

GETTING REAL

THE IMPORTANCE OF BASING ANALYSIS AND REGULATION ON PHYSICAL REALITY

The **benefits of nuclear technology** are clear and simple. They are continually manifested in the real world, here and now. The absence of pollution, the abundance of fuel, the reliability of output, the inherent absence of a significant waste problem, are demonstrable, measurable, and undeniable. The **arguments against** nuclear technology, on the other hand, are hypothetical. The predicted casualties have not happened, even after 40 years with several hundred nuclear power plants. Peer-reviewed analysis shows that physical science precludes creation of a serious public health hazard after any realistic series of mishaps. Why then is there opposition?

We blame it on the media, the politicians, and our inability to communicate, but in fact **our message has been heard and understood**. We have told people that radiation poses an unprecedented hazard to humanity, that we can control it only by superhuman skill and discipline. We tell them we must create a new priesthood to preserve throughout millennia of changing and warring societies, the dreadful secret of where our waste is buried. We invent the guillotine break, the China syndrome, the mass evacuation plan, the nuclear mutant, and the land forever abandoned to contamination. All this is the product of the proponents! And then we wonder why people are frightened.

In 1982, the US Nuclear Regulatory Commission published “worst case” accident studies for each of the 130 nuclear power plants then operating, a-building or planned. If everything went wrong, how bad could it be? Sandia Lab, as NRC’s contractor, dutifully tabulated the answers: up to **610,000 “early injuries,” 100,000 “early fatalities,” 25-mile “fatal radius,” 70-mile “injury radius” and hundreds of billions of 1980 dollars lost in a single plant casualty**. Many other such reports have been produced before and since. A 2002 news report cited “a special report prepared by experts within the NRC” that claimed “fatal, radiation-induced cancers as far as 500 miles from the site,” adding that “millions of people within such a 500-mile zone might have to be evacuated for periods ranging from 30 days to one year, and that people within 10 miles of a nuclear power plant such as Indian Point might never be able to return to their homes,” noting that 93 million people live within 500 miles of the plant. The report was characterized as “an official NRC planning regulation...[that] provides the basis for any future NRC regulation on evacuation needs, safety requirements and insurance.” A named NRC expert who worked on the study reportedly said, “how many millions of people might have to be evacuated following a real spent fuel pool fire would depend on the cost of evacuation and what is perceived to be an acceptable death rate.”

We can hardly blame the media for giving such reports prominent coverage. And we shouldn’t be surprised that opponents of nuclear power still quote these figures today—they’ve never been effectively repudiated. The fact that these consequences were said to be highly improbable is little comfort. And new claims of this sort are published repeatedly. If there is any validity to such estimates, we should have long ago stopped operating nuclear power plants. If the claims are not valid, the public deserves to be shown why, and we should stop using such unrealistic premises in policy, engineering and operations.

The purpose of this paper is to show that **such consequences are not realistic**—i.e. **not relevant to the real world**. They are not merely improbable; they are in fact realistically impossible. The difference is important. No valid prediction can result from calculations based on events that are physically impossible.

For this paper we examine a realistic but highly improbable situation: **simultaneous destruction of systems outside containment, rupturing containment penetrations, melting the reactor core, and producing ground-level unfiltered releases within about one hour**. This is the worst realistic casualty, and if we found the consequences were intolerable, we would have to examine all the steps that might lead there and show that we had made them sufficiently improbable. But we have found that even this extraordinary situation could **yield few if any fatalities**, whereas casualties actually experienced with *non-nuclear* means of generating electricity--natural gas systems, oil, coal, dams, etc.—have repeatedly caused hundreds, and even thousands, of deaths.

We know a great deal about what is physically possible with nuclear reactors. We have demonstrated that **nuclear fuel retains most of its fission products**, even when molten. We have measured the limited distribution of the fission products that do escape, especially in a water environment. And we have seen how **most of what escapes clumps and drops out** and does not stay aloft to be carried far away. We know this with the same physical and chemical certainty that we know a power reactor cannot explode like an atomic bomb.

And we know that **trivial amounts of radiation do not cause cancer or other harm**, and that computer models that multiply trivial individual radiation doses by millions of people to get thousands of cancer deaths are not just improbable. They are not conservative. They are simply wrong. Hundreds of millions of medical patients have received low to moderate doses that refute this premise, along with hundreds of millions of people that have lived in high natural background areas. We've been told that it is merely prudence and good practice to presume that things are worse than they are. "Better safe than sorry." But good policy does not result from a distorted picture of reality. And we will describe briefly what **a high price we pay for assuming otherwise, without any compensating benefit**.

