relationship in the region of interest, and the only way to investigate it is through experiment. Unfortunately, traditional approaches to such investigations are very strongly inhibited by statistical problems. At least many tens of thousands of subjects would be required, and no such studies are in prospect.

However, an innovative approach to testing the linear, no-threshold relationship with no statistical limitations has recently been described in *Health Physics* (Cohen 1995). It utilizes an ecological approach, but it shows that "the ecological fallacy," which is the usual objection to ecological studies, is not applicable in this work.

It also addresses all other potential problems with ecological studies that have been discussed in the literature, and shows that they have little effect. It includes studies of potential confounding by 54 socioeconomic variables plus many climatic variables and geographical factors. The conclusion is that the linear, no-threshold theory fails very badly in the low-dose region, grossly overestimating the risk of low-level radiation. In the ten weeks since that paper appeared, no letters to the editor critiquing it have been received.

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## Threshold Proven for High LET Radiation?

*Carl H. Distenfeld*

Professor Bernard Cohen, in his article *Relationship Between Exposure to Radon and Various Types of Cancer* (Cohen 1993), made the point that for linear, no-threshold dose effect response the ECOLOGICAL FALLACY DOES NOT APPLY. He first published this finding in the Int. J. Epidemiology (Cohen 1990).

If the ECOLOGICAL FALLACY does not apply, then the massive mortality and ecological data Cohen published is valid for risk estimation. Cohen's risk results show a negative relationship between environmental radon exposure and lung cancer, for either sex, with or without correction for smoking. Under the condition noted above, Cohen's work provides compelling statistical evidence for a threshold, if not a beneficial effect for high LET exposures of lung tissue at environmental levels.

What compelling evidence exists for linear, no-threshold effects? Should we continue to ignore the counter evidence and retain the linear, no-threshold extrapolations from acute high exposures? I believe it is past time to act on what we know, and I hope this may help reverse the morbidity of nuclear research, applications, and power.

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## The Linear Hypothesis is Too Expensive

*A.N. Tschaeche*

The use of the linear hypothesis in setting radiation protection standards was appropriate 50 years ago. Now, we know much more about the actual harm that low levels of radiation DO NOT cause in humans. No peer-reviewed study to date demonstrates that annual doses on the order of 0.05 mSv (5 rem) per year cause significant harm to humans. Therefore, the linear hypothesis should no longer be used. Instead, a specific value such as 0.05 mSv (5 rem) per year should be the level below which no resources should be spent to further reduce the dose. Populations that receive such doses should be studied to verify that the level is appropriate to maintain safety.

The ICRP, NCRP, and EPA should use a philosophy for setting radiation protection standards that adopts a numerical value for annual dose below which regulatory agencies do not need to provide requirements and above which the process of ALARA is applied. That value should be 0.05 mSv (5 rem) per year for everyone (radiation workers and members of the public alike). Then the United States would not have to spend billions to save hypothetical lives. The public's fear of radiation should be alleviated. We could get on with radiological waste disposal. The United States would be more competitive in the world market. We could stop burning fossil fuels altogether by using hydrogen produced from nuclear-generated electricity to power autos and airplanes and by using nuclear-generated electricity for other things. All of those benefits can be ours if we only get rid of the very expensive linear hypothesis which is not fact. Deleting the linear hypothesis is an idea whose time has come.

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## The Deceptive Nature of a Dose-Based Statement of the Linear, No-Threshold Hypothesis

*V.P. Bond*

The following demonstration of the irrelevancy of a dose-based statement and "proof" of the "linear, no-threshold hypothesis," depends on making a sharp distinction between the amount of the radiation agent, the imparted energy, ε, in joules, and the average energy concentration, ε/m, the absorbed dose in Gy (Bond 1992; Bond et al. 1991).

With many biological systems -- e.g., cells in tissue culture -- one can easily adjust the numbers of cells used at all data points, in the range of about 0.7 Gy to perhaps several Gy, so that a clearly significant fraction of dosed cells will show a radiation-induced "quantal" response, e.g., malignant transformation, death. If that number of exposed cells is held constant and the absorbed dose is progressively reduced, a point is reached at which no significant excess is observable (Bond et al. 1995a).

This situation is frequently "remedied" by including more cells at that point to improve the statistical validity. However, because both axes are normalized, this data point, despite having gained statistical significance, remains at the same energy concentration (dose) value. This gives the false impression that no additional amount of energy is needed to achieve significance, at even the smallest doses.

However, if both coordinates are put in absolute terms, i.e., the number of quantal responses vs. the total amount of imparted energy, and the same exercise of "improving the statistics" is attempted, it then becomes evident that the point resulting from increasing the number of cells must be moved upward on the plot, to a substantially larger value. This exercise shows the irrelevancy of dose as the "amount" in articulating, or attempting to "prove," the "linear hypothesis" (Bond 1995b).

The fact that a proportionately larger population must be placed in the beam as the dose becomes smaller suggests that, for the production of an excess cancer, there must be a minimum average amount of imparted energy delivered to the population. This value, from human cancer epidemiological data and for penetrating photon radiations, is about 3 kJ (Bond et al. 1991). The above does not prove that, with small amounts of energy, the expectation value for cancer must be zero.

However, the extraordinarily large value for the average shows that the associated probability must be vanishingly small and of no public health significance. Accordingly, it is strongly recommended that the "linear hypothesis" be abandoned.

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## It's Time for a Re-Examination

*Andy Hull*

The linear, no-threshold hypothesis was adopted by standards-setting groups in the mid-1950s. It was clearly stated at that time that it was adjudged to be a conservative assumption in the absence of any experimental evidence in the low dose, low dose-rate region. They stated that the true risk of genetic effects and, later in the 1960s, of cancer (as the Japanese data became available), might be much lower and even zero. Hormesis had not yet been proposed. At that time, the focus was primarily on workers and there was little, if any, attention paid to doses to th public much smaller than the 1/10 of the worker standards, which was the prevailing "public" upper limit standard.

With the advent of ICRP-22 and its principle of optimization, the collective dose and the man-rem (later the person-rem) became a consideration. At this time, there were serious proposals for a lower-limit cutoff in its calculation and for standards for the public either at the background level or its standard deviation (Adler and Weinberg 1978).

However, none was adopted and what was initially proposed as a conservative assumption has subsequently been adopted by regulatory agencies as a hard and fast basis for regulation, with calculations of hypothetical cancer deaths as low as less than one per year and comparisons of them with actual deaths from causes other than radiation by way of justifying their actions (EPA 1989).

When the linear hypothesis is used to justify regulation at extremely low levels and the resultant commitment of scarce resources to comply with regulations when the total number of cancer fatalities in this country is approximately 500,000 annually, it seems to me that it is time for its critical re-examination with the hope of steering resources toward more obvious causes of cancer and their alleviation.

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## Discontinue Use of Linear Models

*H. Wade Patterson*

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It seems indisputable that the Linear Model(s) disagree with measured human response to radiation exposure and, as Richard Feynman put it, "If it disagrees with experiment it is wrong."

I therefore suggest that UNSCEAR, BEIR, ICRP, NCRP, EPA, and NRC discontinue their use of the Linear Model(s) for setting protection standards and for assessing risks from low-level exposures.

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## Radium Dial Painters Show A Practical Threshold

*R.G. Thomas*

It has been known for decades that data from the study of persons who had acquired body burdens of radium have shown no radiation-related bone cancers below some level of dose, often referred to as a practical threshold dose. This practical threshold concept was published by Evans et al. (1972) and followed more recently by Maletskos et al. (1992) and by Thomas (1994). The most conservative estimate of this threshold is 4 Gy to the average skeleton. There are over 1300 radium dial painters still alive and carrying skeletal doses upwards of 10 Gy who have not reported evidence of osteosarcomas.

What happens to the theories and practices of those who say that all radiation is harmful when cases like the radium dial painters appear? The perfect example of one way this has been handled is seen in the *Federal Register* (1991). The following is loosely quoted from this reference.

> The Scientific Advisory Board/Radiation Advisory Committee (SAB/RAC) urged EPA to base its risk assessment for radium on human epidemiology data on radium watch dial painters, rather than on modeled estimates, and urged EPA to present its rationale for adopting the modeling approach for radium risk assessment. The SAB/RAC also requested that EPA better describe its dosimetric model in the revised criteria document, including calculated doses and risk to organs, and that if EPA continued to use the modeling approach, uncertainties in the modeling be addressed.
>
> EPA REPLY: The Agency carefully reconsidered this issue. First it should be pointed out that all risk estimates are based on epidemiologic data and require mathematical modeling. The EPA uses the wealth of epidemiologic data on human exposure and risk of radiogenic cancers, including radium dial painters and

epidemiologic data on bone sarcomas resulting from injected $^{226}Ra$.

The watch dial painter data indicate that the incidence of bone sarcomas may follow a dose-squared response, especially at higher exposures. EPA policy, supported by recommendations of SAB/RAC, is to assess cancer risks from ionizing radiation as a linear response. Therefore, use of the dial painter data requires either deriving a linear risk coefficient from significantly non-linear exposure-response data, or abandoning EPA policy and SAB/RAC advice in this case.

As a result of this interchange, the EPA uses data from the 3.6 day half life $^{226}Ra$ to establish some guidelines for 1500 year $^{226}Ra$.

What about the radium threshold? Is it real? Isn't it interesting, the steps that will be taken to avoid reality?

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## LNT Model Impacts NORM

*Susan S. Milsti and Michael J. Kletter*

The DuPont Minerals Business appreciates this opportunity to comment on the linear, no-threshold theory (LNT) for low-dose radiation. Our business manages naturally occurring radioactive materials (NORM) contained in our raw material mineral ores. The precedent of regulating NORM-containing minerals and wastes based upon the LNT could have a material impact on DuPont, and our small business minerals customers, as well as building construction, power plants, coal and ash storage sites, oil and gas, municipal drinking and wastewater plants, landfills, and incinerators. The 1994 UNSCEAR report adds significant scientific weight to the evidence opposing the LNT. Upon re-interpretation of the atom bomb survivor data, UNSCEAR concluded that the data could not be used for statistical verification of effects at low doses. In addition, the existence of hormesis is acknowledged.

There are additional studies which do not support the LNT, only a few of which are documented here. A comparison of Yangjiang County, China, with high natural background radiation, with two adjacent low-background counties showed that cancer mortality was lower in the high-background county (Wei et al. 1990). The BEIR V report states, "No increase in the frequency of cancer has been documented in populations residing in areas of high natural background radiation." It notes several studies where natural background gamma levels were three to four times normal (BEIR V 1990). Recent studies on the effect of indoor radon also throw doubt on the LNT, including a Chinese study measuring the radon level in the homes of women with and without lung cancer (Blot et al. 1990) and a study of non-smoking Missouri women, selected so as to minimize the potentially confounding influence of cigarette smoking (Alavanja et al. 1994). Additional studies are referenced in the 1994 UNSCEAR report and in a paper by Zbigniew Jaworowski (Jaworowski 1995), a former chairman of UNSCEAR.