There is another type of flaw in the computer models that 'predict' massive deaths. **Some of the premises that are not impossible in an unrealistic hypothetical sense are in fact impossible in a realistic sense**. For example, the DOE requirement that calculations of fatalities from a spent-fuel shipping cask casualty assume the event takes place in a high-density city environment and that *no one moves until one year after the explosion* and that *no steps are taken during that year to reduce any contaminant*. Neither of these premises is physically impossible, but most people would agree they are not realistic—i.e. not relevant to the real world. We identify some such premises and replace them with technically justifiable conservative but realistic premises. We also show that the **leading individuals and organizations that created and maintain the present radiation protection policy have affirmed clearly and publicly the judgments we make**, but nevertheless recommend the regulations be based otherwise, "to be prudent."

Finally, the most basic reason to change **current radiation protection policy**, and the regulations that prescribe it and derive from it, is that **it is self-contradictory**. It defines as dangerous, radiation levels that it elsewhere claims are harmless. It requires tearing down a building if it becomes contaminated, while ignoring the higher radiation level of the National Capitol or New York's Grand Central Station or the base of the Statue of Liberty, all of which are built of naturally radioactive granite. It has regulated man-made radiation levels down below those encountered in natural backgrounds, and has then tried to obliterate this contradiction by calling Nature "the silent killer." A responsible professional should not long abide such unscientific policy.

This discrepancy between policy and science is acknowledged in the reports of the advisory and regulatory bodies (see numerous quotes in Annexes 2 and 3 below). Thus, changing the policy to match the science cited in these reports **would not require challenging any current scientific theory or data**. It would merely remove the gratuitous unscientific presumption of damage where none has been observed or predicted scientifically. **We do not become safer by presuming the world is different than it is**.

TO SUMMARIZE: we consider the consequences of some very improbable casualties. But we do not presume conditions which are refuted by tests and experiments, or prohibited by the laws of nature. And having made such analyses, **we find that nuclear power plants and their fuel are not capable of producing the extreme consequences "predicted" by many simplified, unrealistic, reports and are therefore are not a significant public health hazard under any realistic conditions of operation or hostile attack**. We then suggest some actions to bring radiation protection policy, and engineering and operations, into line with these realities. The first step should be for sponsoring government agencies to show and assert clearly that past reports, with "predictions" of **thousands of deaths** from nuclear casualties, are **based on unrealistic premises** and therefore **these deaths would not occur in the real world**.

I am convinced nuclear regulation now needs to be anchored in realistic conservatism...if we are to avoid the twin pitfalls of under-regulation and over-regulation...I use "conservatism" in the sense of preserving adequate safety margins, and I use "realistic" in the sense of being anchored in the real world of physics, technology and experience...When engineering margins are applied to input parameters, they can distort our understanding of what is truly important. Safety margins are better discerned when they are applied at the decision-making stage, rather than at the analysis stage.

Nils J. Diaz, Chairman, US Nuclear Regulatory Commission

To Japanese Atomic Industrial Forum Annual Conference, April 21, 2004, Tokyo, Japan

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Overview

Nuclear technology has been repeatedly characterized in widely circulated public statements as posing public hazards so extensive and unprecedented as to outweigh any possible benefits. The record of several hundred plants operating reliably for decades without any public harm is countered with the fear that a casualty, of a type not yet considered, might some day release radioactivity causing thousands of deaths and injuries over great distances. Underlying this fear is a feeling that nuclear radiation is somehow in a class by itself, not fully controllable by conventional means.

In this situation, informed professionals have an obligation to state the laws of nature and the physical properties of materials that limit the consequences that could result from any casualty to a nuclear power plant or its fuel. **Nuclear materials and processes are not mysterious or unpredictable;** they are governed by the same kinds of familiar physical laws that are the basis of all science and engineering.

Apocalyptic descriptions of nuclear casualties are based on speculation, sometimes aided by simplified computer models, of what might happen under certain extreme premises. Such computer models do not produce real-world data. They produce hypotheticals in numerical disguise. The large numbers of deaths they “predict” rest on false premises. **If the premises are wrong, then the calculated deaths based on them will not occur.**

But we don’t have to speculate about those premises. We have a great deal of credible scientific data on each of them. Engineering analysis and tests show that **nothing could be done to a water-type nuclear power plant or its fuel that could lead to a serious public health hazard.** (See Annex 1.)

Let us look at the scientific evidence for this conclusion:

1. Studying various possible accident scenarios or terrorist acts enables us to design systems to minimize the possibility of fuel meltdown. We cannot foresee every possibility. But **for casualty evaluation, we need only to assume the worst realistic consequence** of any such scenario, which is melting of much of the fuel and compromise of the containment structure. If we can deal with that situation, no other realistic situation could have worse public health consequences.
2. Nuclear fuel is a zirconium-clad very-high-melting ceramic. **Even when molten, it does not readily release much of its fission products.** This is known from theory, from laboratory studies, and from large-scale tests over a period of decades.
3. Harmful quantities of hot **fission products do not stay suspended in respirable form for long.** So they cannot affect people far away. The particles rapidly clump, fall out, or plate onto cold structures or dissolve in on-site water. The noble gases disperse. We have good confirmation of our test data on this from the Three Mile Island incident and other casualties to nuclear reactors or their fuel.
4. **Few, if any, credible scientists claim there is any evidence** to show that low-dose radiation is harmful. They concede as much in official documents. But they argue that we should assume such harm anyway, “just to be prudent.” (Annex 2)
5. Even advocates of extreme scenarios concede that radiation doses to an individual from a nuclear casualty would be very small. But they argue that exposing millions of individuals to small doses will result in thousands of deaths. This is scientifically indefensible. *Groups* don’t get cancer, only individuals do. **If no individual gets a harmful dose, then no individual is harmed.** (Annex 3)
6. But **promoting unwarranted fear** of radiation and wildly overstating hazards from minor spills or the potential of a “dirty bomb” **is not prudence. It is fear-mongering.** The public is scared away from life-saving nuclear medical procedures, from irradiated food, from non-polluting nuclear power plants, and many other benefits. (Annex 4)

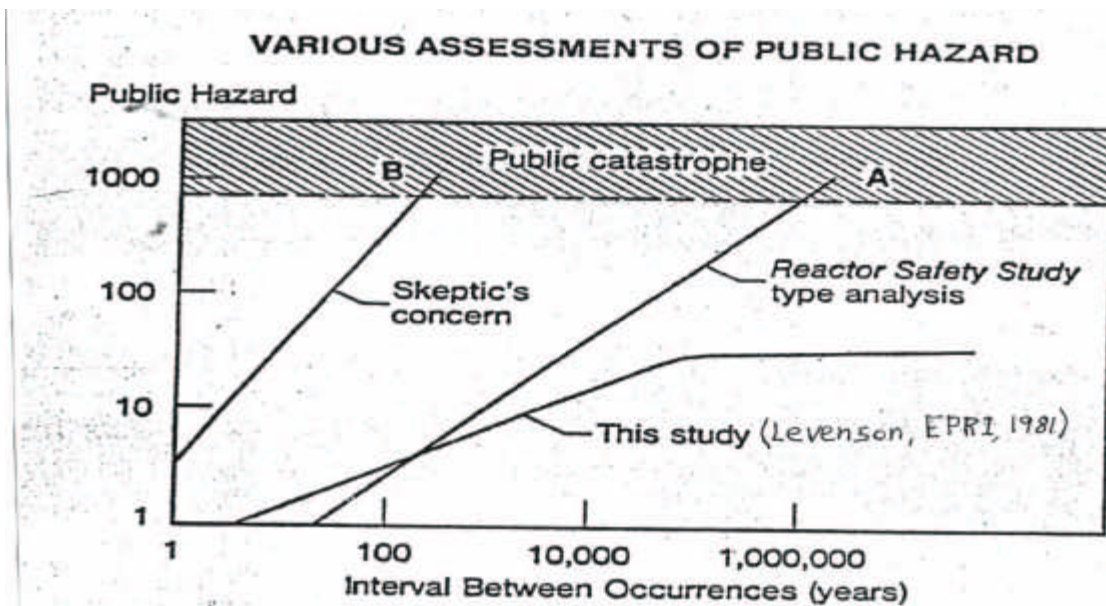
The Release and Dispersion of Radioactivity from Reactor Fuel

Experience with a dozen reactor and fuel casualties has confirmed theoretical studies showing that the release and dispersion of radioactivity from damaged or molten fuel is severely limited by the physical and chemical properties of the materials involved. After the Three Mile Island incident in 1979 made it widely known that the large amounts of radioactivity predicted by unrealistic computer models were not in fact released into the environment, a major multi-year program was carried out by the government and industry to determine the parameters of release and dispersion from damaged and molten reactor fuel.

The program confirmed in numeric detail how **radioactivity remains largely bound in the reactor fuel at very high temperatures**, and how the material that does escape is largely absorbed in the surrounding water and steam, and how it is plated out onto the surrounding cooler structural surfaces even when containment is severely compromised. It showed how “leakage” pathways plug up with moisture to limit the ability of radioactivity to escape. Moreover, it showed that radioactivity other than noble gases that begins to disperse in the classical meteorological plumes tends to clump and drop out, so that **very little remains in hazardous respirable form to travel miles from its source. Noble gases disperse and are chemically inert, and are not an inhalation hazard.**

This work was done at ORNL, ANL, INEL, Karlsruhe and other sites, sponsored by NRC, DOE, EPRI and others. An EPRI summary report of this work by Milton Levenson and Frank Rahn with 48 technical references was published in *Nuclear Technology* (Vol 53, May 1981) with an editorial on page 97 and an article on pages 99-110. The paper was published in all the IAEA languages (10 or so). The author gave invited seminars in England, France, Japan, South Korea, China, Taiwan, and about 10 places in the US. **There were no serious challenges to these findings.**

The figure below shows the significance of this work. Casualties of increasing severity (in projected deaths) tend to be increasingly improbable. The straight line on the right extends to hundreds of deaths, but advocates argue that this is tolerably improbable (like assuming that two large, full, 747s will collide midair and crash into a Superbowl game). Critics reply that they are not convinced that such events are so improbable (left-hand straight line). The work of Levenson and others shows that Nature limits the consequences. (A 200-passenger airplane crashing into the ocean cannot kill more than 200 people, plus the crew, even under the most extreme accident scenario. **This changes the basic nature of the nuclear safety debate.** [See Appendix 1A, where this work is summarized and documented.]