The HPS should urge the EPA, NRC, State Conference of Radiation Control Program directors, and state regulators to utilize their best Radiation Science Advisory Boards, ICRP, and NCRP to review the 1994 UNSCEAR report and other recent publications and encourage full scientific debate to consider all opposing data before imposing costly regulations based on the LNT. The LNT has been translated by the EPA and NRC to a 15 mrem $yr^{-1}$ limit (draft 40 CFR 196, 40 CFR 193, and 59 FR 43200), and via precedent, what may likely be future regulation of NORM. This standard is too low, and for NORM equates to a cleanup of $^{226}Ra$ of 0.1 pCi $g^{-1}$ for a residential site reuse or 0.3 pCi $g^{-1}$ for commercial or industrial use, well within the normal background range of 1-5 pCi $g^{-1}$ in soils.

The HPS should lead public understanding and acceptance of low-level radiation as part of life. Regulators should propose radiation regulations that are easily distinguished from background levels to alleviate public fear and misunderstanding of radiation. HPS can help Energy to avoid betrayal of public trust and backlash at over-regulation which is costly to society without benefit to public health.

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## Radiation Hormesis for Health

*T.D. Luckey*

The Kobe catastrophe reminds us of our timorous existence on this planet. The bad news was the "unquenchable fires" from broken gas (the "clean fuel") lines, disruption of city infrastructures, destruction of homes, individual suffering and over 5,000 deaths. The world sympathizes and will help rebuild Kobe.

Who will help avert the silent catastrophe which accounts for 10,000 premature deaths each week in the United States? At the November 1994 American Nuclear Society Meeting, John Cameron reviewed Matanoski's study showing a 24 percent decrease, $p<0.001$, in the death rate of white male workers with lifetime exposures >5 mSv (Matanoski 1991). This is a perennial health disaster. Matanoski's study and three studies which show significantly reduced total cancer mortality rates in exposed white male workers, a total of about seven million person-years, provide a powerful incentive for radiation supplementation as a public health service (Luckey 1994). Recent results from 15,727 Los Alamos National Laboratory workers support the same conclusion (Wiggs 1994). The use of control cohorts of unexposed workers in each plant negates the usual "healthy worker effect."

Extrapolate Matanoski's results to the total population of the United States, and you get 2,236,000 deaths per year (U.S. 1994). If our exposure to ionizing radiation were increased 1 mGy yr$^{-1}$, equivalent to that of many exposed nuclear workers, we could expect 537,000 fewer deaths per year attributable to a partial radiation deficiency.

Safe supplementation with ionizing radiation should be possible. Generations have lived with >20 mGy yr$^{-1}$ (see Table). No health problems have been attributed to excess irradiation in these populations. Intensive animal studies on growth and development, reproduction, neuromuscular activity, learning and memory, immune competence, infection and cancer mortality, and average life span show that chronic, whole-body exposures to low-dose irradiation is a biopositive force throughout ontogeny (Luckey 1991).

The decreased quality of life and the cost of this massive premature illness and death are devastating. These costs, plus the increased productivity of those 24 percent who died prematurely, would more than offset the costs of: 1) radiation supplementation and 2) quality care for the increased number of old people.

The hormesis model suggests a new plateau of health for the 21st century. If our exposure were doubled to 5 mGy yr$^{-1}$, the premature deaths prevented would be equivalent to a Kobe catastrophe every day. Also, a safe allowance for nuclear workers, 26 mGy yr$^{-1}$ for 20 years, would help to restore our industrial health (Luckey In Press).

TABLE

| Location | mGy yr$^{-1}$ | Ratio |
|---|---|---|
| United States Average | 2.6 | 1.0 |
| Nile Delta | 3.5 | 1.3 |
| Exposed Workers | 3.6 | 1.4 |
| Chernobyl Limit[b] | 5 | 1.9 |
| Proposed Allowance | 5 | 1.9 |
| Kerala India | 4-13 | 3.5 |
| Guarapari Brazil | 10-18 | 5.4 |
| Mesipe Brazil | 22 | 8.5 |
| Gerais Brazil | 23 | 8.8 |
| Kerala Beach | 23 | 8.8 |
| Proposed Worker Limit | 26 | 10.0 |
| Araxi Brazil | 35 | 13.5 |
| Optimum | 100 | 38.5 |
| Ramasari Iran | 243 | 93.5 |
| Guarapari Beach | 263 | 101.2 |
| The Zero[c] | 10,000 | 3,850 |

a. This estimate includes natural plus industrial exposures.
b. The limit (in mSv) used to displace 200,000 persons.
c. The Zero Equivalent Point, this threshold is the limit of low-dose irradiation.

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## The Low Dose Question

*Harald H. Rossi*

Dosimeters can measure the degree of compliance with dose limits but they give only a general indication of radiation risk unless the probability of deleterious effects is proportional to the absorbed dose (or dose equivalent). The dose registered by a dosimeter is the arithmetic sum of various increments regardless of when they were received. The "linear hypothesis" requires the same assumption with regard to effect probability (Rossi 1984).*

The desire to regard the dose as a direct measure of risk has at least influenced the choice of the linear model – especially by organizations that promulgate radiation protection standards. This central tenet can be defended as long as epidemiological data cannot be considered to be in conflict with it. In view of the wide limits of confidence this has been – and remains to be – a mild restriction.

has, nevertheless, become apparent that a "linear-quadratic" rather than a linear dependence on dose is a better approximation in the case of mortality from leukemia. The hope that one could salvage linearity at least at low doses is considerably dampened by a graph in the last report by UNSCEAR (UNSCEAR 1994) where any linear coefficient is negative and the "natural" mortality is reduced by doses of less than 0.2 Sv. The statistics for leukemia are optimal because the risk – at least at high doses – is relatively large and the expression time is relatively short; but various possible sources of error would make it unwise to conclude that a beneficial effect at low doses has been established.

It is, however, possible to claim this in several instances of animal carcinogenesis. "Hormesis" has been found in cases where the natural incidence is so high that a reduction at doses of the order of tenths of grays in carcinogenesis was distinctly identified.

Dose-effect curves for animal tumors also vary greatly in shape and this argues against the assertion that for solid human tumors they are simply straight lines of different slope. It is, nevertheless, not impossible that what are curves of various shapes for individual cancers could add up to something that approaches a straight line for all cancers. However, this should not be considered to be proven. Most of the data come from the studies of Japanese survivors of A-bombs. The neutron component has been incorrectly analyzed (Rossi and Zaider 1990) and while it had been considered to be of minor importance, this has recently been questioned. The relatively precise chromosome assays show the typical linear dependence for Hiroshima survivors and a linear-quadratic dependence for Nagasaki survivors (Straim et al 1993). This kind of difference indicates serious errors in the dosimetry on which these curves are based.

The epidemiological data which carry substantial uncertainties at all doses become essentially useless at doses of less than a tenth of a gray. Substantial extrapolations are required to evaluate the "risk" to radiation workers. They approach or exceed a factor of 100 when extended to such notions as the "risks" from background radiation or the "collective dose" received by populations. ICRP and NCRP can consider any projections to such levels to be quite safe because the "risks" are unmeasurable. However, in view of the complexity of the induction and the systemic responses in carcinogenesis such calculations are less than dubious.

*Assuming the usual case of low probabilities.

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## It's Time to Re-Examine Our Dose-Response Model

*Thomas F. McLeod*
*Thomas E. Boothe*

Our current model to predict cancer induced by low-dose radiation is based upon a linear extrapolation with no threshold from populations exposed to high dose and high-dose rate radiation, a reasonable assumption if no direct measurements exist.

There are now an increasing number of studies designed to directly assess the incidence of cancer in populations exposed to low levels of radiation. Studies of radiation workers do not report excess cancers in this low dose, low-dose rate group. Our conclusion from these data is that the dose limits and accompanying radiation protection programs beginning in the 1950s must have been adequate since the incidence of cancer in these workers does not differ significantly from the unexposed population.

Epidemiological studies of cancer in populations exposed to low dose, low-dose rate radiation by living in high background areas have similarly not shown an increased incidence of cancer. The inhalation of high levels of radon is believed to cause cancer in underground miners but the risk to the general public has not been established and is inferred by extrapolation from the high dose using a linear, no-threshold model.

If this model is in fact correct, the postulated 15,000 lung cancer deaths per year in the United States attributable to radon (Samet 1994) should be detectable by epidemiological studies, even in the presence of the large number of uncertainties. The implication from these studies from three populations exposed to low-dose radiation is that radiation at these levels constitutes a very low risk or no risk.

An interesting observation by some studies (HBRRG 1980; Cohen 1995) is that the groups exposed to radiation appear to have fewer cancers. This puzzling observation, if in fact valid, might be explained by observations that a number of genes are inducible by heat, UV, and ionizing radiation and that this may be an adaptive response (Keyse 1993). While these *in vitro* studies cannot be interpreted as evidence for *in vivo* adaptation to radiation, they suggest that there may be a basis for a threshold.

In conclusion, the studies of populations exposed to low levels of radiation suggest there is no detectable effect (it may even be beneficial) in contradiction to predictions by extrapolation from high dose using a linear, no-threshold

model. We think that the low-dose studies are in several ways more compelling since they are looking for effects at exposure levels commonly encountered and hence it is time to re-examine our dose-response model in this light.

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## Guidance Needed in Use of Models

*Leonard R. Smith*

Health physicists have long relied on expert committees to determine the best models for estimating the effects of low-level ionizing radiation. While this is appropriate, there is also a need for clearer guidance on how these models should be used. Some examples follow.

1. To assign detrimental effects to individuals or populations exposed to ionizing radiation it is necessary to measure those effects in a comparable population or to use a theoretical model to estimate effects.
2. We are currently unable to measure effects due to low doses and low-dose rates and we are also unable to test models proposed for extrapolating from observations at high doses.
3. It is good scientific practice to limit the use of models to estimate effects at doses that are within a factor of tens of doses where effects are quantifiably observed.
4. Measurements and estimates of radiation effects should be best estimates, not conservative estimates.
5. Estimates of radiation effects should be accompanied by specified uncertainties in the estimates including detrimental, zero, and protective effects, as appropriate.
6. Detrimental effects should not be assigned to an individual or population when the uncertainty in estimates or measurements greatly exceeds the magnitudes of the effects.
7. At our current level of understanding, quantitative assessments of detrimental effects can only be made with confidence for individuals who are exposed to doses approaching or exceeding current occupational dose limits.
8. Occupational dose limits and limits on exposure of emergency responders can and should be based on risk estimates and measurements. These radiation risks should be compared with the loss in life expectancy from other hazards in the work place.
9. Guidance on public dose limits and commonly experienced occupational dose require a different justification. An alternative, and preferable, method of justification is the ICRP 60 recommendation that public dose limits should be comparable with common variations in natural background radiation which are acceptable to the public.
10. The often repeated statement that it is "prudent to assume risk at any dose" is not correct when such action results in the abandonment of a beneficial practice involving radiation where there may be no risk, for an alternative practice where there is known risk.
11. It is prudent to consider the potential for risk at low doses. Guidance is needed on how to evaluate the significance of such potential risk.
12. It is very important that the NCRP and ICRP make best estimates of risk and clear recognition of the uncertainties. The tendency to default to conservative risk assessments could cause these organizations to be discredited in the event that future studies show that there is no risk at low doses.