After 9/11, in light of apocalyptic prophesies of the consequences of postulated terrorist attacks on nuclear facilities, 19 members of the National Academy of Engineering knowledgeable in nuclear technology examined the subject anew. They confirmed the earlier findings in the light of their own experience, and published their well-documented conclusions in a peer-reviewed Policy Forum in *Science*, 20 Sept 2002. In the 10 January 2003 issue they responded with further documentation to comments received. (See Appendix 1B.)

These papers transcended the need to justify various casualty scenarios by going directly to the worst realistic endpoint: They presumed the reactor core melted (for whatever reason) and presumed containment was significantly compromised. They concluded that even under these extreme premises, **the release and dispersion of radioactivity would not create a serious public hazard.** Mass evacuation would not be required, and still there would be few, if any, fatalities. They showed that the consequences of TMI, Chernobyl and other massive releases of radioactivity support this conclusion. (See Appendix 1C for authoritative summary of consequences of TMI and of Chernobyl.)

The Health Effects of Low-Dose Radiation

The fact that low-dose radiation is harmless and often beneficial is not a new or minority opinion. It has been widely reported in the science media, and recently in the general media, e.g., *Fortune* (Jun 03), *Discover* (Dec 02), *American Spectator* (Jul/Aug 02), *Crisis* (Jun 02), *Wall St. Journal* (Dec 19, 03), and *Boston Globe* (Dec 12, 03). The proto-scientist Paracelsus said in 1540, "Nothing is poison but the dose makes it so." Within a few months after Roentgen's discovery of x-rays, reports began appearing in scientific journals on the use of x-rays to cure infection (See Appendix 2A). It was recognized even then that the radiation was not strong enough to kill the bacteria directly, and that its effectiveness must result from stimulation of the immune system. This phenomenon—toxicity at high levels and stimulation of healing at low levels—is a nearly-universal biological process, called *hormesis*. Low dose radiation consistently shows that it acts to reduce cancer incidence. Calabrese and Baldwin report (*Nature* 421, 691, 2003) "thousands of studies demonstrating hormesis...we see it across the whole plant and animal kingdom... and at essentially every endpoint...**the hormetic model is not an exception to the rule—it is the rule.**" Jocelyn Kaiser's four-page News Focus on hormesis (*Science* 302, 376, 2003) contained a full-page sidebar documenting the phenomenon's occurrence with ionizing radiation.

There is no lack of data on the effects of low-dose radiation. T.D. Luckey, Chairman Emeritus, Biochemistry, U. Missouri-Columbia, wrote two books, *Hormesis with Ionizing Radiation* (1980) and *Radiation Hormesis* (1991) with more than 2000 references validating hormesis in plants, animals and humans. James Muckerheide, as Chair of the ANS Biology and Medicine Division Committee on Health Effects of Low Level Radiation, organized a series of sessions on Health Effects of Low-Level Radiation at ANS annual meetings, 1994-2003 (See Appendix 2B). The international public interest organization, Radiation, Science, & Health, has amassed and evaluated several thousand documents on the health effects of low-dose radiation (See Appendix 2B and <http://cnts.wpi.edu/rsh/docs>). Edward Calabrese and colleagues at the Northeast Regional Environmental Public Health Center, U Mass School of Public Health, publish a newsletter, *Biological Effects of Low-Level Exposures*, and run an annual international conference on Non-Linear Dose-Response Relationships (See <http://www.belleonline.com>). Evidence that radiation may be essential to life is shown by experiments in which organisms were shielded from background (H. Planel et al., *Health Phys.* **52**, 571, 1987) and in which shielded mice were fed potassium with the K-40 depleted (T.D. Luckey, *Radiat. Res.* **108**, 215, 1986). Populations that live at the lowest levels of natural background radiation have higher cancer rates and shorter lifespans than populations that live in areas with moderate and high background radiation levels.

The nuclear medicine pioneer, **Rosalyn Yalow, Nobel Laureate** in Medicine, asserted:

No reproducible evidence exists of harmful effects from increases in background radiation three to ten times the usual levels. There is no increase in leukemia or other cancers among American participants in **nuclear testing**, no increase in leukemia or thyroid cancer among **medical patients** receiving I-131 for diagnosis or treatment of hyperthyroidism, and no increase in lung cancer among non-smokers exposed to **increased radon** in the home.

The association of radiation with the atomic bomb and with excessive regulatory and health physics ALARA practices [As Low As Reasonably Achievable] has created a climate of fear about the dangers of radiation at any level. However there is **no evidence that radiation exposures at the levels equivalent to medical usage are harmful.**

The **unjustified excessive concern** with radiation at any level, however, **precludes beneficial uses of radiation** and radioactivity in medicine, science and industry. (*Mayo Clinic Proc* 69:436-440, 1994)

Hugh F. Henry at Oak Ridge summarized the low dose data in the *Journal of the American Medical Association*:

A significant and growing amount of experimental information indicates that the overall effects of chronic exposure (at low levels) are not harmful...The preponderance of data better supports the hypothesis that low chronic exposures result in an increased longevity... Increased vitality at low exposures to materials that are markedly toxic at high exposures is a well-recognized phenomenon. (*JAMA*176, 27 May 1961)

The "**Wingspread Conference**" August 1-3, 1997, concluded:

In a surprise move, leading US and international scientific experts agreed in an historic accord that an increase in cancer has not been observed at radiation exposures below 10,000 millirem given to the whole body in a short time.

Prof. W.V. Mayneord, former member of UNSCEAR and ICRP, wrote:

I have always felt that the argument, because at higher values of dose an observed effect is proportional to dose, at very low doses there is necessarily some effect of dose, however small, is nonsense (*Radiation and Health*, p.140, 1964).

In fact, **no credible scientific case has ever been made for the belief that low-dose radiation is harmful**. Long, formal reports by the National Council on Radiation Protection and Measurements (NCRP) discuss effects from high-level radiation and in cells in culture (which do not have functioning immune systems), and other peripheral subjects, but they concede that science does not support the idea of deleterious health effects from low-dose irradiation.

For example, the report NCRP-121, states:

Few experimental studies, and essentially *no human data*, can be said to prove, or *even provide direct support for the concept*...It is *conceptually possible, but with a vanishingly small probability*, that any of these effects *could* result from the passage of a single charged particle...It is a result of this type of reasoning that a linear non-threshold dose response relationship *cannot be excluded*. (p. 45, emphasis added)

And NCRP-136 goes further, to concede:

It is important to note that the rates of cancer in most populations exposed to low-level radiation have not been found to be detectably increased, and that in most cases the rates have appeared to be decreased. (p. 6)

The French Academy of Medicine quotes and concurs with the above statement from NCRP-136, and states publicly:

The hypothesis of the risks of cancer induced by low doses and dose-rates is founded on the extrapolation of data of highly-exposed human groups, applying the risk as being constantly proportional to the received dose without being limited by a threshold, the linear no-threshold (LNT) assumption. This hypothesis conflicts with itself and has many scientific objections (10); and it is contradicted by experimental data (11) and epidemiology. *...[the Academy] denounces utilization of the linear no-threshold (LNT) relation to estimate the effect of low doses...* (Dec 2001)

Even some prominent environmentalists concur; e.g. Gaia proponent **Prof. James Lovelock, FRS**, in his forward to Bruno Comby's *Environmentalists for Nuclear Energy*:

Life began nearly four billions years ago under conditions of radioactivity far more intense than those that trouble the minds of certain present-day environmentalists....We need to keep in mind the thought that these fierce energies flooded the very womb of life.

The two relevant professional societies, the **American Nuclear Society** and the **Health Physics Society**, have also supported this stance in carefully considered Position Statements:

It is the position of the American Nuclear Society that there is insufficient scientific evidence to support the use of the Linear No Threshold Hypothesis in the projection of the health effects of low-level radiation. (*PS-41, June 2001*)

In accordance with the current knowledge of radiation health risks, the Health Physics Society recommends against quantitative estimation of health risks below 5 rem in one year. (*Public Statement on Radiation Risk in Perspective, Jan 1996*)

Both societies agree in these statements that:

Below 10 rem...risks of health effects are either too small to be observed or are non-existent.

The Situation is Clearly Ripe for Reform

Prof. Gunnar Walinder, former Chair, Swedish Radiobiology Society and UNSCEAR member, wrote in his book *Has Radiation Protection Become a Health Hazard?*:

Not only do the current models of radiation carcinogenesis disagree with modern oncology, but most important they have contributed to a number of misconceptions about radiation risks. What concerns me most is whether the radiological doctrines have sometimes caused greater health and environmental problems than those we seek to avoid.

Walinder called this situation "the greatest scientific scandal of the century" and **Lauriston Taylor** called such practices "deeply immoral uses of our scientific heritage."