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## Broad-Range Cooperative Study Needed

*Bob Tuttle*

We have seen many epidemiological studies on radiation dose effects that failed to achieve adequate statistical significance because the small effects at low doses require large populations. That deficiency has recently been attacked by the combination of studies on nuclear industry workers (Cardis et al. 1994) in which the records of nearly 96,000 nuclear industry workers were studied. This is a step in the right direction but, considering that the lowest dose range, just at and above natural background, currently creates the greatest economic, political, and technological impacts, it is still an inadequate step. Other occupationally exposed groups such as the Naval Shipyard Workers (Matanoski 1991) should be included, and so should the large public populations studied by the Massachusetts Division of Environmental Health Assessment (Morris and Knorr 1990) and by the National Cancer Institute (Jablon et al. 1990), as well as populations living in high natural background areas. Populations exposed in the former Soviet Union to military radioactive waste discharges and to the Chernobyl releases, and work done on radon exposures, should also be included. My point here is that the data set should be as comprehensive and complete as possible.

The data interpretation must accommodate a broad range in the quality of these data, and should be able to recognize

the apparent variety of beneficial, neutral, and detrimental health effects that results from various dose ranges, types of exposure, and forms of radiation. It is no longer adequate nor appropriate to only search for how harmful radiation exposure might be; the full range of effects must be considered. This interpretation must make sense of low, medium, and high exposures and single acute exposures, multiple acute (fractionated), chronic continuous, and chronic intermittent exposures, and must not simply throw away the "healthy worker" effect as a complication to the study. (An interesting reflection on the current DOE inquiry into the human radiation exposure experiments is that several "hopelessly ill" subjects were apparently saved by the radiation dose received experimentally, or perhaps they had been misdiagnosed? Their long survival after radiation exposure does not seem to have been identified as the result of "radiation-induced cures" Beardsley 1995).

Just such an integrated approach to data interpretation has been in use for the past 40 years or so in the interpretation of neutron cross-section measurements, which often produced data of greatly different quality, over broad, discrete, or limited energy ranges. This field of data interpretation has created many effective techniques and many associated practitioners, such as Charles Dunford at the National Nuclear Data Center at Brookhaven National Laboratory, Donald Smith at Argonne National Laboratory, and Francis Perey at Oak Ridge National Laboratory.

I think that a broad-range cooperative study, using the most complete set of data obtainable, interpreted by use of modern techniques, in an objective search for the most likely forms of radiation dose-response functions would be a most valuable investment for our future. However, I must add a pessimistic caution: the most influential government agencies in this field owe their current prosperity, in part, to public ignorance and fear of radiation, in the range of exposures where I propose we should search for truth. Because of this, funding, support, and even encouragement will be difficult to come by.

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## Thyroid Cancer in the Low-Dose Domain

*Ralph E. Lapp*

The combination of high radiosensitivity and low incidence would appear to qualify a thyroid cancer epidemiology as the illuminator of the low-dose domain. In addition, the enhanced effect in infants would justify focusing on a very young cohort. A Swedish study (Lundell et al. 1994) of 14,351 infants under 14 months in age observed 17 thyroid cancers versus seven expected. A mean external irradiation of 27 rad was found, yielding a risk of 0.9 per million thyroid-rad-year (TRY).

To apply this risk to internal radiation from radioiodine, a factor of three reduces this risk to $0.3 \times 10^{-6}$ TRY. This risk may be used to estimate the potential excess thyroid cancer among the very young milk consumers living near the Hanford nuclear site during the first years of plutonium production. A pilot study (Davis et al. 1995) of 3,200 children exposed to an $^{131}I$ dose of 11 rad has been endorsed by the National Research Council (1994). The collective dose of 35,000 thyroid-rad yields $1.1 \times 10^{6}$ TRY. This results in a risk of 0.3 excess thyroid cancers for the CDC study. Such a radioiodine risk is not statistically sensible.

The prudence of the CDC (Davis et al. 1995) epidemiology needs to be examined by comparing its effective collective dose to that of the Swedish study (Lundell et al. 1994). The latter is 20-fold greater than the CDC study. A recent analysis of seven thyroid cancer studies shows no comparable epidemiology (Ron et al. 1995). Radiation-induced thyroid cancer in infants remains speculative. The CDC project (Davis et al. 1995) cannot illuminate the issue.

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Editor's Note: Scott Davis, Fred Hutchinson Cancer Research Center, is preparing a Hanford Thyroid Disease Study response to Ralph Lapp's article. It will be published in our July issue.

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## The Scientific Method and Radiation

*Fritz A. Seiler*

In the last few decades, efforts to model radiation risks have been carried out under the banner of scientific endeavors. On closer inspection, however, it becomes clear that these efforts were not guided by the scientific method. In fact, important aspects of these modeling efforts are in flagrant contradiction to some of the cornerstones of the scientific method.

An application of the six requirements of critical scientific thought (Lett 1990; Seiler 1994a), shows that the first, sufficiency, is fulfilled because there are sufficient data for a model in the low dose, low-dose-rate exposure regime of radiation protection. The second, replication, is met because there is enough evidence to confirm radiation carcinogenesis. The third requirement, however, is violated routinely, because not all the data available are included in the evaluations. In fact, some of the most pertinent data are ignored: data on cancer incidence in areas with different background doses. By the almost exclusive choice of A-bomb survivor data, we are led to believe that it is better to extrapolate cancer fatality data over six orders of magnitude in dose rate than to do careful evaluations of population doses accumulated at rates appropriate for the radiation protection of workers and the general population (Alvarez 1995).

The fourth requirement, that of a logical approach, is badly warped by regulatory policy. In the last decades, the question asked seems to have been "How do we keep the linear dose-effect relationship alive?" rather than "What do the data tell us?" The fifth, scientific honesty, has also suffered badly. In part, that requirement can be phrased as "What kind of scientific statement can we honestly make?" and here we are all at fault, mostly by keeping silent while regulations were discussed and promulgated which implied that we are able to measure, predict, and control risks with incredible accuracy, as accurate as $3 \times 10^{-4}$ for some NRC regulations and $1 \times 10^{-6}$ for NESHAPS. Recently, it has been shown that the situation is worse than expected, that the minimum significant radiation risk is as high as a few percent, and that there may be severe problems if we try to push it down toward $1 \times 10^{-3}$ (Seiler 1994b).

The sixth, and often deemed the most important, requirement of the scientific method is falsifiability: the experimental testing of model predictions is of fundamental importance to the integrity of science. It is here, at low doses, that the linear model has failed decisively. At high-dose rates there is a threshold near a dose of about 0.3 Sv (Alvarez 1995; Shimizu 1993). Below that dose and its equivalent at low-dose rates, there is a region of hormesis, as demonstrated by Luckey (1991) and the 1994 UNSCEAR report (Jaworowski 1994). Once a scientific model has thus been falsified, the scientific method requires that it be abandoned and replaced (Seiler 1994a). It is our collective responsibility as scientists to see to it that the new model is constructed in strict adherence to the scientific method.

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## Need for a New Model for Radiation Risk Assessment and Management

*J.L. Alvarez*

The linear-to-zero paradigm for radiation risk was initially introduced as an upper bound estimate for standard setting. It necessitates the introduction of concepts such as acceptable risk and "as low as reasonably achievable" but, above all, it is a model of convenience which has no basis in scientific fact. Nevertheless, it is touted at present as a dogma based on irrefutable fact. Two prestigious committees, BEIR 1990 and ICRP 1991, stated that the linear-to-zero model could neither be proven nor refuted, and that it was a biologically plausible model, although neither committee specified the properties which would make it linear to zero dose. In reality, there is no physical, chemical, or biological effect that has been shown to be linear down to zero dose.

This model has been disproved repeatedly in epidemiological studies involving radiation background and in radiation worker studies, but both committees dismiss all these studies as possibly confounded. However, their own data, the Japanese Atomic Bomb Survivor data, also refute the model in the low-dose region. In a paper submitted to *Health Physics* (Alvarez et al 1995), these data were examined for support of the linear-to-zero model and, at low doses, the data denied the existence of a carcinogenic effect, thus refuting the model. Several alternate models were examined and found to fit the data better than the linear-to-zero model. In all cases these were non-linear models with explicit or implicit thresholds. At high-dose

rates, the threshold was found to lie near 0.3 Sv. Further analysis showed that the model systematically overestimated the risk below 0.5 Sv, fulfilling the original intent of being an upper bound. Finally, no basis could be found for extending any high-dose rate model to low-dose rates.

These scientific deficiencies of the paradigm could be accommodated if there were a scientific method of managing risk. The major problems with the present way of managing risk are a lack of understanding of uncertainty and control, and a tendency to apply risk management to an isolated risk instead of all the risks involved (Seiler 1994a). Also, attempts to reduce risks, supported by a cost-benefit analysis, are doomed to failure due to the excessive conservatism in the evaluation of the risks. The lack of understanding of uncertainty and control arises mostly from not carrying uncertainties through the decision process and into the management of risk. This would lead to a minimum level of risk requiring action, which is completely analogous to minimum significant risk levels (Seiler 1994b). Above all, uncertainty restricts control: If the cancer rate is $0.25 \pm 0.02$, then risks of $0.001 \pm 0.002$ and lower do not alter an individual's cancer risk. Also, any effort to reduce a risk of $0.001 \pm 0.002$ must fail from lack of control.

Consequently, the current paradigm for radiation risk must be replaced by one which is scientifically defensible. Concurrently, risk management and control must be put on a scientifically valid basis.

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## Radiation Protection is Not a Science at Low Doses

*John Cameron*

The statement by the National Council on Radiation Protection and Measurements (NCRP) that radiation risk may extend down to zero dose is quoted by many non-scientists (and some scientists) as though it had the same certainty as the laws of physics and chemistry. Biology at the human level is not a science. There are no quantitative laws similar to those of physics and chemistry. Even general health rules are subject to large variations. What is lethal for one person may have little effect on another.

This large biological variability has been known for centuries by medical practitioners. It is also well documented in the radiobiological literature. It led NCRP Scientific Committee 40 to conclude: "Because of the large range of RBE values for all endpoints reviewed, it must be a matter of judgment as to which values are to be used in selecting Q values for use in radiation protection" (NCRP 1990). Knowledge of Q (now $W_R$) values is necessary to calculate the basic radiation protection quantity *equivalent dose*. I was surprised when NCRP Report No. 116 (NCRP 1993) gave $W_R$ values with no hint that they may not be valid. The reference for the values was ICRP Publication 60 (1991) while NCRP Report No. 104 was not referenced – it is a non report! However, NCRP still has confidence in its risk estimates. NCRP Report No. 115 (NCRP 1993) states that: "Finally, it should be noted that the current estimates provide a robust basis for radiation protection guidelines." This statement is one page after a list of five major sources of uncertainty in the risk factors, which does not include uncertainty in $W_R$ values!

The most dramatic and convincing evidence of the failure of the linear, no-threshold assumption comes from the long-term study of radiation-induced osteogenic sarcoma in radium dial painters (Evans 1974). These data show a very large threshold of over 10 Gy of cumulative alpha particle dose to the skeleton for the radiation induction of bone cancer. If one uses a $W_R$ (or Q) value for alpha radiation of 20, the threshold is over 200 Sv or 20,000 rem. Not only was the linear, no-threshold assumption contradicted but the stochastic model of cancer induction was strongly contradicted. Incidence of radiation-induced sarcoma was nearly independent of dose. Most of the women with cumulative skeletal doses over 250 Gy did not have osteogenic sarcomas. The general results of this important 1974 publication were recently confirmed (Rowland 1974).

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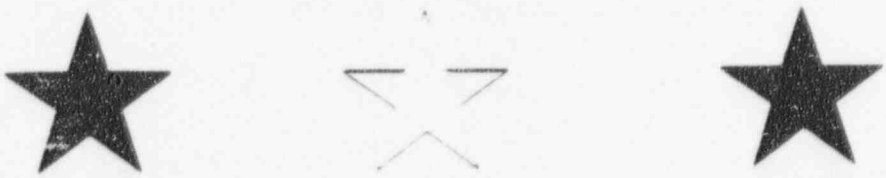
Health Physics Society:

Don't quantify risk below
5 rem/yr or 10 rem lifetime

*Charlie Willis*

US Nuclear Regulatory
Commission



# Health Physic Society:
# Don't Quantify Risk Below 5 Rem $Yr^{-1}$ or 10 Rem Total

***Charlie Willis***

**"... the Health Physics Society recommends against quantitative estimation of health risk below an individual dose of 5 rem in one year or a lifetime dose of 10 rem in addition to background radiation." [1]**

I. Questions raised
- A. Why?
- B. Why the Health Physics Society?
- C. Scientific validity?
- D. Impact if generally accepted?

II. Purpose: counteract radiation phobia and over-regulation
- A. Resistance to food irradiation kills thousands and affects millions annually [2]
- B. Patient fear of radiation delays early detection of cancer and other problems
- C. Radiation phobia promotes unreasonable awards for "damages"
- D. Radiation phobia supports the radwaste fiasco
- E. Regulation inhibits research
- F. Regulation causes exorbitant costs in decommissioning & cleanup
- G. Regulation increases costs of research, medicine, power production, etc.
- H. Extension of regulation to natural radiation threatens agriculture, industry, construction, and most everything else [3]

III. Health Physics Society's reasons for acting
- A. Reason for existence: worker and public protection
  - 1. Includes indirect effects
  - 2. Fundamental tenant: do more good than harm
- B. First-hand knowledge of impacts of the present system
- C. In-depth knowledge of the science
- D. Inaction of ICRP & NCRP
  - 1. Evident commitment to the linear no-threshold hypothesis (NL-TH)
  - 2. Evident lack of concern about indirect effects
- E. Limitations of consensus standards
- F. Inaction of the regulatory agencies
  - 1. EPA seen as scare-monger
  - 2. NRC seen as wedded to ICRP/NCRP
  - 3. DOE seen as paralyzed
- G. HPS claim to objectivity
- H. Others lend strength
  - 1. French National Academy

2. BELLE [10]
3. ANS [11]

IV. Scientific bases for the HPS Position

A. Absence of direct evidence of detriment from low doses [4]
   1. A-Bomb survivors
      a. Excess cancers evident above ≈50 rad
      b. Mental retardation: D≥ 50 rads, 8 to 15 weeks
      c. Mortality reduced for men with 50-150 rad doses
   2. Cervical cancer patients: D≥ 250 rads
   3. Ankylosing spondylitis patients: D≈ 200 rads to lungs
   4. Underground miners: D≥ 50 WLM
   5. U. Chicago stomach cancer patients: D≈ 160 rads
   6. Stockholm thyroid patients, D≈ 50 rads to thyroid: No ill effect
   7. Marshall Islanders: D≥ 30 rads
   8. Thorotrast patients: D≥ 150 rads α to liver
   9. Tinea capitis patients: D≥ 120 rads to brain
   10. US Radiologists: 200 ≤D≤ 2000 rad
   11. Nuclear workers & neighbors: No detriment
   12. "High" natural radiation areas: No detriment
   13. Radon in homes: No detriment; refutes LN-TH [5]

B. Radiation ill effects well understood [6,7]
   1. Investigation since 1896
      a. Scientifically interesting
      b. Funding available from Government & medical community
   2. Ill effects almost all identified by 1911
   3. Vast investigations related to nuclear development
   4. National Academy of Science: "best understood environmental hazard"

C. Biological knowledge
   1. Virtually every material thing is harmful at high-enough doses
   2. Virtually nothing is harmful at low-enough doses
      a. Harmful deficiencies are commonplace
      b. Pharmacology based on benefits from low doses of very hazardous substances

D. Evidence for hormesis [8]
   1. Power of the paradigm
   2. Hormesis data not sought in recent decades
   3. Hormesis data suppressed in recent decades
   4. Much supporting data still available
   5. Historical: spas, cures & radio-stimulation

IV. Potential Costs and Benefits of General Acceptance

A. Improved communications with public
B. Reduction of radiation phobia
C. More cost-effective regulations

D. More cost-effective radiation controls
E. Important improvements in public health
   1. Food "Pasteurization" by radiation
   2. More general application of diagnostic radiology
   3. Facilitated medical research
F. Substantial redirection of regulatory programs
G. Substantial redirection of radiation training and protection programs

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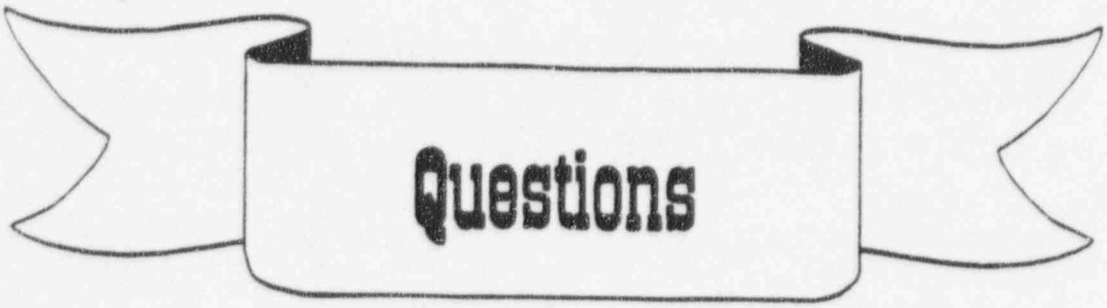



- Purpose?
- Why the Health Physics Society?
- Scientific validity?
- Impact if generally accepted?

# Purpose: Counteract Radiation Phobia and Over-Regulation

- Phobia
  - ☒ Blocks food irradiation; kills thoudands
  - ☒ Patient fears deter early detection
  - ☒ Produces unreasonable court awards
  - ☒ Maintains radwaste fiasco
- Over-regulation
  - ☒ Inhibits research
  - ☒ Exacerbates decom/decon costs
  - ☒ Costly: power, medicine, research, etc.
  - ☒ Extension to natural: general threat

# Health Physics Society's Reasons for Acting

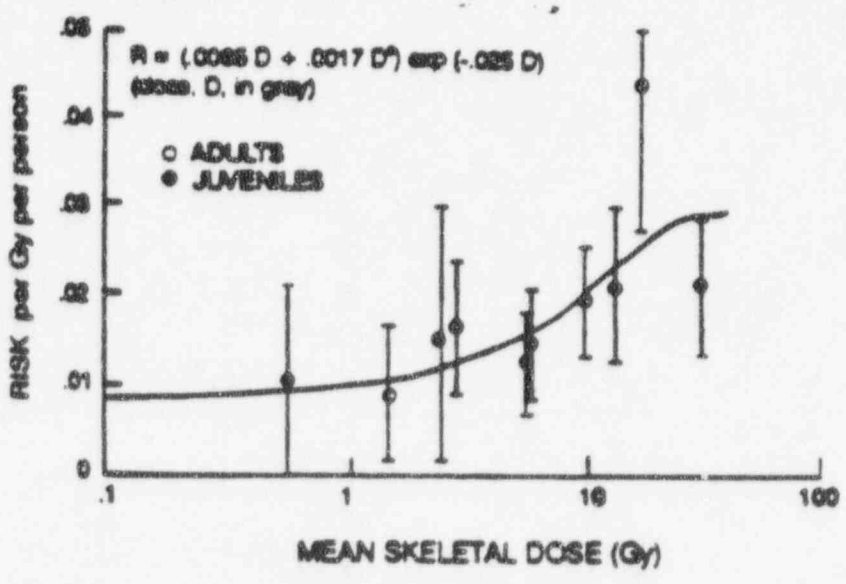
- HP purpose: worker & public protection
- Knowledge of impacts
- Knowledge of science
- ICRP/NCRP inaction
- Consensus standards limitations
- Regulatory agency inaction
- HPS claim to objectivity
- Support of others

# W.K. Sinclair
## Challenge to Threshold Proponents

- If there is a threshold, at what dose level could it be?
- Is it the same for cancer in all organs and tissues?
- What if just one cancer were proven to be truly linear? What then?
- How would a threshold level be agreed upon – given statistical problems?
- How much margin of safety would be needed?
- Would the threshold be for acute exposure or chronic?
- Would a threshold with a very low value of dose – probably the best that can be hoped for – actually be useful in radiation protection?
- Might it not make some limits more stringent than they are now?

WKS 95-183

*Figure 2-22. Risk versus bone dose from radium (from Chemelevsky et al., as in BEIR IV, 1988, Figure 4-7)*