Philip Abelson, Editor Emeritus of *Science*, wrote:

The current mode of extrapolating high-dose to low-dose effects is erroneous for both chemicals and radiation. Safe levels of exposure exist. The public has been needlessly frightened and deceived, and hundreds of billions of dollars wasted. A hard-headed, rapid examination of phenomena occurring at low exposures should have a high priority. (*Editorial in Science 265, 9 Sept 1996.*)

Marvin Goldman, past HPS President, wrote:

It is time to scientifically challenge the old tenet that cancer risk is always proportional to dose, no matter how small...It is time to update our thinking and policies. (*Science 271, Mar 1996*)

The NRC Advisory Committee on Nuclear Waste report to the Chairman, NRC:

Some studies in the U.S. as well as in China, Sweden, Poland and Canada have arrived at conclusions that do not support the LNT model. Other research concludes that it is likely that at least a threshold or perhaps beneficial risk decrements (hormesis) exists at lower doses. We conclude that a reexamination of the regulatory model is appropriate. (July 10, 1996)

THE HARMFUL FALLACY OF COLLECTIVE DOSE

Use of Cumulative Radiation Dose as a Measure of Good Practice or of Casualty Magnitude

Radiation protection policy uses as a prime measure of the severity of a casualty, or the efficacy of “good plant operation,” the total collective radiation dose in person-rem, multiplying trivial individual radiation doses by large numbers of people to “predict” many radiation-induced cancer deaths. That process has been repeatedly condemned as scientifically indefensible. Yet current policy presumes that, in the absence of more data, this is the prudent course. That contention is wrong on both counts: there is no lack of applicable credible data and the data show persuasively that low-dose radiation is not harmful. And use of this unwarranted practice continues to have serious detrimental effects.

NCRP-121 specifically warns that collective dose should not be used to predict death or injury from low-dose radiation:

“The summation of trivial average risks over very large populations or time periods... has produced a distorted image of risk, completely out of perspective with risks accepted every day, both voluntarily and involuntarily.” (p.58)

And again:

“...it is recommended that regulatory limits not be set in terms of collective dose... When the uncertainty in the number of individuals ... is large... collective dose should not be used as a surrogate for risk, even at relatively high levels of individual radiation dose.” (p. 62)

Roger Clarke, Chairman of the **International Commission on Radiological Protection** wrote (1 Oct 98 at <http://hps.org/documents/controllable.pdf>) :

“If the risk of harm to the health of the most exposed individual is trivial, then the total risk is trivial—irrespective of how many people are exposed”.

And the **Health Physics Society**, in its March 1993 Position Statement, emphasized in bold-faced type:

“We strongly recommend that dose limits be applied only (sic) to individual members of the public, not (sic) to the collective dose to population groups.”

The French Academy of Medicine quoted and concurred with the above statement from NCRP-136, and stated in a press release 4 Dec 01:

[the Academy] associates with many international institutions to denounce improper utilization of the concept of the collective dose to this end. These procedures are without any scientific validity, even if they appear to be convenient to administrative ends.

Zbigniew Jaworowski, MD, PhD, the noted member and former chair of UNSCEAR, wrote in “Radiation Risk and Ethics” (*Physics Today*, Sept 1999, 24-29) that use of collective dose:

“was introduced in the early 1960s... the concept is still widely used, although both the concept and the concern [about harmful hereditary effects] ought to have faded into oblivion by now... Individual doses cannot be additive over generations, simply because humans are mortal and the dose dies when an individual does. Similarly, individual doses cannot be added for individuals of the same generation because we do not contaminate one another with a dose that we have absorbed...”

If harm to the individual is trivial, then the total harm to members of his or her society over all past or future time must also be trivial—regardless of how many people are or will have been exposed...

The Price We Pay for Excessive Radiation Protection

Reports recommending the use of the LNT and ALARA down to zero radiation dose generally concede that science does not support this usage and admit that most populations exposed to low-dose radiation (LDR) show no deleterious effects and usually show beneficial effects. But they argue that the practice, even if not necessary, is justified as conservative, i.e. protective of the public health. However, the record is clear that the **continued insistence that any amount of radiation is harmful has been severely damaging to the public welfare in many ways**. Some of these are discussed below.

Zbigniew Jaworowski, UNSCEAR member and former chair, opens his article "Radiation Risk and Ethics" (*Physics Today*, Sept 1999, pp.24-29) as follows:

The psychosomatic disorders observed in the 15 million people in Belarus, Ukraine and Russia who were affected by the April 1986 Chernobyl accident are probably the accident's most important effect on public health. These disorders could not be attributed to the ionizing radiation, but were assumed to be linked to the popular belief that any amount of man-made radiation—even miniscule, close to zero doses—can cause harm, an assumption that gained wide currency when it was accepted in the 1950s, arbitrarily, as the basis for regulations on radiation and nuclear safety....

In the regions of the former Soviet Union that were highly contaminated by the fallout from the Chernobyl accident, the increased radiation dose rate for the local inhabitants is far less than the dose rate in areas of high natural radiation. In those places, the entire man-made contribution to radiation dose amounts to a mere 0.2% of the natural component.

Not only were **depression, alcoholism, absenteeism and suicide** at record heights, but an estimated additional **100,000 induced abortions** were performed in the months following the accident by people downwind, in unwarranted fear of bearing a "nuclear mutant." This is one direct result of characterizing harmless levels of radiation as deadly. The actual rate of birth defects did not increase. Swedes downwind were warned to stay indoors. However, Gunnar Walinder notes that **the hourly dose from natural radon in most Swedish houses was far greater than that from the fallout**.

The whole sorry, multi-billion-dollar saga of Yucca Mountain is caused by the quixotic quest for zero radiation in a naturally radioactive world. The trivial radiation levels we are committed to prevent taking place hundreds of thousands of years in the future are dwarfed by the much more massive discharge of natural radioactivity into the air and water by unstoppable natural processes that we've lived with safely since the dawn of time. It has also been demonstrated that protecting animals and organisms and cells from background levels of radiation is detrimental, causing biological functions to fail.

Terrorism gave new impetus to anti-nuclear activists. Their postulated potential of tens of thousands of deaths dictates unworkable mass evacuations, and the lack of a threshold of harmfulness means that evacuated lands might remain "uninhabitable" forever. This, in turn, makes continued operation of plants like Indian Point appear to present unacceptable public risk, thus accomplishing the terrorist goals without any terrorist action required. Similar arguments apply to potential terrorist attacks on nuclear fuel, in storage or being shipped. Even the ineffective "dirty bomb" has been so characterized. The resulting fear generated threatens to turn even an insignificant event into a life-threatening panic, and to keep us tied up trying futilely to forestall the imagined consequences.

The requirement to reduce even harmless levels of radiation even lower **creates incentives to minimize collective dose at power plants, even at the cost of skimping on necessary inspection and maintenance** in radiation zones (e.g. corrosion or leakage at reactor heads). It has burdened nuclear medicine facilities to the point where some hospitals no longer provide these life-saving procedures. It has scared people away from mammograms and other techniques involving radiation. Researchers are urged

to use less effective colorimetric procedures to avoid the paperwork and constraints associated with using radioisotopes. Life-saving smoke detectors and tritium exit signs are denounced as radiation hazards. Ground water and soil, which EPA was set up to protect, are called "silent killers" when they contain trivial amounts of natural radium, uranium or radon. Tank-piercing depleted uranium ordnance, less radioactive than the natural element, is decried as a health hazard. Irradiated food, which could prevent thousands of food poisoning deaths, is too scary for many.

Unwarranted fear of radiation has been consistently used to block public acceptance of nuclear technologies and increases their cost. As a result, coal-fired power plants are built instead of nuclear. This exacerbates global warming, respiratory problems, acid rain, mercury contamination, the removal of mountain-tops being dumped into valleys, black-lung syndrome, mine casualties, etc.

The use of natural gas instead of coal, has driven gas prices up, depletes this valuable resource, causes repeated fires and explosions, and still contributes to global warming.

Use of nuclear power, via electricity or hydrogen, for transportation would decrease or eliminate our dangerous dependence on foreign oil.

Avoidance of nuclear power requires us to buy industrial and medical isotopes abroad. Since many of the most useful isotopes are short-lived, this constrains our options for diagnosis, treatment, research and industrial uses.

Thus, overstating the consequences of a hypothetical nuclear casualty is not harmless beneficial conservatism but has serious harmful effects without providing any public health benefits. For example:

Theodore Rockwell

Radiation Chicken Little

I was recently invited to observe and offer advice during a revealing drill, spearheaded by the National Academy of Engineering, that tested how well information might be communicated to the public if a "dirty bomb" exploded in Washington. As I watched the interaction of real-life government officials and media decision-makers, I was struck by a glaring discrepancy: The rules for radiological emergencies are wholly inappropriate for such an event. They can change a relatively harmless incident into a life-threatening emergency. These rules apply not only to dirty bombs but also to any casualties involving nuclear power plants or their fuel.

A few minutes into the simulated exercise, a leader of the drill pleaded for some action, warning that radiation was killing people and hospitals were being overwhelmed. This bothered me, because it is well documented by all our official agencies that the radioactivity in dirty bombs is unlikely to seriously hurt anyone. People not injured by the conventional explosion itself could walk away and be out of danger. If concerned about possible contamination, they could remove their clothes and take a shower.

I made this point publicly to the participants, but they said they're getting a different story from the regulators and their scientists. The rules require a hypothetical, squeaky-clean condition, scrubbing the ground and sidewalks down to far less than the natural radiation background of God's good green Earth—less radiation than millions of people get each year

from routine medical procedures. That's the kind of thinking behind statements that the city would have to be evacuated for years after such an attack and that cleanup would cost billions. But these requirements are inappropriate. We don't treat other spills and leaks so fearfully.

If your aim were to remove a public health hazard, you would flush any residual radioactivity down the drain with hoses and be done with it. Would that contaminate the Chesapeake Bay? Not in any practical sense. It would add insignificantly to the bay's overall natural radioactivity. Expensive instrumentation might detect it for a while, but it would not create a public health hazard.

Several participants objected that experts might agree on that, but that the public would panic nonetheless, and that's what we should plan for. At this point, an expert on human behavior got up and said flatly that if you tell people there is no danger, and they have no reason to disbelieve you, they will remain calm. (They did so during the recent blackout.) But if you keep telling them you expect them to panic, they will oblige you. And that's what we're doing.