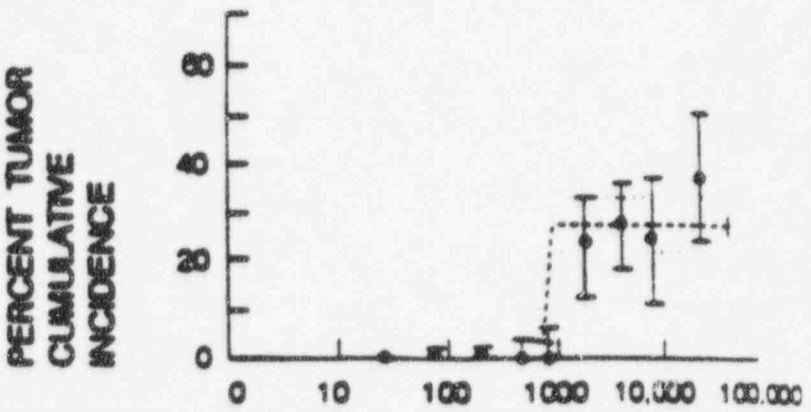



Figure 2-21a

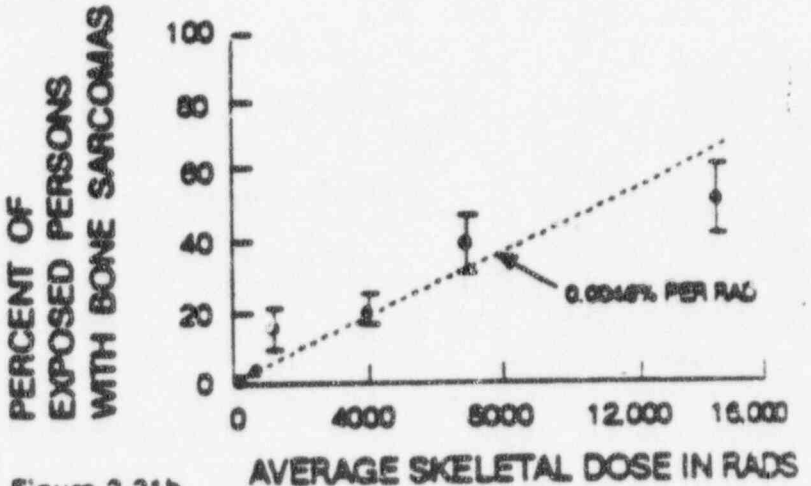



Figure 2-21b

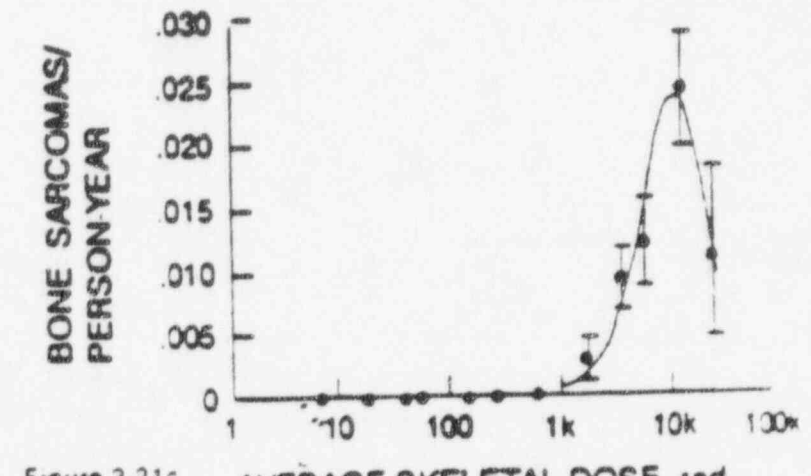
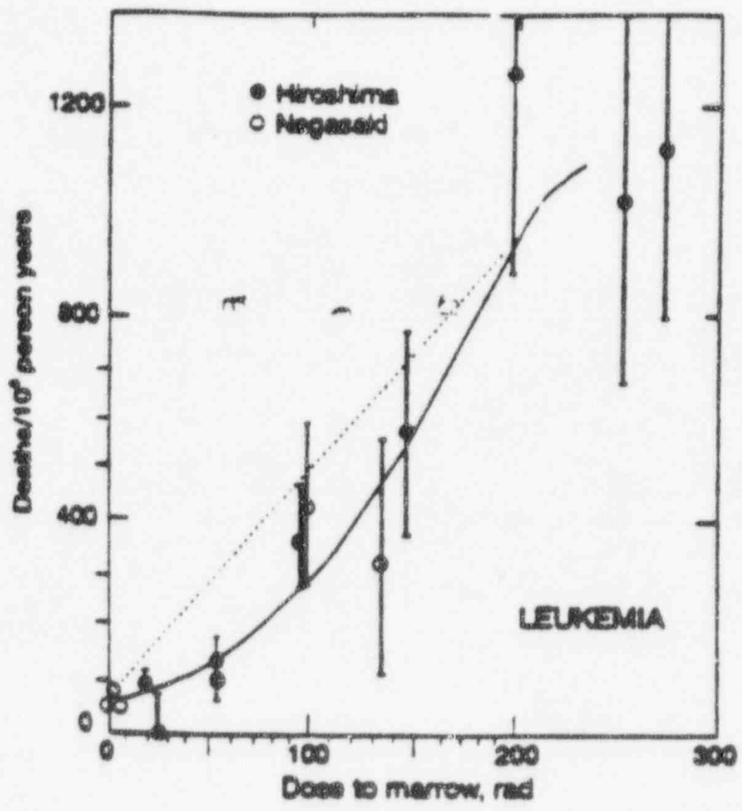



Figure 2-21c


Hiroshima
Nagasaki
1200
800
400
0
Deaths/10⁴ person years
LEUKEMIA
0
100
200
300
Dose to marrow, rad

# Scientific Bases for Position: No evidence of detriment

**No detriment at low doses**

- ★ A-Bomb survivors

**High Doses**

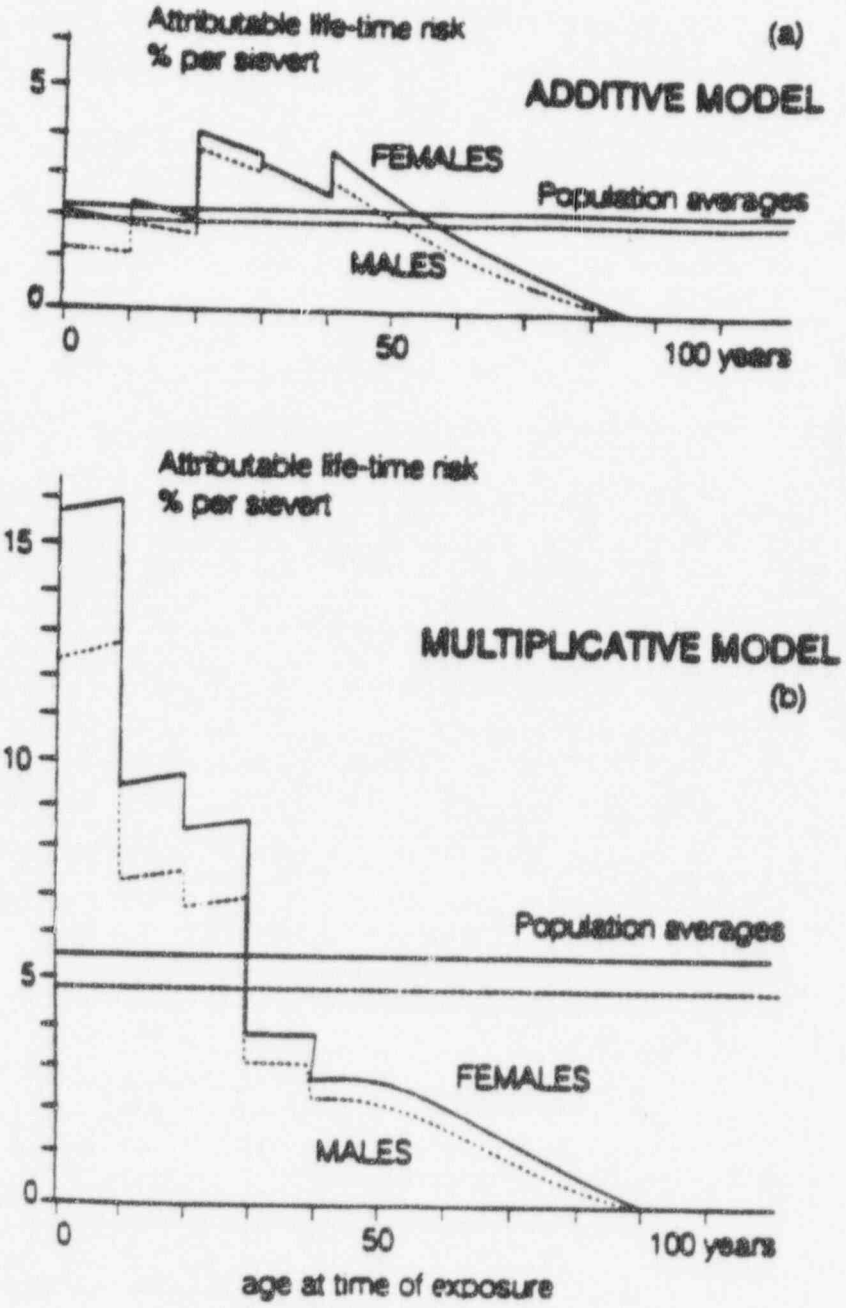
- ★ Cervical Cancer patients
- ★ Ankylosing spondylitis patients
- ★ Unerground miners
- ★ Stomoch cancer parients
- ★ Thyroid patients
- ★ Marshall Islanders
- ★ Thorotrast patients
- ★ Tinea capitis patients
- ★ US Radiologists

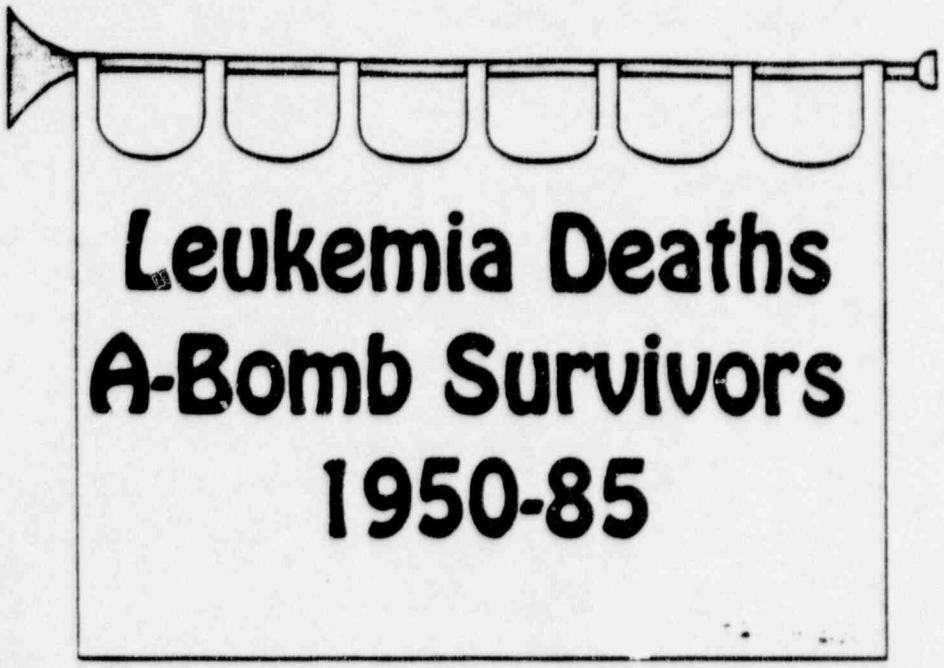
**No Detriment**

- ★ Nuclear workers & neighbors
- ★ "High" natural radiation
- ★ Radon in homes

# Scientific Bases (Continued)

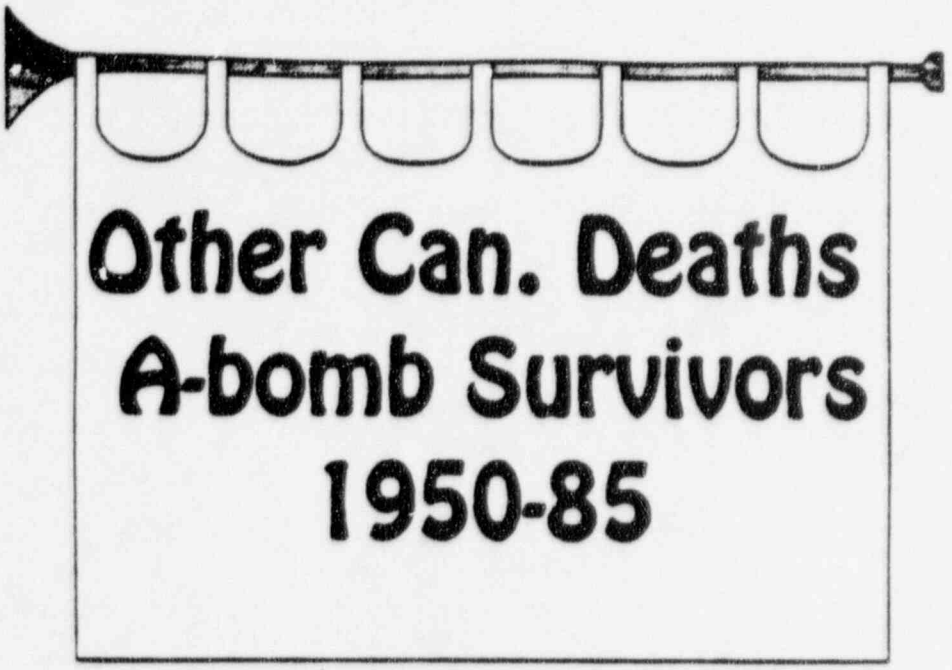
- Detriment well-understood
  - ☑ Studied since 1896
  - ☑ Detriments identified by 1911
  - ☑ Vast studies, nuclear related
  - ☑ NAS: "Best understo... Env. H."
- Basic biology
  - ☑ High-dose: everything harmful
  - ☑ Low-dose: nothing harmful
  - ✓ Deficiencies often harmful
  - ✓ Low dose often helpful
- Evidence for hormesis
  - ☑ Power of the paradigm
  - ☑ Hormesis data not sought
  - ☑ Hormesis data surpressed
  - ☑ Much data available anyway
  - ☑ Historical: spas & treatments