When I raised this issue with a Nuclear Regulatory Commission official years ago, he replied in horror that if he bought my reasoning, he'd have to ask what he was there for. He should, and so should the contractors and scientists devoting their careers to detailing thousands of unrealistic "what-if" scenarios. When pressed, they justify their actions by saying,

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"We're just trying to ensure safety." But pushed to such extremes, we're not safer, we're just wrong. The Nuclear Regulatory Commission chairman, Nils Diaz, has asked that more realistic premises be used to evaluate safety—not looser, not lower, just more realistic. That's a good start. Real safety is based on realistic premises.

On that basis, we should ask why our emergency planning calls for evacuating millions of people around nuclear power plants. Certainly such a mass evacuation would be a mess. (If you really thought the air was full of fission products, would you want to order people to go mill around in it?) The question is, could any realistic damage to the plant warrant such evacuation? The answer, as described in the Sept. 20, 2002, issue of Science, is that one can do nothing to an American-type nuclear power plant or its fuel that would create a serious public health hazard. You might produce a meltdown, as occurred at Three Mile Island, but that event caused no human or environmental injury. Even if the containment structure were also compromised, physical tests and analyses of spent fuel show there would be little dispersion, so there would be few if any radiation injuries. By assuming otherwise, we create unwarranted terror, and the terrorists win.

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ICRP'S PROPOSED NEW RULES Further Departure from Realism

Lauriston Taylor, one of the founders of the ICRP and the NCRP, wrote in 1980:

"No one has been identifiably injured by radiation while working within the first numerical standards set by the NCRP and the ICRP in 1934. The theories about people being injured have still not led to the demonstration of injury and, if considered as facts by some, must only be looked upon as figments of the imagination. "

At the eleventh quadrennial meeting of the International Radiation Protection Association in Madrid, May 27, 2004, the International Commission on Radiological Protection (ICRP) presented the first proposed revision of its position since ICRP-60 was issued in 1990. In apparent agreement with Dr. Taylor's 1980 statement, the ICRP asserts that it "recognizes the need for stability in regulatory systems at a time when **there is no major problem identified with the practical use of the present system of protection...**" Despite this assertion, it then proceeds to tighten even further the ALARA-to-zero noose. ICRP reaffirms its position that "**there is presumed to be some probability of health effects even at small increments,**" but proposes nevertheless that it is not necessary to address radiation protection for doses below 0.01 mSv (1 mrem).

ICRP reports are not to be taken lightly. When confronted with the harmful effects of their pronouncements in the real world, ICRP members generally protest that they report only on the science, and that regulatory authorities are free to follow their advice or not. But at Madrid, ICRP was less conciliatory: "**These restrictions...should be considered as obligatory, and not maintaining these levels of protection should be regarded as a failure...**where action to avert the dose is virtually certain to be justified."

As instruments become more sensitive, as increasingly extreme practices become the norm, there is no end in sight. After setting extreme requirements, the Commission looks to local authorities to go further: "**the Commission therefore recommends that further, more stringent, measures should be considered for each source...The Commission expects that the resulting national values of constraints will be lower** than the maximum values recommended by the Commission, but probably not by as much as a factor of ten."

The ICRP does recommend "optimization," but it defines optimization as simply dose reduction: "the concept of optimization...is to engender a state of thinking in everyone responsible for control of radiation exposures such that they are **continually asking themselves the question, 'Have I done all that I reasonably can to reduce these doses?'**" Since radiation dose is often caused by discretionary time spent inspecting and testing in radiation zones, this quixotic quest for zero dose creates an ill-advised incentive to reduce that time for no health benefit, at increased risk of missing a situation (such as corrosion or leakage) important to real safety.

ICRP also continues to use "collective dose" as a measure of health effects, despite widespread objection. *Groups* do not suffer health effects; only individuals do. ICRP also continues to distinguish between "natural" and "artificial" radiation sources, although there is no scientific basis for doing so.

Although it is not discussed explicitly in ICRP's summary handout, ICRP Chair Roger Clarke and others stated that the Commission is not justifying its recommendations on the basis of risk, but simply on the basis of dose limits. They have nominal comparisons to background radiation, which is taken to be 1 mSv (100 mrem). This is the low range of background radiation, and excludes radon. Radon is not included

because it has been made subject to radiation protection control. This blurs the rationale for the limits. It obscures the lack of health benefits obtained for the enormous costs committed to radiation protection. This may explain the reason for the change

The ICRP states that the aim of its recommendations is "to make value judgments about the relative importance of different kinds of risk and about the balancing of risks and benefits. In this, **they are no different from those working in other fields** concerned with the control of hazards." But in fact, these recommendations are of entirely different type and magnitude than encountered in other fields. Other potentially toxic agents are given a tolerance level, and regulation is thereby made clear and unambiguous. There is no public health and safety basis to treat radiation in a different manner, and ICRP's approach should be vigorously opposed.