Attributable life-time risk
% per sievert
(a)
ADDITIVE MODEL
5
FEMALES
Population averages
MALES
0
0
50
100 years
Attributable life-time risk
% per sievert
15
MULTIPLICATIVE MODEL
(b)
10
Population averages
5
FEMALES
MALES
0
0
50
100 years
age at time of exposure

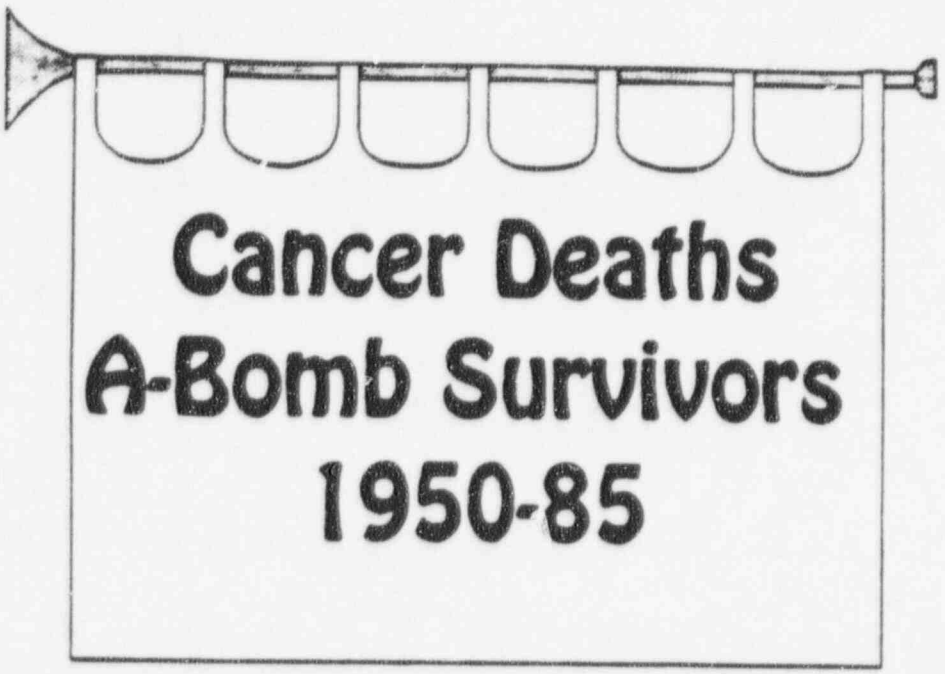


# Leukemia Deaths A-Bomb Survivors 1950-85

| Rems | People | L. D. | Expt | Excs | Unc. | |
|---|---|---|---|---|---|---|
| 0-1 | 34272 | 58 | 58 | | 15 | |
| 1-5 | 19192 | 36 | 33 | 3 | 15 | |
| 6-9 | 4129 | 2 | 7 | -5 | 3 | |
| 10-19 | 5172 | 13 | 9 | 4 | 7 | |
| 20-49 | 6558 | 21 | 11 | 10 | 9 | ✓ |
| 50-99 | 3616 | 19 | 6 | 13 | 9 | ✓ |
| 1-200 | 1946 | 23 | 3 | 20 | 9 | ✓ |
| 2-300 | 637 | 15 | 1 | 14 | 8 | ✓ |
| 3-400 | 211 | 9 | 0 | 9 | 6 | ✓ |
| 400+ | 258 | 6 | 0 | 6 | 5 | ✓ |

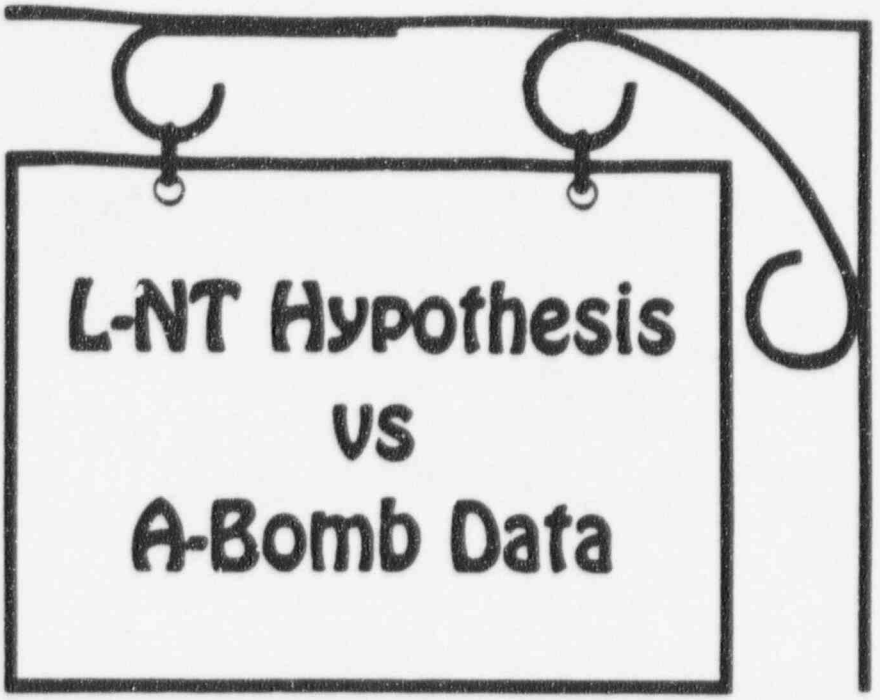



| Rems | People | O.C.D | Expct | Excs | Unc | |
|---|---|---|---|---|---|---|
| 0-1 | 34272 | 2443 | 2443 | | 97 | |
| 1-5 | 19192 | 1332 | 1375 | -53 | 90 | |
| 6-9 | 4129 | 333 | 298 | 35 | 38 | |
| 10-19 | 5172 | 413 | 371 | 45 | 43 | ✓ |
| 20-49 | 6558 | 537 | 467 | 70 | 49 | ✓ |
| 50-99 | 3616 | 330 | 255 | 75 | 37 | ✓ |
| 1-200 | 1946 | 221 | 137 | 84 | 30 | ✓ |
| 2-300 | 637 | 78 | 45 | 33 | 17 | ✓ |
| 3-400 | 211 | 23 | 15 | 8 | 9 | |
| 400+ | 258 | 31 | 17 | 14 | 11 | ✓ |

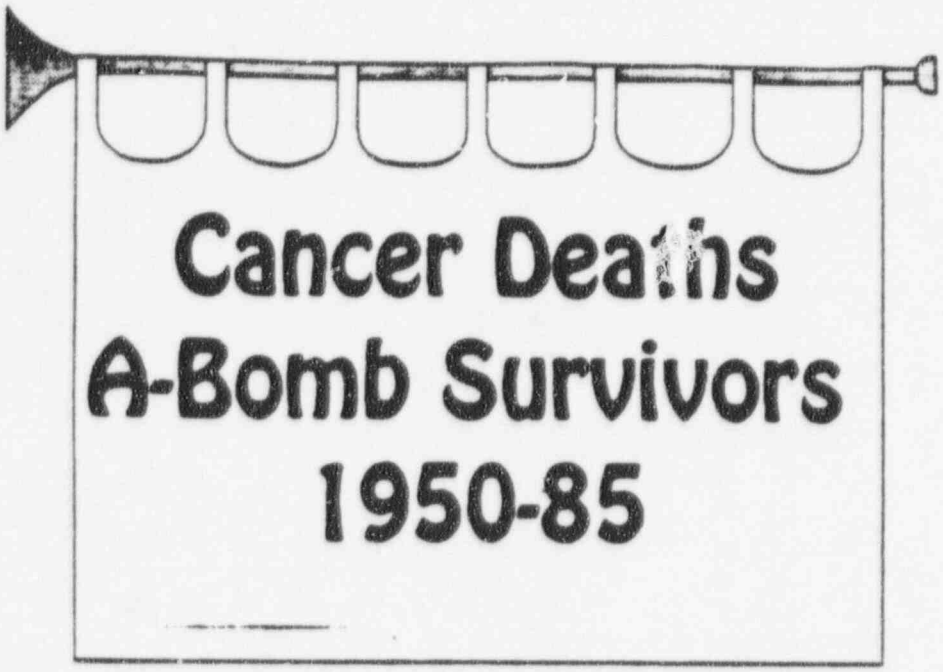


# Cancer Deaths A-Bomb Survivors 1950-85

| Rems | People | C. D. | % CD | UnCrt | |
|---|---|---|---|---|---|
| 0-1 | 34272 | 2501 | 7.3 | .3 | |
| 1-5 | 19192 | 1358 | 7.08 | .4 | |
| 6-9 | 4129 | 335 | 8.11 | .9 | |
| 10-19 | 5172 | 429 | 8.29 | .8 | |
| 20-49 | 6558 | 558 | 8.51 | .7 | ✓ |
| 50-99 | 3616 | 349 | 9.65 | 1. | ✓ |
| 1-200 | 1946 | 244 | 12.5 | 1.6 | ✓ |
| 2-300 | 637 | 93 | 14.6 | 3. | ✓ |
| 3-400 | 211 | 32 | 15.2 | 5.3 | ✓ |
| 400+ | 258 | 37 | 14.3 | 4.6 | ✓ |




| Rems | L. Exs | LNTH | O.Exs | LNTH |
|---|---|---|---|---|
| 0-1 | | | | |
| 1-5 | 3 | 4 | -53 | 17 |
| 6-9 | -5 | 2 | 35 | 8 |
| 10-19 | 4 | 5 | 45 | 22 |
| 20-49 | 10 | 16 | 70 | 66 |
| 50-99 | 13 | 19 | 75 | 78 |
| 1-200 | 20 | 20 | 84 | 84 |
| 2-300 | 14 | 11 | 33 | 46 |
| 3-400 | 9 | 5 | 8 | 21 |
| 400+ | 6 | 8 | 14 | 33 |



# Cancer Deaths A-Bomb Survivors 1950-85

| Rems | C. D. | % CD | % Exs | UnCrt | |
|---|---|---|---|---|---|
| 0-1 | 2501 | 7.3 | 0 | | |
| 1-5 | 1358 | 7.08 | -0.26 | .4 | |
| 6-9 | 335 | 8.11 | 0.73 | .9 | |
| 10-19 | 429 | 8.29 | 0.94 | .8 | ✓ |
| 20-49 | 558 | 8.51 | 1.21 | .7 | ✓ |
| 50-99 | 349 | 9.65 | 2.43 | 1. | ✓ |
| 1-200 | 244 | 12.5 | 5.32 | 1.6 | ✓ |
| 2-300 | 93 | 14.6 | 7.3 | 3. | ✓ |
| 3-400 | 32 | 15.2 | 8.0 | 5.3 | ✓ |
| 400+ | 37 | 14.3 | 7.5 | 4.6 | ✓ |

# Radiation Effects Milestones

1896: X ray burns: Grubbe & E. Thompson
1899: Blood vessel degeneration: Gassman
1901: X rays fatal to Lab. animal: Rollins
1902: Cancer in X ray ulcer: Frieben
1903: Leukemia induced: Heinke
1904: Clarence Dally died of radiation dermititis/cancer
1911: Leukemia in 5 radiation workers: Jogie
Mutations induced: Loeb & Bancroft
1921: Ironside Bruce died of aplastic anemia, radiogenic?
1925: Radium dial painters: Martland, et al.
1927: Muller "proves" radiogenic mutations
1929: Cleveland disaster; 125 people killed
1928-55: Thorotrast injections diagnosing brain disease
1935-54: Ankylosing Spondylitis patient irradiation
1945: Atomic bombs dropped on Hiroshima & Nagasaki

# General Acceptance: Potential Cost/Benefit

- Costs
  - Regulatory redirection
  - Protection redirection
  - Retraining
- Benefits
  - Improved communications
  - Reduced radiation phobia
  - Cost savings
    - Control programs
    - Decon/decom
    - Radwaste management
  - Improve public health
    - Food "pasteurization"
    - Medical research
    - Medical practice

NUCLEONICS WEEK

January 25, 1996

## STUDY FAVORS POINT BEACH REPAIRS OVER RETIREMENT BY $500-MILLION

A new Wisconsin Public Service Commission (PSC) analysis shows that replacing steam generators at Wisconsin Electric Power Co.'s (Wepco) Point Beach-2 would save ratepayers nearly $500-million over the alternative of retiring the unit and getting the power elsewhere.

The $494-million savings is up from the $297-million savings estimated for the same option in a 1994 PSC study (NW, 3 Nov. '94, 6). The deteriorating condition of the steam generator tubes at Point Beach-2 means that, without new generators, the unit would have to be retired this year. That fact eliminated some options considered in the earlier study and caused a jump in the savings to be realized by steam generator replacement, according to Sarah Jenkins, a PSC senior environmental planning analyst who worked on the analysis.

One variable in the analysis is the possible future retire-

*Continued on page 11*

## WORLD'S FIRST ADVANCED BWR COULD GENERATE ELECTRICITY NEXT WEEK

Tokyo Electric Power Co.'s (Tepco) Kashiwazaki-Kariwa-6, the world's first advanced boiling water reactor (ABWR), is "on target" to generate its first electricity at the end of the month, according to an industry source.

Tepco officials said that Kashiwazaki-Kariwa-6, which reached criticality in late December and is now at 15% power, is scheduled to synchronize with the grid and generate first electricity in February. Plans call for commercial operation of the unit, in Japan's Niigata Prefecture, to begin in December.

Construction at both Kashiwazaki-Kariwa-6 and -7 is running about 2.5 months ahead of schedule, according to General Electric officials, and the project is expected come in within budget. Tepco officials place the cost of the first 1,356-MW unit at [illegible] billion yen (about $4.3-billion, or some $3,170 per [illegible] kilowatt). In 1994, the company put the cost of the second unit at 380-billion yen (NW, 25 Aug. '94, 2). It is scheduled to enter commercial service in 1997.

The design and manufacture of the ABWR has been a joint effort of GE Nuclear Energy, Toshiba, and Hitachi, under Tepco's coordination. Components for the nuclear plant were manufactured in GE's U.S. plants in Wilmington, N.C. and Cleveland, Ohio, and in Japan by GE's licensees, Toshiba and Hitachi, said Steven Hucik, general manager, nuclear plant projects for GE Nuclear Energy. Design work on the ABWR has been underway for more than 15 years.

"The key item that differentiates the ABWR is that we evaluated all the BWRs operating around the world and combined all the best and most advanced qualities in this reactor," Hucik said in a January 22 interview. The ABWR design incorporated internal reactor pumps, which eliminat-

*Continued on page 12*

## EUROPEAN UNION TO ADOPT NEW RADIATION PROTECTION NORMS

The European Council is expected to adopt new basic safety standards for radiation protection without debate next month, following a recommendation from member state ambassadors to adopt the definitive version of a text first proposed by the European Commission (EC) in July 1993.

The standards, which would incorporate into European Union (EU) law the 1990 recommendations of the International Commission on Radiological Protection (ICRP), have been the object of controversy in Brussels' expert group on the subject for nearly three years. The stiffest opposition came originally from France, where an internal debate on the scientific foundation of the ICRP's recommendations is still waging.

The 1990 ICRP publication, ICRP-60, recommends lowering annual exposure limits for radiation workers from 50 milliSieverts (mSv), contained in the ICRP's 1977 recommendations, to 20 mSv, averaged over five years, and to reduce annual exposure limits for the public from 5 mSv to 1 mSv. Some environmentally militant member states, like Denmark, Luxembourg, and Iceland, argued for a strict 20

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overused.

[redacted] French scientists [redacted] to prove the 50 mSv level was sufficiently [redacted]. But in mid-1994, as the standards were being debated [redacted] the IAEA's Board of Governors, the government made a political decision to follow the mainstream international recommendations.

France's Academy of Sciences studied the issue of low radiation doses at the request of the French government and reported last November that there was "no scientific justification" to lower the current level in force in France for workers, 50 mSv/year (NW, 23 Nov. '95, 1). However, the Academy's secretary also said in a preface to that report that the government might have to judge the issue on other criteria besides strict scientific justification.

French Environment Minister Corinne Lepage announced, also in November, that France would indeed adopt the EC recommendations, putting the issue to rest.

**However, Vittorio Ciani of the EC's** directorate general for environment & nuclear safety (DG XI) said a note accompanying the text submitted to the Council calls on the EC to "follow closely" the evolution of scientific knowledge in the field of low-dose effects to permit modifications in the standards should they be judged necessary.

Following a European Court of Justice ruling in 1992, jurisprudence allows member states to apply stricter standards than the "minimum" contained in the new text, Ciani noted, so Europe may end up with a two-tiered system.

In any case, the standards will apply in reality only once they are translated into national law in each EU country. The Commission's original proposal would have given member states only two years to pass the new standards into national legislation, but Ciani said that position had to be relaxed to accommodate some member states.

The process could take some time. Although some member states, notably the U.K., are already applying the lower limits in practice, others are not, and experience has shown the legislative and administrative process can grind slowly. Ciani said that Italy finally concluded the process of adopting the ICRP-77 recommendations, which the EU adopted in 1980, only last year.

He said that because the vast majority of radiation workers in the EU are already under the 20-mSv yearly limit, the new standards will "not have much impact in reality."—*Ann MacLachlan, Paris*

## HYDRO BOARD MEMBERS REINSTATED AS FIGHT OVER FUTURE HEATS UP

Five members of the Ontario Hydro board of directors, fired without notice January 10, were reinstated by court order January 19. At least four of the five will continue opposing the provincial government's plans to restructure and at least partially privatize the utility over the next four years.

[redacted] chief, energy and [redacted] Ontario's hard-line Conservative [redacted] the Hydro board to 17 [redacted] would [redacted] (NW, 18 Jan., 13). Critics noted that the savings [redacted] minuscule, and government lawyers defending Elliot's action before Ontario Court Justice Alvin Rosenberg did not mention economy as reason for the firings.

The five members reinstated to the board are: John Murphy, president of the Power Workers Union (PWU); Kealey Cummings, a former Hydro union official; Michael Cassidy, former New Democratic Party (NDP) leader in Ontario; Jim MacNeill, an NDP appointee and environmentalist; and James Hinds, a lawyer named to the Hydro board by a Liberal government in 1987. All but Hinds were parties to the court action which claimed the government had no cause to fire the directors.

Ruling in the directors' favor, Rosenberg rejected the government's claim that it could fire Hydro directors for any reason. While the law provides that a director can be removed from office before the expiration of his or her term "for cause" the judge found no valid reason in this case. The government's action was "unauthorized, invalid, and without effect," he said.

At least four of the five oppose privatization proposals for Hydro, although MacNeill told Nucleonics Week he was going into a Hydro board meeting Tuesday "with an open mind on privatization."

### Four C's

The five reinstated directors joined the 14 others (three seats are vacant) on the board January 21 to discuss a contentious "Four C's—Competition, Convergence, and Customer Choice" plan that would pave the way for the 90-year old public utility to be sold off.

The proposal, drafted by senior Hydro staff at the government's direction, is to be submitted January 29 to former federal finance minister Donald Macdonald. He was named late last year to head a committee that will advise Premier Mike Harris in April on how Hydro should be restructured and possibly privatized.

PWU head Murphy has been most vocal in his opposition to the privatization move. In mid-November, he mounted the first public attack on Hydro Chairman William Farlinger's call for the privatization (NW, 23 Nov. '95, 11). The PWU anti-privatization campaign was launched less than two weeks after the Harris government named Farlinger head of Hydro and appointed Macdonald to advise on how to "introduce competition to Ontario's electricity system."

Before his appointment, Farlinger wrote a report entitled "Ontario Hydro and the Electric Power Industry: Vision for a competitive industry; helping Ontario to thrive to and beyond 2000," and soon thereafter a Hydro strategic planning group authored the "Four C's" report which urged Hydro directors to "recommend to government that the process of opening the Ontario market to competition should evolve from competition in generation to direct retail access."



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NUCLEONICS WEEK

November 23, 1994

## NUCLEAR PHASE-OUT ADVICE UNLIKELY FROM SWEDEN'S ENERGY COMMISSION

The government-appointed commission reviewing Sweden's energy policy is unlikely to recommend early nuclear decommissioning, a commission member indicated last week, even as Energy Minister Joergen Andersson suggested that the law could be changed to allow development of more hydropower to replace nuclear.

Separately, a top Sydkraft official said the question of new nuclear capacity in Sweden will become moot after the electricity market is deregulated January 1. But the head of ABB Sweden told an audience at a day-long energy conference, "It's clear there will come a day when Swedish industry will say, 'We need to build more nuclear power.'" ABB owns both BWR vendor ABB-Atom and PWR vendor ABB-Combustion Engineering.

Representatives of Swedish business and industry have mounted a highly visible, well-orchestrated and -financed campaign to ensure that none of the country's 12 reactors

*Continued on page 8*

## FRENCH ACADEMY REJECTS 1990 ICRP NORMS AS NOT BASED IN SCIENCE

The French Academy of Sciences has reaffirmed its opinion that the latest recommendations of the International Commission on Radiological Protection (ICRP) are not sufficiently grounded in science to justify lowering exposure limits for either nuclear industry workers or the general public.

In a report in progress since September 1994 and expected to be released today (November 23), the Academy lays out a wealth of scientific data, published since the ICRP's most recent recommendations in 1990, which it claims demonstrate that the ICRP's assumption of a linear, no-threshold relationship between dose and effect is simplistic at best and incorrect in many cases. Among other explanations, the academy says the ICRP has overestimated the extrapolation between health effects at high doses and dose rates and those at low doses and dose rates.

The Academy's working group on the effects of low doses, whose work was approved for publication by the full Academy, says there is no reason to change the basic safety standards in force in France today. Those set a yearly limit of 50 milliSievert (mSv) (5 rem) for workers and 5 mSv for the general population, with a recommendation that no one accumulate more than 1 Sv (100 rem) over a professional life.

Those limits stem from ICRP-26, the recommendations issued in 1977 by the international commission, which are the basis of most national regulations at present, including in France and the U.S. In ICRP-60, published in 1990, the commission recommended lowering exposure limits to 100 mSv over 5 years for workers and to 1 mSv per year for the public. Some countries have put these limits into law—Switzerland, Sweden—and the U.K. is applying them informally pending their adoption by the European Union (EU).

Background radiation averages 2.5 mSv/year, but gener-

*Continued on page 9*

## JACKSON WON'T LET DRESDEN OPERATE INDEFINITELY ON PROBLEM PLANT LIST

NRC Chairman Shirley Jackson made it clear to Commonwealth Edison's (ComEd) top brass last week that she won't let the troubled Dresden nuclear plant operate indefinitely on the agency's problem plant list.

Jackson stopped short of saying the commission would order the dual-unit BWR station closed, but during a briefing November 16, she put ComEd on notice that the plant must show tangible progress soon.

Calling the operating performance of Dresden "intolerable," Jackson warned ComEd CEO James O'Connor and Michael Wallace, senior vice president and chief nuclear operating officer, that their focus "has to be operating" the plant well, "not on managing the regulators."

Dresden has been on the NRC problem plant list for six of the last nine years, is on the list now, and is expected to be there again when NRC issues a new list early next year.

Commissioner Kenneth Rogers noted that in the nearly eight years he has served on the commission, ComEd has

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[redacted] phase 700-million kro-
[redacted] upgrading and a further 1-
billion kroner [redacted] is planned. "That's a com-
pletely different [redacted] investment," he said, "and the
reactor would still [redacted] competitive."

*—Ariane Sains, Stockholm*

## ACADEMY STUDY — *From page 1*

ally varies between 1.5 and 6 mSv and reaches 15 mSv/year in some places; medical irradiation averages 1 mSv/year.

The French Academy reached the same conclusion in its last report on the subject, in 1989. The new report says that research results since then tend to support the position that there is a qualitative difference between the effects at high doses and dose rates, and those at low doses and dose rates, and that the ICRP's choice of a multiplicative risk factor and a linear-quadratic model to extrapolate from the high doses of Hiroshima and Nagasaki to far lower exposures is "disputable."

The working group underlines that recent contributions of molecular biology support the hypothesis that cancer-causing mechanisms of cell damage differ markedly depending on dose and dose rate, due to the way DNA lesions are repaired in the two situations, and adds that recent epidemiological data "are in complete harmony with this conclusion."

### Cancers Don't Arise As Predicted

The academicians cite numerous epidemiological studies that they believe support criticism of the ICRP's approach to estimating radiation risk at low doses and dose rates. For example, the study of nuclear industry workers published last year by the International Association for Cancer Research (NW, 27 Oct. '94, 1) failed to show any of the 21 excess solid cancers that were predicted by the Unscear (U.N. Scientific Committee on the Effects of Atomic Radiation) model used by ICRP, although the number of leukemias in the nuclear workers cohort, among subjects who received over 400 mSv, was "compatible" with ICRP-60 estimates, the report notes.

The academicians explain that the dose-effect relation is different for leukemias than for other cancers. But they cite other epidemiological evidence that has shown no excess leukemias in areas with high background radiation. For instance, a study in an area of China, where the ICRP model predicted an excess of 20% because of high background radiation, found 30% fewer leukemias than expected in the areas where the lifetime dose was highest. Another recent study of non-smoking women has shown no influence of radon concentration in houses on the incidence of lung cancer.

The group acknowledged that the studies are not yet powerful enough to exclude health effects at single doses below 200 mSv (X-rays and gamma irradiation) or chronic irradiation of 400 mSv, although no cancer or leukemia effects have been observed at these levels. "It is thus, in the [redacted] legitimate to effect an extrapolation [redacted] (with observed effects at high doses and dose rates) is using, as the ICRP has done, a linear extrapolation associated with a dose reduction factor," the academicians write. However, they censure the very low dose reduction factor adopted by the ICRP—reducing the dose-effect relation predicted by high doses by only a factor of two at low doses—and question the "legitimacy" of the ICRP's linear and linear-quadratic no-threshold models for predicting effects at low doses, which they say are "not justified by available data" in either basic science or epidemiology.

The group also finds evidence for the existence of a threshold for carcinogenic effects from chronic irradiation by alpha particles, noting that no effects have been found among miners and other cohorts studied, despite doses exceeding 1 Sv. They attribute this to either the absence of an effect at low doses and dose rates, or the fact that the latency period for development of these cancers exceeds the lifetimes of the subjects.

For this and related reasons detailed in the report, the working group's majority concluded: "There is no scientific fact that argues in favor of lowering (the limit) to 1 mSv/year for the public in France," and "There is no scientific fact, indisputable and recent, that argues in favor of lowering the standards in force in France for workers." They say workers should undergo checkups every 10 years to make sure they do not risk accumulating a lifetime dose higher than 1 Sv.

### Minority Urges Conservatism

The report says, however, that "a small minority" of the working group's members, while they agree with the conclusion that the ICRP's new proposals are "difficult to justify...consider nevertheless that it is not desirable for France to dissociate itself from the position of other countries." This small minority also prefers that workers be limited to a five-year dose of 100 mSv.

For these two reasons, the report says, "certain members of this minority consider it preferable to accept, in the name of conservatism, all the dose limits proposed by the ICRP...while reserving the possibility of a potential upwards revision of the standards relative to the public" depending on the progress of knowledge in radiology and radiopathology. Other members of the "small minority," the report adds, "propose to take into account only the ICRP's proposals relative to workers, and consequently support the majority's recommendations" concerning exposure of the public.

The ICRP-90 recommendations, which have already been adopted in new Basic Safety Standards by the IAEA and other international organizations—after initial French resistance—are under scrutiny by the EU, charged with harmonizing radiation standards across the Union's 15 member states. If the lower norms become EU law, France is in principle obliged to incorporate them into national regulations, unless the EU guidelines are so formulated as to leave the door open to variants.

Normally, an opinion by the Academy, the highest scientific authority in the country, would weigh heavily [redacted]



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Prompted by the [illegible]
Health turned to the Academy of Sciences [illegible] opinion on low doses in September 1994 [illegible] controversy within the national scientific [illegible], 2 July '96, 15). The Academy's report that [illegible] eagerly awaited as a possible sign of how far France [illegible] in resisting the change of standards proposed in [illegible] (NW, 3 Aug., 8).

However, in approving the working group's report for publication, the French Academy's report committee noted that such a "delicate question" as the effects of low doses "cannot receive a scientific and rigorously justified response alone." Thus, the committee said, "the Academy leaves it up to the (government) authorities to decide" what approach to take to the issue of changing national radiation safety standards, "no doubt on the basis of considerations which the Academy, (as a scientific body), does not have to take into account."

Indeed, the radiological protection community often argues that given the uncertainties that persist in interpreting data on radiation health effects and the lack of powerful epidemiological data on low doses, the only proper course of action is prudence, to make sure the most sensitive members of the public, especially children, are protected.

## No Problem For Industry

The French nuclear industry has said it generally has no problem meeting the ICRP-60 dose limits, although a very small number of individuals might be affected. Problems could be encountered with uranium miners, people around mill tailings, and some workers in the fuel cycle industry. An effort is under way, under the aegis of the Ministry of Health, to establish a more realistic way of calculating doses due to artificial radiation, for example by adopting the "critical group" approach used in the U.K.

However, some influential French scientists have warned against adopting any approach that is not scientifically well-grounded, because it will be politically impossible to revise the standards upwards even if future scientific evidence proves the ICRP was wrong.

The Academy of Science's working group on low doses was composed of 23 members and was chaired by Francois Gros, permanent secretary of the Academy of Sciences.

The editorial committee included Academy members Raymond Castaing, a solid-state physicist from the University of Paris-Sud, Raymond Latarjet of the Institut Curie, and Maurice Tubiana of the Antoine Beclere medical center, a legendary figure of the French nuclear medicine community.

The report is scheduled to be made public today at a hearing called by Claude Birraux (Centrist-Haute Savoie), specialist on nuclear regulatory affairs for the Parliamentary Office for Evaluation of Science & Technology Options. Tubiana and two other members of the working group's editorial committee will explain how they reached their conclusions. It promises to be a lively session: Birraux also invited Roger Clarke, chairman of the U.K.'s National Radiological Protection Board and of the ICRP, to outline the ICRP's reasoning in ICPR-60.—*Ann MacLachlan, Paris*

## COURT BARS STATE FROM SHUTTING DISPUTED MORSLEBEN WASTE FACILITY

An appeals court ruling last week severed the link between intervenors, who aim to stop operation of Germany's only low- and medium-level radwaste (LLW/MLW) repository, and the state government of Saxony-Anhalt, which has vowed to oppose waste dumping as long as there is a legal avenue to do so.

The Superior Administrative Court of Magdeburg November 16 ruled that the German Atomic Act does not give Saxony-Anhalt the right to suspend or nullify the Morsleben facility operating permit. Chief Judge Burkhard Gunlau wrote that such a decision is solely within federal jurisdiction.

Grassroots opponents of Morsleben had claimed that, under the atomic act, Saxony-Anhalt, which is responsible for nuclear regulation for the repository, could order the site closed on grounds that its operating license, granted by the former German Democratic Republic (GDR), was not valid.

The fresh verdict against Saxony-Anhalt's case last week followed the argument of the Federal Ministry of Environment & Nuclear Safety (BMU), which since 1992 has disputed intervenors' claims that the state could invalidate the Morsleben permit. The court said, should intervenors choose to continue their battle, they must bring a new lawsuit against BMU which, since 1991, is the repository operator.

Saxony-Anhalt is governed by a coalition of Social Democrats (SPD), formally opposed to nuclear energy, and environmentalist Greens. Its nuclear regulator, Heidrun Heidecke (Green), ordered a partial halt to operation at Morsleben earlier this year. But operation resumed weeks later when BMU, Germany's federal nuclear regulatory authority, ordered Heidecke to rescind her closing order. Saxony-Anhalt then vowed to continue opposing operation of Morsleben until legal avenues to shut the facility were exhausted.

Morsleben, formerly a salt mine, was licensed by the GDR in the early 1980s to take LLW/MLW from research institutions and from PWRs then operating at Rheinsberg and Greifswald. It holds about 20,000 metric tons of LLW/MLW, and is planned for disposal of waste from operating West German reactors as well as scrap from the East German PWRs, all now shut and undergoing decommissioning. After this decade, BMU plans to seek a new license to continue to put LLW/MLW into the facility.

Heidecke based her objections to Morsleben operation in part upon what she termed unresolved radiation health questions surrounding the current practice, licensed by the GDR, of dumping liquid LLW into underground pits. Liquid waste dumping is not planned for a second LLW/MLW disposal facility, the former Konrad iron mine in West German territory, which is still being licensed. According to BMU, there are no grounds for raising health physics issues at Morsleben, but intervenors charge that the dumping of liquid waste would never be allowed in a West German facility.


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